CHAPTER 22

ENVIRONMENTAL STUDY ON HASIK - SHUWAYMIYAH ROAD

CHAPTER 22

ENVIRONMENTAL STUDY: HASIK-SHUWAYMIYAH ROAD

22.1 OBJECTIVE OF THE PROJECT

Hasik is a fishing village located about 170 km in the east of Salalah. There is a paved road connecting Hasik to Salalah via Mirbat and Sadah. This road is being extended towards Shumaymiyah along the coast but currently stops at 8.6 km in the east of Hasik along the coast, just before reaching Wadi Atawnt. Therefore, if the existing road connecting Hasik with Sadah is closed, the residents of Hasik cannot evacuate. From Shuwaymiyah towards Hasik, there is a track road along the coast which is about 30 km long and stop at small village called Jinawt.

There has been a strong traditional tribal ties between Hasik and Shwaymiyah. However, currently, there is no road along the coast connecting these two villages hampered by extremely ragged terrain along the coast. Therefore, the communication of people between these villages is depending on boat, which may be sometimes dangerous when Arabian Sea is rough.

In view of the present condition as described above, this section is considered to be one of the “missing links” in the road network of Oman.

On the side of Shwaymiyah, there is a track road connecting Shwaymiyah with Shelim. (Paving of this road is included in the Master Plan as Project No. N10.) The Distance between Shelim and Thumrayt is approximately 220km and there are long unpaved sections. Therefore, the distance between Hasik and Shwaymiyah along the existing road exceeds 400 km while the distance along the coast is less than 100 km.

About 20 km to the north of Hasik along the coast, there is a beautiful wadi named Wadi Sanaq. There is a lagoon at the mouth of the wadi. The Governorate of Dhofar hopes to develop this wadi as a tourist spot. The Project Road is necessary to develop this tourist spot.

When the Project Road will be completed, the following main effects are expected:

- Completion of the coastal road between north and south of the Saltanate.
- Completion of circuit route connecting Salalah-Mirbat-Hasiki-Shuwaymiyah-Shelim-Marmul-Thumrayt
- Provision of detour route for the Coastal Route of the North-South Corridor (NR

39 and NR 41) between Shelim and Salalah.

- Support for social activities of the area.
- Promotion of tourism of the coastal area, especially that of Wadi Sanaq
- Improving the overall function of the road network.

While the Project Road is expected to bring the above-listed benefits, this area is designated as a Natural Reserve Area as explained in Section 22.5. Therefore, diligent consideration on the environment is required in planning and designing the Project Road. This Chapter discusses the consideration on the environment, as an example of road planning in environmentally sensitive area.

Figure 22.1-1 shows the location of the Project Road.

Figure 22.1-1 Location of the Project Site

22.2 ALIGNMENT

22.2.1 Physical Features of the Project Site

The area that the Project Road is to traverse is a part of Dhofar Mountains Chain. The highest peak in this area is about 1,800 m above sea level. However, this peak is located between Salalah and Hasik, and the elevations of the highest peaks along the coast between Hasik and Shuwaymiyah are in the order of 500 to 600 meters above sea level.

Figure 22.2-1 shows the topography along the coast between Hasik and Shuwaymiyah.

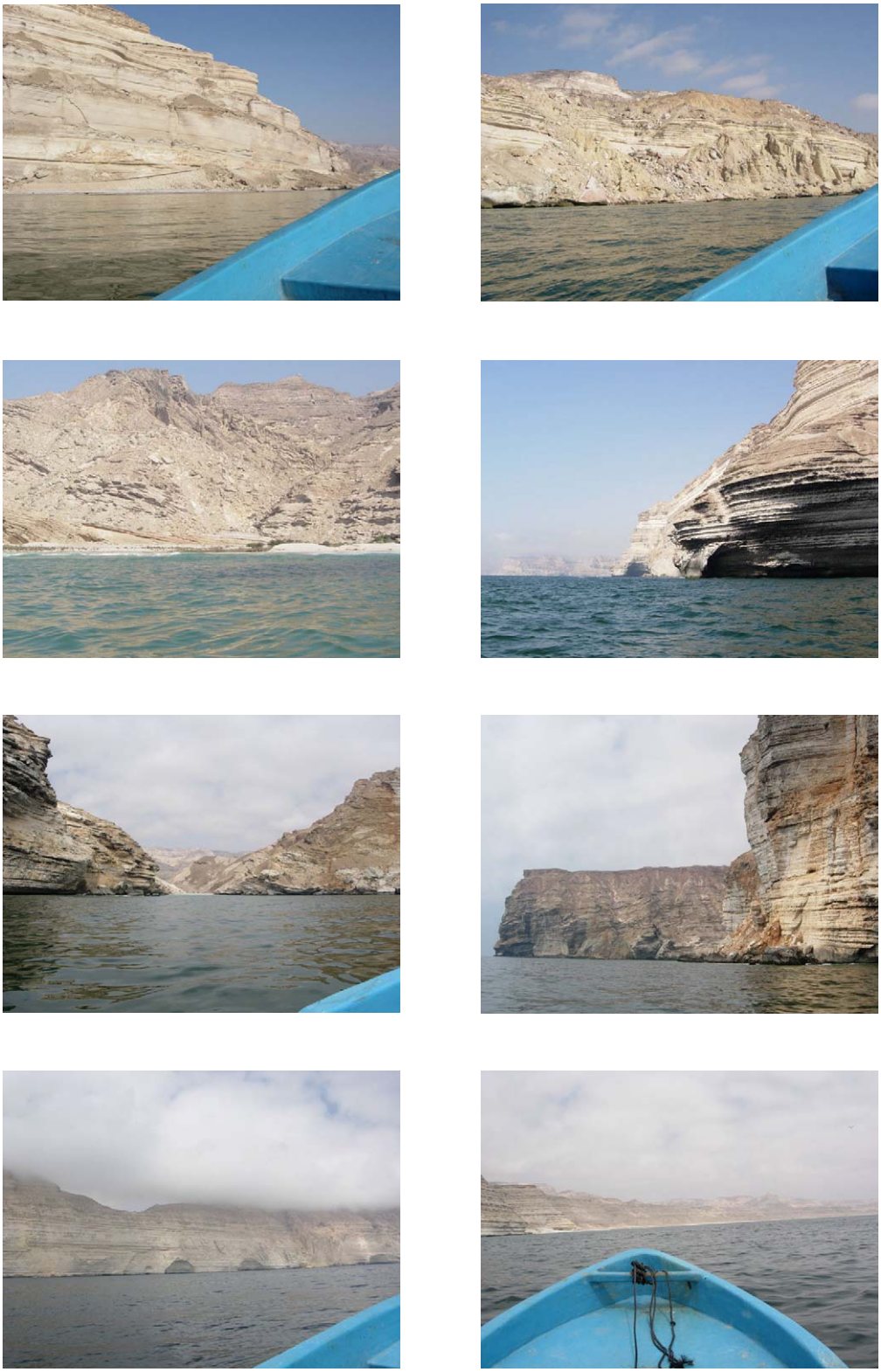


Figure 22.2-1 Topography of the Coast between Hasik and Shuwaymiyah (Photos)

Although the peaks are not extremely high, the topography is very ragged. As shown in Figure 22.2-1, the cliffs along the cost is very steep and often a few hundred meters high. At some locations, the feet of the cliffs are eroded by the seawater and the slopes of the cliffs are almost vertical or even overhanging. Often, loose debris containing huge blocks of rock, up to the size of a small house, are covering the cliff. These debris are supposed to be obstacles for both construction and maintenance of road.

Beyond the cliffs, the topography of the inland area is a sort of "plateau". There are many valleys (wadis) with steep slope on both sides and a few hundred meters deep carved into the plateau. Accordingly, if a road is to traverse this inland area, the road has to cross these valleys either by constructing many high-pier, long-span bridges or by descending and climbing up the steep slopes of the wadi banks.

22.2.2 Existing Road Condition

As stated before, there is no existing road passable for vehicles connecting Hasik and Shuwaymiyah. There is a track road, however, that is extended from Hasik up to Wadi Sanaq with a length of 8.6 km. From the other side at Shuwaymiyah there is also a short track road section with a length of 20.9 km.

22.2.3 Assumed Road Alignment

A preliminary study for exploring the possible routes have just been contracted between DGC and a consultant firm, in which three alternatives are to be studied. In the process, a topography map with scale of 1:5,000 is to be prepared. However, no practical work has been started yet. Accordingly, the Pre-Feasibility Study by the Study Team has to be carried out based on NSA maps with the scale of 1:100,000 and air photos. In addition, there is no existing road traversing the area. There is even no road reaching the coastal area from the Coastal Route of the North-South Corridor (NR 39). The only possible method to investigate the project site is through visual inspection from a boat traveling along the coast. Therefore, the following discussions are made based on the result of through visual inspection from the boat and analysis of the above-mentioned topographical maps and air photos.

Three possible alignments are considered. Figure 22.2-2 shows the assumed routes of three alternatives. Alternative 1 is further divided into two sub-alternatives according to the basic road structures and the route adopted for traversing steep cliff section.

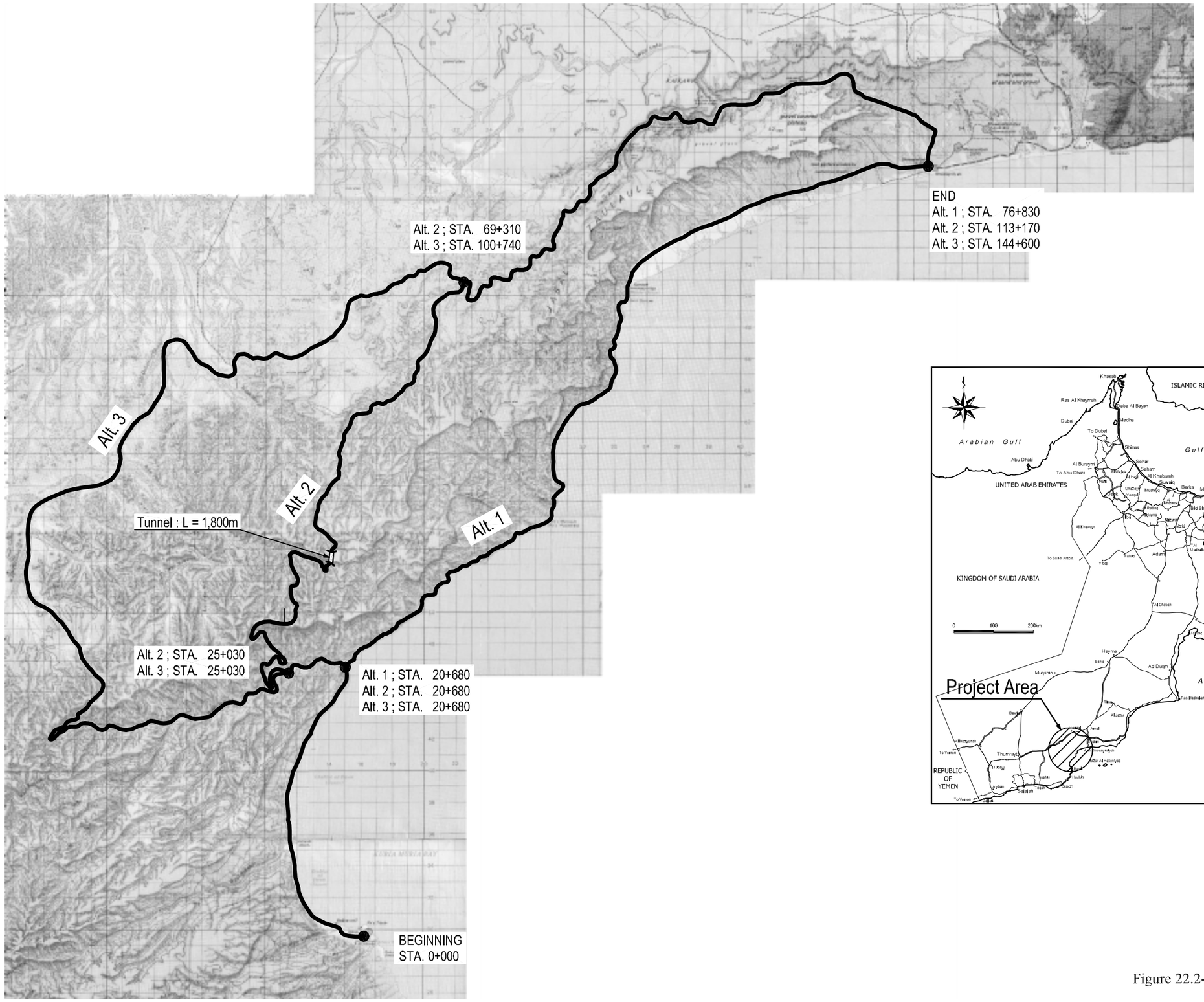


Figure 22.2-2 Assumed Alignments of Alternatives

1) Alternative 1

The alignment of this alternative is to basically follow the coastal line for the entire section between Hasik and Shuwaymiyah. For the first section from chainage 0+000 to 8+600 (several hundred meters before Wadi Atawnt), the already constructed paved road is used. From this point to Wadi Sanaq (chainage 20+680), the road is to traverse relatively wide and flat shore. Therefore, construction of road is relatively easy, although removal and stabilization of debris containing large blocks of rock is necessary at a few locations.

From Wadi Sanaq to Jinawt (chainage 55+930), the road has to pass the steep cliff section. Two sub-alternative routes are considered. Figure 22-3 shows the assumed routes of these sub-alternatives.

Alternative 1-1

This alternative assumes that the roadway be basically constructed by excavating the slopes of the cliffs (Figure 22.2-4). Considering the high cliff tops, the road should be constructed at elevations as near to the cliff tops as possible to minimize the heights of cut slopes. On the other hand, the elevation of the road needs to be within a certain level so that the road can easily climb from, and come down to, nearly sea level to cross wadis many times. As the result, the heights of cut slopes are supposed become very high, and sometimes exceed 100 m. Technical feasibility of constructing and maintaining such high cut slopes needs further study.

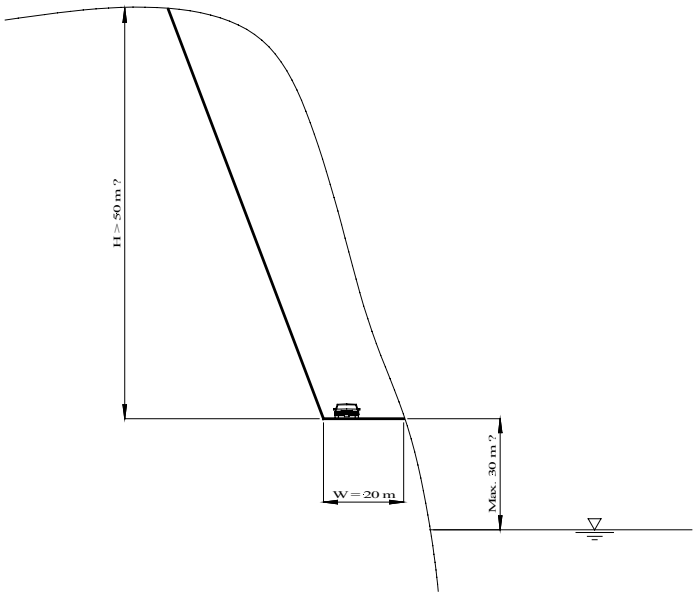


Figure 22.2-4 Conceptual Cross Section of Alternative 1-1

Figure 22.2-3 Assumed Routs of Sub-Alternatives of Alternative 1

In addition, this alternative has the following technical difficulties which need further study:

(i) Prevention of rocks and soils falling into the sea during excavation

The sea along the coast is also designated as a natural reserve to protect marine biology. Therefore, rocks or soils should not be allowed to fall into the sea during excavation. The method of excavation and measures for prevention of disturbance of marine environment needs further diligent study.

In addition, the Ministry of Regional Municipality, Environment and Water Resources commented, in response to the query by the Study Team, that it will not agree on the usage of explosives in excavating rocks. Therefore, excavation of cut slopes needs to employ other methods which may require additional cost.

(ii) Removal and stabilization of debris with large blocks of rock

As shown in Figure 22.2-1, there are several locations where there are debris containing large blocks of rock. Method to remove these debris without disturbing the marine environment and measures to stabilize the remaining debris needs further study.

Where the water depth near the bottom of the cliff is relatively shallow, it may be possible to construct the road on rock blocks placed in the sea. An actual example of this structure is seen in the case of Khasab Coastal Road in Musandam Governorate (Figure 22.2-5).

Figure 22.2-5 Example of Road Constructed on Large Rock Blocks Placed in Sea

Alternative 1-2

To avoid the problems of Alternative 1-1, the alignment of Alternative 1-2 is assumed to pass a few hundred meters to 5 km from the coast.

From Wadi Sanaq (Chainage 20+680) the assumed alignment climbs up the slope by crossing the small valleys carved in the slope with bridges. After reaching the elevation of about 300 m above sea level, the alignment runs roughly parallel to the coast line with distance from the coast up to 2 km, until reaching Chainage 43+380. Tunnels with length of 200 to around 800 meters and bridges with length of 100 to 200 meters are to be constructed. (The lengths of tunnels and bridges are arbitral.)

