CHAPTER 4

ROAD NETWORK

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4.1 TRANSPORT SYSTEM OF OMAN

The characteristics of the transport system of Oman are expressed in two words, “three concentrations”. They are concentration to vehicular transport, to Muscat and to private mode transportation.

4.1.1 Concentration to Vehicular Transport

1) Person Movement

There are two ways of transport of persons in Oman; one is by plane and another by automobile.

All of the commercial domestic flights connect Muscat with other cities. This means that all the passengers using domestic commercial air transport either arrive at, or depart from, Seeb International Airport.

The present road Origin-Destination (OD) tables of personal movement crossing Wilayat boarders were estimated based on the field data collected in the Study. Based on this OD tables, total daily trips in terms of number of passenger before seasonal adjustments are estimated at approximately 160,000. It means that 99.5% of total passenger trips use vehicular (road) transport, assuming domestic annual air passenger of 2004 as 300,000.

2) Commodity Movement

There are three ways of transport of commodity in Oman; by plane, by ship and by automobile. As for commodities transported by plane, loading and unloading data at Seeb International Airport are shown in Table 4.1-1. They are equivalent to the total annual volume of air cargo movement as explained in the preceding subsection.

Table 4.1-1 Domestic Annual Cargo Movement at Seeb International Airport

Year	1998	1999	2000	2001	2002	2003
Domestic Goods (ton)	696	818	1,332	1,859	1,361	1,610

Loading and unloading to/from boats at the Sultan Qaboos Port are presented in Table 4.1-2. Some boats ship to domestic ports and some to foreign ports nearby.

Table 4.1-2 Boats Cargo Flow through Port Sultan Qaboos

Year		1998	1999	2000	2001	2002
Goods (ton)	Loaded	-	-	668	-	722
	Unloaded	-	18,300	37,957	21,976	26,688

The present road OD tables of commodity movement crossing Wilayat boarders were estimated based on the field data collected in this study. Based on the OD, total daily movements in tonnage are about 148,737. It means 99.9% of total commodity movement uses automobile (road) transport, assuming domestic annual air cargo of 2004 as 2,000 tons and sea cargo as 30,000 tons.

4.1.2 Concentration to Muscat

As discussed in Section 7.1, trips for both passengers and commodities are concentrated to the Governorate of Muscat.

4.1.3 Concentration to Private Mode Transportation

By assigning OD data onto the present road network, passenger of private car and bus are obtained. Table 4.1-3 presents the summary results, which obviously indicate concentration to the private mode.

Table 4.1-3 Total Person-km of Private Car* Users and Bus Users

Mode	Share (%)
Private Car*	71.5
Bus	28.5

Note: * Including Passenger Car, Taxi, 4WD and Van

4.1.4 Transport Infrastructure

The transport infrastructure in the Sultanate of Oman is composed of roads, ports and air transport. International railway network is being considered to connect all the countries in the region but does not exist at present. In addition, pipelines are widely used for transportation of oil and gas.

1) Air Traffic

After steady increase in passenger and goods transport until 1998, stagnant phase started (Table 4.1-4). In addition to Seeb International Airport, the country has five other airports, located at Salalah, Masirah, Khasab, Diba and Sur. The government announced that it intends to build an airfield near Sohar.

In addition to those, oil companies operate a number of landing strips at remote oilfield locations and the military force has a number of air bases.

In early 2002 management of Seeb and Salalah airports was turned over to a private consortium led by a UK firm.

Table 4.1-4 Passengers and Goods at Seeb International Airport

Year		1998	1999	2000	2001	2002	2003
International	Passengers (1000 psn)	2,460	2,514	2,436	2,434	2,154	2,602
	Goods (ton)	52,253	61,397	67,298	71,219	45,573	47,020
Domestic	Passengers (1000 psn)	296	286	285	263	293	284
	Goods (ton)	696	818	1,332	1,859	1,361	1,610

2) Ports

The Sultanate is served by five major commercial ports; the Khasab, the Shinas, the Sohar, the Sultan Qaboos and Salalah. In addition, another major port is being planned in Duqm. Further, there are two major ports which are used for handling specific items. The Fahl Port, located in Muscat is designed to handle export of crude oil and petroleum products. The Sur Port serves for LNG export. The Sultan Qaboos Port is located in Muscat and is the country's main commercial port. Other major ports are:

a. Salalah Port

The Salalah Port is specialized in the trans-shipment under the management of Sea-Land/Maersk, as partner of Salalah Port Services. Government is exerting efforts to develop the port area of Salalah. The Salalah Free Zone Company was established by 100% government capital and the construction of free trade zone (FTZ) will start in 2004.

This port is the deepest (16.5m) containers port in Oman and serves as a trans-shipment centre. Today, the Port of Salalah has four modern container berths, and Salalah Port Services is planning to install two additional container berths by 2003, increasing capacity to more than three million teu. It is already ranked amongst the top 20

container ports in the world. An expansion project with a budget of USD 240 million will start soon so it can receive more than 3 million containers annually.

b. Sohar Port

Construction of a new port at Sohar started in late 1999. The facility is expected to cost US$250 million and is designed to support a proposed aluminum smelter and oil refinery, as well as the needs of companies located in the nearby industrial zone. The port is scheduled to be completed in 2004.

In June 1998, Oman signed an agreement with the Japanese Export and Import Bank, finalizing a RO 96 million loan to finance Sohar Port. Construction of the 6 km breakwater began in 1999. The first phase of the project comprises two liquid cargo berths, two bulk berths serving the aluminum smelter, two general cargo berths and a container berth. Dredged to 17 meters, the harbor will be able to handle the largest container vessels in service.

c. Khasab Port

The Khasab Port in the Governorate of Musandam is also being expanded, with the aim of encouraging both trade with Iran and spots by cruise ships. The port is being upgraded, to promote new trade across the Strait of Hormuz and attract cruise liners.

Current facilities are:

- 90 meter berth, 5 meters deep.
- A 30 x 5 meter pontoon
- A lifeboat
- A harbor basin and channel dredged to 5 meters.

In future, the harbor will be expanded between 2002 - 2004, adding a 9 meter channel and 8.5 meter harbor, a 300 meter berth, 8.5 meters deep, a fishing harbor with three pontoons of 30 x 6 meters. There will be two 30 x 6 meters pontoons for the Royal Oman Police and for Iranian boats, a 60 hectare repair yard, and infrastructure including administration building, customs building, coastguard headquarters, covered storage areas, water, and electricity.

d. Duqm Port

The Duqm Port in Al Wusta Region is being planned for regional development purpose. Dry dock will be facilitated for repair and maintenance of vessels nearby.

e. Shinas Port

The Shinas Port in Al Batinah Region was transformed from fishery port to commercial port. The authorities expect that the transformation strengthens trading function with Iran. The government is inviting bids for consultancy services to study the feasibility of constructing a harbor that will comprise:

- Harbor basin protected by breakwaters 1,300 meters long, 10 meters deep.
- A 300 meter berth for general freight.
- A second 300 meter berth.
- A fishing dock 2.5 meters deep inside the harbor basin.
- A dry dock.
- Pleasure boat berths.
- Provisioning and infrastructure facilities.

Table 4.1-5 summarizes loading and unloading activities by port.

Table 4.1-5 Loading and Unloading Activities of Ports (1,000 shipping tons)

Port	Loaded/Unloaded	1998	1999	2000	2001	2002	2003
Sultan Qaboos	Loaded	416	473	637	751	935	4,627
	Unloaded	4,033	3,546	3,637	4,456	4,481	1,073
Fahl	Loaded	43,365	43,809	46,072	46,108	42,806	39,079
	Unloaded	0	0	0	0	0	0
Salalah	Loaded	247	531	540	564	728	762
	Unloaded	544	583	623	838	950	580

3) Pipeline

All of crude oil and gas are transported through pipeline. Pipeline network for crude oil is started from oil field and ended at the Fahl port (Mina Fahl at Mutrah). Gas pipeline network connects most of major cities including Muscat, Sohar, Sur and Salalah. Pipeline networks for crude oil and gas are illustrated in Figure 4.1-1.

4) Roads

Condition of roads in the Sultanate is described in the later sections of this Chapter. Therefore, it is omitted here.

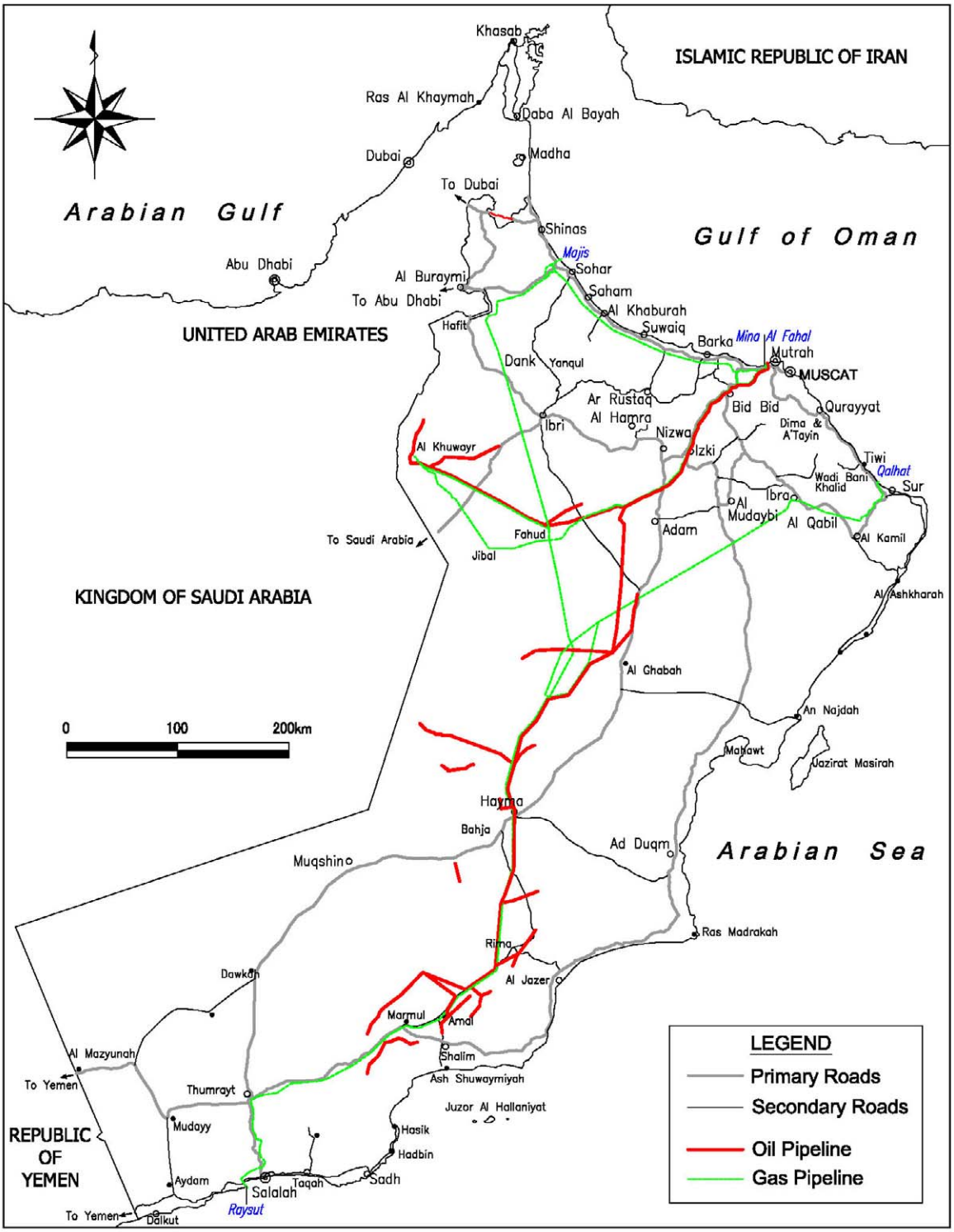


Figure 4.1-1 Oil and Gas Networks

4.2 ADMINISTRATION, LEGISLATION AND ORGANIZATION

4.2.1 Administrative Classification

There are two kinds of road classification which are widely used by highway planners; administrative classification and functional classification[1]. Administrative classification is to categorize roads according to the government agency responsible for construction and maintenance of the road. A typical example of such classification may categorize roads into National Roads, Provincial Roads and Municipal (City, Town or Village) Roads. In such hierarchy of administrative classification, arterial roads which cater for nation-wide traffic are classified as national roads while the roads which serve to regional or local traffic are classified as provincial or municipal roads in accordance with the characteristics of the traffic on the road.

In case of the Sultanate, public roads are classified into two categories; National Roads (or administered by the Ministry of Transport & Communication: MOT&C) and Municipal Roads (or Wilayat Roads). Further, there are roads maintained by Petroleum Development of Oman (PDO) and other authorities.

Table 4.2–1 shows the total length of each administrative road classes in the Sultanate.

Table 4.2–1 Administrative Classification and Road Length by Class

Class		Total Length (km)
National Road*	Paved	7,613
	Unpaved	15,970
	Total	23,589
Municipal Road & Others		Approx. 12,000
Total (As of Year 2003)		Approx. 37,200**

* Source: DGR; as of December 2003

** Source: Statistical Year Book, October 2004, p-311

4.2.2 Administration

National Roads are administered by MOT&C. Within MOT&C, two directorate generals, Directorate General of Roads (DGR) and Directorate General of Communications in Dhofar (DGC) are in charge of administration of National Roads. DGC, particularly Road Department, is responsible for construction, improvement and maintenance of the national roads in the Governorate of Dhofar and the DGR is

[1] As for functional classification, see Subsection 4.3.7

responsible for the national roads in other Regions and Governorate, except Muscat Governorate.

Currently, administration of roads in Muscat Governorate, including major roads such as NR No. 17 and NR No. 15 are responsibility of the Governorate of Muscat.

Although there are cities, there is no city government, and administrative works including construction and maintenance of roads within cities are the responsibilities of either DGR, for major projects, or Municipalities (Wilayat governments). There is no stipulation in laws concerning the definition of public roads, or the roads to be under the jurisdiction of either DGR or Municipalities.

Upon request by a Municipality, DGR implement projects of Municipal Roads. Accordingly, actual jobs of DGR are not limited to National Roads.

1) Maintenance

Maintenance is the responsibility of Maintenance Department of DGR and Road Department of DGC (see Subsection 4.2.2 “Organization”). Actual works of maintenance are contracted out to contractors and supervised by eight (8) Regional Road Departments located at strategic locations over the Sultanate. Typical contract of maintenance is contracted for the period of four (4) years and is to cover one region/governorate. Contracts are made for paved road and track roads separately for each region/governorate.

Table 4.2–2 shows approximate contract amounts of maintenance works for region/governorate. As can be seen in the table, contract amounts for 4-year contract range from approximately RO 0.5 to 2.4 million. From the data shown in the table, it is calculated that annual expenditure for maintenance is around RO 5 million on average.

Table 4.2–2 Contract Amounts of Maintenance (Contract Period 2002-2005)

Region	Paved Road		Track Road	
	Total Length (km)	Contract Amount (RO 1,000)	Total Length (km)	Contract Amount (RO 1,000)
Musandam	115	540	449	851
Al Batinah	1,198	1,596	3,586	2,767
A'Dhahira	638	1,756	2,658	1,517
A'Dakhliyah	1,186	1,840	2,796	1,862
A' Sharqiyah	933	1,756	2,855	2,120 (Include those of Al Wusta)
Al Wusta	1,100	2,382	31 (Included in A' Sharqiyah)	(Included in A' Sharqiyah)
Total	5,170	9,870	12,375	9,117
Total Contract Amount		RO 18.987 million (4 years)		
Per Year		RO 4.747 million		

Typical work items included in a contract for paved road maintenance works are as listed below:

- Road marking
- Maintenance of road furniture
- Protection works of embankment, culverts, bridges etc.
- Repair of washout sections
- Repair of damaged drainage structure
- Bituminous pavement patching
- Bituminous pavement maintenance by sand seal

Typical work items included in a contract for track road maintenance works are as listed below:

- Grading
- Spot patching
- Repair of washouts
- Removal of deposited sand

Contractors generally have sufficient human capacities, equipment and financial capacities to carry out their duties, although close supervision by DGR official or international expert is essential.

2) Traffic control

Responsibility and authority of traffic control rest with Directorate General of Traffic Services, Royal Oman Police (ROP). (See 4.3 "Legislation and Budgetary System" for the description of this subject.)

4.2.3 Legislation

For the purpose of road administration, there are generally three (3) essential matters to be stipulated by law or similar rule; (a) Responsibility and authority of government on road, (b) Definition of roads to be constructed, improved and maintained by the Government (central government and local government), and (c) Traffic rules, specifically the authority of regulations (including prohibition of traffic). Traffic rules often include regulation on size and weight of vehicles which can be operated on public roads.

There are two (2) main laws relevant to road administration in the Sultanate:

1) Royal Decree 63/78 of year 1978 "Law for Establishment of Ministry of Transport and Communications": Stipulates responsibility and authority of government (Ministry of Transport and Communications) on roads.

2) Royal Decree 28/93 of year 1993, "Road Traffic Law" with its Execution Rule No. 23/98 and amended by Decree 91/2001: Stipulates authority of Royal Oman Police for regulating traffic as well as size and weight of vehicles.

Among these laws, Road Traffic Law will be presented in Section 4.3 and Law for Establishment of Ministry of Transport and Communications (MOT&C) is summarized in the following:

Present law was enacted in 1978 to legally stipulate the organization and function of MOT&C. Before this law was enacted, there was a preceding one which was enacted in 1973 and was amended in 1975. Concerning roads, the present law stipulates the following:

a. Function, (responsibility and authority) of MOT&C on roads

Annex A of the Law stipulates that construction and maintenance of roads is the responsibility of the Government. The same Annex A of the Law stipulates that the functions of MOT&C with regard to roads are:

1- connecting different regions of the Sultanate with a paved road network,
2- planning, survey, design, and supervising road projects,
3- construction of new roads and improvement of existing roads,
4- operation and maintenance of paved roads, and
5- constructing and maintaining track roads in coordination with Wilayats.

b. Designation of public roads

Clause 1 of Annex A of the Law stipulates that the Minister of MOT&C has the responsibility and authority to designate and announce public roads for which the government is responsible.

c. Prevention of damage of public roads

Clause 6 of Annex A authorizes the Ministry to set up rules and regulations that assure the optimum use of roads that avoids any damage or destruction.

d. Director General of Roads

The responsibilities of the Director General (DG) of DGR include the following:

1- Policy
DG will implement the policy prepared by the Minister as well as complying with the rules and regulations of the country.

2- Budget
DG shall annually prepare the budget of DGR and to supervise expenditure items based on financial regulations.

3- Management
DG will manage all departments under DGR as well as the behavior of all employees.

4- Expenditures
DG will supervise all expenditure items under the budget and will attend annual meetings with directors and experts to prepare budgetary requirements and expenditures for proposed projects.

5- Supervision of consulting services
DG will directly supervise all consultancy service works done by consultants and prepare regular reports to be submitted to the Minister and Vice Minister, and will handle change-orders and project modifications based on instructions from the Ministry.

4.2.4 Organization

As described in the above Subsection, MOT&C is responsible for administration of National Roads. MOT&C is headed by the Minister who is assisted by two Undersecretaries, one for transport and the other for communications. DGR is under the Undersecretary for Transport, together with DGC, DG of Finance and Administration, DG of Civil Aviation and Meteorology, and DG of Port and Maritime Transport.

Actual works related road administration under the jurisdiction of MOT&C is implemented by DGR and DGC. Figures 4.2–1 and 4.2–2 show the organization charts of DGR and DGC, respectively.

Directorate General of Roads (DGR)

DGR is headed by the Director General and consists of four (4) departments which are in the headquarters proper and eight (8) Road Departments which are located in strategic locations.

DGR is currently staffed with 232 persons. Breakdown of the number of the staff of each Department is shown in Figure 4.2-1.

Considering the length of roads under the jurisdiction of DGR, this number of staff is considered to be insufficient. As a reference, the number of staff working for about 21,000 km of national roads of Japan which are directly administered by the Directorate General of Roads, Ministry of Land, Infrastructure and Transport and its branches located nation-wide is about 12,000 persons. (Administration of the remaining 32,000 km of national roads is delegated to Prefecture Governments.) Table 4.2–3 shows the number of staff for roads in Ministry of Land, Infrastructure and Transport in Japan for comparison.

Table 4.2–3 Number of Staff for Roads in Ministry Land, Infrastructure and Transport (Japan)

Organization	No. of Staff (persons)	No. of Staff Related to Roads (persons)
Whole Ministry	45,788	N/A
Headquarters (in Tokyo)	4,146	210
Regional Branches	29,187	11,700 (Estimated as 40 % of the Left)

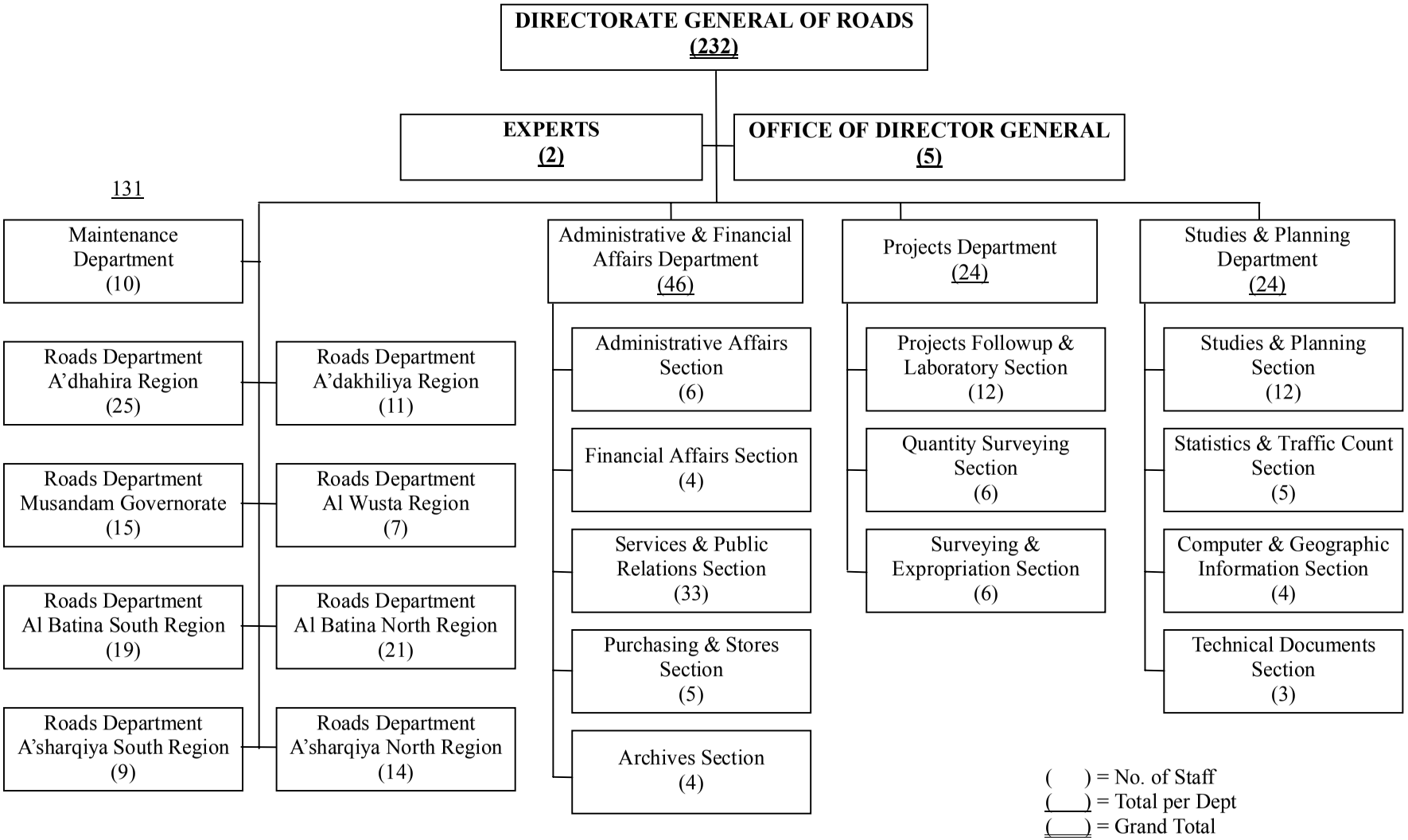


Figure 4.2-1 Organization Chart of DGR - 2003

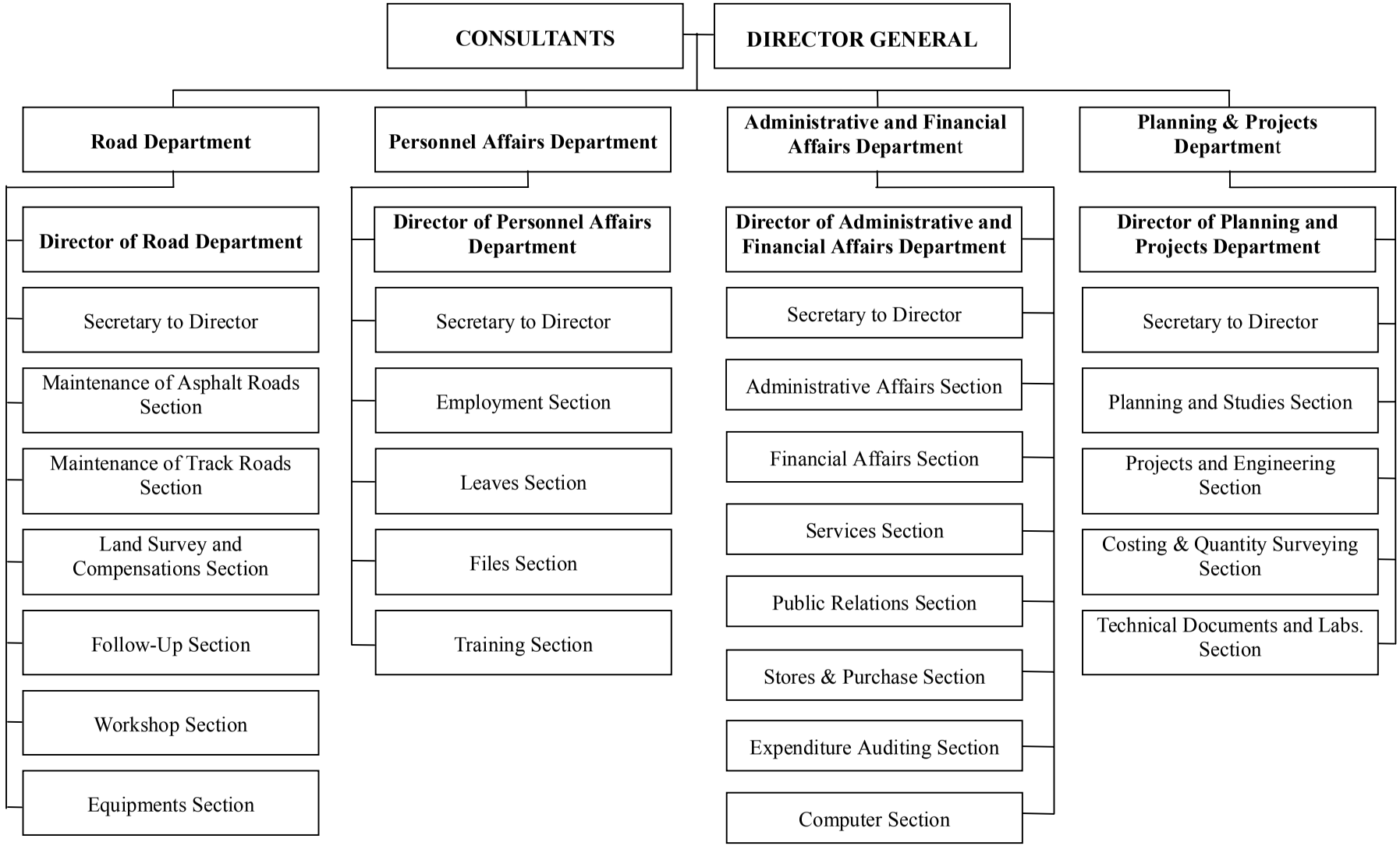


Figure 4.2-2 Organization Chart of DGC in Dhofar

Table 4.2–4 shows the number of DGR staff by job category.