From Chainage 43+380, the road climbs the slope of the wadi and reach the plateau at Chainage 47+580. After this point, the assumed alignment passes the plateau and finally descends the cliff near the village of Jinawt.

The technical problems of Alternative 1-2 are as follows:

(i) Many high-pier, long-span bridges need to be constructed

Many of these bridges need to cross the valleys (wadis) with single span. Because the valleys are deep and slopes are steep, careful study of bridge types and construction planning is required.

(iii) Many tunnels need to be excavated

The Sultanate has very little experience in planning, designing and constructing raod tunnels. DGC needs to study how to supervise both design and construction of tunnels.

Table 22.2-1 summarizes the main features of Alternative 1.

Table 22.2-1 Summary Table of Alternative 1

	Road Length (km)			Structure			
				Bridge		Tunnel	
	Total	Mountain Section	Flat (Shore) Section	No.	Total Length (m)	No.	Total Length (m)
Alternative 1-1	76.83	35.25	41.58	0	0	0	0
Alternative 1-2	91.53	44.26	41.58	14	2,050	8	3,640

2) Alternative 2

The alignment of this alternative is the same to that of Alternative 1 up to Chainage 20+680 (Wadi Sanaq). Then the alignment goes upstream along Wadi Sanaq for about 7 km and climb the cliff of the left bank of the wadi. After reaching the top of the cliff,

it follows a small wadi for about 9 km before shifting to Wadi Amdat via a tunnel. The length of the tunnel is estimated to be approximately 1,800 meters. After the tunnel, the alignment follows Wadi Amdat to reach the edge of the plateau about 7 km north of Shuwaymiyah.

Anticipated technical problems of Alternative 2 are as follows:

(i) Climbing the steep slope on the left bank of Wadi Sanaq
After passing the mouth of Wadi Sanaq, the road needs to climb very steep slope of the cliff. Therefore, the aliginment of this section needs to be selected based on detailed topographical map.

(ii) Tunnel excavation
Similarly to Alternative 1-2, a tunnel needs to be excavated.

Table 22.2-2 summarizes the main features of Alternative 2.

Table 22.2-2 Summary Table of Alternative 2

Road Length (km)			Structure			
			Bridge		Tunnel	
Total	Mountain Section	Flat (Shore) Section	No.	Total Length (m)	No.	Total Length (m)
113.17	90.69	20.68	0	0	1	1,800

3) Alterntive 3

The alignment of this alternative is the same to that of Alternatives 1 and 2 up to Wadi Sanaq. After reaching the mouth of Wadi Sanaq, the alignment of Alternative 3 goes upstream the wadi for about 15 km to reach the location where the height of the cliff becomes considerably lower than that in Alternative 2. After reaching the top of the cliff, the alignment basically follows the wadis. At Chainage 76+960 the alignment turns right and climbs the mild slope to reach the plateau. After traversing the plateau for about 7 km, the alignment joins that of Alternative 2. With regard to the longitudinal gradient of the road, this alternative is most preferable.

Anticipated technical problem of this route is as follows:

- Although the height of the cliff that the road is to climb at Chainage 38+630 to 46+600 is less than that of Alternative 2, it is still high and the slope is very steep. Therefore, diligent study of the alignment based on a detailed topographical map is necessary.

Table 22.2-3 summarizes the main features of Alternative 3.

Table 22.2-3 Summary Table of Alternative 3

Road Length (km)			Structure			
			Bridge		Tunnel	
Total	Mountain Section	Flat (Shore) Section	No.	Total Length (m)	No.	Total Length (m)
144.60	123.92	20.68	0	0	0	0

22.3 PRELIMINARY COST ESTIMATION

Unit costs below are calculated based on the cost estimation of the preliminary design of other similar projects, the actual construction costs in Oman and quotation from general price in Japan. Table 22.3-1 presents the unit costs by types of road structure.

Table 22.3-1 Unit Cost by Type of Structure

Type of Road Structure	Unit cost (RO/km)
Ordinary Road Section	
Flat or rolling terrain	160,000
Mountainous terrain	280,000
Improvement of Existing Track Road In Flat Terrain	90,000
High Cut Slope	1,930,000
Bridge	23,000,000
Tunnel	6,500,000

Premises for estimation of the above unit costs of each section are described below:

Flat or rolling section: The unit cost: 160,000 RO/km, used in the preliminary design of Mahlah - Ismaiyah Road (see Chapter 21) whose condition is similar to the condition of flat or rolling section of Hasik - Shuwaimiyah Road, is applied.

Mountain section: The unit cost: 280,000 RO/km, used in the preliminary design of Hamra - Rustaq Road (see Chpater 18) is applied.

Improvement of existing track road: The unit cost: 90,000 RO/km, which is used in the preliminary design of Hij - Flim Road (see Chapter 20) is applied.

High cut slope section: The unit cost: 1,930,000 RO/km is applied based on the estimation under the condition below.

-Section to be excavated is 20 m in width and 50 m in height.
-Rock quality is “hard rock”.

Bridge: The unit cost: 23,000,000 RO/km is applied. This unit price is estimated for the following type of bridge.

-Bridge type: Pre-stressed concrete
-Span length: 100m

Tunnel: The unit cost: 6,500,000 RO/km, which is estimated based on the cost of the actual tunnel construction in Oman, is applied.

Estimated project cost of each alternative is shown in Table 22.3-2.

Table 22.3-2 Total Cost of Alternatives

Alternative-1.1

Station	Length (km)	Unit cost (RO/km)	Cost (RO)	Remark
0+000 ~ 8+600	8.60	0	0	Existing AC pavement road
8+600 ~ 20+680	12.08	160,000	1,932,800	Flat or rolling
20+680 ~ 55+930	35.25	1,930,000	68,032,500	Big cut; W=20m,H=50m
55+930 ~ 76+830	20.90	90,000	1,881,000	Flat and Existing truck road
Total			71,846,300	

Alternative-1.2

Station	Length (km)	Unit cost (RO/km)	Cost (RO)	Remark
0+000 ~ 8+600	8.60	0	0	Existing AC pavement road
8+600 ~ 20+680	12.08	160,000	1,932,800	Flat or rolling
20+680 ~ 70+630	44.26	280	12,393	Mountain
	2.05	23,000,000	47,150,000	14 Bridges
	3.64	6,500,000	23,660,000	8 Tunnels
70+630 ~ 91+530	20.90	90,000	1,881,000	Flat and Existing truck road
Total			74,636,193	

Alternative-2

Station	Length (km)	Unit cost (RO/km)	Cost (RO)	Remark
0+000 ~ 8+600	8.60	0	0	Existing AC pavement road
8+600 ~ 20+680	12.08	160,000	1,932,800	Flat or rolling
20+680 ~ 113+170	90.69	280,000	25,393,200	Mountain
46+450	1.80	6,500,000	11,700,000	Tunnel
Total			39,026,000	

Alternative-3

Station	Length (km)	Unit cost (RO/km)	Cost (RO)	Remark
0+000 ~ 8+600	8.60	0	0	Existing AC pavement road
8+600 ~ 20+680	12.08	160,000	1,932,800	Flat or rolling
20+680 ~ 144+600	123.92	280,000	34,697,600	Mountain
Total			36,630,400	

As it is seen in the above table, The estimated total costs of Alternatives 1-1 and 1-2 are nearly two times of that of Alternative 2. The cost of Alternative 2 is slightly lower than that of Alternative 3 reflecting the shorter length of Alternative 2 than that of Alternative 3.

22.4 ENGINNERING EVALUATION

Table 22.4-1 summarizes the features of alternatives as discussed in the above subsections.

Table 22.4-1 Summary of Features of Alternatives

Alternative	Length (km)	Cost (RO mill.)	Technical Difficulty
Alternative 1-1	77	71.8	- High cut slopes - Removal and stabilization of debris
Alternative 1-2	92	74.6	- Construction of high-pier, long-span bridges and tunnels
Alternative 2	114	39.0	- Climbing steep cliff of Wadi Sanaq - Construction of Tunnel
Alternative 3	145	36.6	- Climbing steep cliff of Wadi Sanaq

From this table, Alternative 2 is considered as the most realistic route as far as the problem of climbing the steep slope of Wadi Sanaq is solved. If the Project Road will be constructed along the alignment of Alternative 2, the travel distance between Hasik and Shuwaymiyah will be shortened to by about 300 km compared with the present condition.

22.5 ENVIRONMENTAL CONSIDERATIONS AND TOR FOR EIA

22.5.1 Environmental Considerations

1) General

The objectives of environmental considerations at the stage of the "Pre-Feasibility Study (Pre-F/S)" are:

- To confirm the results of the "Initial Environmental Examination (IEE)";
- To clarify present conditions in the project site and specific environmental impacts due to proposed road construction project;
- To re-evaluate comprehensively proposed project road; and
- To provide the "Terms of Reference (TOR)" for EIA in the next "Feasibility Study".

The environmental considerations are examined the following items and procedures:

1. Review of result of the IEE with data and information concerning the project.
2. Environmental investigation at the project site using "Environmental Checklist" (refer to Table 12.1-1).
3. Analysis of environmental conditions and impacts.
4. Comprehensive evaluation.
5. Provision of TOR for EIA.

The content of the site investigation consists of the following environmental items:

(1) Air pollution
(2) Effluent
(3) Noise and vibration
(4) Land subsidence
(5) Topography and geology
(6) Soil and soil erosion
(7) Hydrology and groundwater
(8) Ecosystem, flora and fauna
(9) Landscape (including coastal zone)
(10) Regional development on the natural environment
(11) Hazards
(12) Other impacts on the natural environment
(13) Wastes
(14) Cultural heritage

(15) Regional development on the social environment
(16) Other impacts on the social environment

2) Environmental checklist for the project "HASIK - SHUWAYMIYAH ROAD"

More detailed environmental investigation, analysis and comprehensive evaluation for the road section between Hasik and Shuwaymiyah were carried out along the route Alternative-1 using the environmental checklist. The results of investigation and evaluation are shown in Annex 22-1.

Consequently, environmental impacts due to the proposed project are likely to occur on the environmental items of Topography and Geology, Hydrology and Groundwater, Eco-system, Flora and Fauna, Landscape and Cultural heritage.

a. Topography and Geology

- Present condition:

Topography:
Alternative-1 (see Attachment-3):
The road section from Hasik to Shuwaymiyah (End point: 80.0 km) mostly passes along coastline, however the road section between Wadi Sunayk and Qanawt follows inland route near coastline, as shown Attachment-3.

1-1 From 0km (Hasik, Ra's Tibrar) to 10km (Shuwaymiyah):
0~10km:
The road unit is coastal line with sand beach, ranging in width from 100 to 300m. Backside of beach forms mostly vertical cliff consisting of marl, limestone, calcareous conglomerate and sandstone. Dipping of the beds is mostly flat and very gentle. The cliffs extend from Jabel Samhan. The height of vertical cliff ranges approximately from 100 to 300m.

About 10 km point:
River mouth of Wadi Dahanat, and sand beach extends around the wadi.
10~ 25km:
Sand (and/or gravel) beach extends in the road unit. 23km point: River mouth of Wadi Sunayk.
25~40km (Ra's Muntajib):
Beach might be so narrow and in many places and limestone cliff is directly closed to the sea.

40km (Ra's Muntajib) ~ 60km (Bandar Qanawt):
This road unit might be narrow beach or limestone cliff is directly closed to the sea.
60 km (Bandar Qanawt village) ~ 80km (Shuwaymiyah village):
Wide sand beach extends from Bandar Qanawt to Shuwaymiyah. Backside of beach between them forms also vertical cliff consisting of marl, limestone, calcareous conglomerate and sandstone same as Hasik side. The height of vertical cliff ranges approximately from 100 to 200m.

There is no village and settlement in the route between Hasik and Shuwaymiyah. Qanawt village was presently abandoned.

Alternative-2 (see Attachment-4):
The road section from Hasik to Wadi Sunayk (23 km point) is same as that of Alternative-1. The road section from 23 km point to Shuwaymiyah (End point: 113.2 km) firstly passes 5 km upward along Wadi Sunayk, secondly goes up northern cliff of Wadi Sunayk until High Terrace and Wadi Tarawt, thirdly passes 2 km downward along Wadi Tarawt, fourthly goes up northern cliff of Wadi Tarawt by tunnel to Wadi Shaahashat, and fifthly passes along Wadi Shaahashat until Shuwaymiyah, as shown Attachment-4.

There is no village and settlement in the route between Hasik and Shuwaymiyah. But, Amqasrie village is located 8 km west from the proposed route at Wadi Tarawt. In addition, exploration well site (Sneik-1) of PDO is located near the proposed route.

Alternative-3 (see Attachment-5):
The road section from Hasik to Wadi Sunayk (23 km point) is same as that of Alternative-1. The road section from 23 km point to Shuwaymiyah (End point: 144.5 km) firstly passes 44 km long along Wadi Sunayk, secondly goes up northern cliff of Wadi Sunayk until upper stream of Wadi Thakabay'at, thirdly passes along Wadi Thakabay'at, Wadi Qaharir al Gharbi and Wadi Shaahashat until Shuwaymiyah, as shown Annex-5. The road section along Wadi Shaahashat until Shuwaymiyah is same route as that of Alternative-2.

There is no village and settlement in the route between Hasik and Shuwaymiyah, but it is necessary to confirm in the site.

Geology:
Mostly Tertiary flat marl, limestone, calcareous conglomerate and sandstone beds are widely distributed in the area. And Terraces consisting of Low, Middle and

High Terraces, are locally found in the area.

- Impacts with project:

Alternative-1:
Alternative-1 will be required massive excavation and embankment for paved 2-lane road construction. Hence, large to small scale alteration of topography will occur in the whole project area. In addition, much cuttings caused in the slope will be generally dumped to the slope side and sea shore, so that topographically larger area more than right-of-way (ROW) is likely to be irreversible altered.

Alternative-2:
Alternative-2 passes along the wadis, so that the cutting volume of road construction with this alternative is likely to be less than that of Alternative-1.

Alternative-3:
Alternative-3 passes along the wadis and longer distance than that of Alternative-1 and -2, but cutting volume is likely to be less than that of Alternative-1 and -2.

- Evaluation: 2: Moderate impact due to road construction on each alternative.

b. Hydrology and Groundwater

- Present condition:

Small current flow (waterfall) is found along the Wadi Rakyut and khawr, located in the mouth of Wadi Rakyut, Wadi Dahanat and Wadi Sunayk. Relatively small wadis, including Wadi Rakyut, Wadi Dahanat and Wadi Sunayk, flow out easterly from Jabal Samhan Mountains to the sea.

Larger wadis including Wadi Thakabay'at, Wadi Qaharir al Gharbi and Wadi Shaahashat flow out from Jabal Samhan Mountaims to northeast direction.

Impacts with project:

The proposed alignment of Alternative-1 completely passes along the coastal line. It crosses some khawrs. But the route does not pass in the wadis.

Alternative-2 passes long distance along the wadis.
Alternative-3 passes along the wadis and longer distance than that of Alternative-2.

- Evaluation: 1~2:

Slight to moderate impact to hydrology due to road construction of each alternative.

c. Eco-system, Flora and Fauna

- Present condition:

Beach side is low vegetation, but around downstream and river mouths of the wadis are relatively thick vegetation more than others.

The area, Jabal Samhan Mountains, between Hasik and 60km west from Ash shuwaymiyah (Ra's Tibrar) proclaimed as "Jabel Samhan Nature Reserve" on 28/6/1997 by Royal Decree 48/97.

Flora:

Thick vegetation forming the dominant woodland species consists of various species with various species of wildlife. Tke vegetation mainly consists of Accacia spp., Anogeissus dhofarica (zerkin), Blepbarispermum bitum (khfut), Boscia arabica (simer), Bostvellia sacra (luban), Craton confertus (hor), Maytenus spp., etc. The chief species is Anogeissus dhofarica, which is associated with several othertrees and large shrubs such as Commiphora and Acacia species, forms the woodland vegetation.

Fauna:

Wildlife in the area includes; The last population of the Arabian Leopoard, Nubian ibex, Arabian Gazelle, Striped Hyaenas, Wild Cats, Caracal, Wolves and Foxes. Smaller mammals including rodents and foxes (Lupes lupes arabica) are found in the area, along with a number of bird species. A number of rare species of birds such as Herons, Masked Boobies and Socotra Comorants are also found breeding in the area and on the cliffs.

Marine animals also are likely rich, including sea birds, dolphins, green turtles, fishes, etc. the breeding area of green turtle is limited around Hasik, where wider sand beach exists.

- Impacts with project:

Any development in the area will be considered as having a significant impact as a result of the valuable nature of the habitat, because of rapidly increase of traffic volume in future. The future traffic volume in 2030 is predicted to be 10,000 veh/day in the project area.

Whilst the area does not have official reserve status, permits are required to enter some areas. This area could be one of the protection areas proclaimed as Nature Reserve in near future.

- Evaluation: 3:

Significant impact to eco-system, flora and fauna due to road construction. It is necessary to carry out detailed investigation concerning eco-system, flora and fauna in the area, particularly khawr, beach and sea.

d. Landscape

- Present condition: Mostly natural condition.

Flora:

Vegetation is found along the entire stretch of the project area. The lower lying hills have less vegetative cover than the higher areas, except for depressions and wadi flow channels. The vegetation can be classified as an open xenomorphic Euphorbia community type. Much of this area represents a good example of undisturbed habitat in northern Oman.

Fauna:

Wildlife known to the area includes the Arabian Leopard, Gazelle, Arabian Tahr and other fauna such as the red fox, etc. The IUCN red list of threatened animals (IUCN 1990) describes the mountain gazelle as vulnerable. Leopard and the Tahr are considered endangered.

- Impacts with project:

The landscape in the area will be critically suffered due to alteration of topography by massive excavation of cliff for road construction.

- Evaluation: 1~2: Moderate impact to landscape due to road construction.

f. Cultural heritage

- Present condition:

Unknown so far. However, the project area is likely to have a little potential to exist cultural heritage.

- Impacts with project:

Detail investigation of the cultural heritage in the site might be required before road construction.

- Evaluation: 1~2:

Slight to moderate impact to cultural heritage due to road construction.

g. Other environmental items: Not significant impact.

3) Results of IEE

The comprehensive evaluation for the Hasik - Shuwaymiyah Road is concluded to be 3 as impact rating; summarized in Table 22.5-1. Hence, the implementation of comprehensive EIA before road construction is recommended.

In case that the national road is planned in the Protection Area, i.e. "Jabel Samhan Natural Reserve", a number of countermeasures for the mitigation of various impacts will be required. The mitigating measures concerning protecting area are thought to fence off wadis and trails along the project road for the vehicles, sign boards for the protection area, ecological parking areas, etc.

Table 22.5-1 Results of IEE on the Hasik - Shuwaymiyah Road

- Topography and geology	2	- Alteration of topography
- Hydrology	1~2	- Influence to inlets and wadi mouths
- Eco-system, Flora and Fauna	3	- Passing in the Jabel Samhan Natural Reserve, - Influence to mountainous and marine wildlife including beach and inlets
- Landscape	2	- Alteration of topography
- Cultural heritage	1~2	- Influence to cultural heritage
- Other items	1	

Comprehensive Evaluation	3
Recommendations *1	Recommended to carry out EIA

Note *1 : Comprehensive Evaluation

1 : None to slight impacts : No need to carry out EIA or need to carry out partial EIA after scoping

1~2: Small impacts : Recommended to carry out partial EIA on assigned items after scoping

2 : Moderate impacts : Recommended to carry out EIA

2~3: Relatively significant impacts: Recommended to carry out EIA

3 : Significant impacts : Recommended to carry out EIA

22.5.2 Terms of Reference for the Project

Terms of reference (TOR) on the Environmental Impact Assessment of the Hasik - Shuwaymiyah Road, Sultanate of Oman, are shown in Annex 22-2:

Annex 22-1

ENVIRONMENTAL CHECKLIST (HASIK TO SHUWAYMIYAH ROAD)

Road Section: From Hasik to Al Shuwaymiyah, Existing road condition: No road

Project Road No.: N7, Planning road: Metalled 2-lane road, Distance: 80km

Environmental Items	Present Condition	Impact Rating 1 = Slight 2 = Moderate 3= Significant	Remarks Predicted traffic volume in 2030: 300 veh/day
Air Pollution	(1): Not existing.	1	- Not significant.
Effluent	(1): Not existing.	1	- Not significant.
Noise and Vibration	(1): Not existing.	1	- Not significant.
Land Subsidence	(1): Not existing.	1	- Proposed road alignment near Hasik and shuwaymiyah passes sandy coastal line. - It is necessary to carry out geological investigation before detail planning of road.
Topography and Geology	Topography: (1) 0 (Hasik, Ra's Tibrar)~100km (Shuwaymiyah): 0~10km: The road unit is coastal line with sand beach, ranging in width from 100 to 300m. Backside of beach forms mostly vertical cliff consisting of marl, limestone, calcareous conglomerate and sandstone. Dipping of the beds is mostly flat and very gentle. The cliffs extend from Jabel Samhan. The height of vertical cliff ranges approximately from 100 to	2	- Moderate impact due to new road construction in the area of coastal line and sand beach.  Photo: Limestone cliff at 5km north from Hasik

 Photo: Wadi Atawnt and Photo: Limestone cliff after Wadi Atawnt  Photo: Wadi Sunayk	400m. About 10 km point: River mouth of Wadi Dahanat, and sand beach extends around the wadi. 10~ 25km: Sand (and/or gravel) beach extends in the road unit. 23km point: River mouth of Wadi Simayk. 25~40km (Ra's Muntajib): Beach might be so narrow and in many places and limestone cliff is directly closed to the sea. 40km (Ra's Muntajib)~60km (Bandar Qanawt): This road unit might be narrow beach or limestone cliff is directly closed to the sea. 60 km (Bandar Qanawt village)~80km (Shuwaymiyah village): Wide sand beach extends from Bandar Qanawt to Shuwaymiyah. Backside of beach between them forms also vertical cliff consisting of marl, limestone, calcareous conglomerate and sandstone same as Hasik side. The height of vertical cliff ranges approximately from 100 to 200m. Geology: Mostly Tertiary flat marl, limestone, calcareous conglomerate and sandstone beds are widely distributed in the area. And Terraces consisting of Low, Middle and High Terraces, are locally found in the area. Some stalactites are found in the limestone vertical cliff.		 Photo: Detritus sediments at the foot of cliff  Photo: Ra's Muntajib  Photo: Ra's Qanawt

Soil	(1): soil is poorly developed in the area.	1	- Not significant impact due to road construction.
Hydrology, groundwater	(1): Current flow may not be found along the wadis in the area.	1~2	- Slight to moderate impact due to new road construction passing coastal line as well as wadi mouths and inlets.
Eco-system, Flora and Fauna  Photo: Community of Comorant near Ra's Muuntajib	(1): Beach side is low vegetation, but around downstream and river mouths of the wadis are relatively thick vegetation more than others. - The area between Hasik and 60km west from Ash shuwaymiyah (Ra's Tibrar) proclaimed as "Jabel Samhan Nature Reserve" on 28/6/1997 by Royal Decree 48/97. Flora: Thick vegetation forming the dominant woodland species consisting of various species with various species of wildlife. The vegetation mainly consists of *Accacia spp., Anogeissus dhofarica (zerkin), Blepbarispermum bitum (khfut), Boscia arabica (simer), Bostvellia sacra (luban), Craton confertus (hor), Maytenus spp.,* etc. The chief species is *Anogeissus dhofarica*, which is associated with several other trees and large shrubs such as *Commiphora* and *Acacia species*, forms the woodland vegetation. Fauna: Wildlife in the area includes; The last population of the Arabian Leopard, Nubian ibex, Arabian Gazelle, Striped Hyaenas, Wild Cats, Caracal, Wolves and Foxes. Smaller mammals	3	- The project road is located in the protection area of "Jabel Samhan Nature Reserve". - There are a number of valuable species of flora and fauna, including marine life, in the area. Therefore, significant impact to the eco-system of the area due to road construction and increase of visitors as well as air pollution, water contamination, noise, wastes, etc.

	including rodents and foxes (*Lupes lupes arabica*) are found in the area, along with a number of bird species. A number of rare species of birds such as Herons, Masked Boobies and Socotra Comorants are also found breeding in the area and on the cliffs.		
Landscape	(1): The area is rocky and coastal zone in the Jabel Samhan Nature Reserve.	2	- Moderate impact to the landscape in the area due to alteration of topography by massive excavation of cliff for road construction.
Hazards	(1): Not significant.	1	- Not significant impact due to road construction. - Rocks fall will occur after massive cutting of cliff.
Regional Development on Natural Environment	- Not existing so far.	1	- Unknown.
Other Impacts on Natural environment	- Not existing so far, but road construction is bigger impacts on natural environment.	1	- Not existing.
Cultural Heritage	- Not existing so far.	1~2	- The project road is newly construction. Therefore, investigation of the cultural heritage is required in the site.
Wastes	(1): Not significant so far.	1 1	- Not significant impact due to road construction. - The road is major road connecting between because low future traffic volume. However, it is necessary to make arrangement to keep clean in the area.
Regional Development on Social Environment	0km point: Hasik village. School, public office, mosque, etc. 60km point: Bandar Qanawt village. 80km point: Shuwaymiyah village. School, public	1	- Low traffic volume is predicted and low receptors.

	office, mosque, etc.		 Photo: Qanawt village (abandoned) and coastal sand beach
Other Impacts on Social Environment	(1): Not existing.	1	- Not significant.

Evaluation	**Topography and geology**	**2**	**Alteration of topography**
	Hydrology	**1~2**	**Influence to inlets and wadi mouths**
	Eco-system, Flora and Fauna	**3**	**Passing in the Jabel Samhan Natural Reserve, Influence to mountainous and marine wildlife including beach and inlets**
	Landscape	**2**	**Alteration of topography**
	Cultural heritage	**1~2**	**Influence to cultural heritage**
	Other items	**1**	

Comprehensive Evaluation	**3**
Recommendations *1	**Recommended to carry out EIA**

*1 : Comprehensive Evaluation

1	: None to slight impacts.	: No need to carry out EIA
1~2	: Small impacts.	: Recommended to carry out EIA on assigned items
2	: Moderate impacts.	: Recommended to carry out EIA
2~3	: Relatively significant impacts.	: Recommended to carry out EIA
3	: Significant impacts.	: Recommended to carry out EIA

Annex 22-2

TERMS OF REFERENCE
ON
THE ENVIRONMENTAL IMPCT ASSESSMENT
OF
THE HASIK – SHUWAYMIYAH RORD,

SULTANATE OF OMAN

1. Project Title

"Environmental Impact Assessment of the Hasik – Shuwaymiyah Road, Sultanate of Oman" (hereinafter referred to as "Study")

2. Executive Agency

Directorate General of Road, (hereinafter referred to as "DGR"), Ministry of Transport and Communications, Sultanate of Oman.

3. Location of Project Area

Project area is located along the coastal line of Kuria Muria Bay and in the northeastern part of Jabal Samhan Mountains in the Dofar Governorate, as shown in Attachment-1. The "Jabel Samhan Nature Reserve" as a protection area mostly covers the project area.

4. Background of the project

The Hasik - Shuwaymiyah Road is designated as one of the 7th Plan (2006-2010) proposed roads. This project road is the missing link in the coastal road south of the country in Dofar. The road is considered as an important link in the road network.

5. Objectives of the Study

The Study should carry out to accord the Royal Decree No. 10/82 and its amendments entitled "Law on Conservation of the Environment and Prevention of Pollution" as

well as other relevant regulations, decisions and guidelines.

The principles of the Study 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 should 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 should be applied as early as possible in project's planning stage and before irrevocable decisions are made; and
- Public information is an important component of an open and balanced EIA process.

And, the specified objectives of the Study are show as below:

i) To identify, predict, and assess environmental impacts due to proposed activities on the physical, biological and social environment;
ii) To propose mitigation measures for avoiding and reducing the impacts and evaluating associated risk; and
iii) To submit the Environmental Impact Assessment report and relevant documents.

6. Project Description:

The project description of the Hasik - Shuwaymiyah Road shows as below:

- The project road is located along the coastal line of Kuria Muria Bay and in the northeastern part of Jabal Samhan Mountains in the Dofar Governorate,
- The project area is topographically characterized by high terraced limestone terrain, and limestone terraces are deeply incised by large-scale gully erosion, and the coastal line forms vertical to steep slope limestone cliff facing to the sea,
- The project road has important role of directly connecting between Hasik area and Shuwaymiyah area by paved road,
- The length of the project road is 80 km,
- The road hierarchy of the project road is designated to the secondary road that its right-of-way is 50 m, and
- The project road consists of three alternatives, first alternative is completely traversed along coastal line, second alternative passes inland in the northern part of the project road, and third alternative passes more inland route as shown in Attachment-2.

7. Scope of the Study:

This project is classified as Roads of the Group five (Service projects) in accordance of the "Guidelines for Obtaining Environmental Permits" (Directorate General of Environmental Affaires). In addition, as results of the environmental consideration of the project are recommended that the project should be carried out EIA before project implementation, comprehensive EIA should be required.

In order to achieve the objectives mentioned above, the scope of the Study consist of following items:

1) Collect and review the existing data and information relevant to the project

- Legislative information,
- Topographical, geological and pedological data,
- Aero photographs and/or satellite images covered in and around the project area,
- Meteorological data around the project,
- Hydrological and hydro-geological data relevant to the project,
- Biological and ecological data and information,
- Information of land use and its history,
- Natural scenic spots, national park, etc.,
- Information of open-air recreation,
- Information of natural hazards,
- Sociological data and information,
- Administrative data and information,
- Socio-economic data,
- Cultural and historical heritages,
- Traffic volume data, and
- Other data and information relevant to the traffic, etc.

2) Project description

- Location,
- Road design and design criteria,
- Road capacity,
- Road section for construction,
- Pre-construction activities,
- Construction plans and scheduling,
- Staffing and support,
- Associating facilities and services,

- Operating procedures and maintenances,
- Future traffic volume,
- Land use requirement, and
- Alternative alignments, etc.

3) Site description and its environment (Baseline survey)

The content of the baseline study consists of the following environmental items:

(1) Air quality: Measuring points consist of each villages and settlements as well as start and end points, and number of measuring times is two, i.e. summer and winter seasons, and measuring parameters consist of SO_2, TSP, PM_{10} and fallen-dust,
(2) Water quality: measuring points consist of each surface water flows, wells, water spring, and aflaj water, and number of measuring times is two, i.e. summer and winter seasons, and analysis parameters consist of pH, Electric conductivity (EC), Water temperature, Ca, Mg, Fe, Mn, K, Na, CO3, Hg, Pb, As, Cr, Cd, Se, SO4 and Cl,
(3) Noise and vibration: measuring points consists of each villages and settlements, and number of measuring times is two, i.e. summer and winter seasons, and measuring parameter is dB(A) on the boundary of ROW,
(4) Topography and geology: Topographical and geological investigation, and drilling survey at bridge building site, 2 holes x 10m in depth,
(5) Soil: Pedological investigation consists of soil sections at the point of every 2 km interval and each villages and farmlands,
(6) Surface water and groundwater: Hydrological and hydro-geological investigation consist of outflow and measurement in the sites, comprising of pH, EC and Water temperature,
(7) Ecosystem, flora and fauna: Number of investigating times is two, i.e. summer and winter seasons,
(8) Landscape,
(9) Hazards,
(10) Communities,
(11) Wastes,
(12) Cultural heritage,
(13) Resettlement, and
(14) Traffic volume and traffic accidents: Traffic census and interviews.

While baseline survey, the proponent should be found stakeholders, related to the project, e.g. residents of local communities in the site, indigenous people, experts from government organizations, local government officer, NGO, etc., and should be

collected their opinions in order to get an appropriate agreement and to reflect to the decision-making of the project.

4) Evaluation of project's impacts

The content of the evaluation of impacts with the project consists of the following items:

- Cumulative and indirect environmental impacts, likely to result from the project in combination with existing or planned projects or activities,
- Impact on socio-economic conditions,
- Impact on physical and cultural heritage, and
- Proposal and evaluation of reasonable alternatives to the project and their impacts.

The evaluation should be carried out to use the environmental standards or guidelines to establish significant of the harmful impacts. A risk assessment can be used when there are no applicable threshold standards or guidelines. The following criteria should be applied to determine significant or adverse impacts:

(1) Magnitude,
(2) Frequency and duration,
(3) Location and sensitivity of environment, and
(4) Irreversibility.

5) Mitigating measures and evaluating associated risks

The following approaches can be used to mitigate likely significant harmful impacts:

- Direct prevention by avoiding sensitive areas,
- Reduction by adjusting work schedules, pollution control devices, changes in design, etc.,
- Restoration and remediation measures, and
- Compensation.

6) Final assessment

The final assessment should be done to evaluate through a net effect analysis.

7) Documentation

Documentation I composed of reference and working documents. The former will

contain a detailed record of the work done on the EIA. The latter is the document, which contain the information for action, e.g. the Environmental Impact Statement as well as Summary.

The content of the Environmental Impact Statement should be contained the following items:

- Information describing the EIA,
- Information describing the project,
- Information describing the site and its environment, shown as below:
    (1) Physical features
    (2) Legislative framework
    (3) Assessment of impacts, shown as below:
        a. Impacts on human beings, buildings and man made features,
        b. Impacts on flora, fauna and geology,
        c. Impacts on land,
        d. Impacts on water,
        e. Impacts on air and climate,
        f. Other direct and secondary effects associated with the project,
        g. Environmental management plan – Mitigating measures and risk assessment, and
        h. Conclusions and additional information.