Table 4.2–4 Number of DGR Staff by Job Category (2004)

Job Category	Number of Staff
Engineering/Technical	95
Others	137
Total	232

To supplement the insufficiency in capacity, DGR is currently employing foreign experts. Further, simple works as janitor are out-sourced to private firm by contract.

Out-sourcing is widely adopted also for surveys and designs. These works are basically contracted out to consultants.

Directorate General of Communications in Dhofar (DGC)

DGC is one of Directorate General of MOT&C which is specifically in charge of Dhofar Governorate. Road Department of DGC (RD/DGC) is responsible for roads in the Governorate.

RD/DGC also maintains close contact with Communication Departments of the Municipal Governments.

4.2.5 Budgetary System

Fiscal year of the Sultanate Government starts from January and ends in December. Each ministry prepares its draft budget for next year and submits it to the Ministry of National Economy (MONE) and Ministry of Finance (MOF) in August. MOF evaluates the draft budgets of all the Ministries and prepare the draft national budget. The draft national budget is submitted to His Majesty for his review and approval.

Table 4.2-5 shows the budget for the last seven (7) years. As can be seen in the table, the amounts of DGR budget considerably fluctuated in the past between RO 9.0 million and RO 56.6 million. The percentage of DGR budget to the entire budget of the Government also fluctuated between 0.4 % and 1.86 %.

Table 4.2-5 Budget of DGR (Amounts in RO million)

Year	1997	1998	1999	2000	2001	2002	2003
Entire Government	2,307	2,222	2,269	2,656	2,860	2,940	N.A.
DGR Budget	44.9	9.0	25.2	40.2	36.4	54.6	56.6
% of DGR Budget to Government Budget	1.95	0.40	1.11	1.5	1.27	1.86	N.A.

Source: DGR Budget – Division of Contract and Obligation, MOT&C,
Government Expenditure - Statistical Year Book 2003

For reference, budget for the roads accounts 4 to 8 % of the national budget in Japan. In case of the Philippines, the percentage of the budget for roads, excluding administration, to the entire budget of national government varied from 3.0 to 5.1 for the period of 1999 to 2003, with average of 4.0. Compared with these figures, the percentage of the budget of DGR to the entire budget of the government is considered to be small.

Table 4.2-6 shows the actual expenditure of DGR, with breakdown into expenditures for construction and maintenance. The total of construction and maintenance expenditures ranged between RO 13.4 million and RO 32.7 million. The total of construction and maintenance for each year is considerably smaller than DGR budget, except in year 1998 and 1999. In 1998, only the total expenditure of construction and maintenance alone was more than two times of DGR budget. These figures need further analysis.

Table 4.2-6 Breakdown of Actual Expenditure of DGR (Unit: RO 1,000)

Year	1997	1998	1999	2000	2001	2002	2003	2004	97-03 Ave.
Construction (a)	13,441	15,196	28,529	20,745	14,242	21,107	39,279	12,734	21,791
Maintenance (b)	3,852	4,086	4,133	4,275	3,975	3,809	3,555	671	3,955
Total* (e)	17,293	19,282	32,662	25,020	18,217	24,915	42,834	13,405	25,746
DGR Budget	44,870	9,028	25,158	40,185	36,443	54,598	56,553	57,237	

As can be seen from the table, the expenditure for construction considerably fluctuates every year while the expenditure for maintenance is relatively stable. Average annual expenditure for years 1997 – 2003 (7 years) is RO 21.8 million and RO 4.0 million for construction and maintenance, respectively. This average expenditure for maintenance is comparative to the average contract amount shown in Table 4.2-2.

Budget for Five-Year Development Plans (5YDP)

The budget allocated for 5YDP is the basis of the budget f DGR. The budgets for roads included in 5th and 6th 5YDP are as shown in Table 4.2-7.

Table 4.2-7 Budget of 5th and 6th 5YDP for Roads

	Budget (RO million)	
No. of 5YDP	5th	6th
New Projects	60	81.3
Transferred from Previous Plan	22	62.6
Subtotal	82	143.9
Additional Budget*	138	87.9 (As of May, 2004)
Total	220	231.8

*Source: Director of Planning & Studies, MOT&C

As indicated in the table, more than 1.5 times of originally allocated budget was added as Additional Budget to implement urgent projects in 5th 5YDP and nearly RO 90 million has been give as Additional Budget in 6th 5YDP (as of May 2004).

4.2.6 Traffic Law, Vehicle Registration and Driving License Systems

Traffic Law of the Sultanate was issued on June 5, 1993 and was revised by Decree No. 91/2001 on August 1, 2001. This law was issued based on Royal Decree Nos. 35/90 and 28/93 (Police Law and its amendment), and stipulates the following subjects concerning road and road traffic. (The Traffic Law and its pleading realization are issued in Arabic language. A more detailed summary of main aspects in English is presented in Appendix 4-1.)

(i) Vehicle registration

As presented in Chapter 1 of the Law, number plates of vehicles registered under the Traffic Police Department and its regional branches are divided into the 13 categories of: (1) private, (2) taxi, (3) commercial, (4) rental, (5) driving school, (6) government, (7) diplomat, (8) councilor, (9) United Nations, (10) tractor, (11) motorcycle, (12) export, and (13) under-inspection. Vehicles exempted from registration are those of H.M. the Sultan, military vehicles, transit and temporary visiting vehicles.

(ii) Size and weight of vehicles

Size and weight of vehicles which are allowed to be operated on public roads are presented in Execution Rule, Clause 114-4 stipulates that maximum size and weight of vehicle as summarized in the Table 4.2-8.

Table 4.2-8 Maximum Size and Weight of Vehicle

Item	Traffic Law	HDM
Max. Width (m)	2.7	2.6
Max. Length (m)	12 m (Single Truck) 17 m (Trailer)	18
Max. Height (m)	4.2	-
Max. Gross Weight (t)	46	45
Max. Axle Load (t)	• 13 (Single Axle) • 14.7 (Tandem Axle with Axle Distance > 90 cm; increases with larger distance of axles)	21

(iii) Definition of public roads where the Traffic Law is applicable

Item 21 under Clause 1 defines the road as a public facility to be used either by pedestrians, animals or other means of transport including streets, plazas and under- and over-passes, but does not categorizes simple open space such as wadi, as roads.

(iv) Regulation and control of traffic

The Law states that the Police Law under Royal Decree 35/90 stipulates the responsibility and authority of traffic regulation/traffic control rest with ROP. It is widely interpreted that regulation/prohibition of traffic to secure the safety of traffic, in cases such as occurrence of flush flood, is responsibility/ authority of ROP. On the other hand, the Traffic Law states that installation of traffic signs and traffic signals is done by DGR with instruction of ROP. Therefore, ROP maintains close coordination with MOT&C on this matter through Traffic Safety Committee.

(v) Durability and safety

Chapter 3 of the Traffic Law deals with durability of vehicles and other safety standards and requirements. Policemen have the authority to stop any vehicle that doesn't meet such standards.

(vi) Driving licenses

Rule on issuing different driving licenses are presented under Chapter 4 of the law. Four types of driving licenses are issued:

a. Light vehicle driving license: allow the drive of vehicle up to 6 ton total weight.
b. Heavy vehicle driving license: allow the drive of vehicle > 6 ton total weight.
c. Tools driving license: allow its carrier to drive the tool allowed on the license.
d. Motorcycle driving license' allow the drive of any type of motorcycles

(vii) Traffic rules

Chapter 5 of the law deals with traffic rules, regulatory signs, driving speeds and other regulations required for safe and smooth traffic movement.

(viii) Registration fees and penalties

Chapters 6 and 7 provide other traffic rules issued by the General Inspector including the establishment of driving schools, vehicles' registration fees and applied penalties for different types of traffic violations.

4.3 EXISTING ROAD NETWORK

4.3.1 Overview

According to the Statistical Year Book, 2003, the total length of all the roads in the Sultanate, including those maintained by the Petroleum Development of Oman (PDO) and others, is about 36,000 km. Out of this 36,000 km, the total length of roads under the jurisdiction of DGR, as of December 2003, is 23,583 km. Among these DGR roads, total length of paved roads is 7,613 km. The total length of Track Roads (Unpaved Roads) is estimated to be approximately 15,970 km.

Figure 4.3–1 shows the growth in the length of paved roads and unpaved roads. In the figure, it is seen that the lengths of unpaved roads have decreased in the past ten years while the length of paved roads has increased. Thus, the total length of DGR roads has little increased since 1993. The figure shows abrupt increase in the total length and the length of unpaved road in year 2003. This is due to the result of field surveys of the actual lengths of roads. Also, decrease in the length of paved road is observed in year 2003. This decrease is the result of some of the paved DGR road to Wilayat roads.

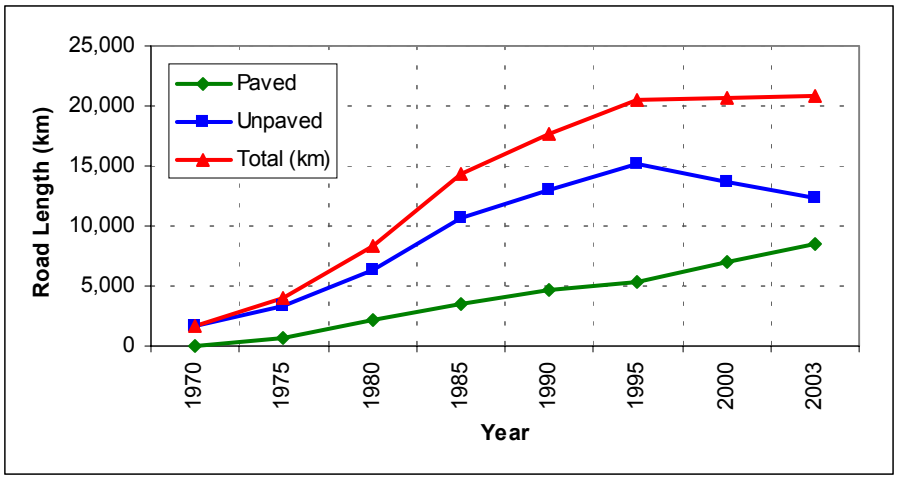


Figure 4.3-1 Growth of Lengths of DGR Roads

4.3.2 Growth of Paved Roads

While the growth in the total length has slowed down since 1993, the growth in the length of paved road in the past ten (10) years has been remarkable. In year 1993, the length of paved road was 5,038 km and it increased to 8,437 km by year 2003. This means that the average increase in the length of paved road is 300 km per year. Increase of paved road is more remarkable in the five (5) years of 1997 - 2001. The total length of paved road under DGR increased from 5,361 km to 7,389 km (increase of 2,028 km) Therefore, an average increase of more than 400 km per year has been recorded. These figures become more remarkable if the fact that length of paved road was merely ten (10) km in 1970 is considered.

If this rate of increase in paved road length will be maintained in the future, it is expected that the total length of paved road will reach approximately 19,000 km which correspond to about 80 % of the total length of the existing road network.

4.3.3 Road Density

Road Density (RD) is defined as the quotient of the total length of roads in a country divided by the area of the country and expressed in terms of km per square kilometer. RD is considered to be an index for the degree of development of road. Table 4.6-1 shows comparison of RDs of the Sultanate and neighboring countries, as well as Japan and Philippines. Road density of the Sultanate is much lower than other countries. This may be natural in view of relatively sparse population density of the Sultanate.

To take the density of population into consideration, Road Density Index (RDI) is sometimes used to see the denseness of road network. RDI is defined as;

$$RDI = L/\sqrt{(A \times P)}$$

Where, L = total length of road in the country
A = area of the country in sq. km
P = population of the country in 1,000

This index is used in consideration on that the densely populated country needs more road than sparsely populated country. Figure 4.3-2 shows Road Density Index of some neighboring countries, Japan and the Philippines. The figure indicates that RDI of the Sultanate is comparable to other Gulf countries.

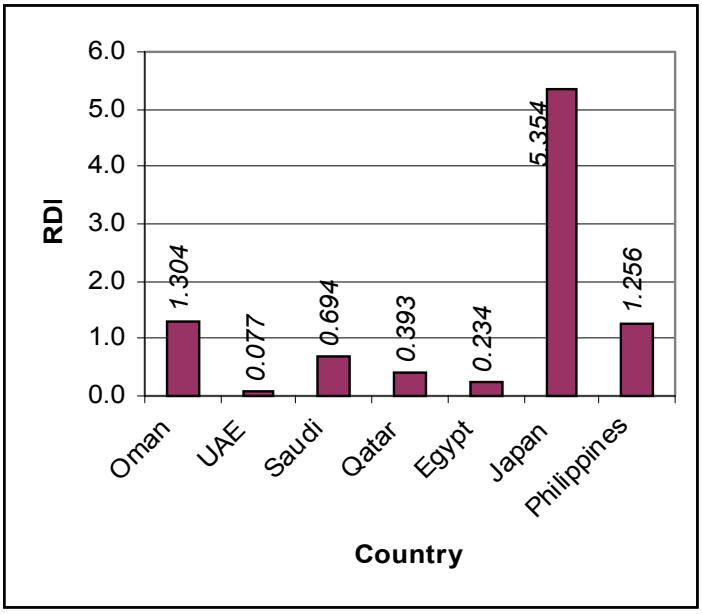


Figure 4.3-2 Road Density Index of Selected Countries

4.3.4 Regional Distribution

Table 4.3-3 shows Road Density (RD) and Road Density Index (RDI) of each Region/Governorate. Figure 4.3-3 graphically shows the road parameters included in Table 4.3-2. (There are some discrepancies on total both paved and unpaved roads between the previously stated figures and those shown in the table.)

High RDs are seen in Al Batinah and Musandam while low RDs are seen in Al Wusta and Dhofar. There is large difference of RD among regions. Highest RD of Al Batinah is approximately 40 times of that of Al Wusta.

Even when density of populations is considered, substantial change of the ranking among regions/governorate is not seen. High RDIs are seen in Musandam and Al Batinah while low RDIs are seen in Dhofar and Al Wusta. However, the difference becomes smaller. Highest RDI of Musandam is approximately three (3) times of that of Dhofar which is lowest. It should be noted that there are considerable length of roads maintained by Petroleum Development of Oman (PDO) in Al Wusta.

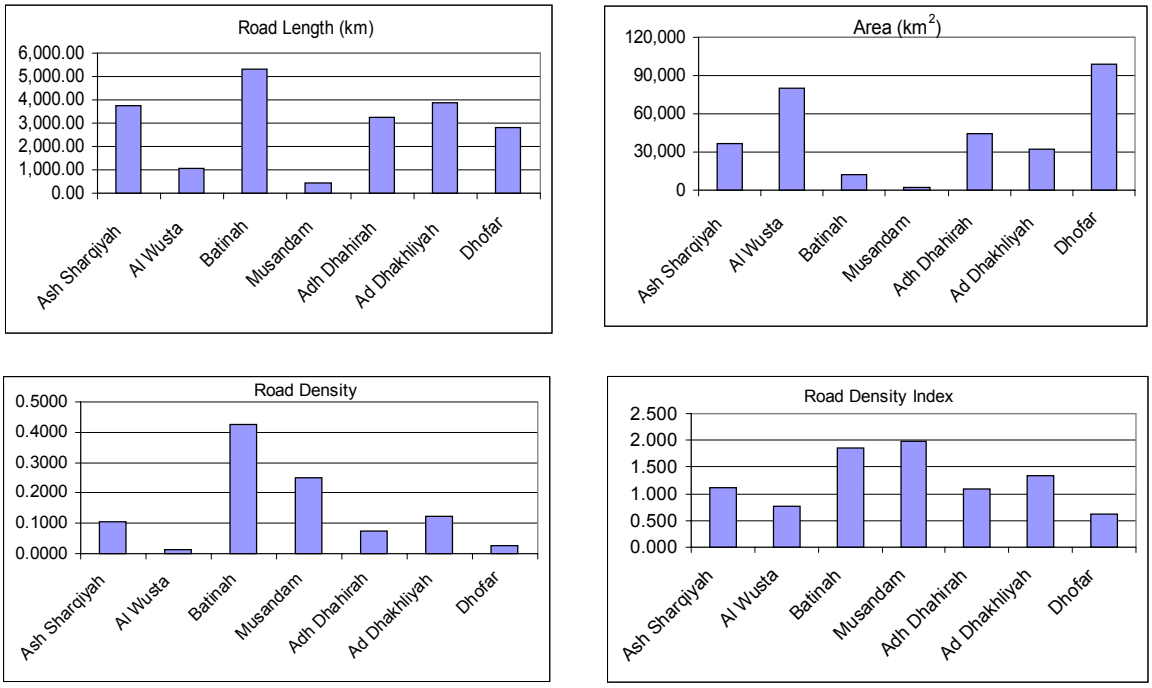


Figure 4.3-3 Regional Comparison of Road Parameters

Table 4.3–1 Comparison of Road Density and Road Density Index

Country		Oman	UAE	Saudi	Qatar	Egypt	Japan	Philippines
Road Length	All Roads	35,000	1,100	151,500	1,200	64,000	1,173,000	202,000
(km)	National Roads	20,300					62,000	30,200
	Paved N Road	8,000	1,100	45,600	1,100	50,000	62,000	18,700
Area (km^2)		309,000	82,900	1,961,000	11,400	1,001,000	378,000	338,000
Population (1000 Persons)		2,331	2,485	24,294	817	74,719	127,000	76,500
Road Density	All Roads	0.113	0.013	0.077	0.105	0.064	3.103	0.598
	National Roads	0.066					0.164	0.089
	Paved N Road	0.026	0.013	0.023	0.096	0.050	0.164	0.055
RDI	All Roads	1.304	0.077	0.694	0.393	0.234	5.354	1.256
	National Roads	0.756					0.283	0.188
	Paved N Road	0.298	0.077	0.209	0.360	0.183	0.283	0.116

Table 4.3-2 Road Density and Road Density Index of Region/Governorate

Region	Road Length (km)			Area km^2	Road Density (km/km^2)					Population	Road Density Index = L/ $(PA)^{0.5}$			
	Unpaved	Paved	Totel		Unpaved	Paved	Rank	Total	Rank		All Roads	Rank	Paved	Rank
Ash Sharqiyah	3,492.00	1,142.00	4,634.00	36,400	0.096	0.0314	4	0.1273	4	312,708	1.374	4	0.338	5
Al Wusta	350.00	1,007.00	1,357.00	79,700	0.004	0.0126	7	0.0170	7	23,058	1.001	6	0.743	1
Batinah	4,098.00	1,872.00	5,970.00	12,500	0.328	0.1498	1	0.4776	1	652,667	2.090	2	0.655	2
Musandam	441.00	115.00	556.00	1,800	0.245	0.0639	2	0.3089	2	28,263	2.465	1	0.510	3
Adh Dhahirah	2,658.00	844.00	3,502.00	44,000	0.060	0.0192	5	0.0796	5	204,249	1.168	5	0.282	6
Ad Dhakhliyah	2,731.00	1,346.00	4,077.00	31,900	0.086	0.0422	3	0.1278	3	265,083	1.402	3	0.463	4
Dhofar	2,200.00	1,287.00	3,487.00	99,300	0.022	0.0130	6	0.0351	6	214,333	0.756	7	0.279	7

4.3.5 Coverage

1) Access to major cities

Figure 4.3-4 shows the network of Primary and Secondary Roads (see Subsection 4.3.7 for the functional classification of roads) and major cities. As the major cities, all Wilayat centers and the cities with population more than 5,000 are shown. As can be seen in the figure, almost all of these major cities are accessed by either Primary or Secondary Roads.

2) Access to major ports

There are six (7) major ports in the Sultanate, namely Khasab, Shinas, Mutrah (Al Mina Al Sultan Qaboos), Fahal, Sohar, Sur and Salalah. Another one is planned at Ad Duqum in Al Wusta Region. Figure 4.3-5 shows the locations of these major ports. As can be seen in the figure, all of these ports are provided with access to Primary Roads.

3) Access to Industrial Estates and Free Trade Zones

There are six (6) designated Industrial Estates and two (2) designated Free Trade Zone. They are:

1- Rusayl Industrial Estate
2- Raysut Industrial Estate
3- Sohar Industrial Estate
4- Nizwa Industrial Estate
5- Buraimi Industrial Estate
6- Sur Industrial Estate
7- Al Mazyunah Free Trade Zone
8- Slalah Free Trade Zone

Figure 4.3-5 also shows the location of Industrial Estates and Free Trade Zones. All of these facilities are directly connected to Primary Roads.

4) Access to airports

There are two international airports in the Sultanate. One is As Seeb Airport which is located in the capital area of Muscat Governorate. Another one is Salalah Airport, but it functions as an international airport only in summer vacation season. Both of these airports are connected to Primary Roads via access roads. (Slalah Airport is connected to NR 31 via urban streets in the city of Salalah.)