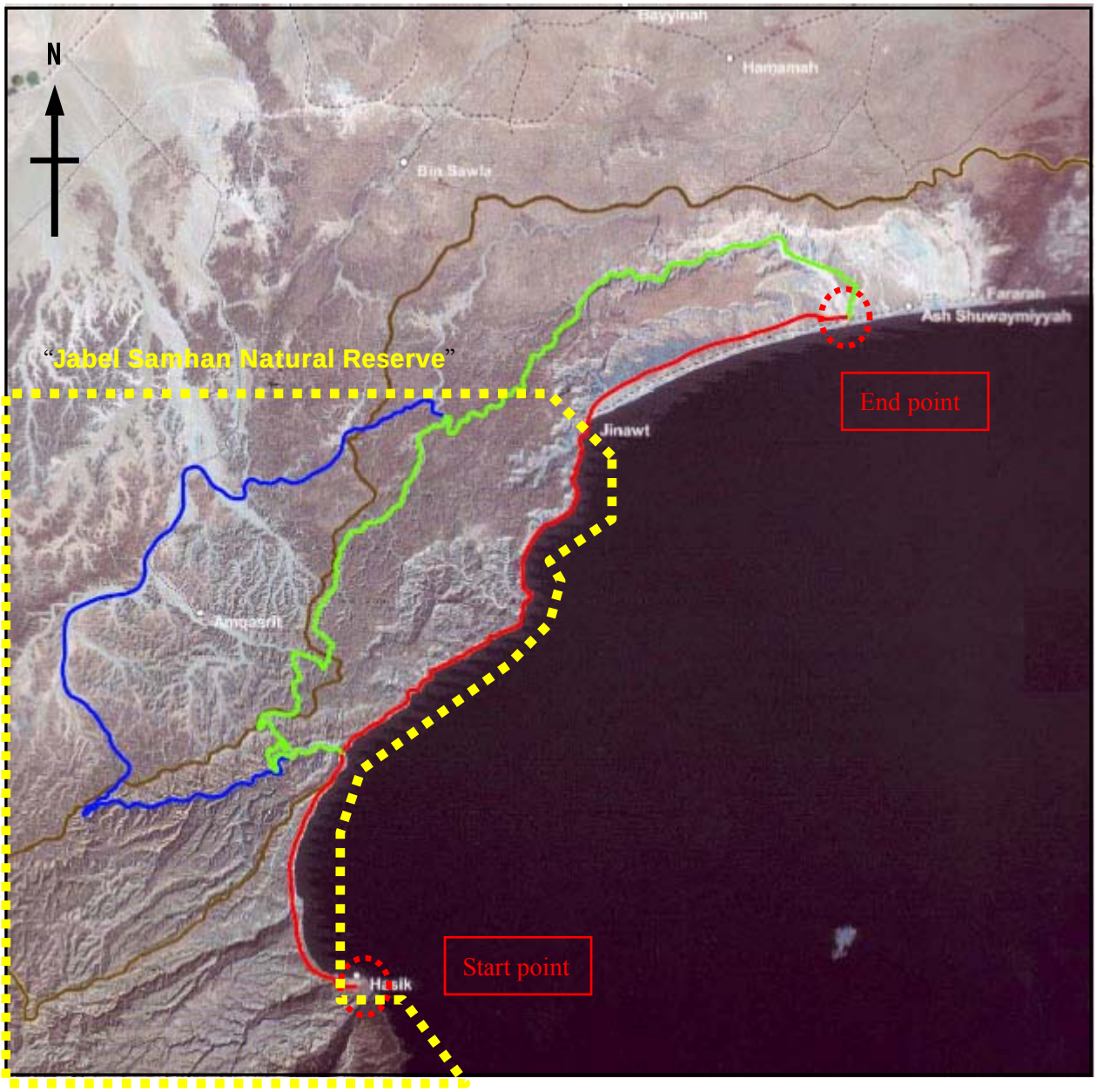
8. Study Timetable

Tentative study timetable of the project shows in Attachment-6.

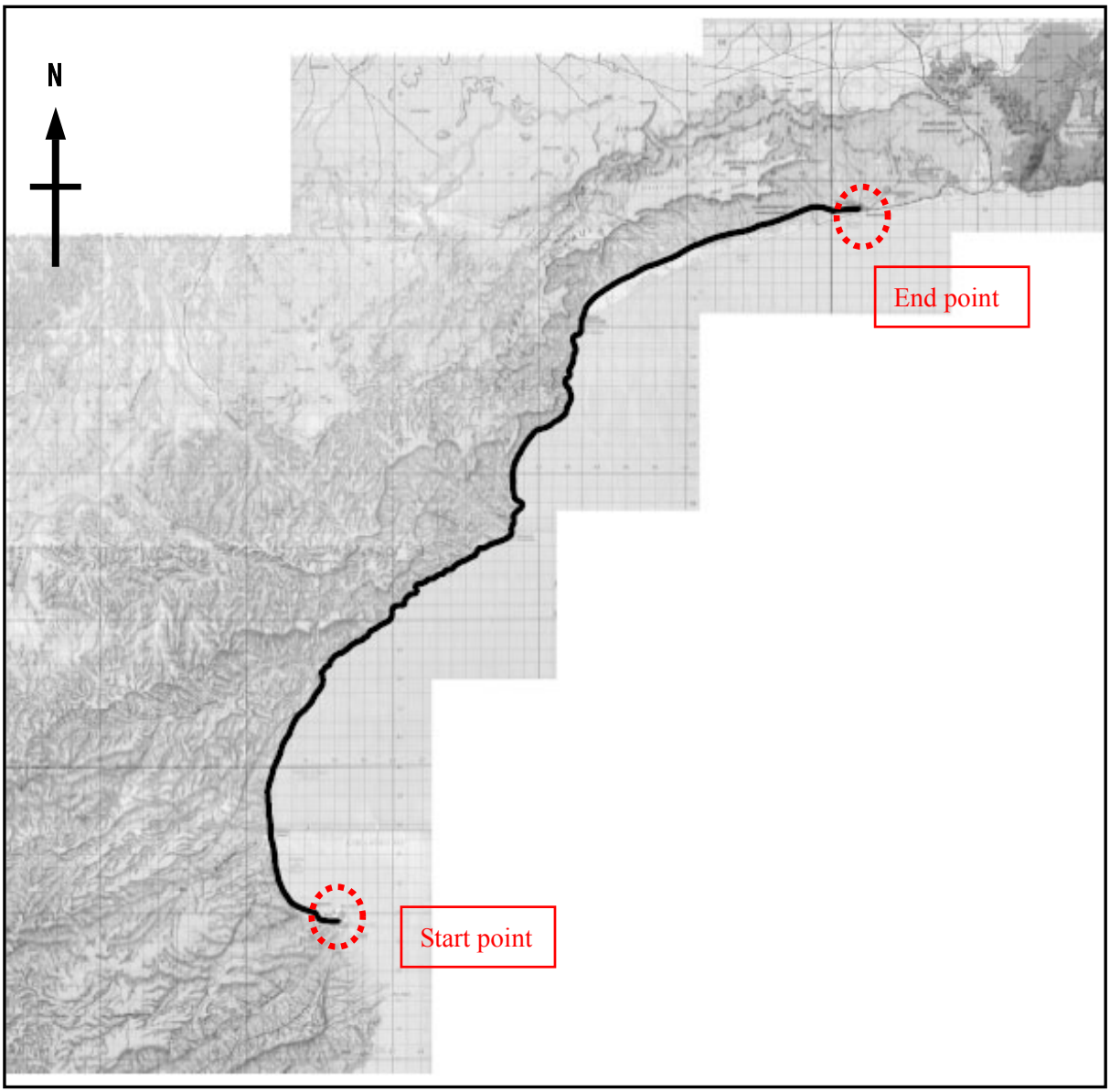
Attachment:

Attachment -1 Location Map of the Project Road
Attachment -2 Topographic Map of the Project Area and Location of Alternative-1, 2 and 3
Attachment -3 Route Map of Alternative-1
Attachment -4 Route Map of Alternative-2
Attachment -5 Route Map of Alternative-3
Attachment -6 Tentative Study Timetable of the Project

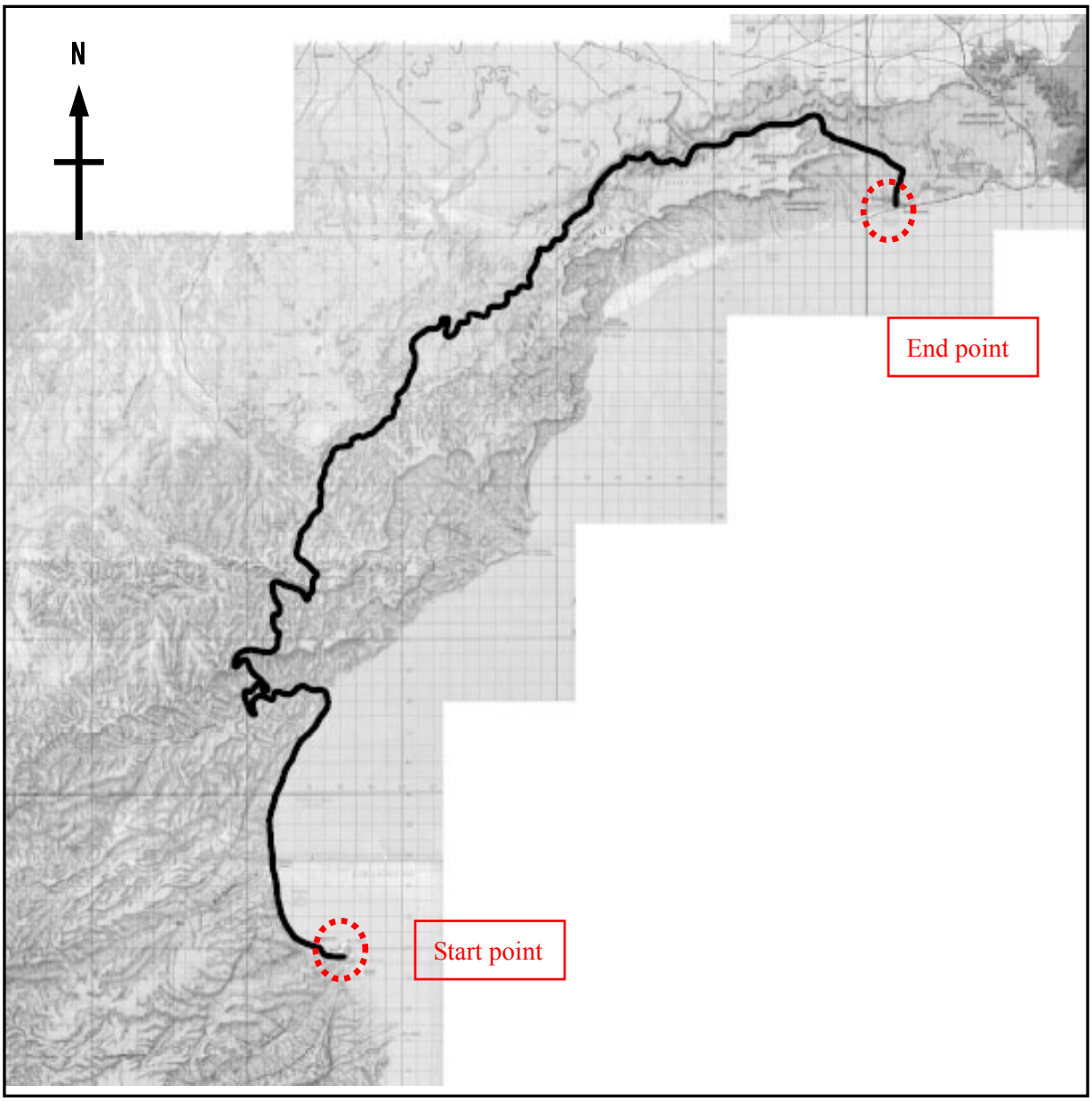
Attachment -1 Location Map of the Project Road



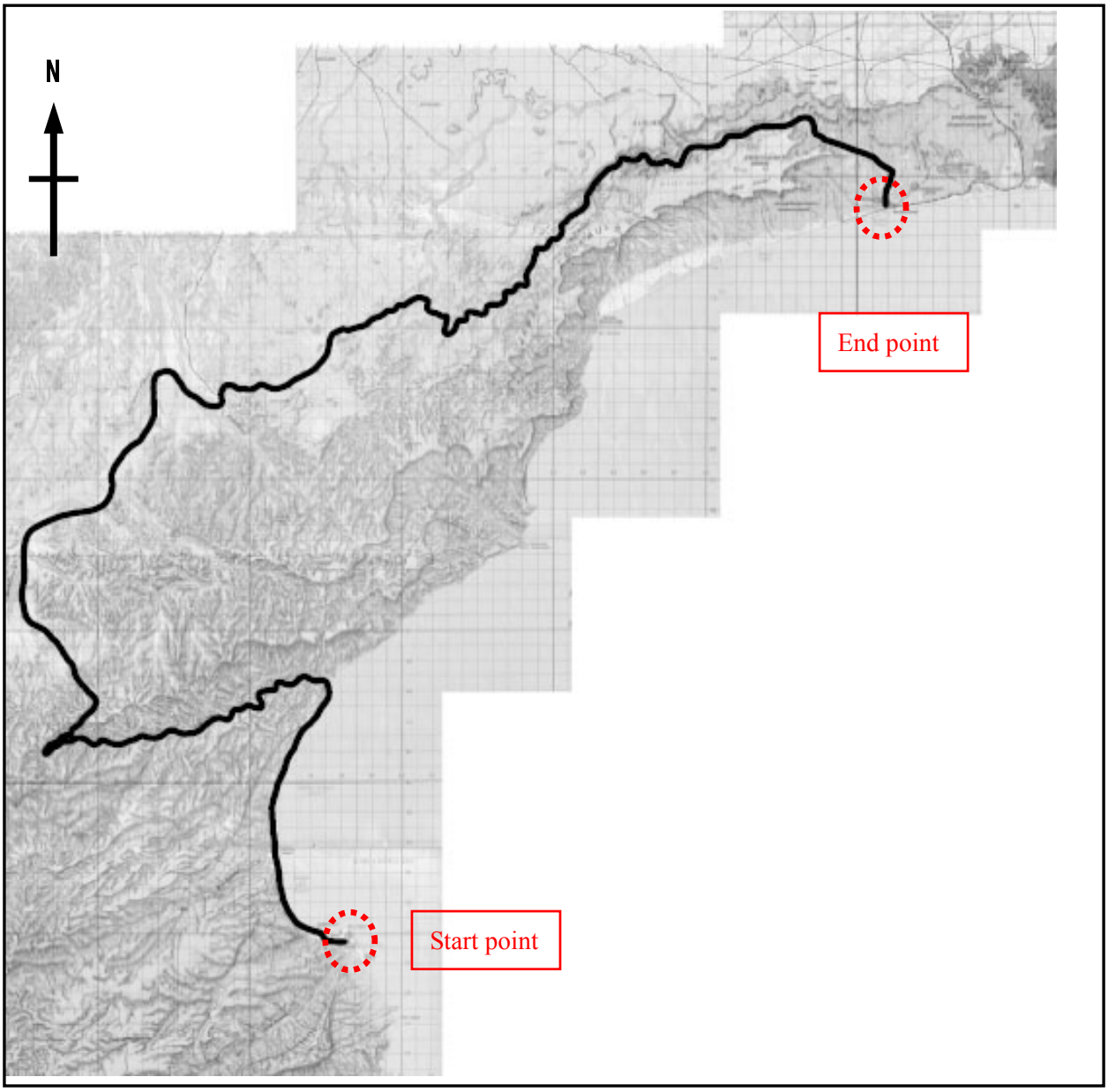
Attachment -2 Topographic Map of the Project Area and Location of Alternative-1, 2 and 3



Attachment -3 Route Map of Alternative-1



Attachment -4 Route Map of Alternative-2



Attachment -5 Route Map of Alternative-3

Attachment -6 Tentative Study Timetable of the Project

Year	200 -															Remarks
Number of month	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**-**	
1. Data collection	▬															
2. 1st. Field investigation		▬	▬	▬												Summer/winter season
3. 2nd. Field investigation								▬	▬	▬						Winter/summer season
4. Data analysis			▪▪▪	▪▪▪	▪▪▪	▪▪▪	▪▪▪			▪▪▪	▪▪▪	▪▪▪	▪▪▪			
5. Reporting	1 △	○	○	○	○	○	○	○	○	○	○	○	○	2 △	3 △	

△ 1 : Inception report
2 : Draft Final report
3 : Final report
○ : Monthly report

▬ : Work in the site
▪▪▪ : Chemical analysis

CHAPTER 23

WADI STUDY ON BATINAH HIGHWAY

CHAPTER 23

WADIS STUDY ON Al BATINAH HIGHWAY

23.1 INTRODUCTION

Al Batinah Highway is one of the most important highways in the Sultanate of Oman, extending along the coast of Gulf of Oman and bordered from the west by Al Hajar al Gharbi Mountains. The Highway is dual four-lane carriageway with total length of approximately 253 km. The location plan of the study road is depicted on Figure.23.1-1

Previous carriageway study of Al Batinah Highway was carried out by M/s Gibb Petermiller in 1992-93. The study covers Bait Al Baraka to Khatmat Malah of 252 km. Rehabilitation works were carried out and the remaining are being completed concurrently with the DGR programmes.