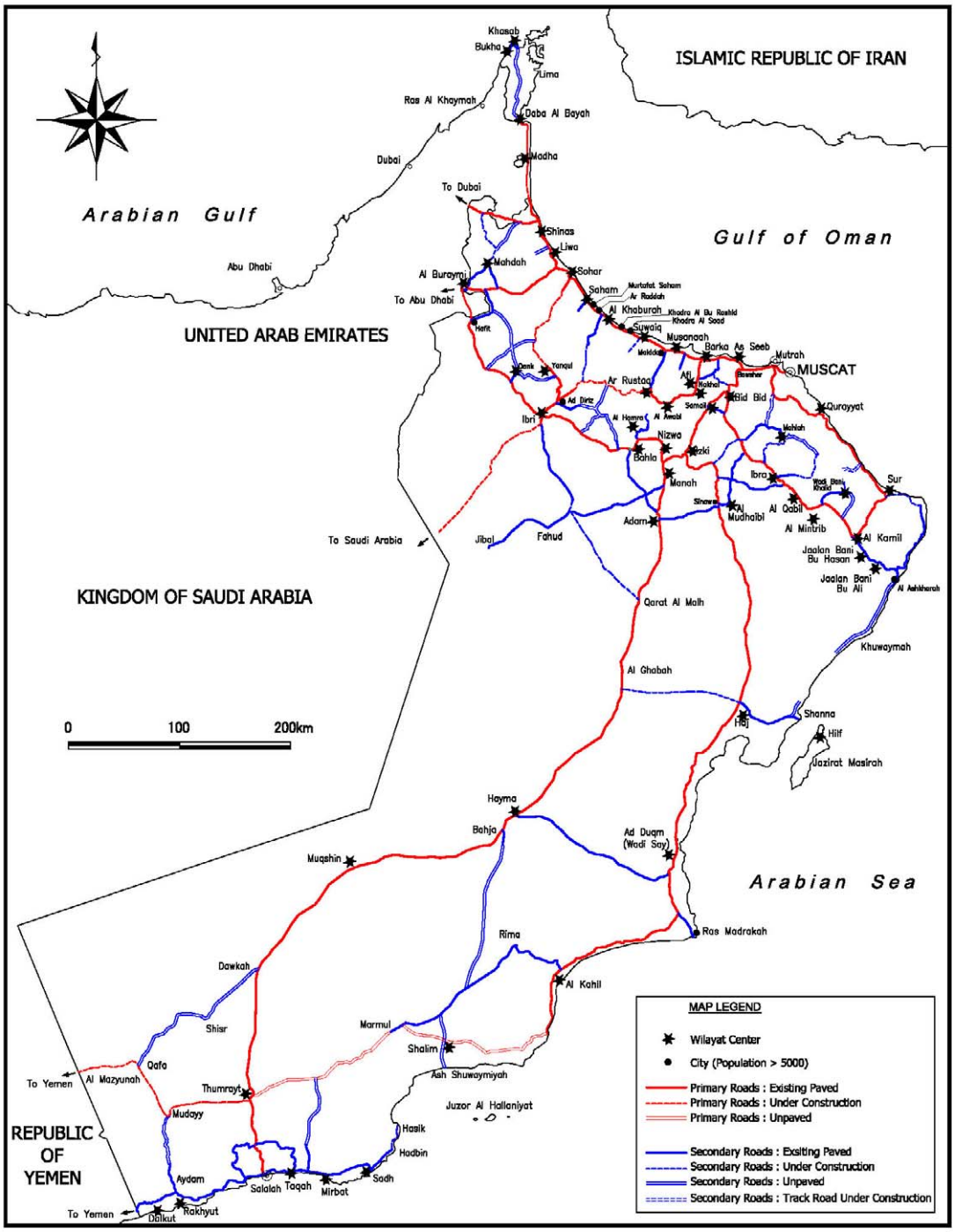


Figure 4.3-4 Location of Wilaya Centers and Cities

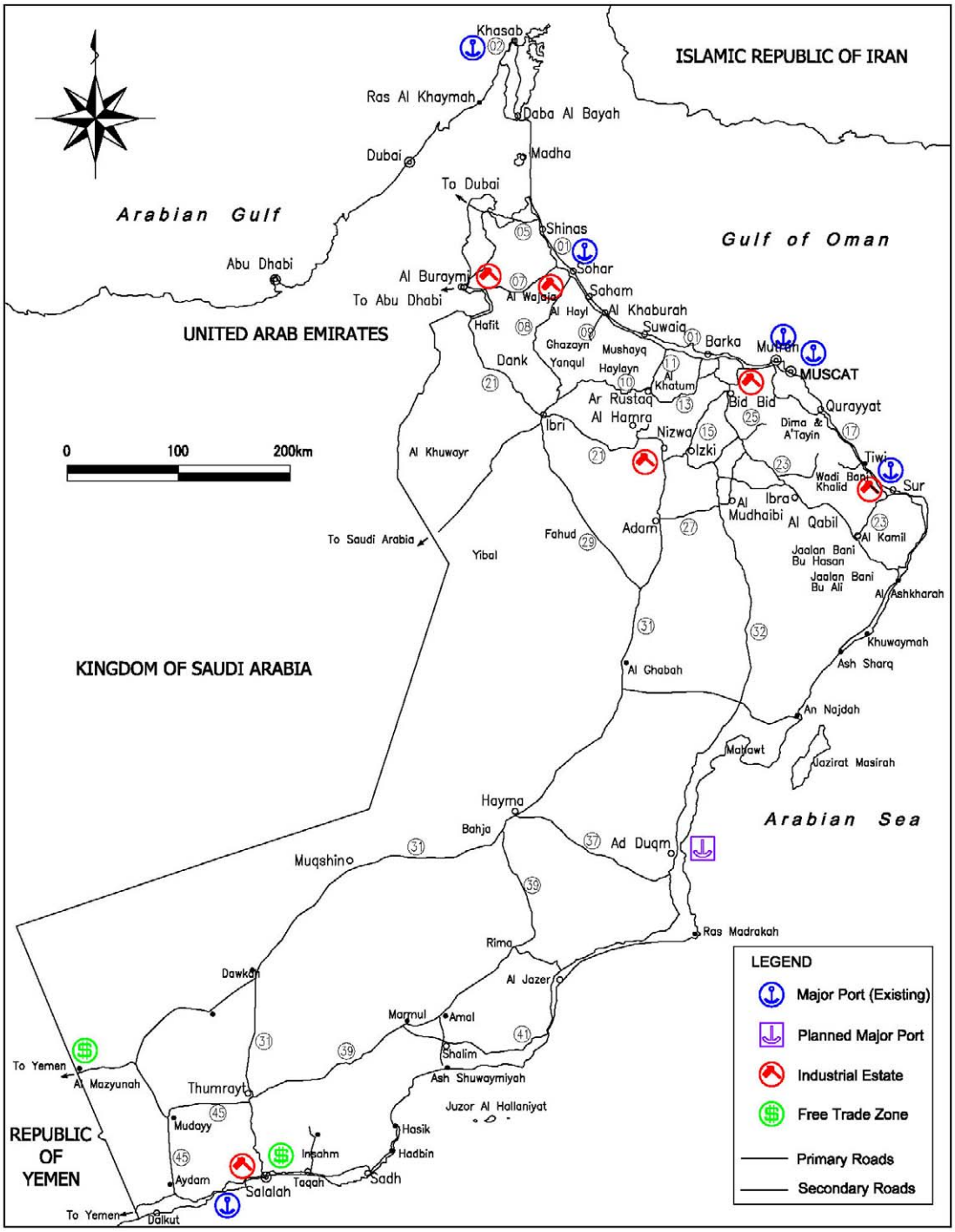


Figure 4.3-5 Location of Major Port, Industrial Estate and Free Trade Zone

4.3.6 Missing Links

Although the present road network of the Sultanate covers important cities and facilities fairly well, there are some road sections which do not exist although they are necessary to increase the efficiency of the network. These sections are called “missing links”. Figure 4.3-6 shows the major missing links in the present road network of the Sultanate.

1) Missing links along the eastern coast

In many countries, roads develop along the coast, if the country has coast. This is due to the fact that people tend to live along the coast where fishing can be the source of diet. Roads tend to develop connecting the settlements along the coast. There are two areas along the coastline where the existing roads are interrupted; one from Ashkharah to Shanna in Ash Sharqiyah Region and another from As Shuwaymiyah to Hasik in Dhofar Governorate.

The section between Ashkharah and Shanna is important to complete a circle of road connecting Ibra- Al Qabil – Al Kamil – Al Ashkharah – Ash Sharq – Al Najdah – Hijj – Al Mudaybi and promote the development of this area. The construction of this section has been difficult because of the continuous charge of sand from Wahayba Desert.

The section between Shuwaymiyah and Hasik is essential to secure the alternative route to NR No. 31 which is practically the only route connecting Salalah to the central and northern part of the Sultanate (at present). Since the section of NR 31 between Thumaryt and Salalah is passing the mountainous terrain, there is possibility of road closure due to slope failure or accidents. If NR 31 is closed due to such incidents, Salalah is isolated. Thus, another route becomes necessary. Construction of the road between Shuwaymiyah and Hasik has been hampered by the rugged terrain.

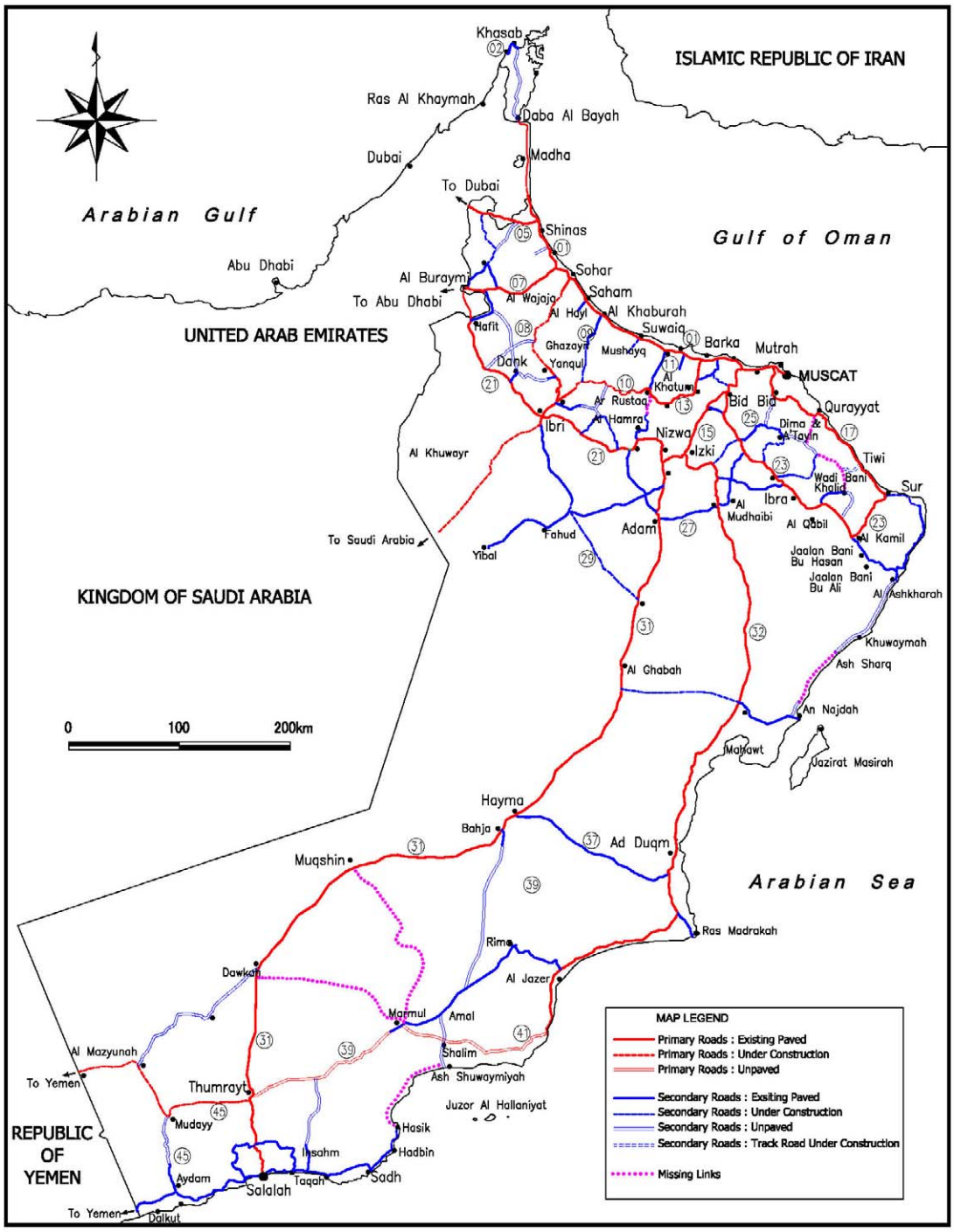


Figure 4.3-6 Major Missing Links in Present Road Network

2) Missing links across the northern mountain range

There are two elongated loops of Primary Roads running along the northern and southern side of the northern mountain range (Hajar): One is the loop connecting Mutrah (Muscat) – Sohar – Buraymi – Ibri – Nizwa – Izki – Bid Bid – Muturah and another one is the loop connecting Mutrah – Qurayat – Sur – Al Qabil – Ibra – Bidbid – Mutrah. The longer sections of these loops need to be connected with each other (NR No. 01 – No. 21 and No. 17 – No. 23) at appropriate interval to avoid long detour of the traffic traveling from either side of the mountain rage to the other side.

This connection across mountain rages is important not only for avoiding the long detour but also for strengthening socioeconomic communication between the both sides of the mountain range and promoting diversification of industry. This problem is discussed more in detail in Section 4.5.

3) Missing Links between NR 31 and NR 32

NR No. 31 and No. 32 are the primary roads connecting Al Wusta Region and Dhofar Governorate with the Northern Regions/Governorates. These two roads function as alternative routes to each other in case that either one cannot be used. To allow the vehicles to divert smoothly and efficiently from NR No. 31 to No. 32, or vice versa, connections between these two roads are need at appropriate intervals such as 100 to 150 km. There are such connecting roads as NR No. 27 (Adam – Sinaw), south of Al Gabah – Hiji (under construction), Hayma – Ad Duqm and south of Hayma – near Al Jazer, but there is no such connecting roads in the south of Hayma. Connections are desired between Muqshin and Amal, as well as between Dawkah and Marmul.

4) Other Missing Links

In addition to the links described above, the following links are considered to be missing:

a. Between Jibjat (Dhofar) to NR No. 39
   This link is necessary to secure alternative route between Thumrayt and Salalah in case of closure of NR No. 31.

b. Alternative route for NR No. 05 along the section passing UAE
   A part of NR 05 is passing the territory of UAE. Although the possibility of this section be closed by UAE is low, there ought to be an alternative route for this section in preparation that this section is closed by UAE for some reason.

4.3.7 Hierarchy and Functional Classification

1) Functional Classification

Functional classification refers to the classification in which roads are categorized according to the role it plays in the road network. Typical functional classification would be such that classifies roads into major (or principal) arterial, minor arterial, collector/distributor and local roads. Such concept has been adopted in the Highway Design Manual of the Sultanate (HDM). HDM classifies the roads into Primary Streets, Secondary Streets, Local Streets and Access Streets (for urban streets), and into Primary Roads, Secondary Roads, Local Roads and Access Roads (for rural roads).

Table 4.3-3 summarizes the definition and main features of classes of rural (inter-city) roads stipulated in HDM. In the classification of urban roads, four classes of roads constitute hierarchy of road network, serving from nation-wide or long-distance traffic to local or short-distance traffic.

Although HDM clearly defines functional classification of roads, roads in the Sultanate have not been actually classified into such functional classification. Attempt was made by the Study Team, through extensive discussion with DGR to classify the existing national roads (roads under the jurisdiction of DGR) into Primary and Secondary Road Network. Figure 4.3-7 shows the proposed network of Primary and Secondary Roads. In this map, it is clearly seen that there are two main corridors; one in east – west direction along the north coast and another in north – south direction connecting Dhofar and Al Wusta with the northern Regions and Governorates. The proposed primary and secondary networks are strategically planned to efficiently secure the movement of passengers and commodities under all expected conditions.

Table 4.3-3 Functional Classification and Definition: Rural Roads

Classification	Definition	Feature (Requirement)
Primary Roads	- Long distance road for fast moving traffic. - Backbone of the road network of the Sultanate. - Connect the main towns and regions. - Join the neighboring countries.	- Alignment should be planned to bypass and avoid separating communities. - Design speed 80 – 120 km/h. - Right of way 80 – 120 m. - Access to property should be generally from service roads. - Junctions can be either grade-separated or at-grade. - Minimum spacing of junctions: 3 km (dual carriageway road); 1.5 km (single carriageway road). - Measures should be taken to reduce noise and visual impact when the road is close to residential area. - No parking or stopping.
Secondary Roads	- Provide access from primary roads. - Connect towns and villages. - Should give priority to traffic.	- Design speed 100 km/h where feasible. - Right of way 50 – 80 m. - At-grade priority junctions or roundabouts. - Direct access to properties permitted. - Parking permitted off the carriageway.
Local Road	- Provide access from secondary roads to villages.	- Design speed 80 km/h where feasible. - Right of way 30 m. - Junctions are simple priority junctions. - Direct access permitted. - Parking permitted off the carriageway.
Access Road	- Provide access to hamlets and farms.	- Design speed 60 km/h where feasible. - Right of way 30 m. - Junctions are simple priority junctions. - Direct access to properties allowed. - Parking permitted off the carriageway.

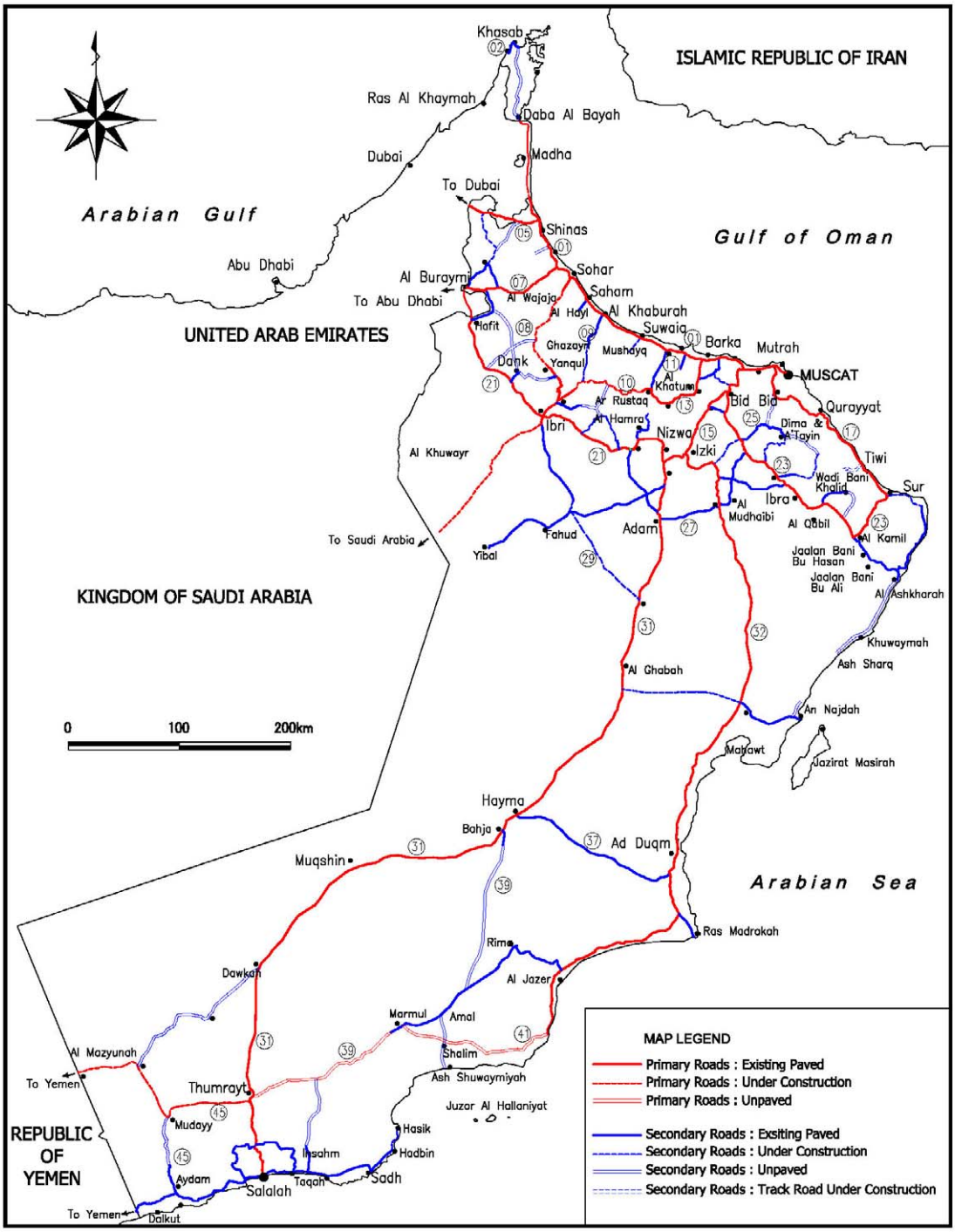


Figure 4.3-7 Primary and Secondary Road Networks

4.4 ROAD INVENTORY SURVEY

4.4.1 Road Inventory Survey

1) Surveyed Roads

The survey was carried out to collect the basic data required for the assessment of the existing road network and to provide required improvement components for future planning. The scope of this Study includes the nationwide primary and secondary road networks excluding Muscat Governorate. Reviewing the existing roads clarified that some of the major roads have road numbers, such as 01 for Batinah Highway; and others do not. Also, it was found that there was no functional classification of primary and the secondary roads for the existing network. Therefore, all the numbered roads and roads shown in the DGR road map that might be classified as primary or secondary considering have been included in the road inventory. Figure 4.4-1 presents the roads subjected to the inventory survey. (A detailed map of survey roads is shown in Appendix A-4.)

2) Field Surveys

Filed survey was conducted by qualified local engineers under the supervision and guidance of the Study Team. Four teams were composed and mobilized to carry out the survey. Each team consisted of a highway engineer as a leader, bridge engineer, wadi surveyor and road inventory surveyor assistant. Inventory sheets were designed to contain main elements of both the road and structures in addition to land-use to clarify roadside activities. Table 4.4–1 shows the main inputs of the record sheet used during the survey.

Orientation was done in which the local experts were given explanation on how to judge and record the items included in the record format. Before starting the actual inventory survey, a pilot inventory survey was carried out to train the surveyors on the right techniques and engineering judgment to carry out the survey with unified concept among all surveyors. The surveyors were also provided with short description list for the explanation of the different survey elements and activities. The actual field surveys were started in Al Batinah Region so that the actual survey can be monitored by the Study Team and the collected data can be verified.

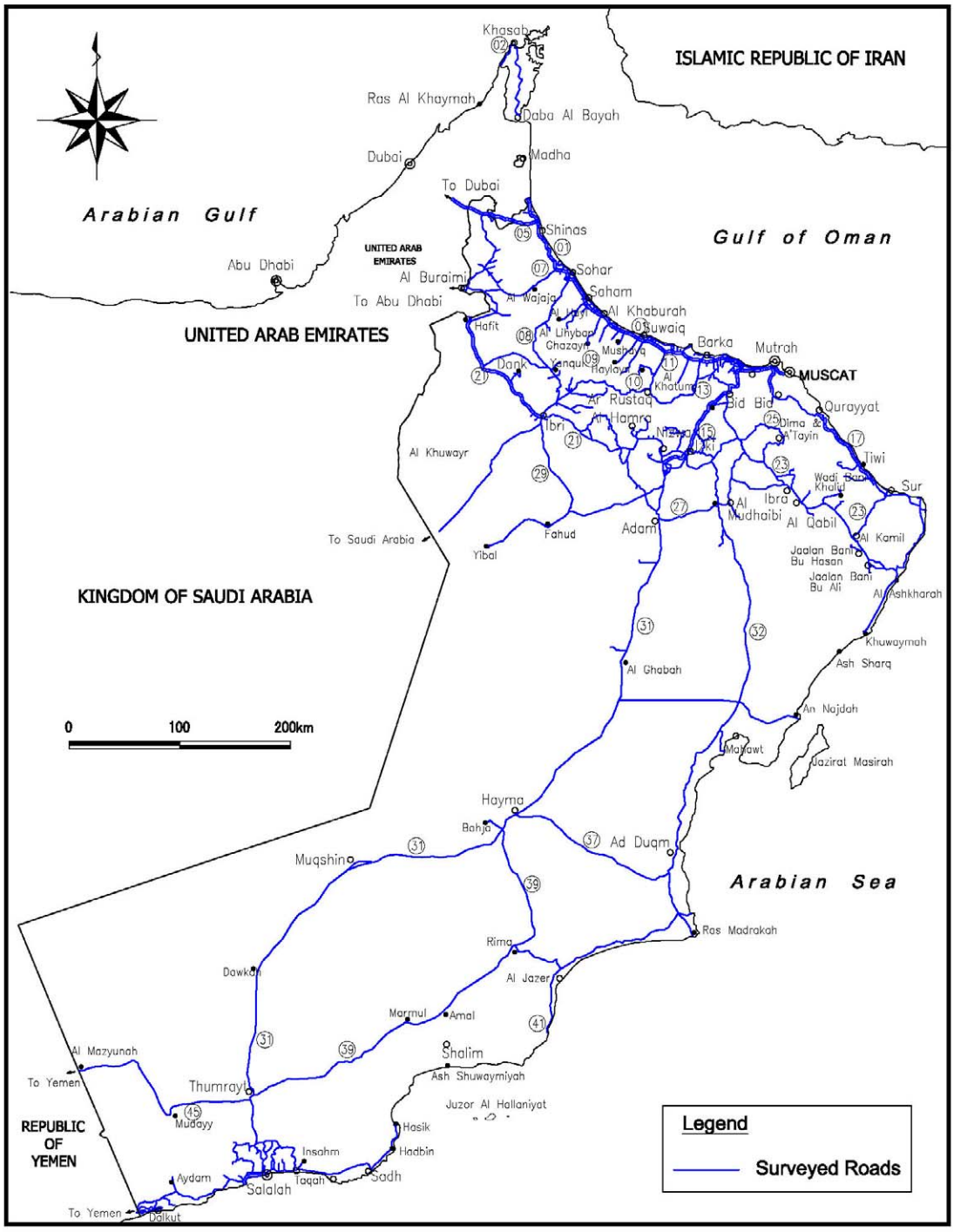


Figure 4.4-1 Study Road Network

Table 4.4-1 Road Inventory Survey Record Items

Item	Classification and Description
Terrain	M: Mountainous, R: Rolling, F: Flat
Roadside Land Use	R: Residential, C: Commercial, I: Industrial, D: Desert, A: Agricultural, U: Unused (Waste Land)
Carriageway Type	AC: Asphalt Concrete, ST: Surface Treatment, CC: Cement Concrete, G: Gravel, E: Earth
Condition	G: Good, F: Fair, B: Bad, VB: Very Bad
Median Division	Write width of median if exist, Write N if Non-existent
Shoulder/Sidewalk Type	P: Paved, G: Gravel, E: Earth
Embankment/Cut	E: Embankment, C: Cut, C/F: Cut/Fill, F: Flat
Drainage Type	PC: Precast Concrete, CL: Concrete Lined, GR: Grouted Riprap, NL: No Lining, WO: Without Side Ditch/Drainage
Substandard Alignment	Record section length with radius R<30m or Longitudinal slope i > 10%
Wadi	IC: Irish Crossing, L: Running in longitudinal direction of the road
Safety Barrier	CB: Concrete Barrier, GR: Guard Rail
Drainage Structure	PC: Pipe Culvert, BC: Box Culvert, IB: Irish Bridge
Side Slope Protection	MR: Mortar Riprap, LR: Loose Riprap, GB: Gabion

The recorded data were encoded and compiled in Excel Format for latter analysis. The encoded inventory sheets are attached as a separate volume for both road and drainage data. Summary of the Road Inventory data are attached as Appendix 4-2.

The roads subject to the inventory survey were divided into sections. The boundaries of sections were set at major intersections (intersection with Primary, Secondary or main roads). Each section was further divided into subsections. The limits of subsections were set at locations where any one of the conditions of the elements to be recorded, such as carriageway width, pavement condition, terrain, etc., changes. The surveyors were instructed to limit subsections at maximum interval of 10 km if road conditions do not change.

2) Numbering system for survey roads

A numbering system for surveyed roads, which include already-numbered roads and roads without numbers, was developed. The existing road numbers were used for the

numbered roads. For the non-numbered roads, a number is given based on the number of the nearest numbered road and its section number. For example, road No. 1 is divided to sections as 01/1, 01/2, 01/3, etc. Consequently, the branch roads connected to these road sections, such as 01/1 were given sequential numbers as 01/1/1, 01/1/2, 01/1/3, etc. The next orders of branch roads were given the sequential numbers as 01/1/1/I, 01/1/1/II, 01/1/1/III, etc as clarified as an example hereafter:

.

Road No.: 01

Sections of 01:	01/1, 01/2, 01/3, etc.
Branches of section 01/1:	01/1/1, 01/1/2, 01/1/3, etc.
Branches of Branch 01/1/1:	01/1/1/I, 01/1/1/II, 01/1/1/III, etc.

3) Surveyed Length

The total length of the surveyed roads is 7,452.2 km. The length of the surveyed dual carriageway was 484.9 km, and the length of surveyed roads having only single carriageway was 6967.3 km. The surveyed length of the numbered roads was 4,387.0 km and the length of the non-numbered roads was 3,065.2 km. Table 4.4-2 presents a summary of these surveyed road lengths.

Table 4.4-2 Total Lengths of Surveyed Roads

Classification	Length (km)
Numbered Roads (01 to 49)	4,387.000
Non-Numbered Roads	3,065.200
Total	7,452.200

The following subsections describe the result of analysis of major survey items. Detailed inventory data are presented in Appendix 4-2.

4.4.2 Terrain Conditions

The terrain condition along the surveyed roads is classified within flat, rolling and mountainous. The surveyors were instructed to consider the surrounding terrain to judge its condition regardless the longitudinal slope (grade) of the roads. This instruction was given in view of the possible cost estimation for widening in the future which will be affected by the types of terrain along the road.

For the entire surveyed roads, the ratio of flat terrain was about 84.0%. The rolling terrain percentage was about 6.0% while the mountainous terrain percentage was about 10.0% as presented in Figure 4.4-2.

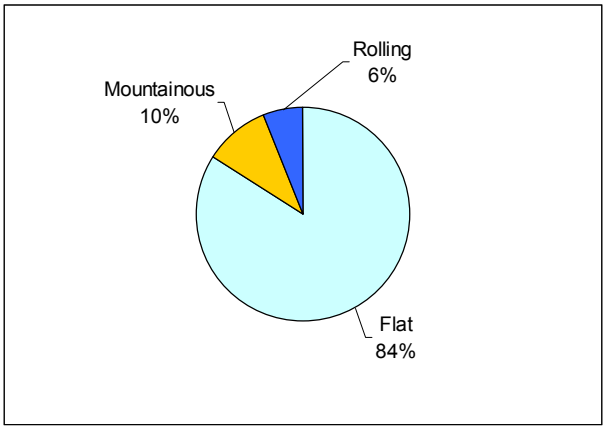


Figure 4.4-2 Terrain Type

4.4.3 Roadside Land Uses

Figure 4.4-3 presents the distribution of the land use activities along the surveyed roads.

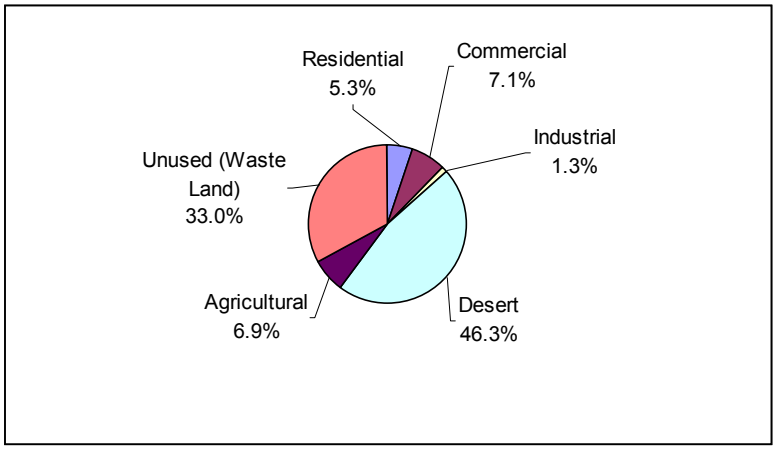


Figure 4.4-3 Road Side Land Use

As shown in the Figure, the majority about 80% of the land uses along the surveyed roads are desert, unused lands and mountainous areas. The other 20% is distributed among different activities in which the industrial areas have the lowest rate of about 1.3%.

4.4.4 Carriageway

The surveyed roads are classified between dual and single carriageways. It is found that almost all the dual carriageways are paved roads, the single carriageways are classified between paved and unpaved roads and the unpaved roads are classified to gravel and earth roads.

1) Carriageway width

The HDM affirm that the standard lane width is 3.65 m and the minimum carriageway width is 6.5m where the ADT larger than 5000 v/day and 6.0 m where the ADT is between 2000 and 5000 v/day. Therefore, for the preliminary check of the substandard carriageway width, 6.0 m is selected. The analysis of the surveyed road results shows that the ratio of substandard width is about 8% of the total surveyed road length meaning that there is about 600 km of road sections with carriageway width less than the minimum standard carriageway width of 6.0 m.

2) Pavement type

The share of the surveyed pavement types of carriageway is presented in Figure 4.4-4. The pavement types considered are AC (Asphalt Concrete), ST (Surface Treatment), CC (Cement Concrete), G (Gravel), and E (Earth).

The survey result shows that about 80% of the total surveyed roads are paved, i.e., about 5,925 km. The surveyed length of unpaved roads (gravel and earth) was about 742 km. The rest of surveyed length about 785 km is shared among surface treatment, under rehabilitation and under construction.

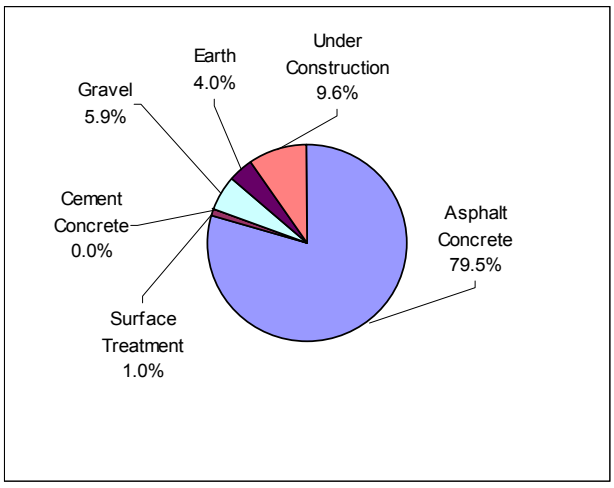


Figure 4.4-4 Share of Pavement Types

3) Pavement condition

The survey on pavement condition was conducted to obtain the basic data required to assess the pavement condition and the required future improvement schemes. Accordingly, pavement condition was rated for the average condition over 3 to 10 km

section lengths.

The surveyed pavement conditions are classified into four types as G (Good), F (Fair), B (Bad) and VB (Very Bad). Table 4.4-3 shows the criteria for judgment of pavement conditions.

Table 4.4-3 Assessment Criteria of Pavement Conditions

Classification	Condition
Good	• No substantial problem
Fair	• Some cracks and/or very minor potholes may be occasionally observed and minor repair/ maintenance works may be needed but there is no or little problem as overall. • Vehicle can travel at an average speed higher than 50–60 km/h where the traffic condition and geometry of road allow.
Bad	• Substantial cracks and/or some potholes are observed and repair/ maintenance work is urgently needed. • Typical travel speed of vehicles may be 50 km/h or lower.
Very Bad	• Extensive cracks and/or substantial potholes are observed. • Rehabilitation of pavement is urgently needed. • Typical travel speed of vehicles may be as low as 30 km/h.

Although travel speed of vehicles is used as one of the criteria in identifying pavement condition, smoothness of pavement surface was generally good to the degree that vehicles can travel at a speed of 100 km/hr, even though there are considerable cracks (this is probably due to favorable subgrade condition and little rainfall). Accordingly, pavement condition was judged mainly based on the degree of cracks and necessity of repair. Figure 4.4-5 presents the distribution of the surveyed carriageway conditions. Figure 4.4-6 shows the map of pavement condition of the surveyed road network.

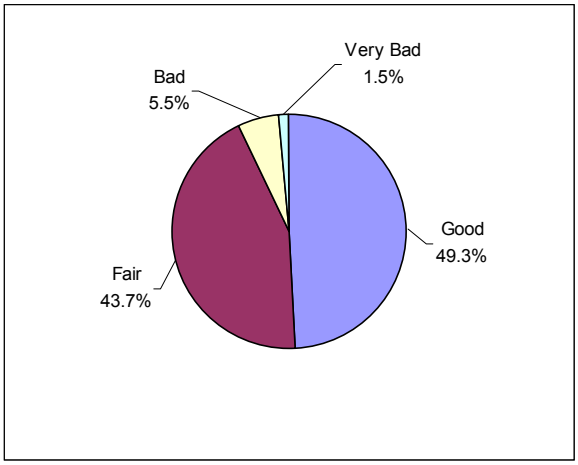


Figure 4.4-5 Surveyed Pavement Conditions

As can be recognized from the Figure 4.4-5, about 49% of the surveyed roads is in good condition. However, the ratio of fair is about 44%. However, sections with “Fair” pavement conditions will shift to “Bad” pavement condition if proper maintenance will not be implemented.

Figure 4.4-6, shows pavement conditions of surveyed roads. Sections rated as “Bad” pavement condition are concentrated on road number 31 (Nizwa – Adam – Haima – Thumarit Road). The pavement of many sections of this road needs urgent repair or even rehabilitation. Actually, DGR is implementing pavement rehabilitation of this road in phases. Although the pavement of these sections need urgent repair/rehabilitation, overall smoothness of the pavement is still in an acceptable level and vehicles are traveling at an average speed of 100–120 km/hr. Other surveyed sections with “Bad” pavement condition are located on such roads as 1, 2, 23, 31, 39 and 47.

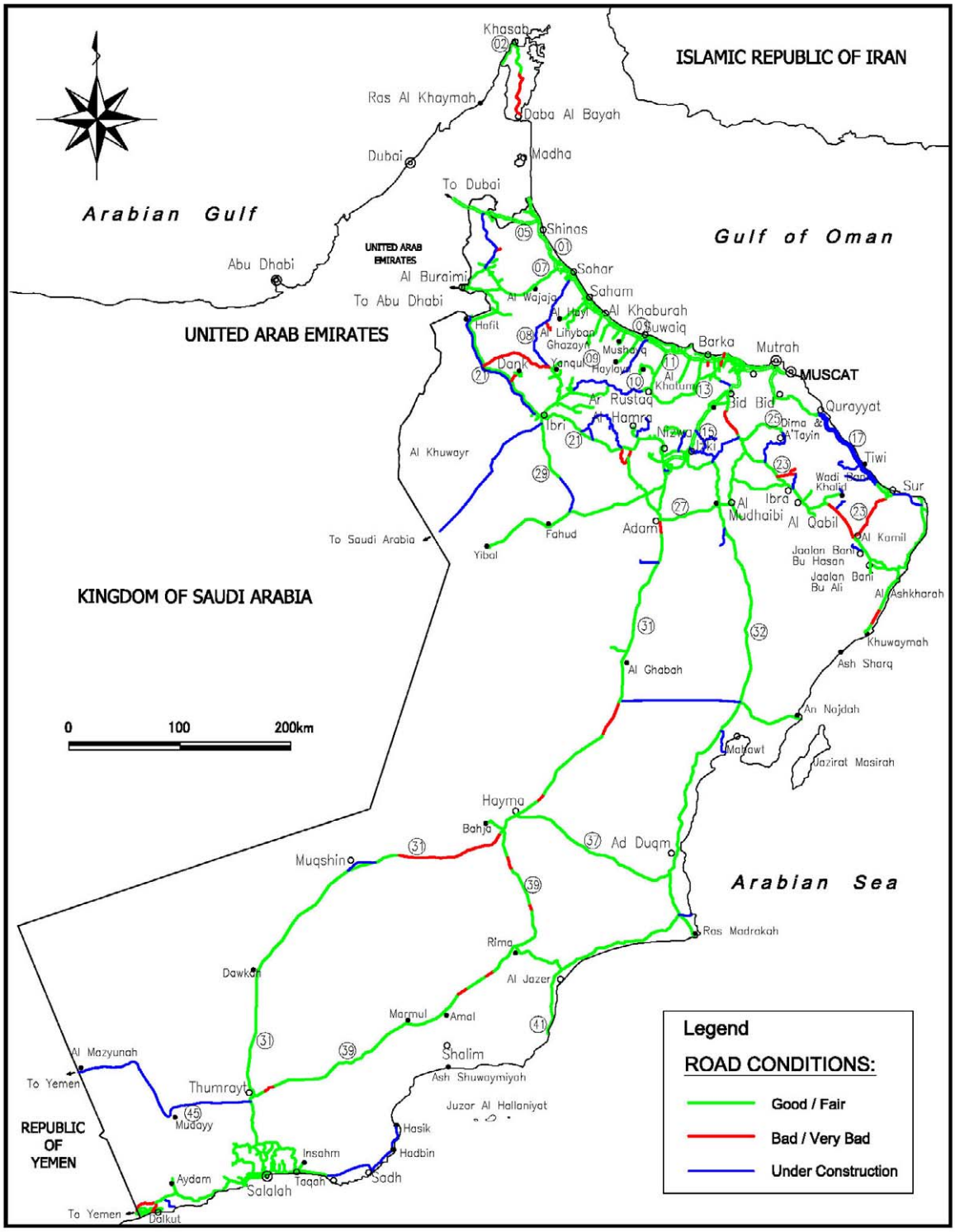


Figure 4.4-6 Pavement Conditions of Surveyed Roads

4.4.5 Shoulders

Shoulder width is particularly important factor for the traffic safety of roads in Oman due to high travel speeds. In HDM the desirable minimum width of shoulder is 2.5 m for Primary Roads and is 1.0 m for Secondary Roads. However, in case of Primary Roads, the shoulder width of 2.0 m or wider is considered to be less problematic because small vehicles, such as passenger car and small truck, can stand within such shoulder. Among the surveyed Primary and Secondary Roads, the percentage of sections with shoulder width less than 1.0 m and less than 2.0 m were found to be about 13% and 25%, respectively (excluding track roads). (See Appendix 4-2)

Figure 4.4–7 shows the distribution of pavement types of shoulder. Shoulder pavement types are classified into P (Paved), G (Gravel) and E (Earth).

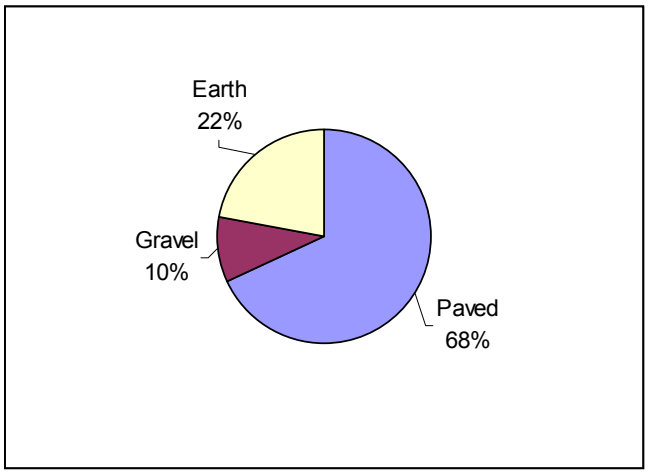


Figure 4.4-7 Shoulder Pavement Types

4.4.6 Substandard Alignment Sections

Substandard alignment sections are considered to be the sections where radius of horizontal curve is smaller than 30 m or where longitudinal grade is greater than 10% where heavy trucks cannot climb/difficult climb such section. Therefore, these sections need to be improved to fit to the stipulation of highway standard. The results of the survey showed that there are few such sections on Primary or Secondary Roads with estimated total length of about 17 km that is less than 0.23% of the total length of surveyed roads.

4.4.7 Drainage Ditches

The drainage ditches are classified to PC (Precast Concrete), CL (Concrete Lined), GR

(Grouted Riprap), NL (No Lining) and WO (Without). The conditions of the ditches are classified into good, fair, bad and very bad. Figure 4.4-8 shows the distribution of the surveyed ditches based on the type of the ditch and Figure 4.4-9 shows the distribution based on the ditch drainage conditions.

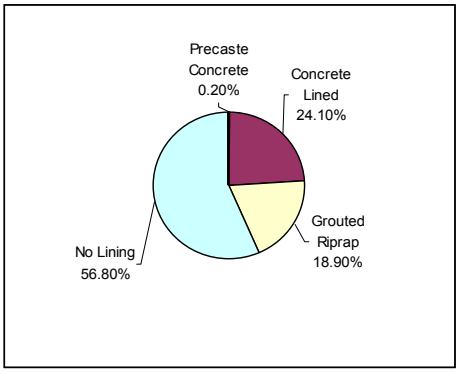


Figure 4.4-8 Drainage Ditch Type

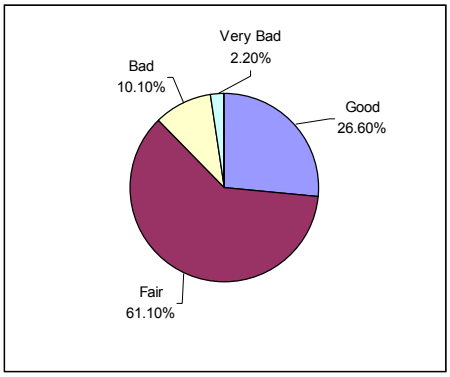


Figure 4.4-9 Conditions of Drainage Ditch

4.4.8 Drainage Structures

The total number of surveyed drainage structures is 4,778. The numbers of surveyed drainage structures are presented in Table 4.4-4.

Table 4.4-4 Distribution of Drainage Structure Types

Drainage Structure Type	Number
Box Culverts (BC)	2126
Box Culverts for Falaj*	2
Irish Bridge (IB)	19
Pipe Culverts (PC)	2610
Box Culverts (BC) and Pipe Culverts (PC)	19
Pipe Culverts for Falaj*	2
Total	4778

*Faraj: Traditional irrigation channel

Figure 4.4-10 presents the distribution of the surveyed drainage structure conditions.

Figure 4.5-11 shows the distribution of the surveyed protection condition of the drainage structures.

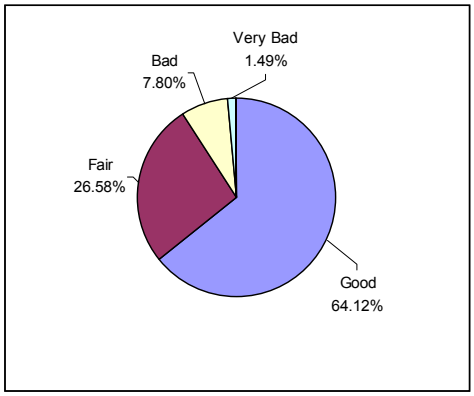


Figure 4.4-10 Conditions of Drainage Structure

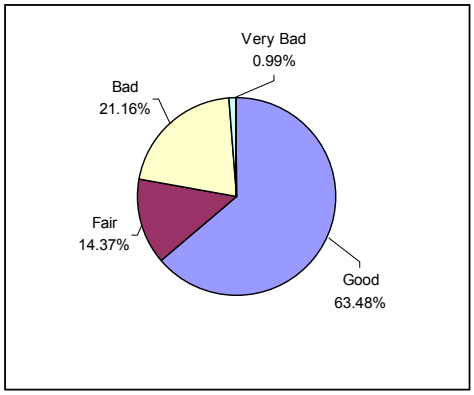


Figure 4.4-11 Conditions of Drainage Protection

The ratios of the bad and very bad conditions clarify that maintenance of drainage structures should be implemented to maintain the efficiency of these existing drainage facilities.

4.4.9 Bridge Structures and Conditions

Nationwide along the roads under the jurisdiction of DGR there are 59 bridges in service. Based on the DGR classification these bridges are classified under two major sectors which are sector A and sector B. Sector A includes Ad Dhahirah Region and Al Batinah Region. Sector B includes Dhofar Governorate, Al Wusta Region, Ash Sharqiyah Region and Ad Dakhliyah Region. There are 25 bridges within Sector B and the rest of 34 bridges are within Sector A. From these 34 bridges there are 30 of them are located along only one corridor that is NR No. 07 (Sohar–Al Buraymi Road). Bridge locations are presented in Figure 4.5-12. Bridge list based on the inventory results and DGR database are presented in Appendix 4-2. The bridges from No.1 to 34 belong to Sector A and the bridges from No.35 to 59 belong to Sector B.

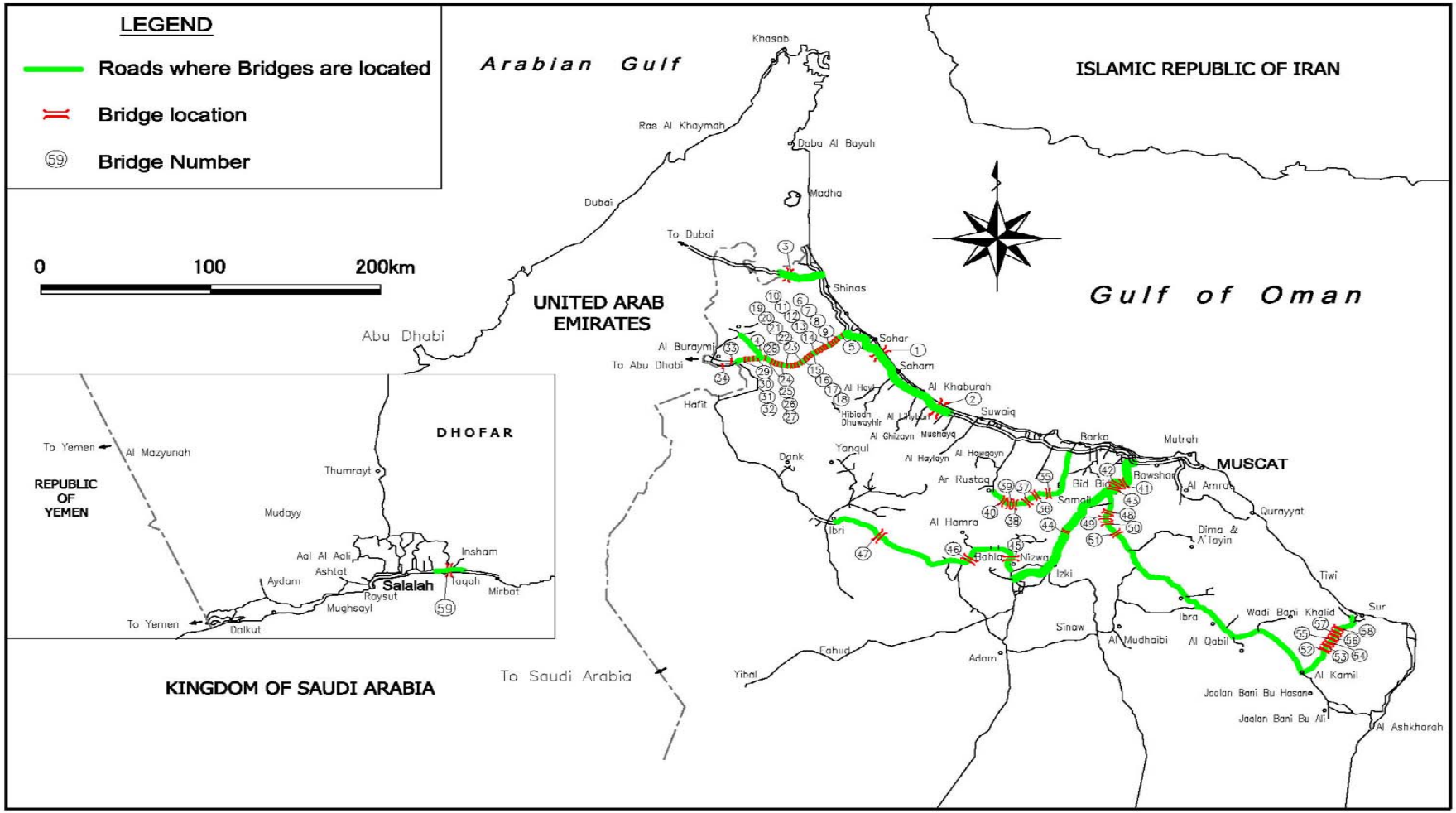


Figure 4.4-12 Bridge Locations

4.4.10 Bridge Assessment Criteria

The main bridges data collected are shown on the Table 4.4-5.