In June 2000 DGR had assigned NESPAC to carry out a study of the existing conditions and rehabilitation of Al Batinah Highway of about 231 km and the dual carriageway from Al Aqr to Alwajaja of 22 km.

In 2004 JICA Study Team, has carried out Wadis Study embraces Hydrological Analysis to the Wadis and its Irish Crossing in order to evaluate the feasibility of carrying out a rehabilitation programme to replace the existing I.C. by Box Culverts. In the framework of JICA Study on "Road Network Development in the Sultanate of Oman", detailed inspection, field surveys to the existing Irish Crossings along the Highway and detailed Hydrological Study to the wadis have been carried out in order to evaluate the feasibility of proposing a rehabilitative programme of the Irish Crossings. Necessary measures for such tasks have been tackled and resolved for further assessment.

The Study encompasses the followings:

- Review and analysis of the present situation of the Irish Crossings along Al Batinah Highway and the feasibility of replacing it by Box Culverts
- Hydrological Wadis Study
- Rainfall Intensity, Duration, Frequency Relationship Study Northern and Southern of Al Batinah Region
- Estimation of periods of road's closing
- Preparation of relational Thematic Maps of ad hoc parameters

- Delineation of the Impact of Dams construction on the flood peaks, growth factors, down stream discharges
- Calculation of Rating Curves for the screened crossings needs rehabilitation
- Cost estimate

23.1.1 Al Batinah Region

Al Batinah region is lying in the northern part of the Sultanate, extending from UAE border to Muscat, along the sea comprising the most significant, coastal plain in the region. This plain has been divided into two zones, the piedmont and the coastal plains.

The piedmont zone comprises of several alluvial origin's terraces of limited extent. The major water bearing formation is located in the modern wadi gravels, which reaches 50 m in thickness. It acts as major conduits to the upper catchment's reaches in the plain. At the lower reaches the wadi fans are prevailing, forming the coastal plain along Al Batinah coast.

Rising water levels and saltwater intrusion may cause potential problems in roads construction, increasing costs due to the saline water and its corrosion impact and subsidence and its effect on the soil particles. Highly cost materials are needed to avoid prospected problems. Knowledge of groundwater levels is necessary for proper roads planning, and design.

Al Batinah region is divided into two main areas.

- The Al Hajar Al Gharbi mountain range runs parallel to the coast from the United Arab Emirates in the North to the Wadi Al Ma'awil in the South. The highest peaks up to 3,075 meters lie to the South East at Jabal Al Akhdar.

- The coastal plain occupies the frontier with the United Arab Emirates for a distance of 270 kilometres South East of Muscat Governorate. It is situated between the coast and the Al Hajar Al Gharbi mountain range. It is one of the most densely populated areas of the Sultanate. The main towns, in Al Batinah Region are Sohar and Ar Rustaq. The principal activities of the population are agriculture and fisheries.

  Sohar is a well-developed town with activities such as construction, industry, trade and agriculture. It is famous for copper mining. Al-Shamma Fort represents one of its famous historical inheritances.

Ar Rustaq is surrounded by Al Hajar Al Gharbi mountain range from three directions and is at a distance of around 160 km from Muscat. It is known by its historical buildings such as Al Hazrn and Ar Rustaq Castles besides Am Al-Kasfa with its hot mineral springs and dates processing factory.

23.1.2 Al Batinah Wadi Gauging Stations

Floods in Al Batinah Highway are hazardous and difficult to predict. Mean velocities sometimes in excess of 5 m/sec and high sediment flowage rates are a feature of torrential wadis. Estimate of flood flows with probable various risks of exceedance are indispensable for a wide range of engineering applications including:

- Highway bridge, culvert and dam spillway design
- Assessment of flood risk including flood zoning/flood risk mapping
- Estimation of flood damage potential-design and development of flood alleviation, protection works, and rehabilitation

Thirty six (36) active gauging stations are currently in operation and sixteen (16) wadi-gauging stations some are downstream of recharge dams that have tangible impact on its flood peak characteristics since their installation. It is noted that the limitation of flood storage in upper gorges means that flood peaks hold up in upper catchment's reaches and flood peaks in the lower catchment's reaches can often be very small proportion of the upper stream floods based on the relative proportion of alluvial plain.

Figures 23.1-1 and 23.1-2 show the location of flood gauges and drainage pattern in Al Batinah Region. Wadi flow data are available for 36 wadi gauging stations throughout Al Batinah Region.

The drainage and catchment's areas are taken from GIS digitized boundaries in most cases but some may later be slightly modified particularly for subjective boundaries within coastal plain areas. There may some degree of flood spillage either into or out the station's nominal drainage area that making the latter only generally indicative.

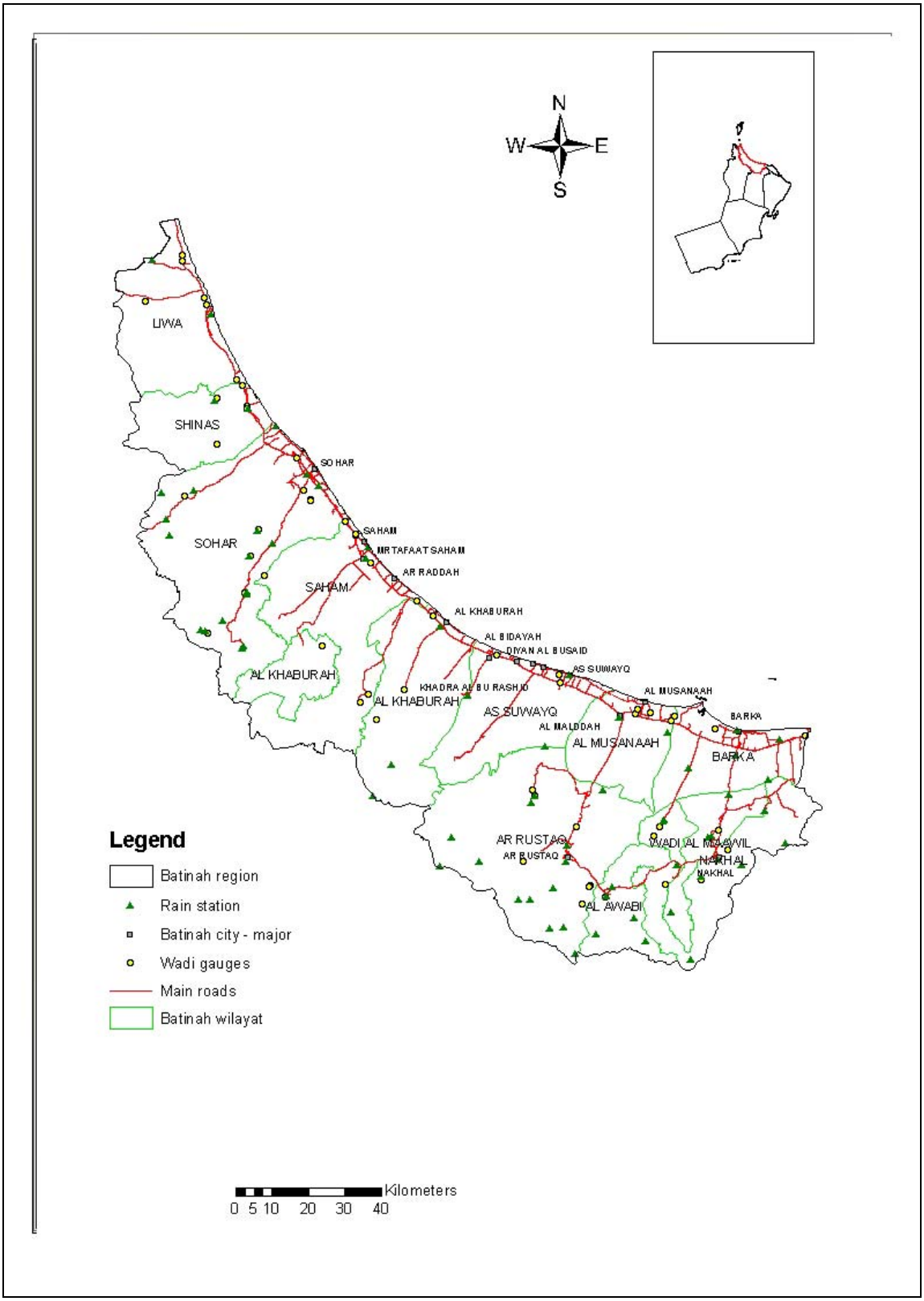


Figure 23.1-1 Locations of Wilayat and Hydrometric Stations

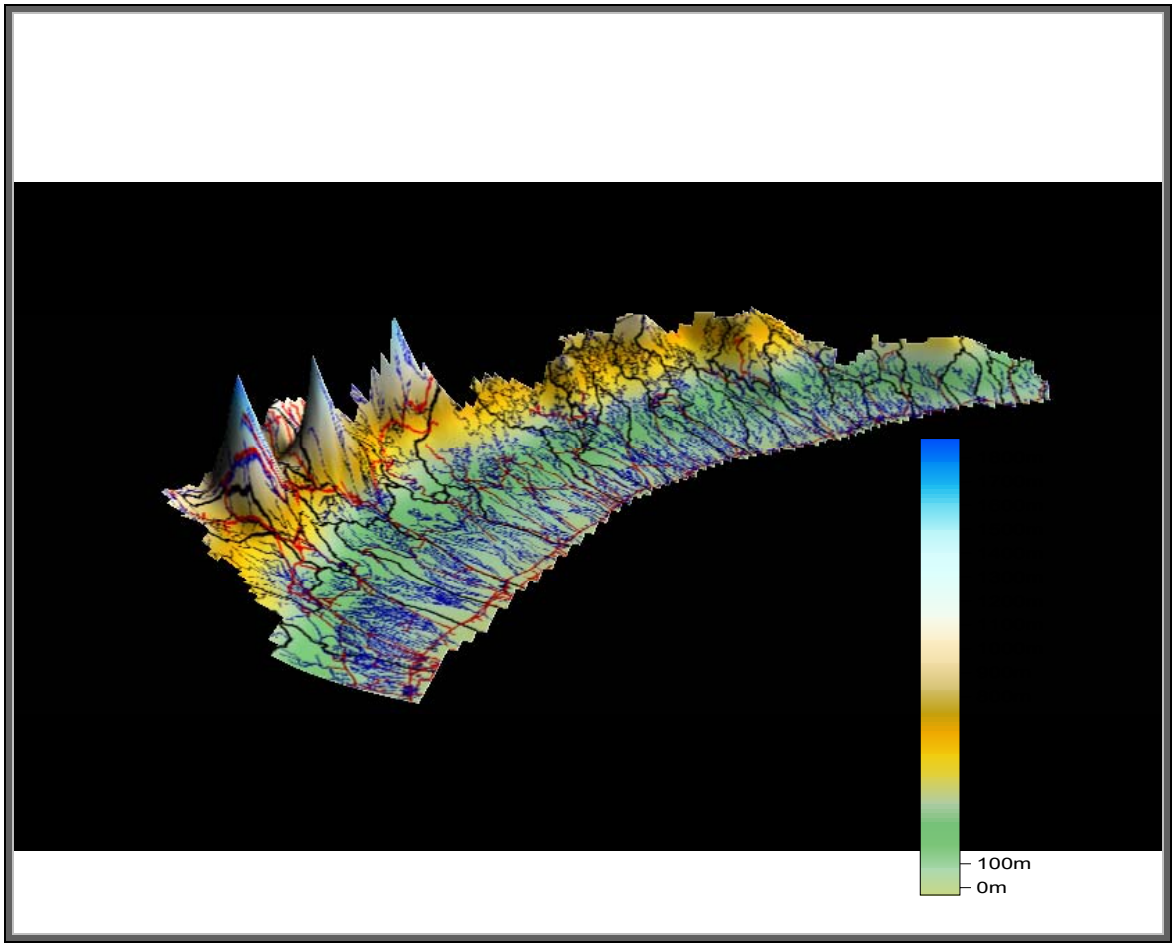


Figure 23.1-2 Location of Wadis and Drainage Pattern

Nearly, all of the stations measure intermittent flows i.e. there is no flow at them for much of the time. A few of the inland or upland stations measure perennial flows much of the time in the form of base flows before they are largely lost to the alluvium further downstream.

Year 1997 was an exceptionally wet in a large part of Northern Oman to the extent that the overall average is seriously biased if that year is considered. In a number of cases year 1998 was also exceptionally wet.

The very large range of runoff rates would be expected to be partly attributable to higher rainfall characteristics within mountain areas. However, important is the opportunity for recharge into wadi alluvium. Where wadis upstream of gauging stations flow over wide alluvial channels or flood plains, a significant proportion of total flow may be expected to recharge into this alluvium and so the runoff rate will be lower.

High runoff rates tend to occur when there is no extensive wadi alluvium upstream that mean limited opportunity for wadi recharge.

Events such as the March 1997 flood demonstrate how a single major event with a very long return period can seriously affect the long term average, and this is known to be particularly true in arid regions. The 1997 floods show that great care needs to be undertaken in decide whether such events should or should not be included in assessing a long term average. They also show the very limited degree of accuracy of long term estimates. Hence for any wadi, the runoff-rainfall ratio would be expected to decrease greatly from upstream to downstream.

The average runoff-rainfall ratio for all of the stations is 5.4% if computed arithmetically, but for the more logical method of area-weighting it is 3.4%. The fact that the latter figure is lower than the former is because the larger the area, the smaller the runoff-rainfall ratio. However, the stations include upstream and downstream stations and so the overall averages do not relate to any specific national average. The national average to the coast and start of deserts, i.e. lost flows, will be very much less than 3.4%, and probably less than 1%. For upstream mountain locations before significant wadi channel alluvium has developed the ratio is likely to be well above 20%.

Figure 23.1-3 shows the Average Rainfall Runoff for Northern Oman Gauged Catchments of 1996. Location of Wadis and flood stations are shown in Figure 23.1-4.

From the maximum recorded flood peaks in Oman, it is observed that nearly all of the highest peaks are related to mountain gorge cases.

Rainfall intensity, duration and frequency relationship for use in determining design storm rainfall was developed by MRMEWR and DGWRA.

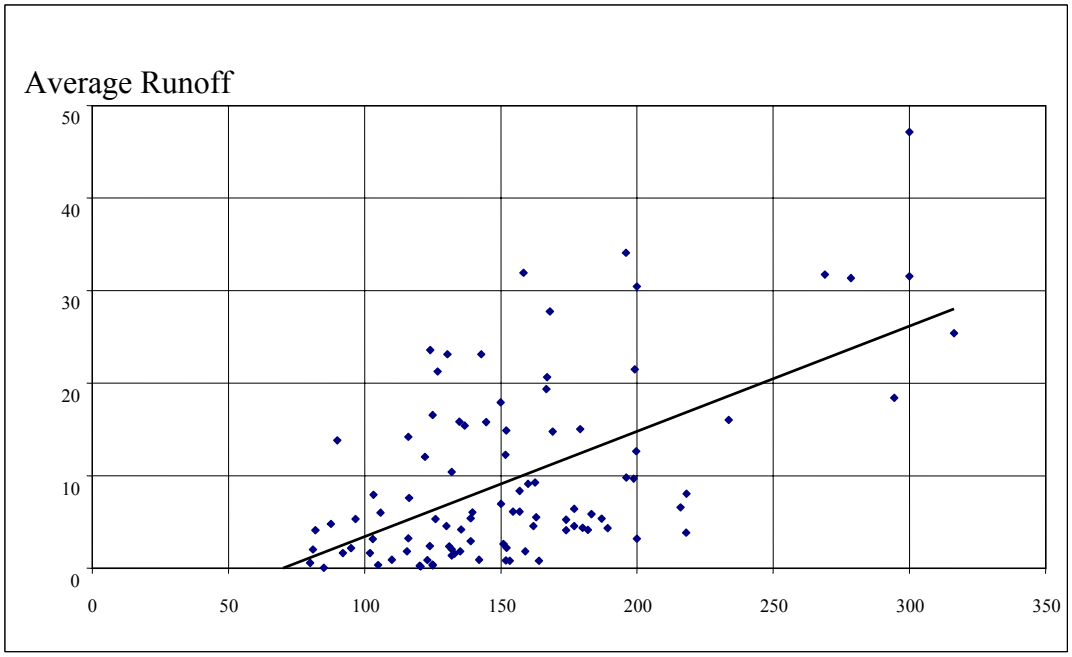


Figure 23.1-3 Average Rainfall Runoff for Northern Oman Gauged Catchments of 1996

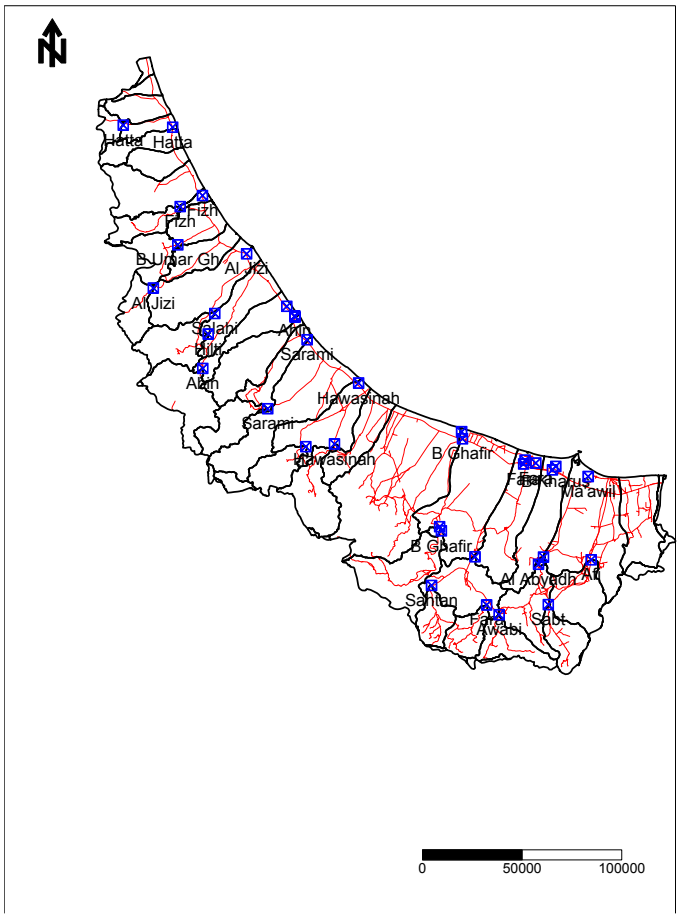


Figure 23.1- 4 Wadis and Location of Flood Stations of Al Batinah Region

23.2 FLOOD FREQUENCIES

23.2.1 Regional Flood Frequency Curves

The criteria for grouping the stations include administrative region, topography (hill/ mountain/plain), catchment's area and catchment's rainfall. The flood series at each of the selected sites is standardized by dividing each by its relevant mean annual flood. Probability weighted moments are computed for each of the flood series, averaged, and used to derive the parameters of the selected distribution. Dimensionless regional growth factors are computed for the derived distributions which are used to compute flood frequency curves for each of the sites included in the analysis. An example of Regional Growth Curves of Northern Oman with and without dam's conditions is presented graphically in Figure23.2-1.