Table 4.4-5 Items of Bridge Data

Item	Sub-Item	Condition			
		VB	B	F	G
Bridge Name					
Road Name					
Region					
Station					
Bridge Type					
Span (m)					
Total Length (m)					
Carriageway Width (m)					
Sidewalk Width (m)					
Traffic Lanes					
Superstructure	Deck				
	Beams				
Substructure	Abutment				
	Pier				
	Foundation Type				
Appurtenance	Guardrail				
	Shoe				
	Expansion Joint				
	Drainage				
	Skew Angle				
Approach	Inbound				
	Outbound				

A pilot inventory survey was carried out to rehearse the surveyor the right technique and engineering judgment to carry out the survey with almost unified concepts among all of them. The surveyors are also provided with short description list for the explanation of the different survey activities. The list includes the following main items:

- Bridge name, road name, region and station
- Bridge Type (RCSG, PCSG, others)
- Bridge Length (Distance between the front faces of the abutments)
- Span length (e.g. 12.0+18.0+12.0 or 12.0+4x15.0+12.0)

- Carriageway width and also number of traffic lanes
- Sidewalk if any and sidewalk width
- Bridge condition for superstructure and substructure components
- The conditions of appurtenance such as guardrail, shoe, expansion joint
- Approach condition such as slope eroded on side right or left for a length of about xx m, there is a steep slope, etc.

In view of large number of bridges involved, time schedule and nature of the study (M/P study and not a bridge rehabilitation study), simplified assessment criteria were established. The objective of the criteria is to recognize the structural element condition as very bad, bad, fair or good.

The preliminary investigation shows that all bridges are almost made of concrete. For concrete structure observation of cracks, exposed steel bars and rusted reinforcement can be simply undertaken then utilized for assessment as follows:

- Few hair cracks with crack width smaller than 0.2 mm are judged as good condition
- Cracks width between 0.2 mm and 0.5 mm are judged as fair condition but it may needs injection with resin and future observation
- Cracks larger than 0.5 mm with concrete splitting and rusted steel bars are assessed as bad or very bad condition

For substructure further to the checking of the concrete condition, inspection of corrosion is significant. A trained engineer is expected to be able to properly judge the stability condition of the piers and abutments and make his conclusion. However, the next criteria are used as the guidelines for assessing the substructure condition in objective manner:

- No corrosion with sufficient protection means good condition
- Few corrosion and/or insufficient protection can be considered as fair condition
- Non-protection and/or severe corrosion means bad or very bad condition

Based on the evaluation of the bridge structural elements the overall evaluation for each bridge was undertaken. In the overall evaluation, the significance of the structural element as a major or secondary element has been taken into consideration. If the investigations clarify a serious problem within the substructure the bridge is classified under the bad or very bad condition regardless the superstructure condition. On the other hand, if the investigations clarify that the substructure is still sound while some secondary superstructure elements classified under bad condition, the overall rating of the bridge may be come under fair condition.

4.4.11 Results of Bridges Survey

The general characteristics and overall assessment of the bridges based on the analysis of the survey data are presented in Appendix 4-3. Furthermore, the data about construction year and design load for several bridges can be obtained from the DGR records.

The overall evaluation shows that almost all the bridges are in fair conditions except the bridges numbers 1 to 3 and bridges numbers 35 to 40 along NR No. 13 (Barka-A'Rustaq Road). The bridges classified under bad conditions need strengthening and/or rehabilitation. The bridges under the fair conditions generally require routine and periodical maintenance. However, the judgment was made based mainly on eye inspection, and further detailed survey may be needed before final judgment for repair will be made.

The DGR is concerned about the substructure of those bridges, and is implementing a rehabilitation study for all bridges, in view of the rapid increase in the actual traffic loading and volumes.

4.4.12 Irish Crossing

During the inventory survey, the wadi locations were investigated for wadi crossing or wadi running parallel to the road. The total recorded lengths along the surveyed roads are 264.066 and 97.975 km for Irish Crossing (IC) and Longitudinal (L) crossing, respectively. The sum of the lengths of these two types is 362 km that represents about 5% of the total surveyed road length.

4.5 PROBLEMS OF EXISTING ROAD NETWORK

Based on the results of observations as described in Sections 4.3 and 4.4, the existing road network of the Sultanate is evaluated to be fairly good in both physical condition of facilities such as pavement and geometry, and for network function such as coverage and density. However, through field surveys and observations as well as comprehensive discussions with the officials of the relevant government agencies, problems of the existing road network can be identified as summarized in the following:

(i) Poor pavement conditions (unpaved or deteriorated pavement) on some sections
(ii) Insufficient shoulder width along some sections
(iii) Substandard alignment (steep grade and small radius of horizontal curvature) at some sections
(iv) Defective bridges
(v) Some roundabouts on heavily trafficked roads
(vi) Traffic accident black spots (sections/intersections where traffic accidents occur frequently)

These problems are referred to as “Road Link Problems”.

In addition, the following problems are pointed from a wider point of view regarding the existing road network as a whole:

(i) Weak connection across the mountain ranges
(ii) Primary road network not suitable for high-speed, long-distance trips
(iii) Vulnerability to flash flood
(iv) Lack of an alternative route to Batinah Highway
(vii) Low pavement ratio of lower-class roads
(viii) Missing links

These problems are referred to as “Road Network Problems”.

The Road Network Problems are nationwide and can be considered as a matter of road planning. They may possibly constitute obstacles to safe, smooth and relable traffic in the Sultanate and hamper sound nationwide development of socioeconomic activities. Therefore, mitigation/elimination of these problems is indispensable for the future development of the Sulatanate.

On the other hand, Road Link Problems are of local nature and should be solved

basically through engineering measures.

Road Link Problems and Road Network Problems are discussed in the following subsections:

4.5.1 Road Link Problems

Road Link Problems, except the problems of roundabout and traffic accident black spots, were already discussed in Section 4.4. The problem of traffic accident black spot is discussed in Subsection 4.5.4. The problems of roundabout on heavily trafficked roads are discussed below:

Roundabouts on Heavily Trafficked Roads

Major road crossings are designed as roundabouts that have its present benefits but they may cause future capacity constraints at such locations. Under the present traffic volumes, roundabouts have started to act as bottlenecks during the peak hours. With expected future increase in traffic volumes, delay at roundabouts will cause serious congestions. As signalized intersections are not recommended on primary and secondary intercity roads, grade-separation structures are required at intersections with heavy traffic volumes.

4.5.2 Road Network Problems

(i) Weak connection across the mountain ranges

Two mountain ranges in the northern of the Sultanate, namely Al Hajar Al Gharbi and Al Hajar Ash Sharqi, are separating northern part of Adh Dhahirah, Ad Dakhiliah and Ash Sharqiyah Regions from most developed areas in the Bathinah Region and Muscat Governorate, as shown in Figure 4.5-1. In Dhofar Governorate in the south, Dhofar Mountains Chain separates the areas of Dalkut, Rakhyut, Salalah and Mirbat from the remaining parts of the Governorate, as shown in Figure 4.5-2.

As for Al Hajar Al Gharbi Mountain Range, DGR is currently constructing paved roads along three routes across the mountain range to connect Sohar and Ibri (NR No. 08), Al Khaburah and Ibri (NR No. 09), and Ar Rustaq / Barka and Ibri. Another paved road is being partially constructed / planned between Al Hamra and Ar Rustaq /Al Awabi. Until the completion of these roads, vehicles have to travel twisty gravel roads across the mountain range.

As for Al Hajar Ash Sharqi Mountain Range, track roads are being constructed along

four routes, (a) between Al Amrat and Mizbar (b) between Ghubbrat At Tam and Hail Al Kabir (towards Qurayyat) (c) between Tiwi and Qaran (towards Ismaiyah) and between Qalhat and Halut. Because of very ragged terrain in the area, construction of road with geometry that satisfies HDM criteria may be possible only after very diligent study on the topography and careful selection of alignment.

Across Dhofar Mountain Range, there are two main roads; NR No. 31 (Thumrayt - Salalah Road) and NR No.45 (Thumrayt - Mudayy - Rakhyut Road). As for NR No. 45, Rakhyut - Aydam Section has been paved and Thmrayt - Mudayy Section is currently being paved, but Mudayy - Aydam Section is not paved. Once NR No. 31 is closed for some reason such as flooding, travel between Thumrayt and Salalah becomes very difficult.

(ii) Primary road network not suitable for high-speed, long-distance trips

As defined in the Highway Design Manual (HDM), the primary roads are to cater to high-speed, long-distance trips. Many of the existing primary roads are of opposed 2-lane carriageway with many at-grade intersections. Accordingly, these primary roads are not suitable for serving to high-speed, long-distance trips.

Even though the many primary roads are opposed 2-lane roads on a single carriageway, vehicles are traveling these roads at high speed such as 100 to 120 km/h owing to relatively favorable pavement conditions. This situation is very hazardous and should not be left as it is now. Provision of primary road network where vehicle can travel safely and smoothly is indispensable for establishing an efficient and sound road network.

(iii) Vulnerability to flash flood

As it is discussed in Section 10.3, road traffic in the Sultanate is sometimes disrupted by flash floods occurring in wadis. Although the influence of natural calamities cannot be completely eliminated, measures are needed to minimize vulnerability to flash floods and secure safe, stable and reliable road traffic to the extent practically possible.

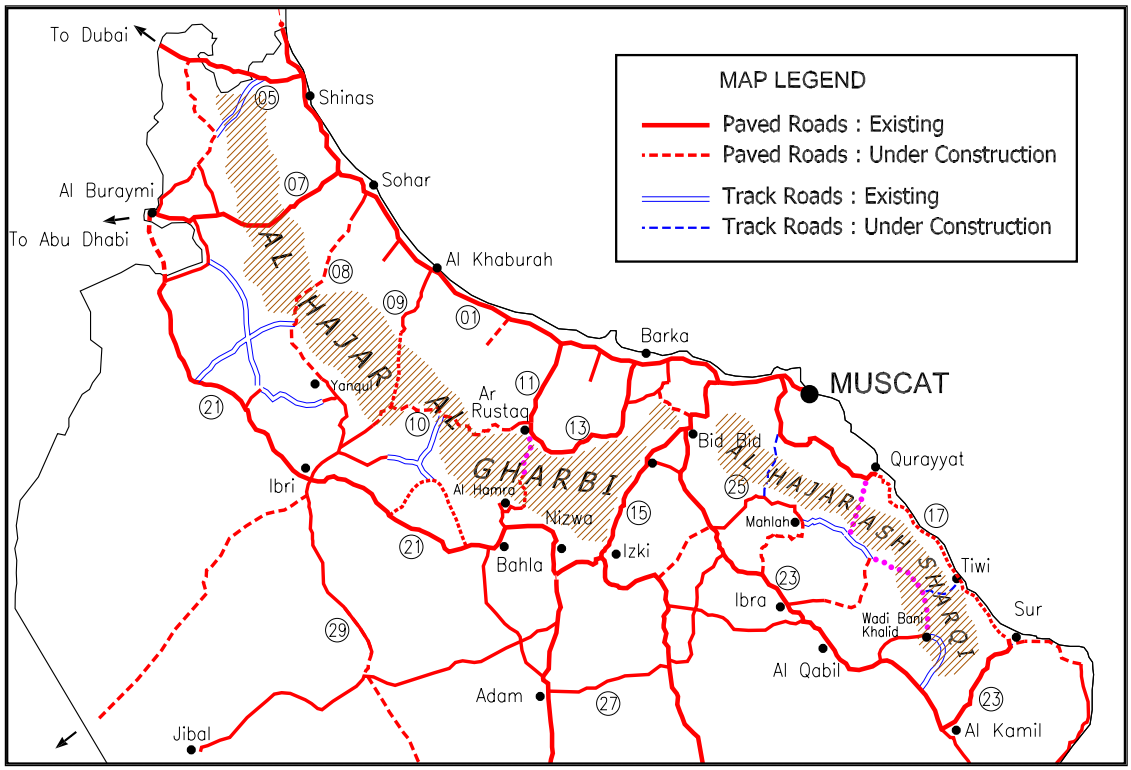


Figure 4.5-1 Existing Roads across Mountain Ranges in Northern Oman

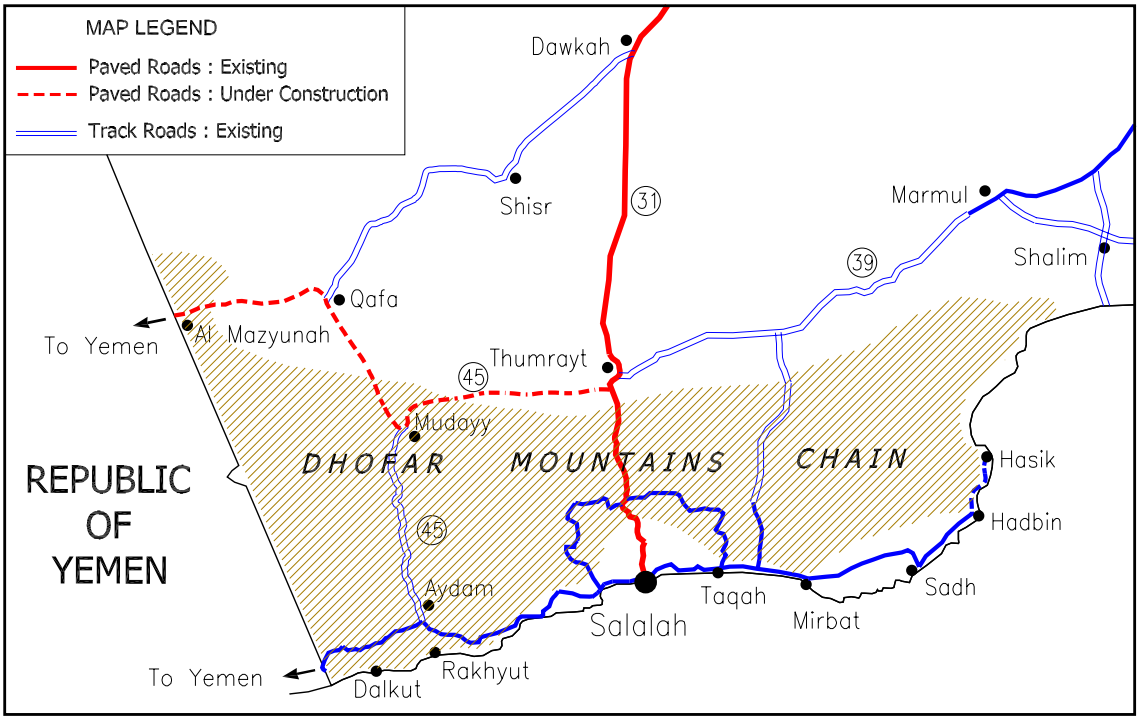


Figure 4.5-2 Existing Roads across Dhofar Mountains Chain

(iv) Lack of an detour route to Batinah Highway

Main primary roads in of the existing road network have alternate routes with each other, as listed in the Table 4.5-1 below:

Table 4.5-1 Alternate Relations Between Main Primary Roads

Alternate Route 1	Alternate Route 2
NR No. 01 (Batinah Highway)	NR No. 15 (Rusayl-Nizwa Road) NR No. 21 (Nizwa-Ibri-Buraymi Road)
NR No 17 (Muscat-Qurayyat-Sur Road)	NR No. 23 (Bid Bid-Sur Road)
NR No. 31 (Nizwa-Thumrayt-Salalah Road)	NR No. 33 (Izki-Sinaw Road) NR No. 32 (Sinaw-Mahut-Ras Mdrakah Road) Ras Mdrakah-Sawqrah Road, No. 41 (Sawqrah-Marmul Road) Marmul-Thumrayt Section of No. 39

In the case of NR No. 01 (Batinah Highway), a special consideration on providing an alternative as a detour route is necessary because of its great importance.

Batinah Highway is the most important highway traversing the most developed area in the Sultanate. Traffic volume on this highway varies from 18,000 veh/day near Sohar to about 30,000 veh/day near Barka in year 2005. This traffic volume is the largest of those of all highways in the Sultanate. Once the traffic is disrupted by any cause such as flash floods at any of the Irish crossings on the highway or severe traffic accident, the influences on the socioeconomic activities are enormous.

Appropriate alternative or detour route needs to be provided to minimize the influence of disruption of traffic on Batinah Highway, but there is not such detour route in the present road network, as shown in Figure 8.2-1. For some vehicles traveling long distances such as between Buraymi and Muscat can detour to NR No. 15 and No. 21 (Bid Bid-Nizwa-Ibri) in case of closure of Batinah Highway if proper information is given to drivers. On the other hand, for vehicles traveling between Sohar and Muscat, detouring to NR No.15 and No. 23 takes excessively longer travel time and there is practically no detour route. It is evident that the traffic between Sohar and Muscat is very important for the socioeconomic activities of the Sultanate.

It should be also noted that Batinah Highway is the only access to As Seeb International Airport and reliable traffic needs to be secured for those people using

international/ domestic flights from this airport.

(v) Low pavement ratio of lower-class roads

Although the pavement ratios of primary and secondary roads are fairly high, many local roads and access roads are left unpaved. Low pavement ratio of these roads are hampering the road users living along these roads from enjoying the benefit of otherwise well developed network of primary and secondary roads.

(vi) Missing links

At present, there are two major coastal missing links in the road network of the Sultanate; one between Khuwaymah and Shanna in Ash Sharqiyah Region and another between Hasik and Ash Shuwaymiyah in Dhofar Governorate.

Without these two missing links, efficiency of the road network is largely decreasing which causes large losses in vehicle operating costs and travel time of vehicles and passengers that use longer alternatives. In addition, providing these missing links will promote and accelerate national and regional development in the coastal areas.

4.5.3 Road Maintenance Problems

Most of the roads are constructed as early as of 1980s that mean the design life-span of road of 20 to 25 years has been already achieved. The condition of primary and secondary road networks is mostly fair to good with few bad roads. The network is expected to handle heavier commodity movements in the future with the development of ports and other socioeconomic activities. Keeping this expanded network in a good condition requires great maintenance works that cannot be accomplished under present situations. These problems will be discussed in Chapter 13.

1) Institutional problem

DGR needs a more powerful maintenance management team with an advanced pavement management system that can cope with future requirements of the network.

2) Drainage structures

The hydrologic characteristics of the country are another source of road problems. The drainage structures are almost under dry condition except during heavy rains of the monsoon season. Under the dry condition without routine maintenance, the drainage structures are suffering blockage and slope failure may occur at several locations. In addition, deterioration of culverts needs to pay especial attention in maintenance

works.

3) Road Disasters

Major expected road disasters in Oman can be classified within flash flood, falling rock/land sliding and earthquake. Problems of flash floods and their measures are discussed in Sections 2.11 and 10.3

Earthquake: Concerning the seismic activities in Oman, historically, only two earthquakes have been recorded in Northern Oman. The first happened at Sohar in AD 879. More recently, an earth tremor was recorded in 1950 that had intensity only to surprise people at Muscat. Therefore, under this weak seismic activity, there are almost no problems until now in the Sultanate concerning earthquakes.

Rock fall: Due to topographical features of the Sultanate, there are many cut slopes with various heights along the roads. According to the DGR officials, there have been very few reported cases of damage to vehicles/people due to rock fall. This may be attributed to (i) relatively small traffic volume on the road sections traversing mountainous areas, and (ii) space for accumulating fallen rocks (debris) set between the toe of cut slope and edge of shoulder. (Fig 4.5-3)

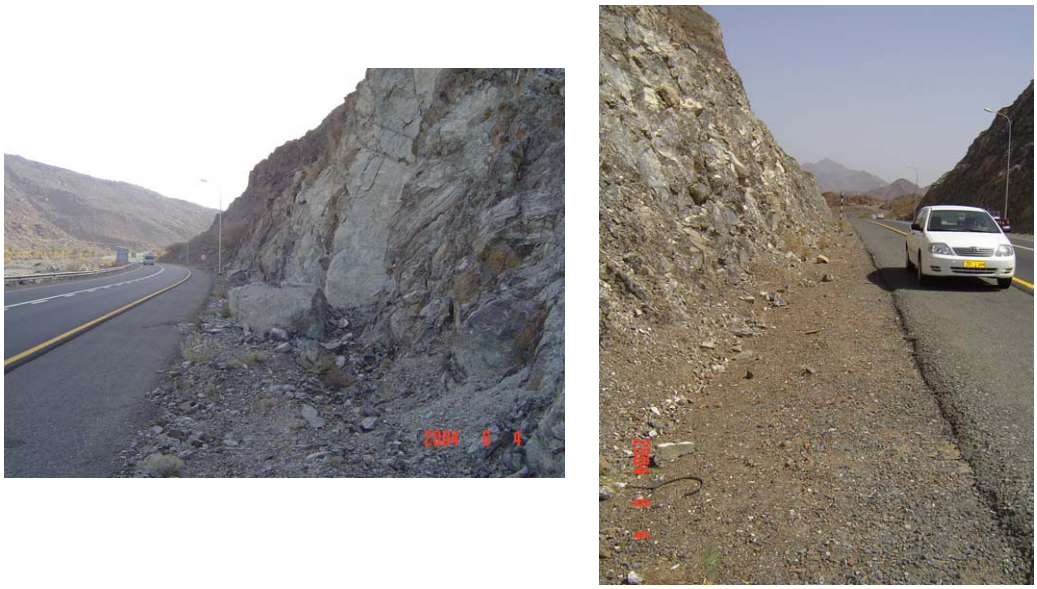


Figure 4.5-3 Space for Fallen Rock between Cut Slope and Shoulder

Accordingly, cut slopes are not imposing serious problems to road traffic at present. However, this may cause some problems in the future when traffic volume on these sections will increase and chances of falling rocks striking the vehicles will increase.

4) Sand dunes and sabkha:

Maintenance of roads traversing sand dune areas often encounter the problem of removal of sand accumulated on the road surface which makes travelling of vehicles hazardous and difficult. Sabkha is Arabic word for a type of soft ground often encountered in the region. Treatment of soft ground needs to be designed and implemented during construction based on the results of diligent soil investigations and their analyses.

4.5.4 Traffic Accidents and Safety

Traffic accidents and safety is one of the major social issues in the Sultanate. The physical condition of the existing road network is considered to be reasonably good. The Royal Oman Police (ROP) is exerting its effort in enforcing the traffic rule. Penalties for traffic violation are clearly stipulated in Traffic Law (Article 50 of Section 6.4.3, Chapter 7). ROP also implements traffic safety campaigns. However, with high standard design speeds of 120 and 100 km/hr, more efforts are required to improve road-users behaves, engineering aspects and enforcement. For example, periodical re-education of drivers at appropriate interval, such as 3 to 5 years, may worth consideration.

1) Road Accidents

The accident statistical data collected and analyzed by the Directorate General of Traffic under the Royal Oman Police (ROP). Figure 4.5-4 presents the trend of traffic accidents, fatalities and injuries in Oman during the last ten years. The number of accidents is decreasing in the last few years after a peak period in the years 2000 and 2001. The numbers of injuries also recently decreased while the number of fatalities is almost between 500 and 600 annually. It should be noticed that population of Oman is about 2.3 millions and the running vehicles on the roads are about half a million.

Figures 4.5-5 to 4.5-8 give the main characteristics of the accident patterns of the year 2001. Regarding the type of accidents, collision with other cars is the most dominant type and is followed by collision with fixed objects.

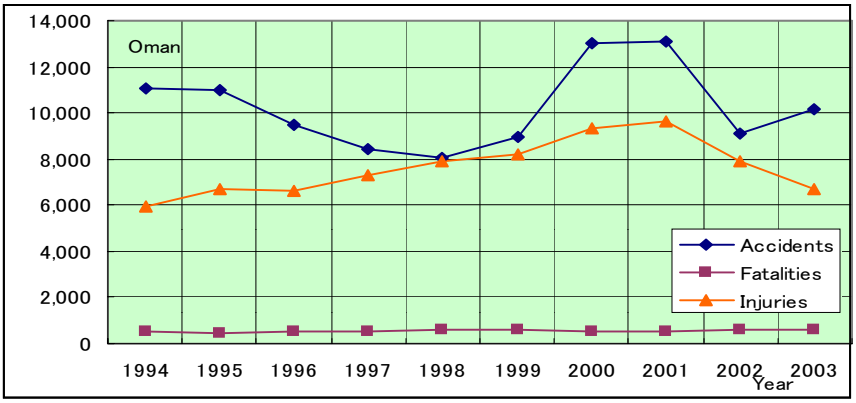


Figure 4.5-4 Trend of Traffic Accident in Oman

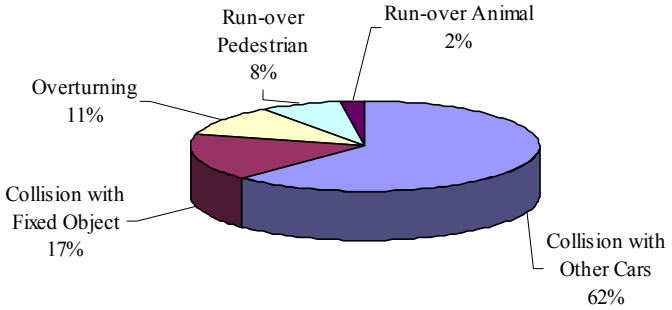


Figure 4.5-5 Types of Road Accidents – 2003

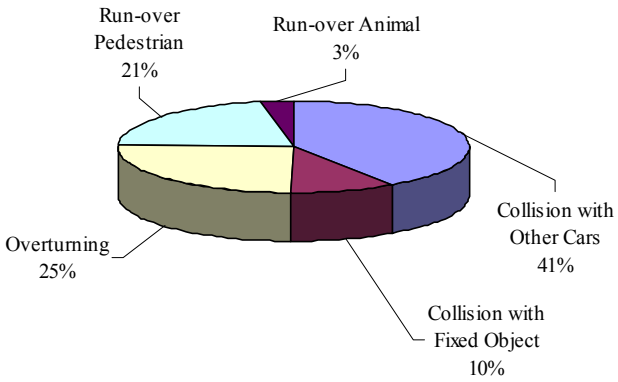


Figure 4.5-6 Fatality per Accident Type – 2003

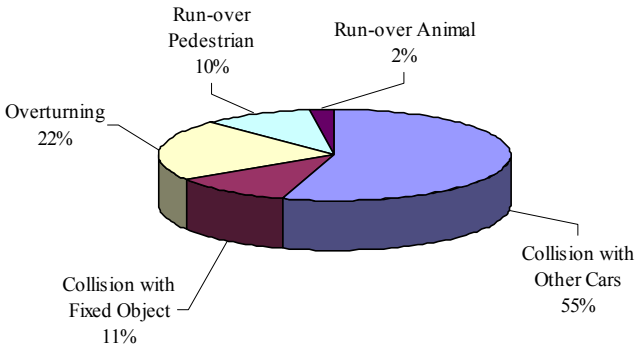


Figure 4.5-7 Injury per Accident Type – 2003

Running-over animals provides a quite high ratio of 10% due to the existing of camels and other animals on some roads. The same order of types is applied also for the number of fatalities as well as injuries per accident type. Speed driving is classified as the most prominent cause of traffic accidents. It is followed by neglect of drivers that don't follow traffic rules and safety regulations.

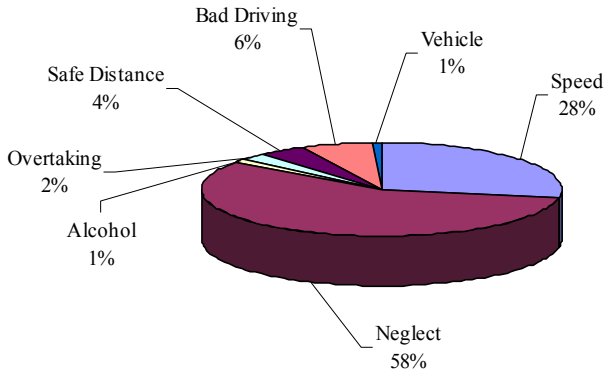


Figure 4.5-8 Accident Causes – 2003

As bad driving manner is the third cause of accidents, it is clear that the human element is causing more than 90% of the total accidents. The road elements, including insufficient sight distance, are causing 5% while the car malfunction is causing only 1% of the total number of accidents.

Figure 4.5-9 shows the distribution of accidents in the different regions of Oman. It is seen that that Muscat Governorate has the highest number of accidents and injuries,

while accidents in Al Batinah Region is characterized by the highest number of fatalities due to high speeds on its highways. From the accident severity point of view, it can be noticed also that, only in the two governorates of Muscat and Dhofar, the number of accidents is higher than the number of fatalities and injuries, as most of these accidents are property-damage-only without causalities.

Analysis of the data shows that the highest fatality rates (per number of accidents for the average of 10 years) belong to Al Wusta (19.4%) and Ad Dakhliyah (10.1%) regions while the lowest rates are those of Muscat (2.6%) and Musandam (3.4%) governorates. The same two regions of Al Wusta and Ad Dakhliyah have also the highest injury rates of (132.2%) and (114.2%) respectively, while the lowest rates belong to the Governorates of Muscat (51.0%) and Dhofar (59.6%).

In the last few years, there is remarkable decrease in the number of accidents in the regions of Al Batinah, Ad Dakhliyah and the Governorate of Dhofar, and to some extent in Ash Sharqiyah Region. Other regions have some increase that should be investigated to apply required safety measures.

2) Black Spots

Black spots that have high numbers of traffic accidents were identified by ROP, as presented in Table 4.5-2, based on statistical data of 2000 and 2001. Safety measures and improvement works were done only at few locations due to budgetary limitations. In 2000, the number of accidents at black spots in Muscat ranged between 25 and 88 accidents with 8 fatalities at one location; Al Khouda roundabout; at which a grade-separation structure is recently under construction. The locations of major black spots are shown in the map of Figure 4.5-10.

Table 4.5-2 Number of Black Spots

Region/Governorate	Number of Black Spots
Muscat Governorate	9
Dhofar Governorate	3
Al Batinah Region	6
Ad Dhahira Region	5
Al Wusta Region	2
Ad Dakhliyah Region	3
Ash Sharqiyah	5
Total	33

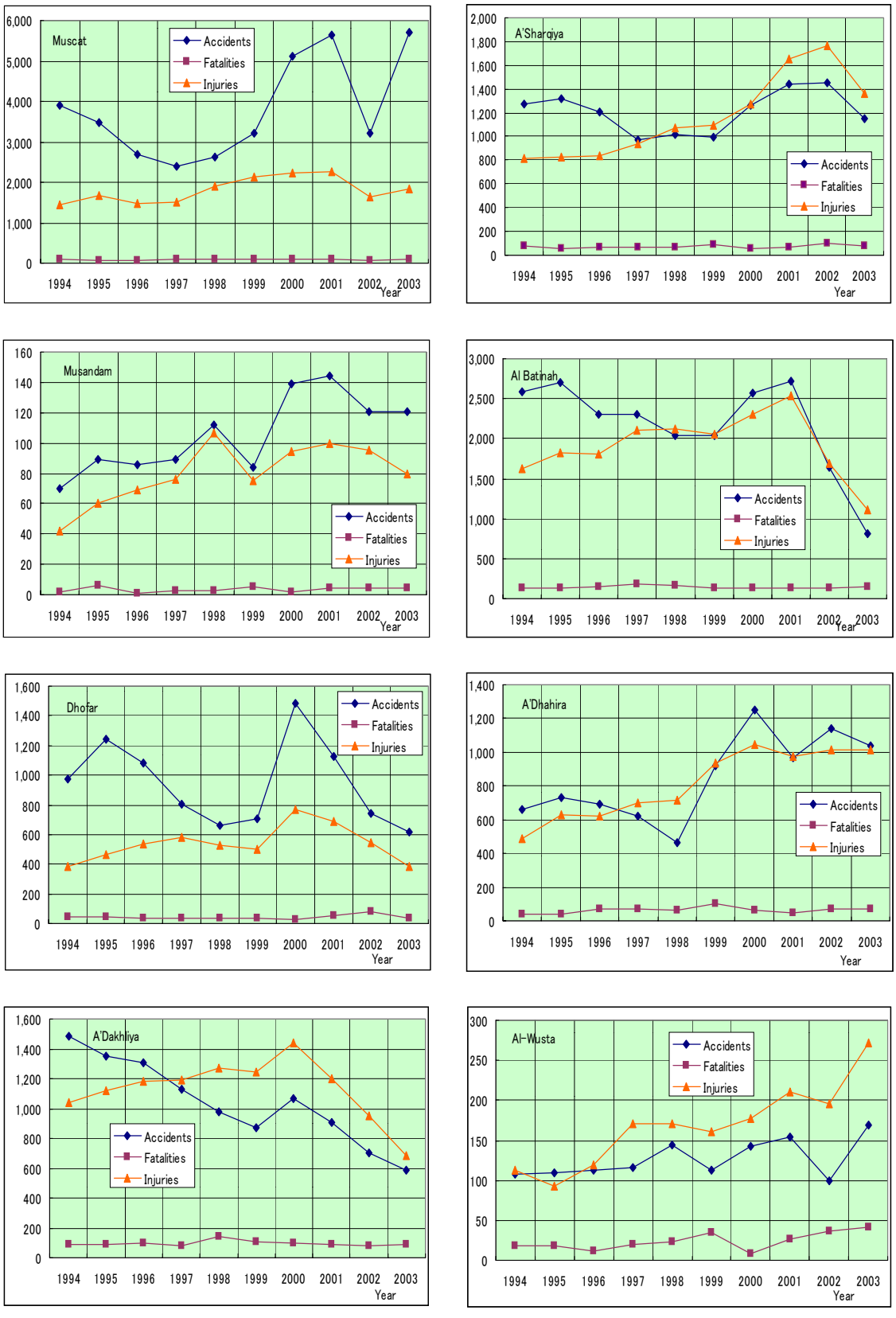


Figure 4.5-9 Regional Trends of Traffic Accidents

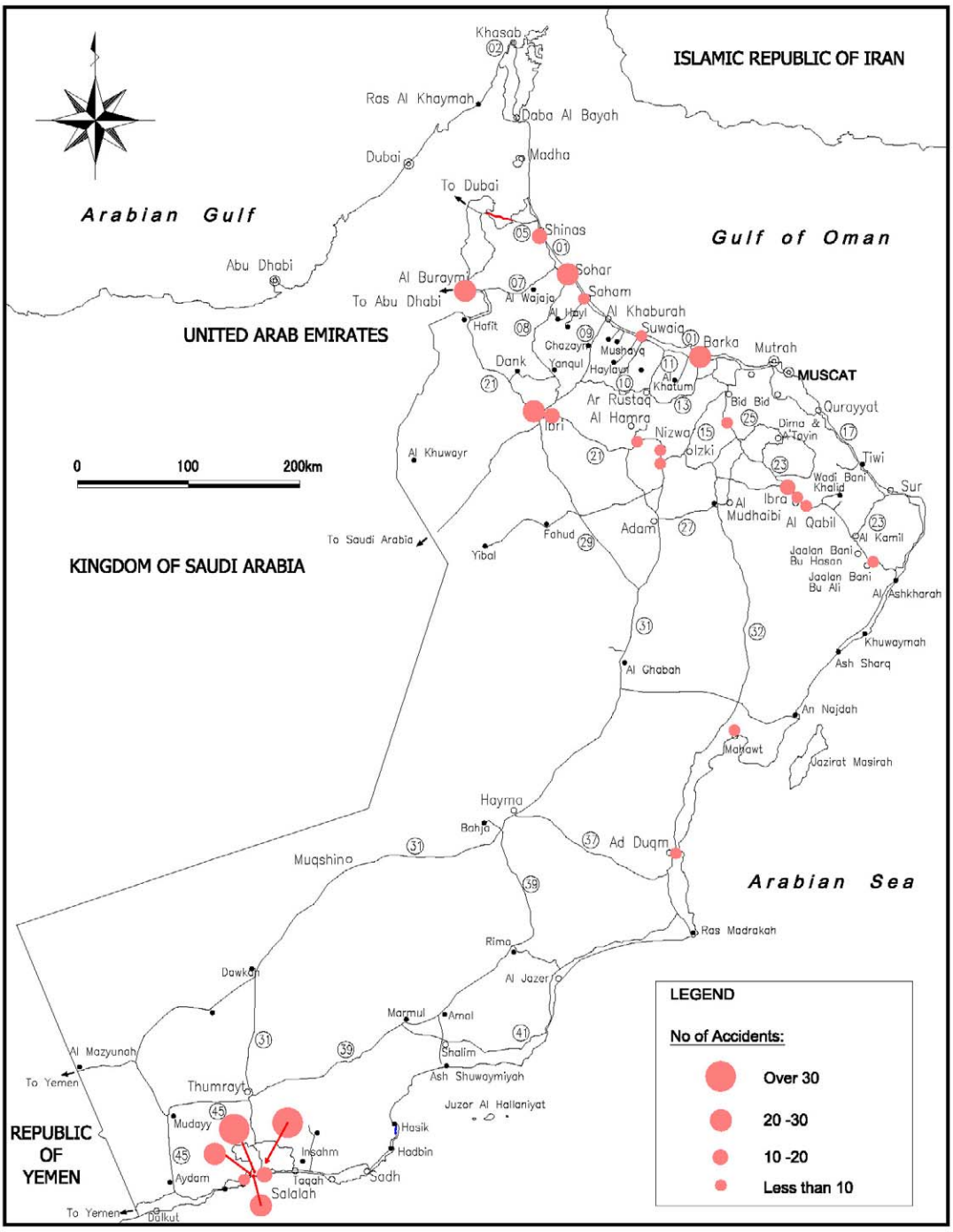


Figure 4.5-10 Location of Major Black Spots

4.6 CONSIDERATIONS FOR ROAD NETWORK PLANNING

Through the discussions in the preceding sections, the following problems have been identified on the existing road network:

(1) Road Link Problems

(i) Poor pavement conditions (unpaved or deteriorated pavement) on some sections
(ii) Insufficient shoulder width along some section
(iii) Substandard alignment (steep grade and small radius of horizontal curvature) at some sections
(iv) Defective bridges
(v) Roundabouts on heavily trafficked roads
(vi) Traffic accident black spots (sections/intersections where traffic accidents occur frequently)

(2) Road Network Problems

(i) Weak connection across the mountain ranges
(ii) Primary road network not suitable for high-speed, long-distance trips
(iii) Vulnerability to flash flood
(iv) Lack of an alternative route to Batinah Highway
(v) Low pavement ratio of lower-class roads
(vi) Missing links

(3) Road Maintenance Problems

(i) Institutional problems
(ii) Drainage structures
(iii) Sand dunes and sabkha

Measures for road link problems and road network problems are considered and incorporated in the planning of road network as described in Chapter 10 and 11. Measures for Road Maintenance Problems are discussed in Chapter 13.

Damaged Culverts

Closed Culverts

Heavy Vehicles on the Roads

Topographical Constraints

Road failure at Wadi


Camels on the Roads

Flash Floods at Wadis

CHAPTER 5

ENVIRONMENTAL CONDITIONS

CHAPTER 5

ENVIRONMENTAL CONDITIONS

5.1 ENVIRONMENT LEGISLATION AND REGULATIONS

5.1.1 General

Oman has respected conservation of natural environment since RD 26/75 established the government structure of the Sultanate of Oman in 1974. And several laws and regulations related to the environment had been instituted and revised as shown in Table 5.1-1. The environmental legislation in the Sultanate of Oman consists of the Royal Decree (RD), Ministerial Decision (MD) and Internal Regulation (IR) as shown in Table 5.1-1. The Royal Degrees as established national strategies and policies mainly consist of "Law on the conservation of environmental and preservation of pollution", "The Law on Nature Reserves and Wildlife Conservation", etc. The Ministerial Decisions and Internal Regulations mainly consist of much specified regulations and environmental standards, such as "Regulation for Air Pollution Control from Stationary Sources", "Omani Standard No.8, and Drinking Water", etc.

The Law on the Conservation of Environmental and Preservation of Pollution, which is the environmental basic law of Oman, was initially instituted as RD 10/82 in 1982, and was devised as RD No. RD 114/2001 in 2001. The law consists of three chapters and 43 articles as follows:

Chapter one	:	Definitions and General Provisions
Chapter two	:	Basic Rules and Principles to ensure safety of Omani Environment
Chapter three	:	Penalties
Appendix No.(1)	:	Animals and Birds of the first category
Appendix No.(2)	:	Animals and Birds of the second category

The law mainly establishes on the protection the Omani environment, nature conservation, historical and cultural heritages, pollution standards, environmental permit for the project, environmental impact assessment study, monitor and control the ecosystem, hazardous waste, marine environment, exploitation of natural resources, monitoring work, etc. In addition, the animals and birds listed in Table 5.1-2 are designated as endangered rare wildlife. And the "National Biodiversity Strategy Action Plan" as the national strategy was declared in 2001.

Table 5.1-1 Environmental Laws and Regulations (1/2)

No.	No. *1	Laws and Regulations
Environmental Planning and Site Approvals		
1	RD114/2001	The Law on Conservation of the Environment and Preservation of Pollution.
2	MD187/2001	Regulates issuance of "Environmental Approvals" and the "Final Environmental Permits".
3	MD396/1998	Regulates permitting of some small shops and service facilities in the Wilayats (car repairs, workshops, car washes, etc.).
4	MD219/1999	Regulates design, location and operation of livestock farms, slaughter houses, tanneries, poultry farms; meat, chicken and fish shops; transporting vehicles. Provides minimum setback requirements.
5	MD200/2000	Regulates permits for crushers, quarries and mining sand from wadis and beaches.
6	MD192/2000	Determination of the Adh Dhahirah Region Water Supply Well field Protection Zones.
7	MD187/2001	Regulation on Issuance of Environmental Approvals and Final Environmental Permit. And, Initial Environmental Permit: for the site approval and construction phase of the development. Final Environmental Permit: for operation phase of the project. Temporary Environmental Permit: for operation phase of the project. Environmental Permit: for infrastructure projects (roads, buildings, exploration and/or seismic/drilling etc.).
Nature Reserves		
	RD6/2003	The Law on Nature Reserves and Wildlife Conservation
	RD114/2001	The Law on Conservation of the Environment and Preservation of Pollution.
Air/Noise & Radioactive Materials		
	MD5/1986	Regulation for air pollution control from stationary sources. (MD18/1993)
	MD80/1994	Regulation for noise pollution control in the working environment.
7	MD79/1994	Regulation for noise pollution control in the public environment.
	MD249/1997	Regulation for the control and management of radioactive materials.
	MD37/2001	Regulation for the control and management of ozone depleting substances (ODS). And, Permit: to import/use radioactive materials. Permit: to import and distribute ODS.
Water/Wastewater/Non-Hazardous & Hazardous Waste		
	RD115/2001	Law on Protection of Sources of Potable water from Pollution.

*1: RD: Royal Decree, MD: Ministerial Decisions, IR: Internal Regulations

Table 5.1-1 Environmental Laws and Regulations (2/2)

No.	No. *1	Laws and Regulations
Water/Wastewater/Non-Hazardous & Hazardous Waste		
	RD24/2002	Endorses the Protocol on Controlling Sea Transportation of Hazardous Waste and Other Waste Across Borders and Disposal of the Same Signed in Teheran on 17/03/1998.
	MD5/1986	Regulations for external building drainage.
	MD17/1993	Regulations for the management of solid non-hazardous waste. And, License: to operate non-hazardous waste disposal site. License: to transport non-hazardous waste. License: to dispose non-hazardous waste. License: to recycle non-hazardous waste.
	MD18/1993	Regulation for the management of hazardous waste. And, License: to operate hazardous waste disposal site. License: to transport hazardous waste. License: to dispose hazardous waste. License: to recycle hazardous waste. License: to store hazardous waste. Permit: to discharge or reuse wastewater. Permit: to construct wastewater treatment facility.
	MD40/1988	Wadi Adai water supply well field protection zone and action plan.
	MD45/1988	Salalah water supply well field protection zone and action plan.
	MD11/1989	Western water supply well field protection zone and action plan.
Marine		
	MD7/1984	Regulation concerning the disposal of liquid effluents to the marine environment.
	RD24/2002	Endorses the Protocol on Controlling sea transportation of hazardous waste and other waste across borders and disposal of the same signed in Teheran on 17/03/1998.
		Permit: for dumping at sea under the International Maritime Organization, London Convention 1972.
Potentially Toxic Chemicals		
	RD46/1995	The Law of Handling and Use of Chemicals.
	MD248/1997	Regulation for the permit and handling of toxic substances.
	MD317/2001	Regulations on packing, packaging and labeling of hazardous chemicals.
		Permit: environmental permit for dealing with toxic chemicals.

*1: RD: Royal Decree, MD: Ministerial Decisions, IR: Internal Regulations

On the other hand, Oman has been ratified the Conservation Treaty on Biological Diversity of Rio-Summit in 1992, Convention for the Protection of the World Cultural

and Nature Heritage in 1972, and United Nation's Marine Law Treaty in 1982. But Washington Treaty for the Dealing of Wildlife and Ramsar Convention, Barzel Treaty, etc. are not ratified yet.

5.1.2 Environmental Laws and Regulation Related to the Road Development

The environmental laws and regulations related to the road development, listed in Table 5.1-1, mainly consist of the protection areas for nature conservation and marine environment, pollution, management of hazardous materials, and environmental standards.

Table 5.1-2 Designated Animals and Birds as Endangered Wildlife by RD No. 114/2001

Appendix No. (1) Animals and Birds of the First Category

S. No.	Scientific Name	Common Name
1	Oryx lencoryx	ARABIAN ORYX
2	Panthera pardus	ARABIAN LEOPARD
3	Hemitragas jayakari	ARABIAN TAHR
4	Gazella subgutturosa	REEM (SAND GAZELLE)
5	Gazella gazella	ARABIAN GAZELLE (IDMI)
6	Capra ibex	NUBIAN IBEX
7	Felis Caracal	CARACAL LYNX
8	Chelonia myds	STRIPED HYAENX
9	Felis silvestris	WILD CAT
10	Canis lupus	GREY WOLF
11	Mellivora capensis	HONEY BADGER
12	Felis margarita	SAND CAT
13	Vulpes rueppellii	SAND FOX
14	Lepus capensis	HARE
15	Eretmochelys imbricata	HAWKSBILL TURTLE
16	Chlamydotis undulata	BOUBARA BUSTARD

Appendix No. (2) Animals and Birds of the Second Category

Red Fox
Green Turtle
Loggerhead Turtle
Olive Rudely Turtle
All falcon, owl, vulture, eagle, flamingo, pelican, gull and tean species
All mammals species not mentioned in Appendix No. (1) except tamed mammals

Fourteen protection areas designated as the nature conservation by Royal Decree are shown in Table 5.1-3 and Figure 5.1-1. These areas are highly regulated and controlled by the Ministry of Regional Municipalities, Environment and Water Resources (MRMEWR).

Table 5.1-3 Protection Areas in Oman

No.	Name of area	Location (Region)	Total area (km^2)	Year of Proclamation	Reserve resources (Biological, others)
1	The Arabian Oryx Sanctuary	Al Wusta	24,785.4	18/1/1994 (RD 4/94)	Arabian oryx, Nubian ibex, etc., conserving biodiversity
2	As Saleel Natural Park	Ash Sharqiyah	220	28/6/1997 (RD 50/97)	Simr, Arabian gazelle, Gordon's wild cat, protecting wildlife
3	Ra's al Hadd Turtle Reserve	Ash Sharqiyah	42	23/4/1996 (RD 25/96)	Turtles, Coral reefs, Mangroves, Prosopis cineraria and birds, protecting wildlife
4	Jebel Samhan Nature Reserve	Dhofar Governorate	4,500	28/6/1997 (RD 48/97)	Leopard, Ibex, Arabian wolf, Gazelle, Blanford's fox, protecting wildlife
5	Dimaniyat Islands Nature Reserve	North of Muscat	203	3/4/1996 (RD 23/96)	Coral reefs, fish, birds, and turtles, conserving wildlife
6	The Khawrs Reserve of Dhofar Coast	Dhofar Governorate	-	28/6/1997 (RD 49/97)	Khawrs, springs, and archaeological sites, Mangroves, sustainable use of the resources
	1) Khawr Mughsayl	Ditto	0.6	Ditto	Ditto
	2) Khawr Dahareez	Ditto	0.6	Ditto	Ditto
	3) Khawr Balle	Ditto	1	Ditto	Ditto
	4) Khawr Awqad	Ditto	0.16	Ditto	Ditto
	5) Khawr Qurm as Sagheer and Khawr Qurm al Kabeer	Ditto	0.175	Ditto	Ditto
	6) Khawr Sawli	Ditto	1	Ditto	Ditto
	7) Khawr Taqah	Ditto	1.07	Ditto	Ditto
	8) Khawr Rawri	Ditto	8.20	Ditto	Ditto

(By MRMEWR)

(1) The Arabic Oryx Sanctuary
(2) As Saleel Natural Park
(3) Ra's al Hadd Turtle Reserve
(4) Dimaniyat Islands Nature Reserve
(5) Jebel Samhan Nature Reserve
(6) The Khawrs Reserve of Dhofar Coast

Figure 5.1-1 Protection Area in the Sultanate of Oman

On the marine environment, the Regulation for Conservation of Marine and Coastal Environment as MD20/90 and Decision no. 19/90 of the Supreme Committee for Town Planning (SCTP), which was instituted in 1990, is established control zone of development being within 50 to 300 meters from natural coastal line, mentioned as below.

(Restriction Zone on Development)

1) Landscape management area : 300 m from high tide line
2) Beach area : 150 m from high tide line
3) Other areas (Rocky beach, etc.) : 50 m from high tide line

And the protection areas related to the marine environment, namely Ra's al Hadd Turtle Reserve, Dimaniyat Islands Nature Reserve, Jebel Samhan Nature Reserve, Khawrs Reserve of Dhofar Coast, are designated.

The pollution control laws, consisting of air quality, water quality and noise levels are established by MD 18/93, MD 145/93 and MD 79/94, respectively.

On the hazardous wastes, MD 18/93 has been established in 1993 and the Ministry of Regional Municipalities, Environment and Water Resources control these.