The impact of dam's construction on the determination of regional growth curves reveals quite minor changes on the calculation of flood frequencies and peaks. The constructions are resulting in a reduction of the values and hence on the downstream structures require rehabilitation.

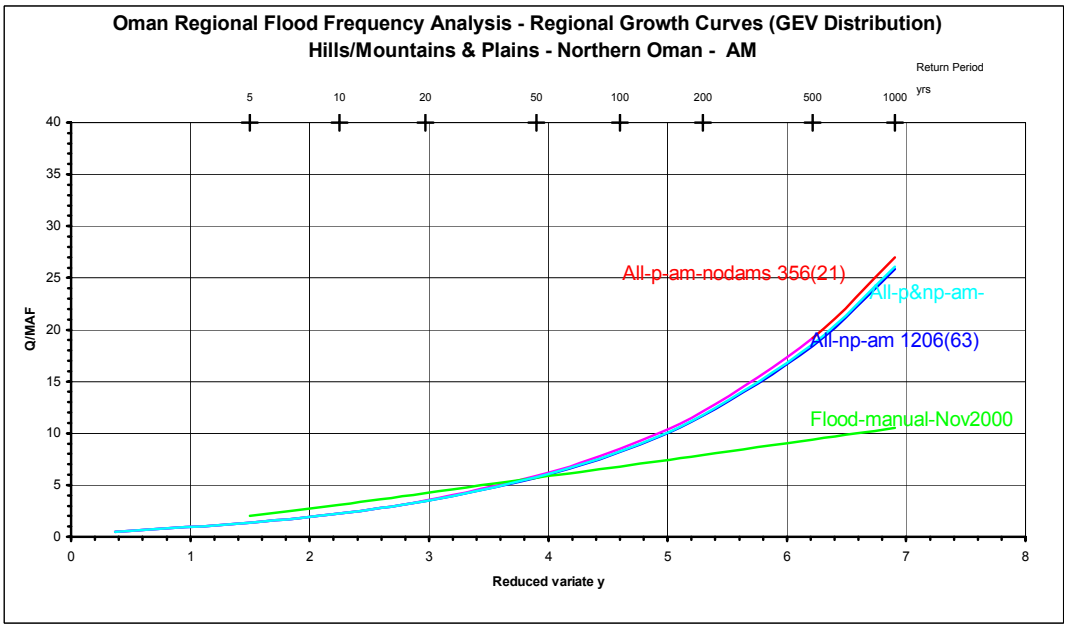


Figure 23.2-1 Regional Flood Frequencies Analysis (Growth Curves for Northern Oman)

The most recent rainfall intensity-frequency curves developed by SWS for various storm-duration and average recurrence intervals that have been developed for Oman can

be utilized in the assessment. The latest results of frequency of rainfall intensities for plains, hills and mountains of the Sultanate of Oman are depicted in figure 23.2-2

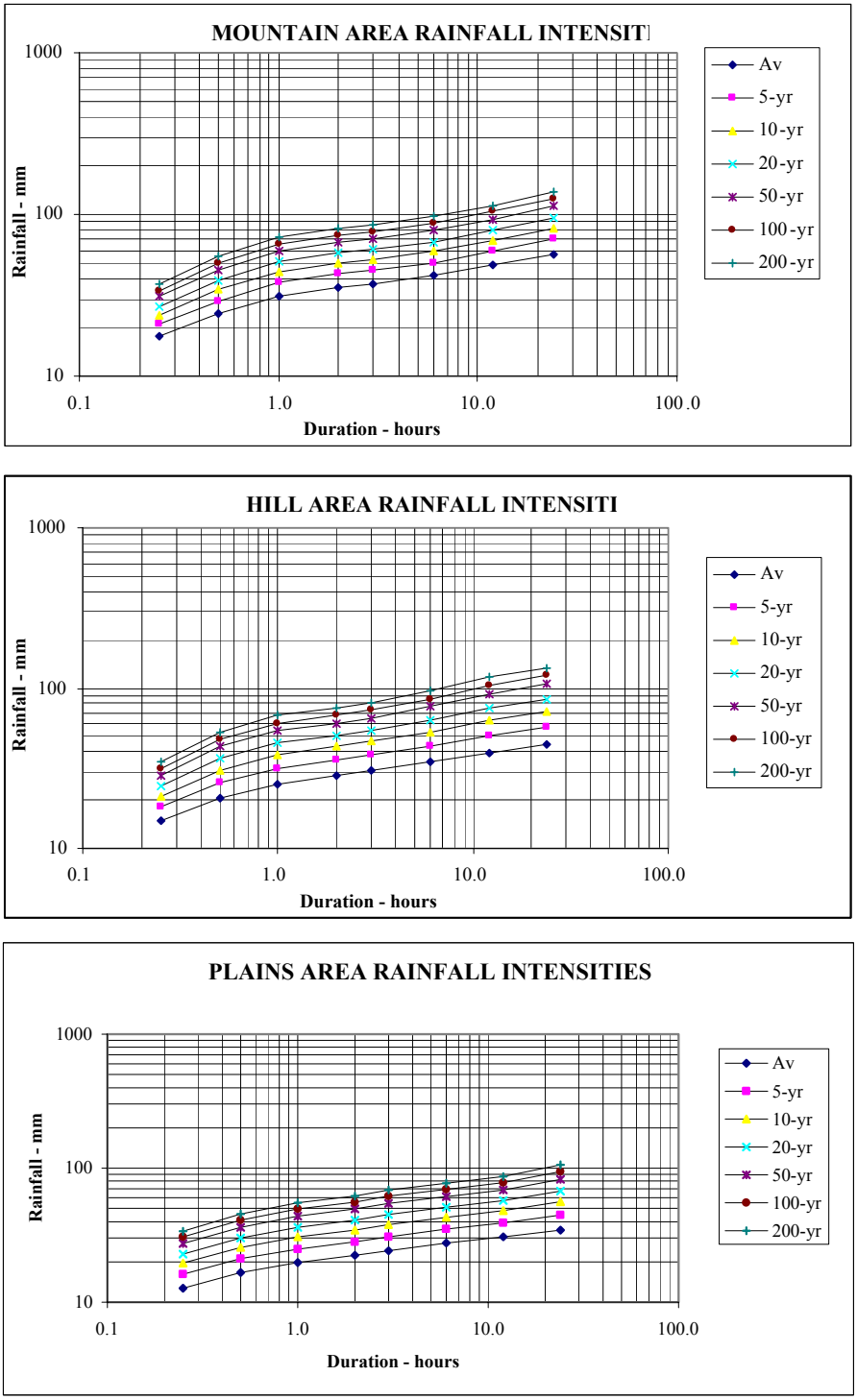


Figure 23.2-2 Frequency of Rainfall Intensities for Plains, Hills and Mountains

For the design of highway drainage structures (Culverts and Bridges) and to optimize the construction cost, return period of flood as 20 or 50 or 100 years is determined as specified in design standard. Table 23-2.1 shows the specified return periods of structure types as defined on the HDM.

Table 23.2-1 Frequency of Flooding for Design of Highway Drainage Structures

Type of Structure	Frequency
Bridges	1 in 100 years (1%).
Culverts, Irish crossings, Irish bridges	1 in 50 years (2%)
Channels and Ditches	1 in 10 years (10%)
Storm Water Systems	1 in 5 years (20%)

23.2.2 Determination of Peak Discharges in Al Batinah Highway

For natural catchment less than 10 km^2, reference is made to the Rational Method in comparing the calculated discharge using the Flood Frequency Curves for Oman. The rainfall intensity for particular time used to be obtained from the regional intensity-duration-frequency relationship shown in Figure 11.2 of HDM. Rainfall intensity (I) is recommended to be derived using curves of rainfall intensities for plain, hilly and mountainous catchment's areas developed by MRMEWR, Figure 23.2-2 shown above.

23.2.3 Preparation of Flood Peaks Frequency Calibration Maps of Al Batinah Region

Following to the determination of Peak Floods Frequency values in (m^3/sec) several thematic and synoptic maps for further calibration have been prepared for the first time in Al Batinah Region.

Relevant to road's crossings of the regions under study, Ad hoc maps encompassing aerial distribution of Flood Peaks and frequencies for return period have been developed. This map can be utilised in the calibration of estimated flood peaks discharges and for hydraulic calculations under different Al Batinah Region's conditions. Figure 23.2-3 shows the results of the obtained map. The figure shows changes of Flood Peaks Frequency of 50 years return period for areas more than 10 km^2 ,decreasing from more than 750 m^3/sec to about 50 m^3/sec covering Al Batinah Highway. From the figure it can be noticed that values are decreasing steadily along the coast of Al Batinah Region where the locations of Irish Crossings are also clarified.

By comparing the above estimated conventional flood peaks with calibrated values, the lowest are selected. Table 23.2-2 shows Mean Annual Floods of the drainage areas of

the Wadis in Al Batinah Region where 36 areas can be defined and the areas 2 to 32 were found to be in direct contact with the highway.

Table23.2-2 Mean Annual Floods (MAF) of Wadis in Al Batinah Region.

Wadi	Drainage Area (km²)	MAF (m^3/s)
Hatta	437	303
Hatta	523	105
Fizh	266	104
Fizh	282	37
B Umar Gh	275	91
Al Jizi	630	307
Al Jizi	-	119
Salahi	89	58
Hilti	242	93
Ahin	734	405
Ahin	879	59
Ahin	936	82
Ahin	-	37
Sarami	212	142
Sarami	355	22
Bani Umar	204	152
Hawasinah	387	197
Hawasinah	878	84
B Ghafir	591	266
B Ghafir	602	258
B Ghafir	745	50
B Ghafir	952	54
Sahtan	165	109
Fara	171	234
Far	687	333
Fara	1014	-
Fara	1014	74
Fara	-	9
Awabi	253	121
Sabt	199	121
Al Abyadh	761	261
Al Abyadh	767	262
B Kharus	1112	36
B Kharus	1117	26
Afi	316	231
Ma'awil	-	36

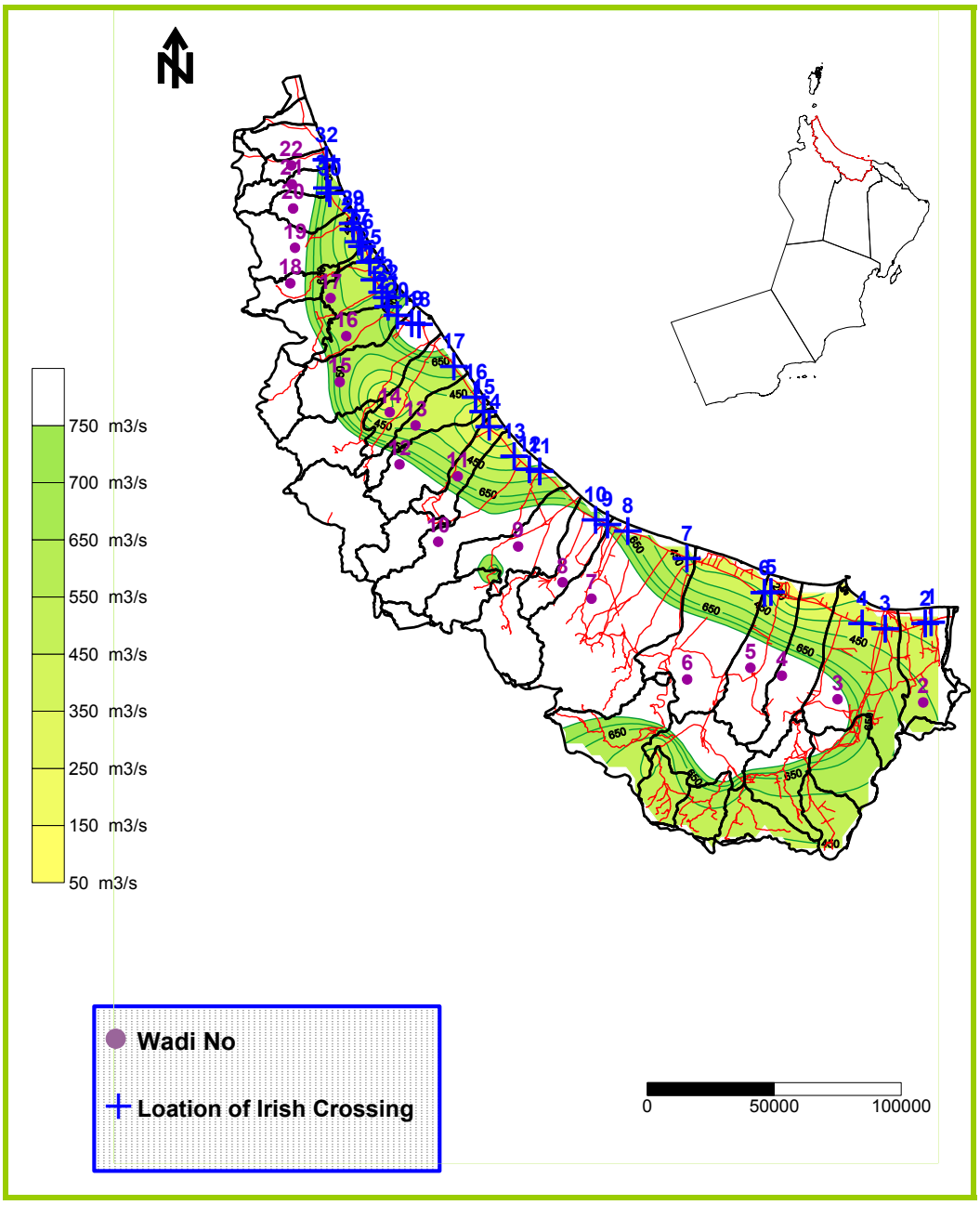


Figure 23.2-3 Flood Peaks Frequency (m^3/sec) for Areas Greater than 10 km^2
Al Batinah Region (50 Years Return Period)

23.2.4 Hydraulic Calculations (Design) of Al Batinah Highway

Hydraulic calculations have been discussed in Chapter 11 of this study. The hydraulic calculations (design) are based on the Omani Standards.

Reference is made to section (11.18 of HDM) of open channel calculations for evaluating the flow regime under uniform flow conditions.

For cross drainage structures, Manning equation (refer to section 11.19 of HDM) can be considered. Typical values of Manning Coefficients (n) recommended by HDM, are shown in Table 23.2-3.

Table 23.2.-3 Typical Values of Manning Coefficient's (n)

Material	n
Concrete lined channel	0.016
Smooth rubble channel	0.020
Reno mattresses or gabions	0.025
Rough riprap	0.040
Gravel , cobbles and not many large boulders	0.03-0.5
With large boulders	0.04-0.7

Capacities of Irish Crossing can be determined using road weir formula reproduced below:

$Q = 1.69\ B\ (H)^{1.5}$

Where,

B= Length of wadi crossing
H= Specific energy head including average water depth and velocity head

Nomographs recommended by the Sultanate of Oman, Highway Design Manual are used for the analysis of culverts (HDM Figure 11.7 for Pipe culverts and HDM Figure 11.8 for Box culverts).