Four monitoring stations are installed for air quality under the Directorate General of Environmental Affairs of MRMEWR. The stations are located in Mina al Fahal (Muscat), Ruseil (industrial area at Seeb), mobile station at Muscat and Majis (Sohar industrial area). The monitoring work for water quality is carried out by the Directorate General of Water Resources of MRMEWR. No monitoring points for noise exist.

5.1.3 Environmental Standards

The environmental standards are established by MD 18/93, MD 145/93 and MD 79/94. The air quality standards, effluent standard for wastewater and water quality standards, drinking water, and noise level standards are shown in Table 5.1-5 and 5.1-6, respectively.

Tab1el 5.1-4 Standards of Emission of Grid and Dust for Schedu1ed Works

No.	Items	Standard value (g/m^3)
1	Grit and dust	0.050
2	Aggregates works particulates	0.050
3	Asbestos works (Total particulates)	0.050
4	Asphalt works (Bitumen fume) (Tota1 particu1ates)	0.030 0.050
5	Cement works (Particulates) (Hydrogen su1phide)	0.100 Nil
6	Ceramic works (Particulates)	0.050
7	Copper works (Total particulates) (Copper compounds as copper) (Zinc compounds as copper) (Cadmium compounds as copper)	0.200 0.100 0.100 0.200
8	Incineration works (HCl) (HF) (NO_2)	0.200 0.100 0.200
9	Lead works (Lead or its compounds) (Total particulates)	0.030 0.050
10	Lime works (Particulates from kiln)	0.100
11	Petro1eum works (Particulates from CO from catalytic crac1cers) (Sulfur recovery units) (Minimum H_2SO_4)	0.100 0.5% by volume 95% efficiency 5% by volume
12	Power p1ants (Particu1ates from coal or oi1 firing)	0.100
13	Di-isocyanates (VoIati1e Di-isocyanates) (Particulates Di-isocyanates)	0.100 0.001

Table 5.1-5 Effluent Standard of Waste Water (mg/L)

Parameters	Area A	Area B		Parameters	Area A	Area B
BOD	15	20		Hg	0.001	0.001
COD	150	200		Mo	0.01	0.05
SS	15	30		Ni	0.1	0.1
TDS	1,500	2,000		N	5	50
EC	2,000	2,700		NO_3	50	10
SAR	10	10		Oil & grease	0.5	0.5
pH	6-9	6-9		T-Phenols	0.01	0.002
Al	5	5		P	30	30
As	0.1	0.1		Se	0.02	0.02
Ba	1	2		Ag	0.01	0.01
Be	0.1	0.3		$S0_4$	400	400
B	0.5	1		S	0.1	0.1
Cd	0.01	0.01		V	0.1	0.1
Cl	650	650		Zn	5	5
Cr	0.05	0.05		Faecal liform		
Co	0.05	0.05		bacteria		
Cu	0.5	1		(per 100mL)	200	200
CN	0.05	0.1		Viable		
F	1	2		nematode ova		
Fe	1	5		(per L)	<1	<1
Pb	0.1	0.2				
Li	0.07	0.07				
Mg	150	150				
Mn	0.1	0.5				

Area A: Vegetables likely to be eaten raw. Fruits are likely to be eaten raw and within 2 weeks of any irrigation / Public parks / Hotel Lawns Recreational areas / Areas with public access / Lakes with public contact. (Except places which may be used for praying and hand washing.

Area B: Vegetables to be cooked or processed / Fruits if no irrigation within 2 weeks of cropping / Fodder, cereal and seed crops / Pastures / Areas with no public access.

Tab1e1 5.1-6 Water Quality Standard for Drinking Water (mg/L)

Parameters	Maximum pemissib1e leve1
Pb	0.10
Se	0.01
As	0.05
Cd	0.01
CN	0.05
Hg	0.001

Tab1e 5.1-7 Environmenta1 Standard for Noise

Noise Pollution Control in Working Environment
<85 dB(A)

5.2 ENVIRONMENTAL MANAGEMENT SYSTEM AND FUNCTION

5.2.1 Environmental Management System

The environmental management in Oman is mostly executed the policy by the Directorate General of Environmental Affairs of MRMEWR.

The Law on Conservation of the Environment and Pollution Prevention, established by RD 10/82 and its amendment RD 114/2001, assigned the following responsibilities to the MRMEWR.

1. To prepare and implement a national plan for the conservation of the environment and prevention of pollution. Implementation of the plan must be coordinated with all concerned ministries and governmental agencies.
2. To develop all environmental laws, regulations and rules.
3. To coordinate all environmental protection efforts with other ministries and governmental agencies.
4. To provide the staff and equipment necessary to enforce laws and rules.
5. To undertake and sponsor environmental research.
6. To train Omani staff in the field of environmental conservation and the prevention of pollution.
7. To establish an environmental data center.
8. To set pollution discharge standards.
9. To issue discharge permits for new and old sites, to monitor all discharge sites to insure conformity with environmental discharge standards.

This basic law establishes a comprehensive legal framework that consists of legal

objectives, duties of individuals, and responsibilities of Ministries and organizations for managing pollutants in a manner that minimizes environmental damages. And the law established also a requirement to obtain a license for certain types of activities. For these activities, a developer must undergo an environmental review process and an "Approval for Development", before development can proceed. The flow of the approval process for development activities in Oman is shown in Figure 5.2-1. In addition, proposed projects including road construction project must obtain an "Environmental Permit" as well as "Approval for Development".

5.2.2 Environment Permit Procedure

The environmental system in Oman, shown in Figure 5.2-2, consists of two levels of permits, namely "Preliminary Environmental Permit" and "Final Environmental Permit". A "Preliminary Environmental Permit" is issued for a specific period of time at the planning stage of the project following a site inspection and review of an application. The "Final Environmental Permit" is issued for a period of 1 to 5 years (renewable) after the completed construction stage of the project following a site inspection.

The Directorate General of Environmental Affairs of MRMEWR has issued the "Guidelines for Obtaining Environmental Permit" for the Environmental Impact Assessment Study.

According the guideline, the applicants should submit the application of "Environmental Impact Statement Form and Supporting Documents" to the MWMEWR. The Ministry has to respond to the appeal within sixty days. The application form consists of the following sections:

1) Section 1 : Project Description
2) Section 2 : Project Details
3) Section 3 : Environmental Impacts
4) Section 4 : Mitigation Measures and Monitoring Programs
5) Section 5 : Addenda
6) Section 6 : Signature

The outline of the Environmental Permit Procedure according the guideline is described as below.

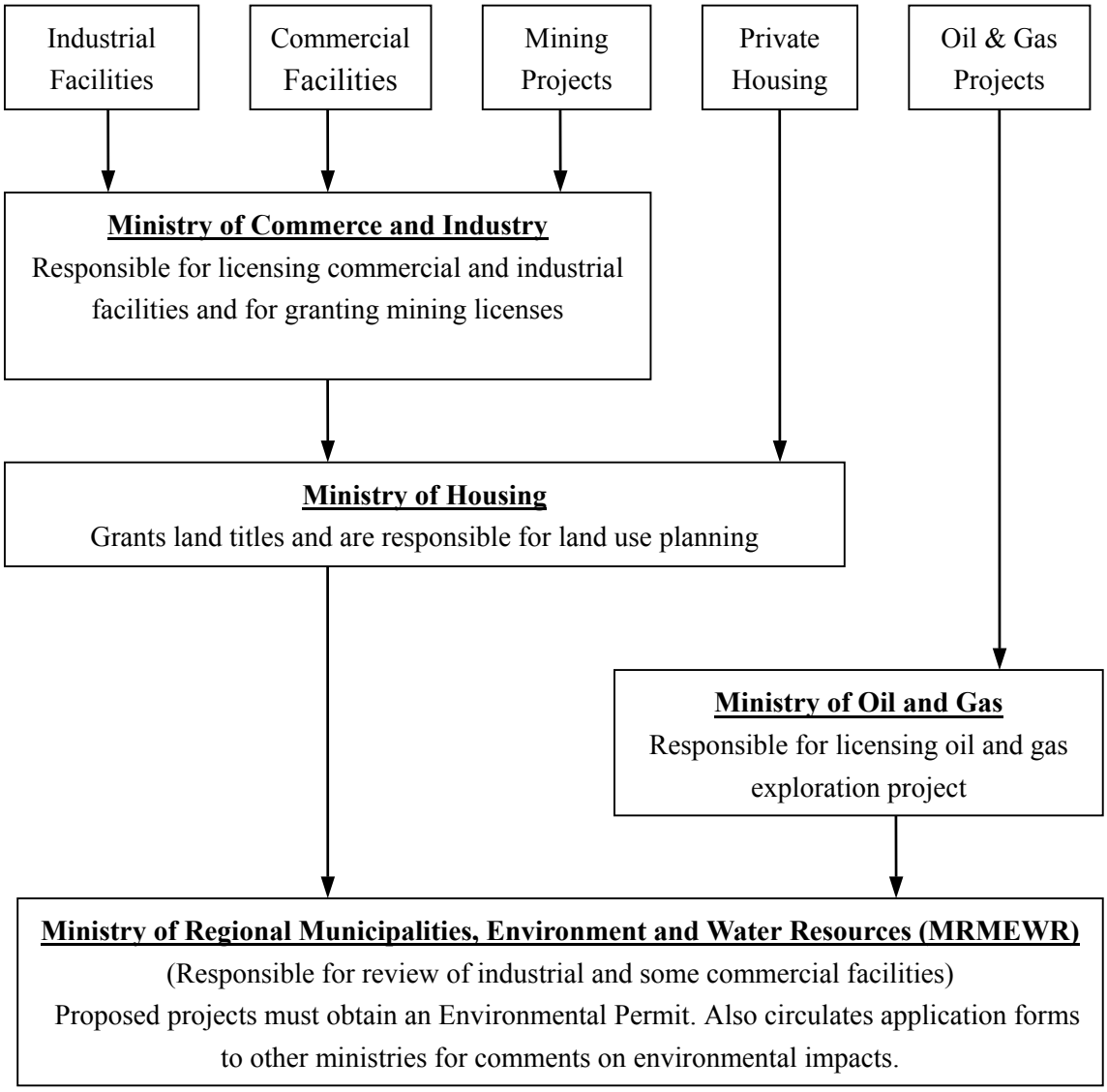


Figure 5.2-1 Approval Process for Development Activities in Oman

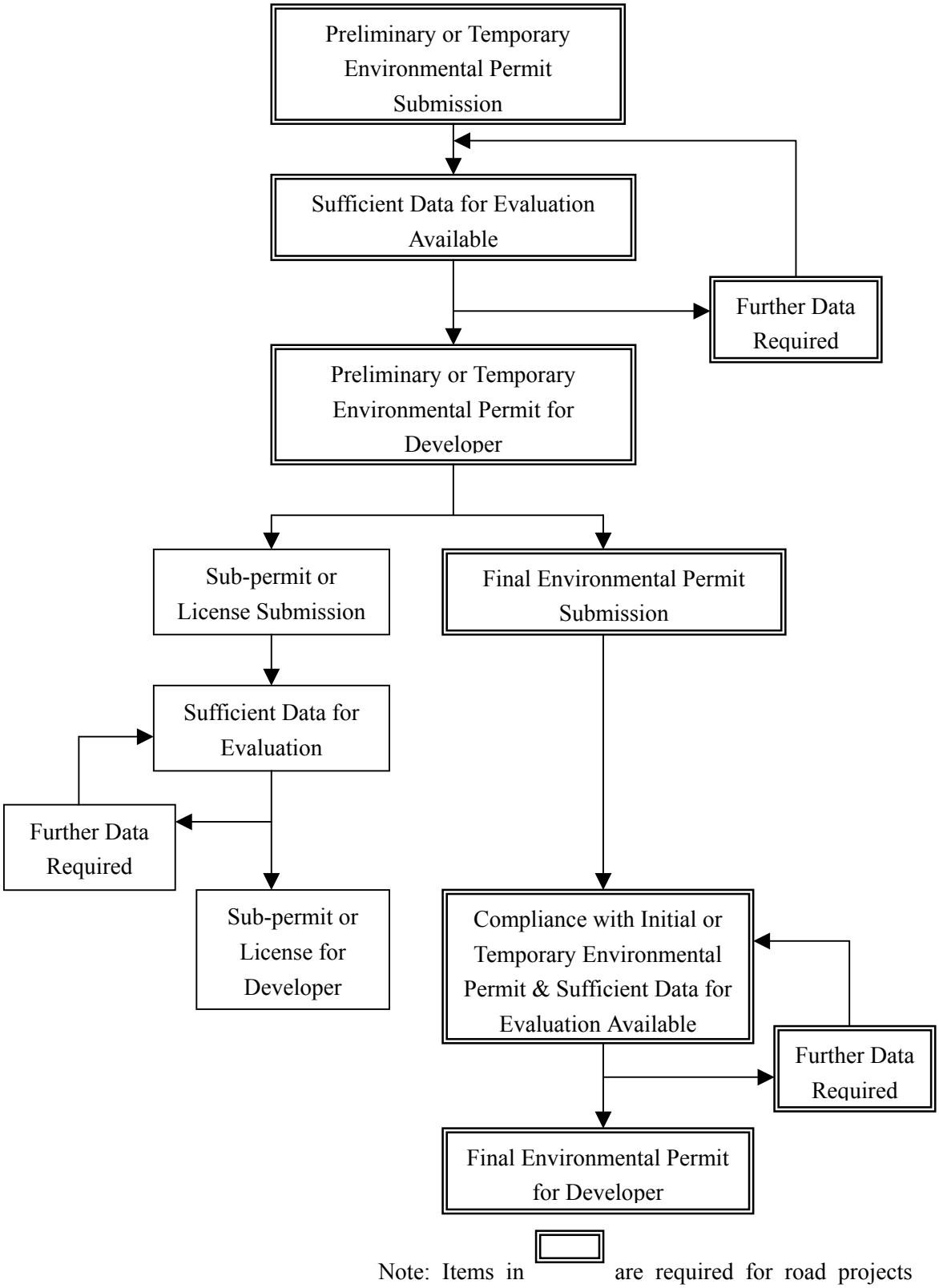


Figure 5.2-2 Flow of the Environmental Permit and License System in Oman

(1) Preliminary consultation

Before submitting the application, the proponents are encouraged to contact MRMEWR to discuss details of required documentation. The proponents are encouraged to discuss proposed projects informally with staff of the Ministry at early stage, before detailed studies or plans are drawn up. A feasibility study, complete with its environmental chapter, may be utilized during this preliminary consultation. Preliminary consultation may give the proponent an early warning of environmental sensitivities of the chosen area, or serious secondary effects related to the project.

(2) Application review process

The procedure for processing of an application for the Environmental Permit from the Ministry can be divided into three stages.

Stage 1: Application submission stage

This stage begins the application review process and consists of submitting a completed set of documents required by the Ministry. The submission package shall consist of completed and signed copies of Environmental Impact Statement forms 1, 2, 3 or 4 (as appropriate), i.e. technical documents and permits from other Ministries (if necessary). Once this stage is completed, the application package undergoes a technical appraisal by the Ministry.

Stage 2: Technical stage appraisal / screening

At this stage of the review process, technical staffs of the Ministry conduct a site visit and screening followed by a detailed review of the application to determine the type of environmental analysis that is required for the project. In many cases for simple small business / light industries the requirements of the Environmental Permit review process will be fulfilled by filling out necessary forms and the subsequent issue of an Environmental Permit with appropriate conditions. For large-scale potentially environmental impacting / polluting industries a comprehensive environmental impact assessment study (EIA Study) may be required.

EIA and other analysis are the responsibility of the applicant, but Ministry's staff is available to assist whenever requested, for example in discussing the scope of the EIA Study or terms of reference. EIA is a flexible process, designed to accommodate the entire range of projects and different circumstances.

There is no fixed list of specific industries, development or their sizes, which would

trigger a detailed EIA; instead, the Ministry's procedure relies on screening, identifying significant impacts on sensitive areas, and discussion between the Ministry and applicant to identify any critical issues and to establish the scope of the EIA. However, certain types of projects or their elements commonly fall into categories of projects requiring a detailed EIA Study.

In order to simplify procedures for obtaining environmental permits, this handbook (guidelines) classifies projects into eight according to the technical aspects of their construction and operation phase.

Group one:	Industrial projects
Group two:	Mining projects
Group three:	Agricultural projects
Group four:	Food projects
Group five:	Service projects
Group six:	Marine and coastal projects
Group seven:	Tourism projects
Group eight:	Light projects

These groups are further subdivided into a number of subgroups according to the industries commonly found in the Sultanate. For each group the Ministry specifies a list of general requirements that apply to all the projects within the group and a list of technical requirements that apply to specific subgroups. The road construction project is involved group five (Service projects).

In addition, the following Table 5.2-1 contains strictly illustrative examples of some these categories.

A detailed EIA Study is normally unnecessary for projects, which due to their scale location or characteristics are unlikely to cause significant environmental impacts. MRMEWR will decide in consultation with the applicant whether or not a detailed EIA Study is required. The final decision is that of MRMEWR.

Table 5.2-1 Illustrative Examples of Some Projects that Commonly Require a Detailed EIA Study

- Aquaculture projects
- Dams and reservoirs
- Electric plants and industrial estates (Large scale)
- Irrigation and drainage schemes (Large scale)
- Mineral development (Including oil and gas)
- Pipeline (Oil, gas, water)
- Port and harbor developments
- Desalination plants
- Primary and rural roads
- Thermal power development
- Large scale tourism projects
- Urban water supply and sanitation (Large scale)
- Transportation (Airports, railways, roads)
- Urban development (Large scale)
- Manufacture, transportation and use of pesticides or other hazardous and/or toxic materials
- Projects which pose serious accident risks
- Projects with the potential for significant impact on the following sensitive areas; marine environment, groundwater, designated and proposed National Parks and Nature Reserves, the atmosphere
- Large scale Government camps and military training areas
- Regional and sub-regional development plans
- Any project or activity designated by the Minister.

Stage 3: Decision and permit stage

After technical review of the complete application package (with or without EIA Study), the Ministry decides whether to issue the Environmental Permit or send back the request for revisions.

5.2.3 Environmental Impact Assessment Guideline (Draft Version)

MRMEWR has issued the draft version No. 2 of Interim Guideline on Environmental Impact Assessment, on June 6, 1999. The legislative authority of the guidelines is based on the RD 10/82 and RD 114/2001, the "Law on the Conservation of Environmental and Preservation of Pollution". The principles of the EIA are as follows:

- EIA is a process to help decision makers to protect, conserve and manage Oman's environment, according to the principles of sustainable development, maintaining human well-being, healthy environment and a sound economy.
- The EIA process must ensure that the individual, company or government agency, proposing a project considers its effect on health, economy and culture of surrounding community as well as its impact on air, land and water.
- The EIA must be applied as early as possible in project's planning stage and before irrevocable decisions are made.
- Public information is an important component of an open and balanced EIA process.

At the initial stage, MRMEWR conducts an environmental screening and scoping to ensure the proposed project for carrying out an appropriate environmental assessment.

5.3 NATURAL ENVIRONMENTAL CONDITIONS

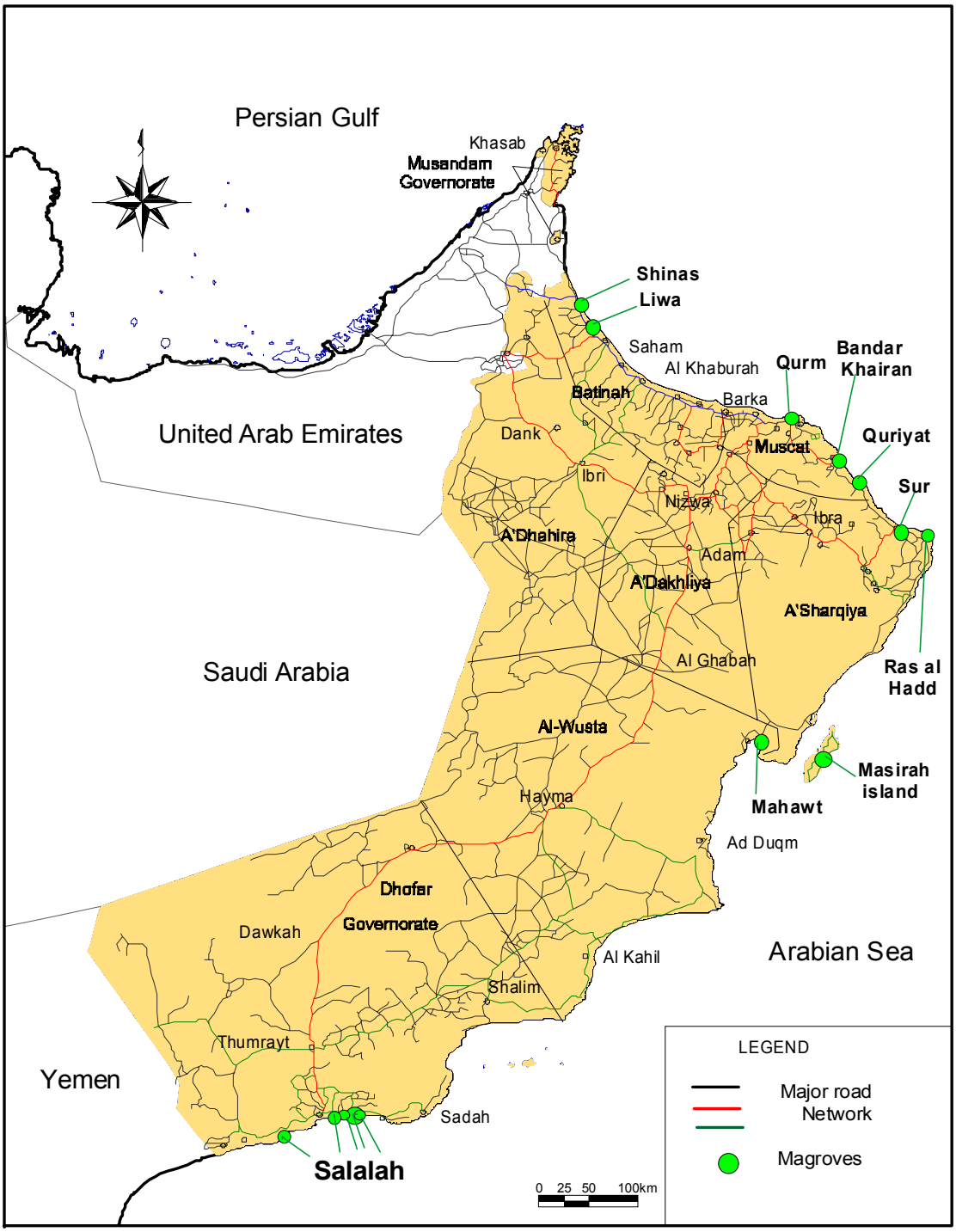
5.3.1 Marine

The coastline of Oman is approximately 1,700 km long and has an varied unique landscape, including rocky coasts, beaches, mangroves, coastal lagoons, tidal inlets, etc., that are very important location for the wildlife and ecosystem productivity as well as recreation activities and tourism.

Administrative offices related to the marine environment consist of three directorates, namely Environmental Inspection and Control Department of MEMRWR, Marine Pollutions and Coastal Zone Management Section of MRMEWR, and Directorate General of Fisheries of MOAF. Several coastlines are legally covered by MD20/90 and SCTP Decision no. 19/90 and the protection areas related to the marine environment, namely Ra's al Hadd Turtle Reserve, Dimaniyat Islands Nature Reserve, Jebel Samhan Nature Reserve, Khawrs Reserve of Dhofar Coast are proclaimed by the Royal Decrees.

The mangroves are scattered along the beaches from north to south of Oman as shown in Figure 5.3-1. The distribution areas of Mangroves are as follows:

1) Batinah Region: Shinas, Liwa
2) Mascat Governorate : Qurm, Bandar Khairan, Quriyat
3) Ash Sharqiah Region: Sur, Ras Al Hadd (Khawr Jaramah)
4) Al Wusta Region: Mahawt Island



(By MRMEWR)

Figure 5.3-1 Distribution Areas of Mangroves in Oman

5) Dhofar Governorate: Salalah Area (Mugsayl, Khawr Qurm Al-Sahir, Khawr Qurm Al-Kabir, Khawr Taqa, Khawr Baleed)

The marine biota is not generally well known except for a few groups, such as fishes (1,142 species known from Omani waters), seaweeds (232 species), and corals (75 species). According the "National Biodiversity Strategy and Action Plan", key issues for the marine environment of Oman comprise of as below.

- Over-fishing
- High levels of fisheries waste and poor quality of catch
- Unsustainable levels of by-catch, particularly wildlife species
- Habitat damage arising from fishing gear and practices
- Inadequate fisheries monitoring, surveillance and control system
- Marine habitats under represented in protected areas system

And it proposes to ensure sustainable development and protection of marine habitats (particularly, coral reefs, sea grasses and mangroves).

Ophiolite, which is found widely in the Oman Mountains, mainly consists of basalt, dolerite, gabbro, peridotite and dunite, etc. As these rocks feature by easily alteration and well-developed fractures, the rocks are easy to collapse locally.

The limestone area, which is widely found in the eastern, central and southern parts of Oman, is marked by rugged topography and caves.

5.3.2 Meteorology

(1) Total Rainfall

Yearly total rainfall ranges from 3.8 to 387.6 mm. The lowest point of rainfall, 3.8 mm, is Qurm Alam station, located in the central part of Oman, and the highest point, 387.6 mm, is Saiq station, located in Jabal al Akdar of the central part of the Oman Mountains.

Although most area of Oman is arid to sub-arid area, ranging in yearly total rainfall from 3.8 to 247.8 mm, rainy season in Oman except Salalah and Saiq areas is between December and March. Salalah area, including Qairoon Hairiti, Salalah and Mina Salalah stations, is featured by rainy season between June and September, ranging in monthly total rainfall from 13 to 83 mm. And Saiq area has rain at the all times of the year.

(2) Mean Humidity

Monthly mean humidity ranges from 24 to 94 %. Relatively low humidity points, including Buraimi, Rustaq, Saiq, Nizwa, Fahud, Qurm Alam, Marmul and Qairoon Hairiti stations, are located inland of Oman. On the contrary, relatively high humidity points, including Khasab, Sohar, Mina Surtan Qaboos, Masirah, Yalooni, Salalah, and Mina Salalah stations, are located in the coastal area.

(3) Air Temperature

Air temperature consists of absolute maximum temperature, mean temperature and absolute minimum temperature. The absolute maximum temperature ranges from 21.9 to 48.7℃. Most of the areas except Salalah area shows same pattern of air temperature. Hot season is between April and September, and relatively cooler season is between October and March. The air temperature in the Salalah area shows relatively low temperature during rainy season between July and September.

Absolute minimum temperature ranges from -0.6 to 29.8℃. The difference between maximum and minimum temperature is approximately 20℃. Particularly, Saiq shows below the freezing point in January, where is located in the highland.

(4) Prevailing Wind Direction and Wind Speed

Prevailing wind direction in the central and southern parts of Oman mostly shows between southeast and southwest. However, that of the Batinah Region located in the northeastern wing of the Oman Mountains, including Sohar, Rustaq and Saiq stations, shows different direction between north and east.

Wind mean speed ranges in an hour from 2.7 to 16.2 knots (1.4～8.3 m/sec), and higher wind speed mostly reveals during hot season (June to August). The areas of Fahad, Qurm Alam, Masirah and Marmul stations, located in the central and southern part of Oman, show relatively stronger wind than that of other stations (Figure 5.3-2).

(5) Maximum Gust Direction and Mean Gust Speed

Maximum wind direction in Oman shows between south and west. Mean gust speed ranges in an hour from 10.8 to 56.0 knots (5.6～28.8 m/sec), and higher gust speed mostly reveals during hot season (June to September). Khasab, Saiq, Nizwa, Fahad, Qurm Alam and Marmul stations, located in the north most and central parts of Oman, reveals strong wind more than 30 knots.

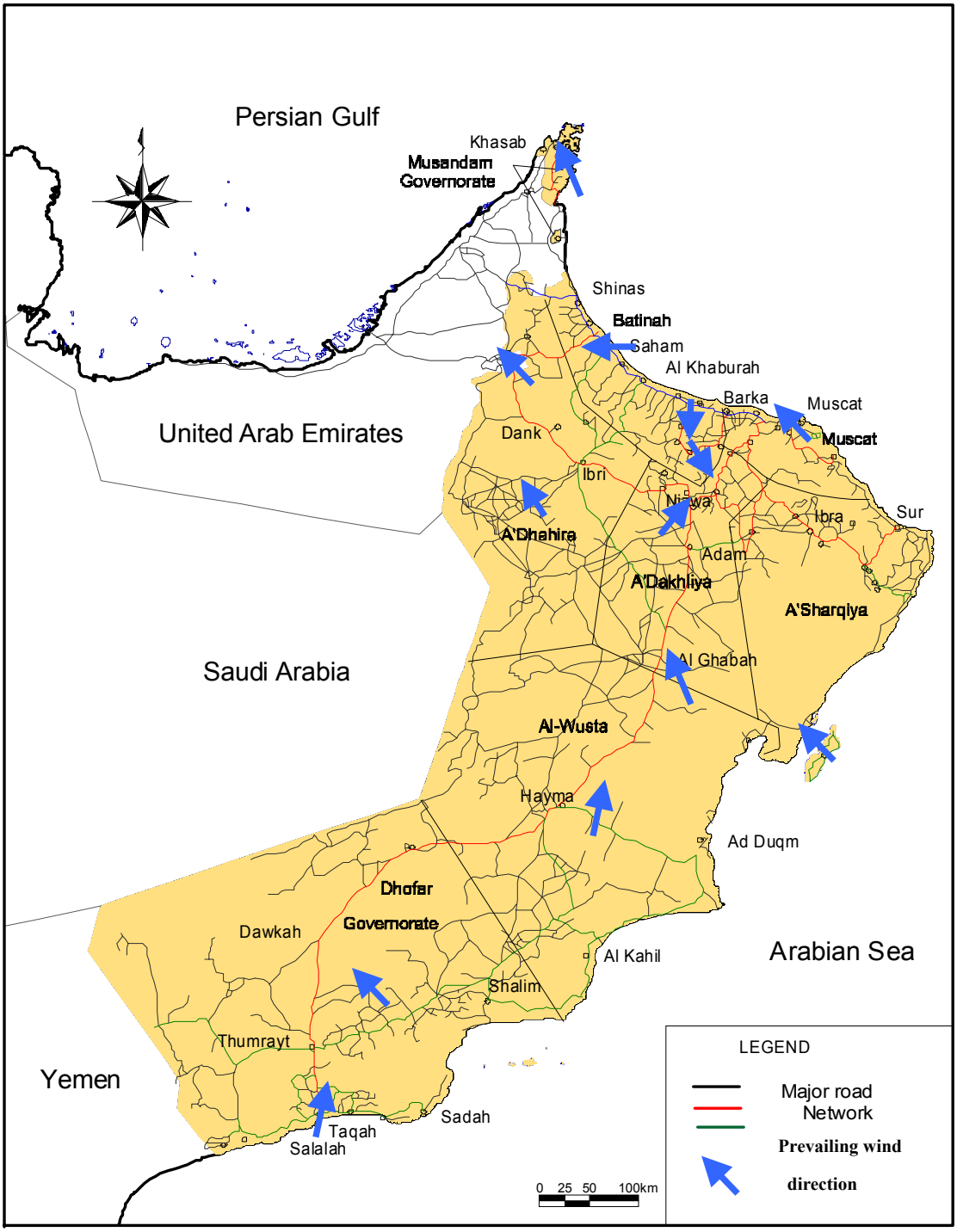


Figure 5.3-2 Prevailing Wind Direction in Oman

5.3.3 Fauna and Flora

Numerous kinds of wildlife, vegetation and marine life under the arid to sub-arid environment of Oman have been confirmed. And the Oman government has expended effort to conservation and protection of wildlife and vegetation including marine life since 1974.

Presently, the hunting of wildlife is under the ban by the law (R.D. 114/2001), and Royal Decree shown in Table 7.1-3 and Figure 7.1-1 proclaims fourteen protection areas for the nature conservation. The biological reserve condition of each protection area (MRMEWR) shows as below.

(1) The Arabian Oryx Sanctuary

The Arabian Oryx Sanctuary is located in Al Wusta Region of the central plateau of Oman. The sanctuary is home to many different wildlife species including the Arabian Oryx (Oryx leucoryx), which was reintroduced to the wild in 1980.

Vegetation: Over 140 species of plants has been recorded in the Sanctuary, including 12 endemics. Whilst some species are short-lived after rain the fog supports the longer-living species. Grasses are the main source of food for the Sanctuary's herbivores, and trees provide an important food source during drought.

Wild animals: At least 15 species of mammals have been recorded on the Jiddah and Huqf Escarpment, of which the Arabian Oryx is the best known. On the Arabian Oryx, in 1974 H.M. Sultan Qaboos decided to restore the species to its original habitat. In 1980, the first animals arrived in the Sultanate from Phoenix Zoo, USA. Recently, numbers of the animals are gradually increased.

(2) As Saleel Natural Park

As Saleel Natural Park, located in the southwest of Sur, is an alluvial plain of mainly acacia woodland providing good habitat for some of the medium-sized mammals of Oman. It has been designated with the aim of future development for educational purposes and wildlife tourism, whilst at the same time bringing benefits to the local people.

Vegetation: The designated area has three distinct vegetation zones, of which the most important and visible is the sloping alluvial plain covered with acacia woodland. The second zone of major importance is that containing the wadis, which furrow the higher mountains. The third zone is that of the sparsely vegetated boundaries and the

higher elevations having mainly grass and small shrub cover.

Wild animals: There are approximately 45 Arabian Gazelles in the National Park. The rare Gordon's Wild Cat has been seen on several occasions in the park whilst wolves and Red Fox occur in the nearby mountains in limited numbers.

Management of the park's natural resources aims to achieve sustainable use of the plants by wildlife.

(3) Ra's al Hadd Turtle Reserve

The Turtle Reserve, located in the east most part of Oman, covers an area of 120 km^2 of beaches, coastal lands, sea bed and two Khawrs (Khawr al Hajar and Khawr al Jaramah). The Royal Decree, which proclaims this area for the conservation of turtles, it the culmination of work started in 1976 tostudy and protest these unique and rare marine species.

Ra's al Hadd Peninsula is of great importance for its turtle nesting beaches, which attract the largest number of green turtle nesting in Oman. Conservation in this area, therefore, makes a significant local, regional and international contribution towards preventing this endangered species from becoming extinct. It hosts between 6,000 – 13,000 turtles annually, which have mitigated from the Arabian Gulf, remote areas of Red Sea and East African coast.

Khawrs: Khawrs support scattered mangrove bushes, which along with the coral reefs in the area, provide breeding grounds for fish. All these fragile resources are sensitive to human interference and require protection.

(4) Jebel Samhan Nature Reserve

Jebel Samhan Nature Reserve, located in the northeast of Salalah, contains a wilderness of limestone highlands, rising steeply from the coastal plain and sloping more gently towards the north. Jabel Samhan, a range of barren, scalloped peaks separated by deep wadis and canyons, includes the 1,500 m high escarpment that overlooks the foothills and coastal plain between Marbat and Sadh, known as Thalawt. There is also a coastal escarpment towards the east.

Biological Resources: The deep canyons with water pools and various species of plants provide an ideal habitat for the last population of Arabian Leopard, Nubian Ibex, Arabian Gazelle, Striped Hyaenas, Caracal, Wild Cats, Foxes and Wolves are also present in the area. In the wadi, Khawr surrounded with vegetation exists and

attracts nesting tuetles. Migrant birds nest on the adjacent cliffs. Shrimps and abalone are found in the marine area and whales are seen along the coast between Hadbin and Shuwaymiyah.

(5) Dimaniyat Islands Nature Reserve

The Dimaniyat Islands Nature Reserve, located in the north of Muscat and east of Barka, is an archipelago of nine islands along the coastal of Wilayat as Seeb and Wilayat Barka, surrounded by rocks and shallow seas, which lie only 16 –18 km from the coast and can only be reached by boat. The islands are characterized by their virgin nature and fascinating beauty, offering shelter to a variety of animals.

The Nature Reserve is both a nationally and internationally important conservation area, rich in the diversity of both its marine and terrestrial wildlife. Thousands of migratory birds, such as ospreys, nest on the islands in the summer and many other species of vividly colored reef fish live amongst the coral reefs, providing a beautiful area for diving and swimming.

Biological Resources: The area is a nationally, regionally, and internationally important and great conservation area, in which thousands of marine birds nest in summer, creating a wonderful panorama.

(6) The Khawrs Reserve of Dhofar Coast

The khawrs and springs of the Dhofar coast are valuable resources with an abundance of wildlife. In historical times some of these inlets provided safe anchorage for the ships, whilst the fresh springs feeding them enabled people to establish permanent settlements.

The khawrs contains large numbers of fish, mainly the edible milkfish and mullet. These species have a high tolerance to fresh water and can easily adapt to decreasing salinity. The wide range of salinity is reflected in rich vegetation.

One of the most important reasons for protecting the khawrs is their use by large numbers of migratory birds for food and rest during annual migration. More than 200 species of birds have recorded in these khawrs.

Traditionally the local people used these khawrs, with their lush vegetation and abundance of fish and birds in a sustainable manner. They would water and graze their livestock there while the fish provided for additional fishing, especially during the monsoon season when the seas were too rough to allow safe fishing.

With the increase of people and their livestock in the area and the expansion of Salalah into a major city, it has become clear that some of the resources of the khawrs are threatened by over-utilization. Hence, the Government of Oman has decided to proclaim 8 areas as protection areas, shown as below.

Khawr Mughsayl
1) Khawr Dahareez
2) Khawr baleed
3) Khawr Awqad
4) Khawr Qurm as Sagheer and Khawr Qurm al Kabeer
5) Khawr Sawli
6) Khawr Taqah
7) Khawr Rawri

In case of the road improvement between Hyma and Duqm crossing the protection area of the Arabian Oryx Sanctuary, the project had been gotten the Environmental Permits without order of any large changes, because of the only paving improvement. Hence, it is necessary comprehensively to examine the impacts by detailed site investigation, in case of the project of newly road construction or accompanied with large scaled alteration of topography.

5.3.4 Landscape

The landscape of Oman features unique topography, formed by erosion under the arid to sub-arid climate. Particularly, Oman Mountains, mainly consisting of ophiolite, limestone, chert, etc. forms steep cliff and deeply incised valley. And coastal line also shows various features, including rocky coast, sandy beach, etc.

14 Protection Areas have an element of landscape, shown as below.

(1) The Arabian Oryx Sanctuary

Physical resources: Alluvial fans, fossil coral reefs and a series of low hills.

(2) As Saleel Natural Park

Physical resources: Flat plains, Sand dunes, High hills and Rocky slops.

(3) Ra’s al Hadd Turtle Reserve

Physical resources: White sandy beaches, mountain range.

(4) Jebel Samhan Nature Reserve

Physical resources: Limestone highlands, deep wadis, coastal cliffs and beaches.

(5) Dimaniyat Islands Nature Reserve

Physical resources: Sandy and rocky escarpments and limestone.

(6) The Khawrs Reserve of Dhofar Coast

Physical resources: Khawrs and springs.

In case that a large scaled cut, embankment, borrow pits, etc. accompanied with the road construction, it might be necessary to examine the impact to the landscape due to the alteration of topography.

5.4 SOCIAL ENVIRONMENT CONDITIONS

5.4.1 Historical and Cultural Heritage

The Ministry of Heritage and Culture, Ministry of Commerce and Industry as well as the Municipalities are concerned on the historical and cultural heritages in Oman. Carrying out site investigations is one of the functions of the Ministry of Heritage and Culture.

5.4.2 Waste

The disposal of wastes, including wastewater, liquid industrial waste, solid non-hazardous waste, hazardous waste and liquid effluents to the marine environment, have been established by the Ministerial Decisions.

In case that the wastes, including solid and liquid wastes usually occur during road construction, any wastes should be cleared out without leaving at the site.

5.4.3 Land Acquisition and Resettlement

(1) Land Acquisition

The land acquisition procedure concerning national road construction in Oman is

described in the Sections from 1.8 to 1.11 of the "Highway Design Manual Volume 1" (1994), showing as below.

1.8 It should be noted that although the information required for land acquisition should be gathered at the preliminary design stage, the formal land acquisition procedures should not be started before the scheme has been approved by the Client. This avoids purchase of land for work, which is subsequently modified or cancelled. In addition the Ministry of Housing must review and issue a no objection letter (see below).

1.9 The Ministry of Housing is responsible for the assembly of land to be acquired. The procedure is as follows:

- The Client Authority submits its plans to the Ministry of Housing.
- MOH reviews and issues a no objection letter, if the plans are acceptable.
- The plans are then submitted to the office of the Ministry of State for Legal Affairs, which prepares a Royal Decree.
- When the Royal Decree is made, the compensation that the landowner will receive is fixed in accordance with standard scales. The details are agreed between the owner and the compensation committee of either Muscat Municipality, the Office of the Ministry of State and Governor of Dhofar, or the Ministry of Regional Municipalities and Environment as appropriate.
- The scales of compensation to be followed are set by the Supreme Committee for Town Planning (SCTP), and in cases of dispute, or where the standard scale does not cover a particular case, SCTP fixes the amount.
- Generally, compensation for the land to be acquired will be in the form of land to an equivalent value elsewhere.
- Any cash to be given in compensation (e.g. for loss of crops) will come from the Budget for the scheme.

1.10 Where required, "Land Reference" drawings showing general details for all cases in the scheme should be prepared for schemes which require land acquisition, accompanied by a land reference schedule denoting owners, case numbers and other details. Preparation of these drawings requires co-ordination between all the concerned Ministries.

1.11 From the Land Reference drawings in every acquisition case a "Land Interest" drawing should be prepared giving all details of the individual land acquisition. The information shown on the drawing should include the owner's name, area of land to be acquired and the unit cost. It must also include any accommodation works to be carried out within the road construction contact (e.g. replacement of a boundary wall) and any direct compensation for such as crops.

On the land appraisal concerning land acquisition for the public services between 1999 and 2000, Decisions no.1/99 and 2/99 of the Supreme Committee for Town Planning (SCTP) has issued in 1999. The Decisions will be periodically renewed each two years.

The Decisions consist of the following chapters:

Chapter one:	General
Chapter two:	Provision of Compensation
Chapter three:	Current Land Price of each Region and Governorate

(2) Resettlement

In case of newly construction or alignment of road improvement, resettlement of residents including farms usually occurs. The land acquisition will be carried out based on the above-mentioned procedure, so that most of the cases seem to be smoothly solved.

5.4.4 Disaster (Risk)

The disasters related to the roads in Oman include of traffic accidents by rainfall, traffic interruption and scouring, and bank erosion by flash flood along wadis, traffic interruption by sand storm and fog, slope failure (including land slide), interruption by sand dune, land subsidence in a limestone area, etc.

(1) Traffic Accidents by Rainfall

Rainfall like shower rarely has in the northern (Oman Mountains) and southern (Salalah area) parts of Oman. Numerous traffic accidents occur by slippery road due to rainwater, because of high speed. Although the probability of occurring traffic accidents cannot calculate as well as rainfall.

(2) Flash Flood

Most of wadis have a record occurred flash flood in the past. The Directorate General of Water Resources, MRMEWR, reports several areas of flood disasters. However, compiling work for flood records are not reached so far to the whole area of Oman. The main parameters of evaluating magnitude and frequency of flood in an area consist of catchments area, volume of rainfall, frequency of rainfall, and shapes of wadis.

(3) Sand Storm and Fog

Sand storms mainly occur during hot season (June to September) at central (Umm As Samim) and eastern (Wahiba Desert) parts of Oman. A part of sand storm is transported by the southerly wind to Rustaq area across the mountain range.

Fogs sometimes occur in the early morning during hot season (April to June) in the Batinah area. Fogs in Salalah area also occur during rainy season (June to August).

(4) Slope Failure and Falling Stones

Relatively small-scaled slope failures are locally found in cut slopes along the roads located Muscat area and Northern Mountains Ranges. The phenomenon occurs restrictively in case of high gradient, high slope higher than 5 m, in fractured or altered zone.

Falling stones slope failures are seen at some of cut slopes, but most of them are small in scale. Therefore, the critical accidents due to slope failure and falling stones have not been reported.

(5) Sand Dune

Sand dunes are broadly found in Wahiba Desert and central part (Umm As Samim) of Oman. And small-scale sand dunes are scattered around the Umm As Samim and along the National Road No. 31 between Muscat and Salalah.

These sand dunes, taking shape of “Barchan”, move slowly to the leeward and cross the existing roads.

(6) Land Subsidence in a Limestone Area

Limestone, which is located between Quraiyyat and Sur has caves, and some caves cause depression on the ground surface in some places. Many hidden caves are assumed to exist not only the area between Quriyyat and Sur but also other area including Salalah area and central part of Oman.

(7) Traffic Accident of Animals

Numerous traffic accidents involving domestic animals, including camel, donkey, goat and sheep occur during day and night times. Particularly, camels and donkeys are

large in size and can cause a serious damage not only to animals the selves and vehicle but also to drivers and passengers.

In addition, many wildlife, including rabbit, fox, hedgehog, bird, dear, etc., damaged by traffic accidents in many places.

5.4.5 Air Quality

No air pollution is presently reported on DGR roads due to traffic.

5.4.6 Water Quality

No water pollution is presently reported on DGR roads due to traffic.

5.4.7 Noise

No noise pollution is presently reported on DGR roads due to traffic.

5.5 ENVIRONMENTAL ISSUES AND ASSESSMENT

5.5.1 Environmental Issues

The environmental issues related to the road and road construction in Oman mainly consist of flash flood, slope failures, sand dune, etc. as a natural disaster, large-scaled cut and borrow pits, etc. as a technical aspect for road construction, and traffic accidents, air pollution, noise and vibration as a public aspect.

(1) Natural Disasters

a. Flash floods

Various scale of surface current occurs during rainfall in the mountainous region, and in many cases the current develops to various scale of flash flood during and after rainfall at downstream of wadi. The scale of surface current and flash flood mainly depends on its catchments area, volume of rainfall, frequency of rainfall, and shapes of wadi. In addition, as the natural disasters recur in many cases, it is possible to evaluate by the records in the past.

The influences due to the flash flood mainly consist of traffic interruption, personal and car damages, direct damage to the road facilities, and current erosion. As the road

construction in future will be developed in the mountainous region with various topographical features, the influence of flash flood to the road environment will be surely increased in many places.

b. Slope failures and falling stones

Relatively small-scaled slope failures are locally found in the cut slopes along the roads. These phenomena depend on the geology, topography, scale of cutting, etc. And small-scaled falling stones mostly occur in some places of the cut slopes.

As the road construction in future will be developed in the mountainous region with various topographical features, the influence of slope failure and falling stone to the road environment will be surely increased in many places.

c. Sand dunes

Sand dunes are broadly found in Wahiba sand and central part (Umm as Samim) of Oman. And small-scaled sand dunes are scattered surrounding of the Umm as Samim and along the National Road No. 31 between Muscat and Salalah. These sand dunes are moving very slowly by prevailing wind. Hence, the influence of sand dunes to the road environment in Oman is presently very small.

As the road construction in future will be developed in the Umm as Samim area, surrounding of the Wahiba sand and east coastal zone of Wahiba sand, the influence of sand dunes to the road environment will be increased.

d. Traffic accident of animals

Numerous traffic accidents due to domestic animals and wildlife have occurred during day and night times in many places. As the road construction in future will be developed in the mountainous and coastal areas, the possibility to occur traffic accidents by animals will be surely increased. Hence, it is necessary to examine for creating the “Eco-Road”, such as eco-tunnel, etc., for the protection of the domestic animals and wildlife.

(2) Technical Aspect

a. Large-scaled cut

Presently large-scaled cut more than 30m high accompanied with the road construction is thought to be rare cases, and the damages by the large-scaled cut, such

as slope failures and landslides, etc., had not been reported.

As the road construction in future will be developed in the mountainous area, large-scaled cuts will be increased and the possibility of occurring large scaled slope failures or landslides will be revealed. In addition, it is necessary to examine the change of the landscape and influence to the environment before construction (EIA stage).

b. Borrow pits

Numerous and various size of borrow pits accompanied with the road construction had been used, and most of them are thought to be reclaimed or readjusted land. Some of them have been remained without land readjustment. It is necessary to reclaim borrow pits area as soon as possible.

c. Others

Wastes such as un-used asphalt, gravel and sand, etc. for the road constructions, are scattered in some places. It is necessary to clean up them before completion of the road construction.

(3) Social Impact

a. Air pollution:

Presently no serious air pollution due to road traffic is recognized. However, in case that the traffic volume is exponentially increased in the urban area in future, there is possibility to occur locally air pollution.

b. Noise and vibration:

Presently no noise pollution due to road traffic is recognized. However, in case that the traffic volume is exponentially increased in the urban area in future, there is possibility to occur locally noise and vibration pollution.

c. Resettlement

In case of newly construction or alignment of road improvement, resettlement of residents including farms occurs in many cases. The land acquisition procedure has been established, and most of their cases seem to be smoothly solved.

d. Waste

Litter boxes are installed each parking area and bus stop along the major roads. The Directorate General of Roads (MT&C) has a function to manage of cleaning of the national roads, and major roads relatively are kept to be clean.

However, wastes, broken tires and abandoned asphalt in some places along the roads, so that it is necessary to hang out signboards for passengers.

e. Nature conservation

Oman has respected conservation of natural environment since RD 26/75 established the government structure of the Sultanate of Oman in 1974. The law mainly establishes on the protection the Omani environment, nature conservation; control the eco-system, marine environment, etc. In addition, the animals and birds are designated as endangered rare wildlife. And the "National Biodiversity Strategy Action Plan" as the national strategy was declared in 2001.

The road maintenance and newly construction of roads should be respected the nature conservation. Hence, the environmental impact assessments concerning newly road construction and associated works have been carried out before construction according the procedure of the Environmental Permission.

However, the roads adjoined to the nature reserve area should make a marked arrangement not only to mitigate impacts due to road construction but also cooperation with the MRMEWR and MOHC, etc.

5.5.2 Environmental Assessment

Although most of present major roads had been planned and constructed under the relatively better situation, such as flat area, enough space, etc., the road construction in future will be developed in the urban, mountainous and coastal regions. Hence, it is thought that the influence to the environment due to the road improvement or newly construction will be surely increased in many factors, including natural, technical and public aspects.

In case of road improvement and newly road construction, it is strongly recommended to carry out the environmental impact assessment according to the legislation in Oman and to create better roads to the environment, so-called "Eco-Road".