An example of some estimated capacities of Box / Pipe Culverts existed in the area of one cell of each are listed below:

- Capacity of PC of 1.0 m diameter is 1.6 m^3/s
- Capacity of PC of 0.9 m diameter is 1.2 m^3/s
- Capacity of BC of 1.5 m wide by 1.0 m height is 3.0 m^3/s

- Capacity of BC of 2.0 m wide by 1.0 m height is 11.2 m^3/s

It is worth mentioning that the difficulties encountered in measuring flood peaks at some places of Oman has introduced some limitation to the reliability of ad hoc data since wadi flows tend to be swift and dangerous to measure flood peaks on the basis of recently adopted conventional procedures. Some wadi gauges are remote and not accessible during flood incidents. When highways Irish Crossings inhibit traffic, peak flow tends to pass quickly giving no enough time to reach gauging stations. In the mean time wadi beds are typically wide, unstable and not ideal for gauging purposes.

23.2.5 Evaluation of Flood Peaks Frequency of Existing Al Batinah's Bridges

Figure 23.2-4 shows the Locations of Bridges along Al Batinah Highway. There are only two existing bridges along the existing Batinah Highway.

Bridges design discharges and coordinates have been worked out using all available data especially on the basis of conventional control methods, calibrated points and prepared synoptic calibration maps pertaining to the return periods of 50 and 100 years, in order to be utilized in the evaluation of existing and calculated capacities pertaining to Al Batinah Region of Oman.

Table 23.2-4 shows the results of flood peaks frequencies determined for 50 and 100 years return period.

Table 23.2-4 Calculated Flood Peaks Frequency of Existing Bridges

Coordinates		Bridge no.	Road no.	Flood Peaks Design 50 years return Period (m^3/s)	Flood Peaks Design 100 years return Period (m^3/s)
X	Y				
513905	2648380	2	1	600	700
478480	2686799	1	1	630	750

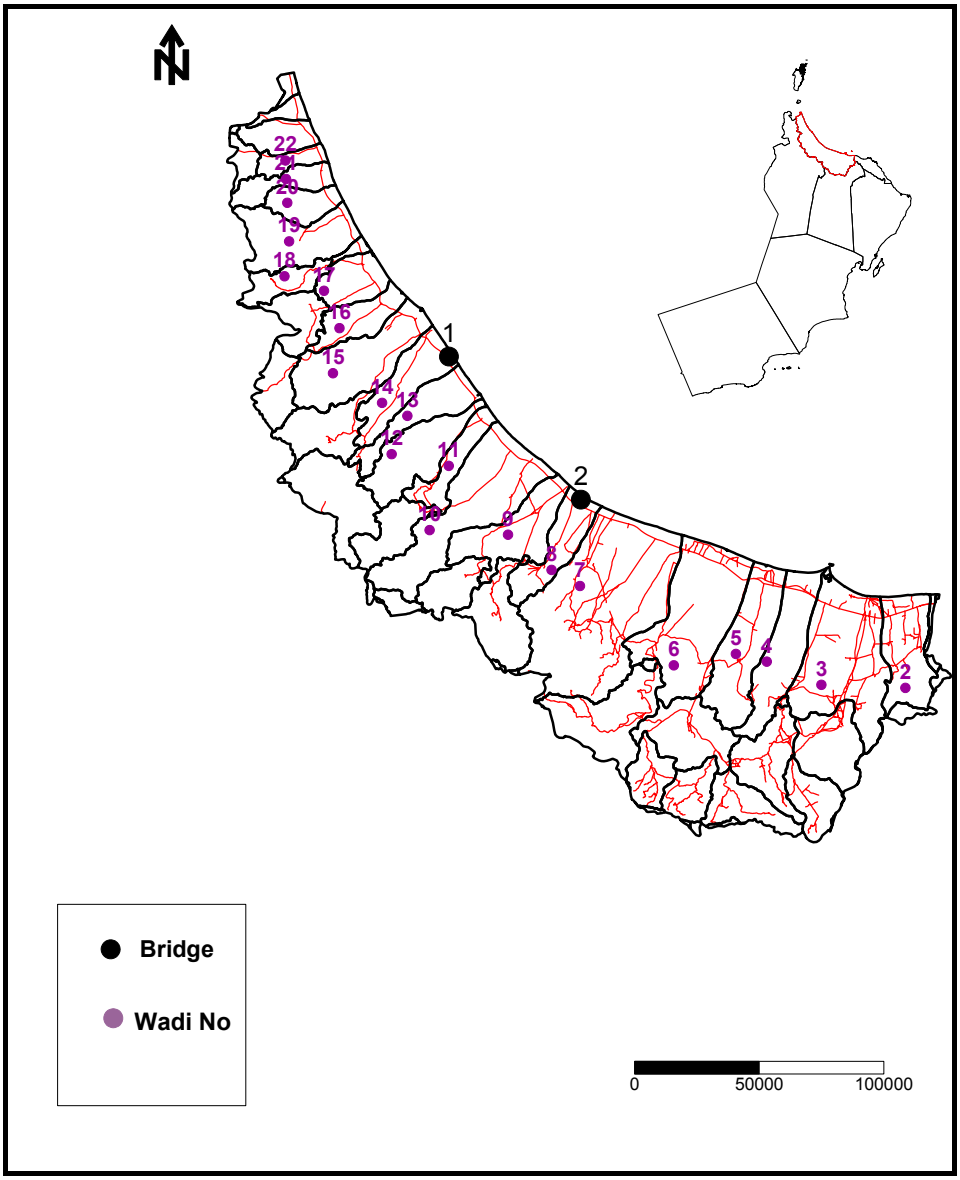


Figure 23.2-4 Locations of Bridges along Al Batinah Highway

23.3 PRESENT DRAINAGE CONDITIONS

23.3.1 Structures Condition Survey

Locations and visual conditions survey of the existing Irish Crossings along Al Batinah Highway was conducted to evaluate the existing structures and to establish the extent of remedial works required.

Each structure has been numbered. The existing structure capacities have been assessed and evaluated with reference to the new findings. Table 23.3-1 shows locations and characteristics of 32 Irish Crossings surveyed along Al Batinah Highway from the starting point at Bait Al Barakah R/A. towards Shinas R/A.

Figure 23.3-1 shows the locations of surveyed Irish Crossings along Al Batinah Highway.

The visual examination of concrete was carried out by DGR in 2000 accordance with the guide lines provided by corps of engineers and ACI 201-IR-92. The purpose of condition survey was to inspect the deterioration of structures. A total of 748 structures were inspected by DGR. The existing drainage structures including the recently surveyed I/C structures are:

Box culvert	=	221
Pipe culverts	=	483
Irish Bridges	=	18
Irish crossings	=	26, (32 as recent inventory of 2004)

Most of the culverts contained blockage due to the presence of sediments and debris inside the culvert barrel therefore, these culverts needs regular cleaning.

The condition of concretes provided in the Irish Crossings and Irish Bridges were good without any sign of major defects or deteriorations.

It is noted that gabion protection works were provided on upstream along the entire length of Irish Crossings adjacent to the cut-off wall. These gabions were broken and sited up at certain places, which need to be cleaned and repaired. The asphalted and concrete surfaces of these Irish Crossings were in normal conditions.

Figure 23.5-2 (in Section 23.5 Multi Culvert Functions) shows schematic diagram of the Location and length of Irish Crossings in Al Batinah Highway.

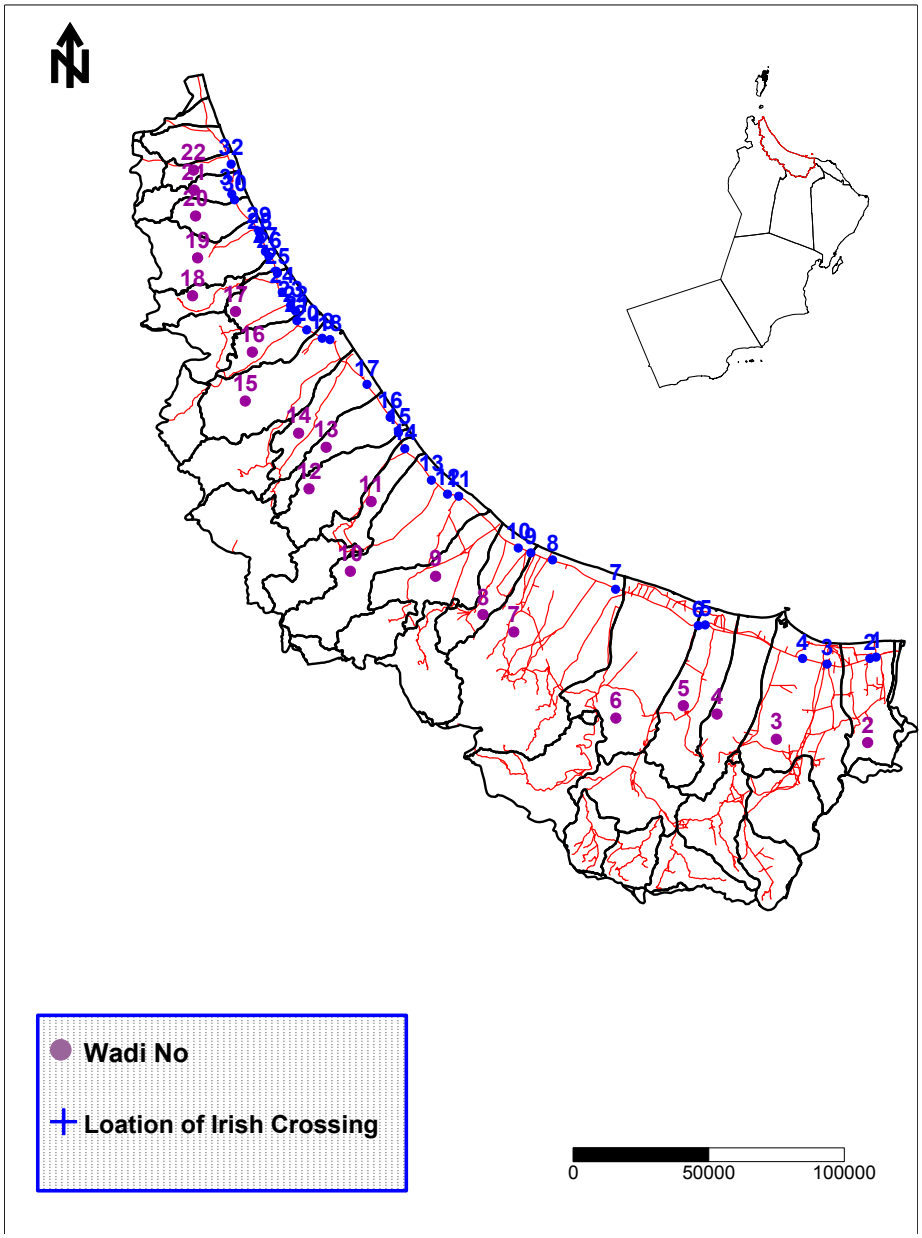


Figure 23.3-1 Location of Surveyed Irish Crossings along Al Batinah Highway

Table 23.3-1 Location and Characteristics of Surveyed 32 Irish Crossings along Al Batinah Highway (Sept.2004)

X	Y	I.C. No.	Length (m)	Altitude (m)	Station
603137	2618976	1	250	25	06+500
601580	2618630	2	325	27	07+000
591023	2617246	3	460	25	08+000
584976	2618630	4	485	26	08+900
560936	2626932	5	415	28	16+400
559206	2626759	6	320	21	19+200
538797	2635753	7	490	20	28+000
523232	2643017	8	315	24	29+100
517870	2644746	9	425	22	74+600
514757	2645957	10	525	24	97+900
500056	2658756	11	700	22	113+400
497289	2659274	12	510	14	120+100
493310	2662733	13	485	18	123+000
486738	2670516	14	475	20	150+800
485181	2674494	15	450	14	161+200
483106	2678299	16	440	23	165+100
477398	2686428	17	305	31	169+500
468231	2697497	18	505	24	181+200
466329	2697843	19	440	22	194+600
462524	2699919	20	335	25	195+500
460103	2702167	21	250	26	201+500
459757	2704589	22	375	20	203+900
458546	2705972	23	425	25	206+500
456471	2709258	24	380	21	208+400
455260	2713928	25	625	24	213+300
453185	2718079	26	765	18	218+200
452320	2719290	27	320	15	224+600
450936	2722576	28	665	22	229+100
450763	2724132	29	405	19	230+500
444710	2732088	30	270	20	241+700
444018	2733472	31	330	21	243+200
443845	2740909	32	570	14	249+300

23.3.2 Dams and Hydrological Conditions

1) Hydrological Conditions

The former Ministry of Water Resources (MWR), now Ministry of Regional Municipalities Environment and Water Resources has established well distributed hydrometric network throughout the Sultanate covering climatological, wadi flow stations, Falajs and Groundwater boreholes.

It is known that wadi flow measurements in the Sultanate are difficult, due to its wideness, high sediment loads and flow channels variables. Flash Floods, even relatively rare but characterized by high velocities that may damage flow measurement instruments and difficulties in accessing the site adds some error in recording wadi flows. Most of the gauges are concentrated in the most populated areas north of the country. Rating curves based mainly on slope area method except for a few gauging stations at culverts where theoretical culverts flow can be used. Direct current meter crest gauges are installed at most wadi gauges to verify the record peak stages and for computation purposes using slope-area method after each significant flood event.

The sultanate of Oman is deprived of perennial wadies flow to the sea throughout the year but few are perennial in part of their upper and middle reaches. Generally, surface water flow in Oman is rare and It occurs few hours or days following to a storm and flooding.

Due to the transitional conditions of the surface flows, rainfall is resulting in shortage of rechargebility of the alluvial. The government has built many recharge dams to retain a portion of the peak flows to give a chance for gradual release of water to the lower reaches, allowing more opportunity for recharge, and to protect the lower catchments communities from the potential hazards.

The Ministry has made significant progress in planning, and development of schemes to increase recharge, enhance surface water storage, and to improve efficiency of aflaj water use. Recharge dams are designed to intercept flood flows in wadies, which would otherwise run to waste in the sea or inland into the desert. Water is released at a reduced rate of flow often through culverts in the dam and infiltrates the ground water aquifer beyond the dams in controlled flow. This recharged water moves gradually in the aquifer to replenish boreholes downstream of the dams.

2) Dams

Eight dams have so far been completed at Al Batinah Regiopn as shown in Table 23.3-2 and several small dams and water structures have been built in Jebel Akhdar.

Table 23.3-2 Existing Recharge Dams of Al Batinah Region

No.	Name	Location	Capacity (million m^3)	Length (m)	Max. Height (m)	Spillway Types	Year Completion
1	Hilti / Salahi	Sohar	0.55	9063	4.5	Gapion	1985
2	AL-Jizi	Sohar	5.4	1234	20.4	Concrete Weir	1989
3	Ma'awil	Braka	10	7500	8.3	Gapion	1991
4	Fara	Rustaq	0.6	638	12	Rock Armour	1992
5	Fulayj (Halban)	Halban	3.7	4500	7.7	Gapion	1992
6	AL-Taww	Barka	5.1	3000	7,7	Gapion	1992
7	Ahin	Saham	6.8	5640	8	Gapion	1994
8	Hawasinah	Kabura	3.7	5900	6.8	Concrete Weir	1995

The Ministry of Agriculture and Fisheries prepared a master plan for building recharge dams in 1986. The original intention was to build 58 dams in preliminary identified sites, mostly on the coastal and interior sides of the northern mountains. During each 5-year development plan period, progress towards this aim is assessed and modifications are made in the light of experience.

Dams with significant storage have been constructed upstream of 4 of the wadi gauging stations, thereby having the effect of reducing the natural. Additional dams would be constructed in order to enhance artificial recharge and protect downstream areas from flooding; this may have significant impact on the flood peaks and on the proposed design of prospected road constructions in the region.

Figures 23.3-3 and 23.3-4 show the location and distribution of existing and proposed dams along Al Batinah Region. Locations of proposed dams are listed in Table 23.3 -3.

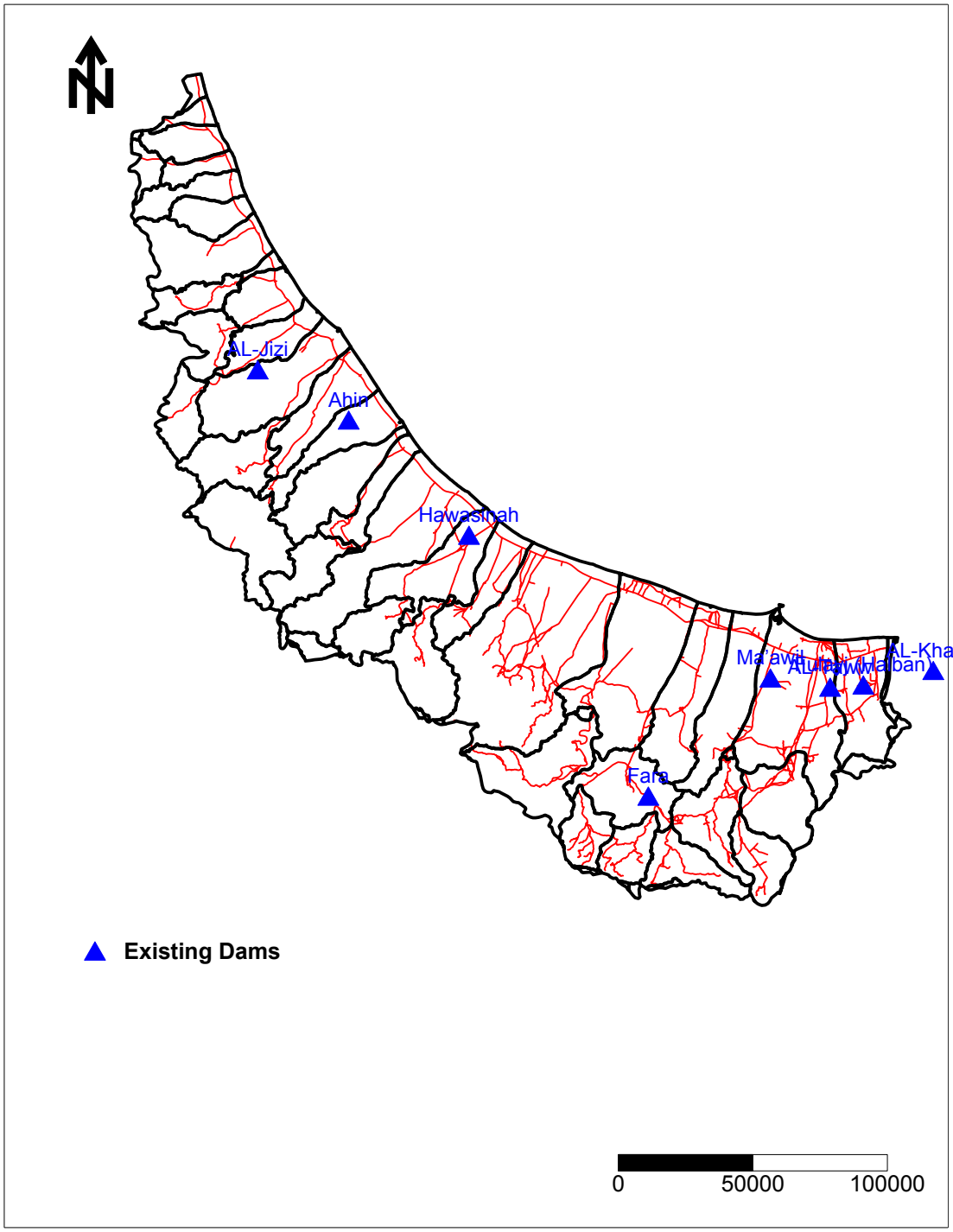


Figure 23.3-3 Locations of Existing Dams in Al Batinah Region.

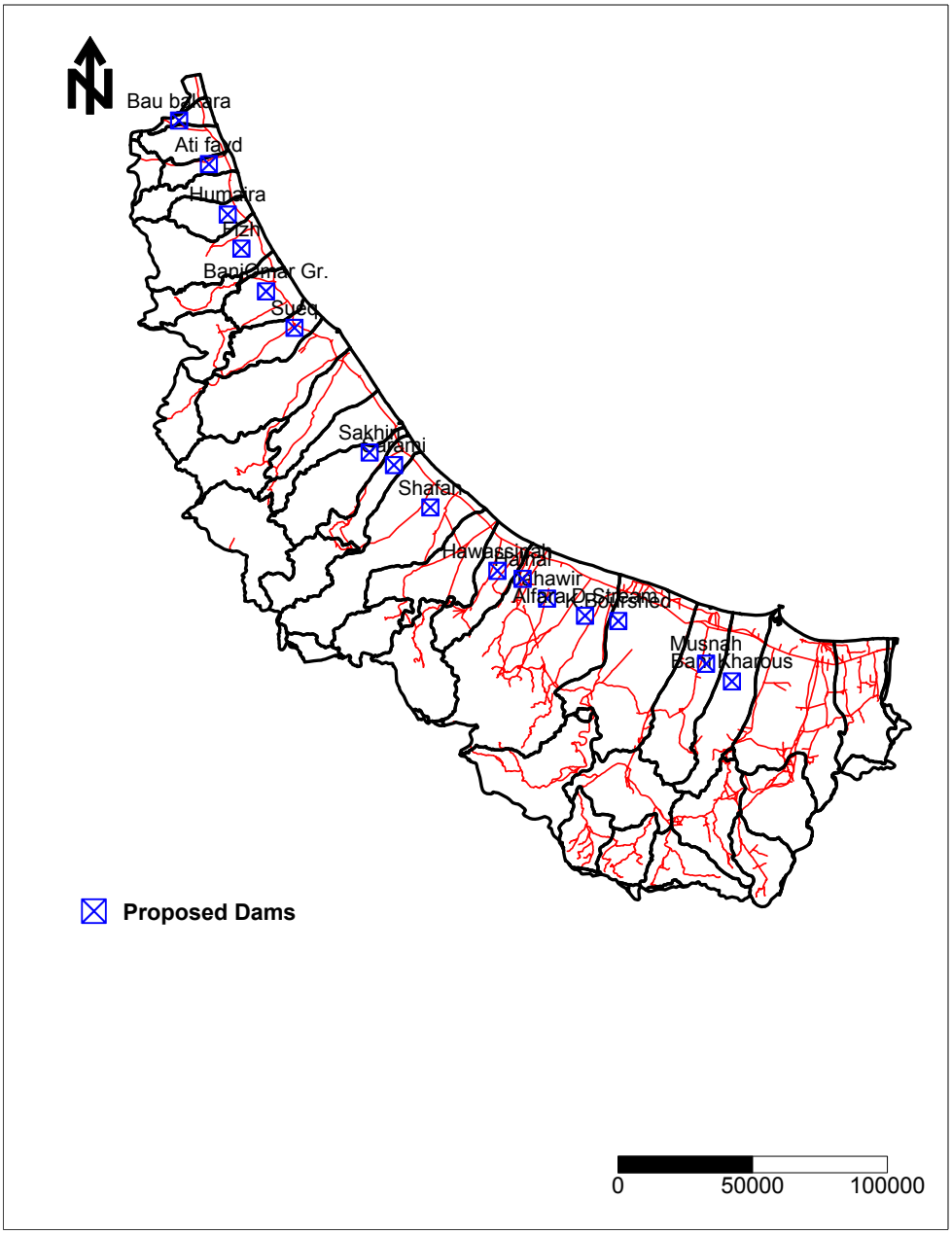


Figure 23.3-4 Locations of Proposed Dams in Al Batinah Region.

Table 23.3-3 Locations of Proposed Dams

X	**Y**	Wadi Name
568996.7	2612363	Bani Kharous
562545.8	2616725	Musnah
540756.5	2627353	K.Bourshed
523051.3	2632899	Jahawir
516994.8	2637795	Halhal
510706.4	2639791	Hawassinah
494045.4	2655547	Shafan
485018.7	2666035	Sarami
478962.2	2669191	Sakhin
460305.6	2700123	Sueq
431623.4	2751562	Bau bakara
439040.8	2740754	Ati fayed
443703	2728250	Humaira
447093.8	2719773	Fizh
453239.6	2709177	Bani Omar Gr.
532498.8	2628647	Alfara D.Stream

Figure 23.3-5 shows selected Dams along Al Batinah Region at Fulayj, Al Ma’awil and Jizzi.

Wadi Fulayj Barka Dam

Wadi Alma'awil Recharge Dam

Wadi Jizzi Recharge Dam

Figure 23.3-5 Fulayj, Al Ma'awil, and Jizzi Dams at Al Batinah Region

3) Dams Effect on Al Batinah Highway

Monitoring networks of rain gauges, wadi flow gauges and boreholes are installed at strategic sites behind and downstream of the dams.

Historically, a very severe flood occurred at the end of March 1997 on Wadi Hawasinah. Storm rainfall was exceptional at this time, and enormous flood volumes were also generated in Wadi Dank on the other side of the Hajar Mountains.

Despite Hawasinah Dam just upstream with 3.7 million m^3 of storage would normally expect to provide some degree of flood relief.

Khaburah was very badly affected by this flood, for which the volume recorded at the dam over the period 28 to 29 March was nearly 11 million m^3.

The flood peak at Khaburah wadi gauging station on this occasion was estimated to be 642 m^3/sec. The previous highest recorded flood at this location was 273 m^3/sec in 1982, which was also regarded as a severe event but clearly not in the same order as March 1997 event.

However, March 1997 flood flow largely bypassed the Khaburah wadi gauge by flowing to both south (at the proposed Irish bridge locations) and north. March 1997 was the highest full flood recorded. This is confirmed by the massive peak flow recorded out of the dam, which was remarkable of 2,764 m^3/s on 29th of March. The latter is expected to be a realistic estimate and probably much more accurate than the normal indirect measurements because it was based on the recorded depth of outflow over a smooth concrete spillway. This dam peak outflow would be expected to reduce somewhat as a result of flood plain storage in the 7 km to the Highway and some would also infiltrate. However, in such an intense flood, these effects would probably be relatively limited.

The main spillway directs flow along the main Wadi Hawasinah towards the Khaburah wadi gauge. There is a bottom outlet on the east of the dam which directs flow downstream towards the east of the wadi gauging station and probably towards the proposed Irish bridge. However, the capacity of this pipe outlet is quite small.

Immediately downstream of the spillway there are signs that there were significantly high flows passing along a scoured channel to the east of the spillway which probably also ended up at the site of the proposed Irish Crossing, and which therefore contributed to the terrible devastation caused by the floods in Khaburah itself.

In case of the wadi disgorges on the alluvial plains towards the sea such as the case in Al Batinah coast, it shows rapid decrease in the stream flow due to the spreading in alluvium and rapid infiltration of water. Part of the flood may reach the sea.

23.4 ESTIMATED ANNUAL CLOSING DAYS

In Section 23.3, Table 23.3-1 shows the location where the Irish Crossings are constructed at major wadi crossings. In spite of the relatively low cost of the Irish Crossings, the road is anticipated to be closed for several hours/few days every year. The number of closing hours/days is an important parameter in the economical assessment and evaluation of the road upgrading or construction of New Batinah Expressway.

In order to estimate the expected number of closing hours/days, it necessitates a detailed hydrological study of the area. The study requires several parameters such as long records of rainfall, flows, wadi details (complete drainage survey), catchment's areas, levels etc. Type of storms (shape, dimension, peak values) and correlation among measuring stations have to be related to reach those hydrological parameters.

In this Study, analysis on the available data of some wadies has been carried out to estimate the numbers of closing hours/days in Al Batinah Region.

Bearing in mind that the results obtained from the preparation of Flood Frequencies Maps shows a homogeneous distribution values along the highway, the judgment at specified catchment can be extrapolated to the neighboring catchments in the region with acceptable accuracy level. Wadi Jizzi has been selected as a representative wadi for the estimation of annual closing hours/days. The analysis is based on the following assumptions:

1- The probabilities of rainfall occurrence in two rain gages separated a maximum distance of about 35 km is 0.6 (Hofman and Rambow, 1995).

2- The storm lasts only 1-3 hours.

3- The runoff may last up to 18 hours.

4- If the water levels exceed 25 cm the Irish crossing location is closed for normal vehicles and if exceed 40 cm it is closed even for 4WD vehicles.

5- The smallest unit of closing the road is counted in days.

23.4.1 Rainfall Intensities for Durations up to 24 Hours

Rainfall intensities for durations up to 24 hours were derived by (SWS) using a station-year approach with all available data based on more than 1,000 station-year. Storm intensities are needed for both the rational formula approach to design floods for small catchment's areas and for the development of design storm profiles for full hydrograph analyses. They are also needed for urban or paved area drainage analyses.

The frequencies are divided into 3 terrain categories plains, hills and mountains. Figures 23.4-1 and 23.4-2 show the results of Rainfall Intensity Frequencies of 12 and 24 hours for plain, hills and mountains terrain, respectively.

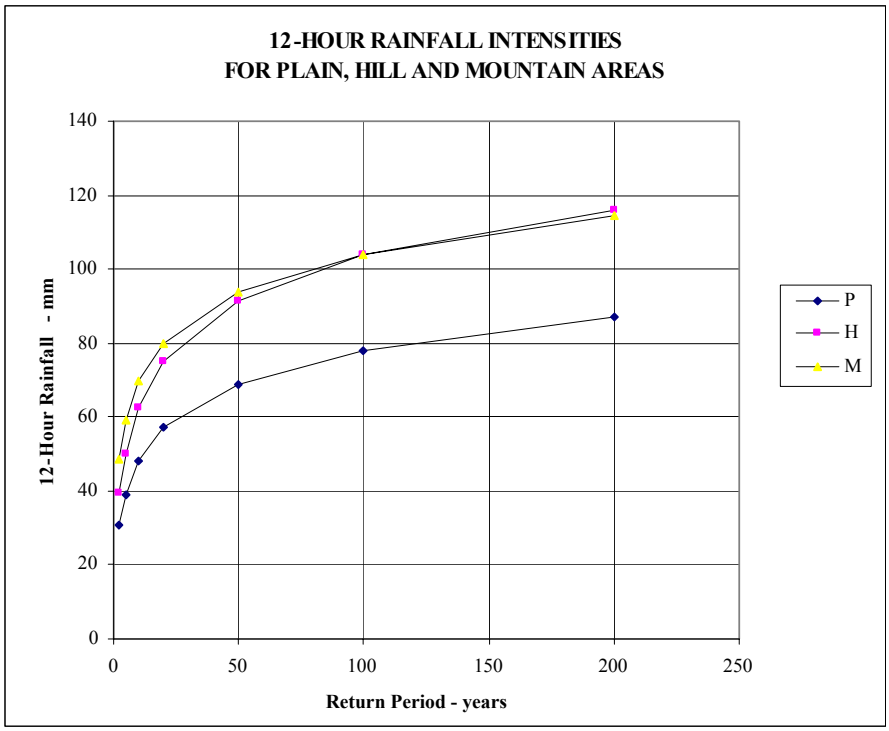


Figure 23.4-1 Rainfall Intensity Frequencies of 12 Hours for Plain, Hills and Mountains.

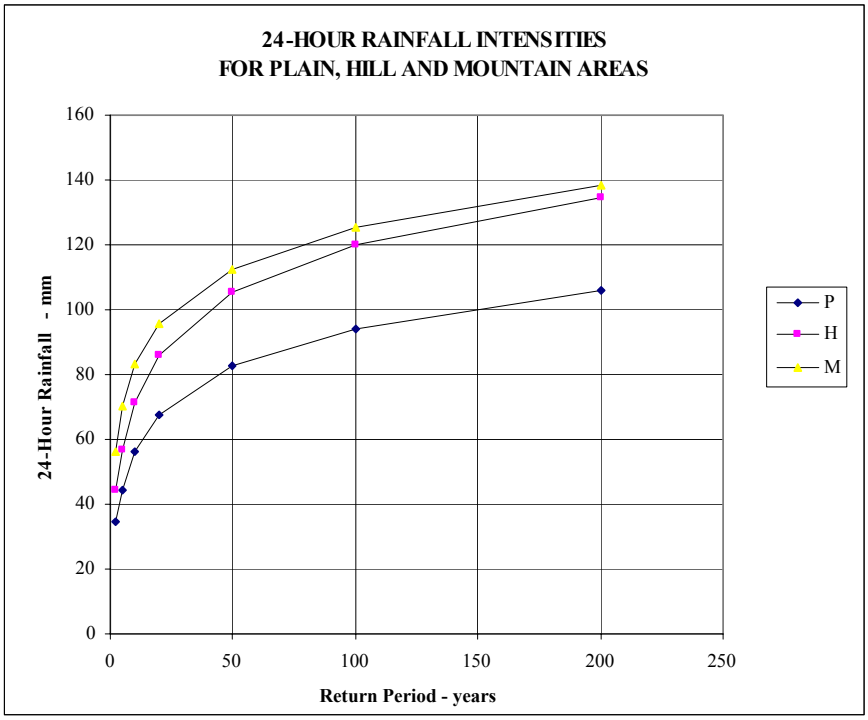


Figure23.4-2 Rainfall Intensity Frequencies of 24 Hours for Plain, Hills and Mountains.

23.4.2 Daily Rainfall Frequencies

Storm rainfall frequencies for durations of 1 day to 3 days have been computed using the station-year approach for all long term rainfall stations. The results have been published in the report: "Daily Rainfall Frequencies for Oman" (SWS 2000).

The results of 1-day, 2-days and 3-days maximum rainfall frequency plots are shown on Figure 23.4-3 for plain areas of Northern Oman.

Plain Area Daily Max. Rainfall Frequencies
(POT Series, Log Pearson III)

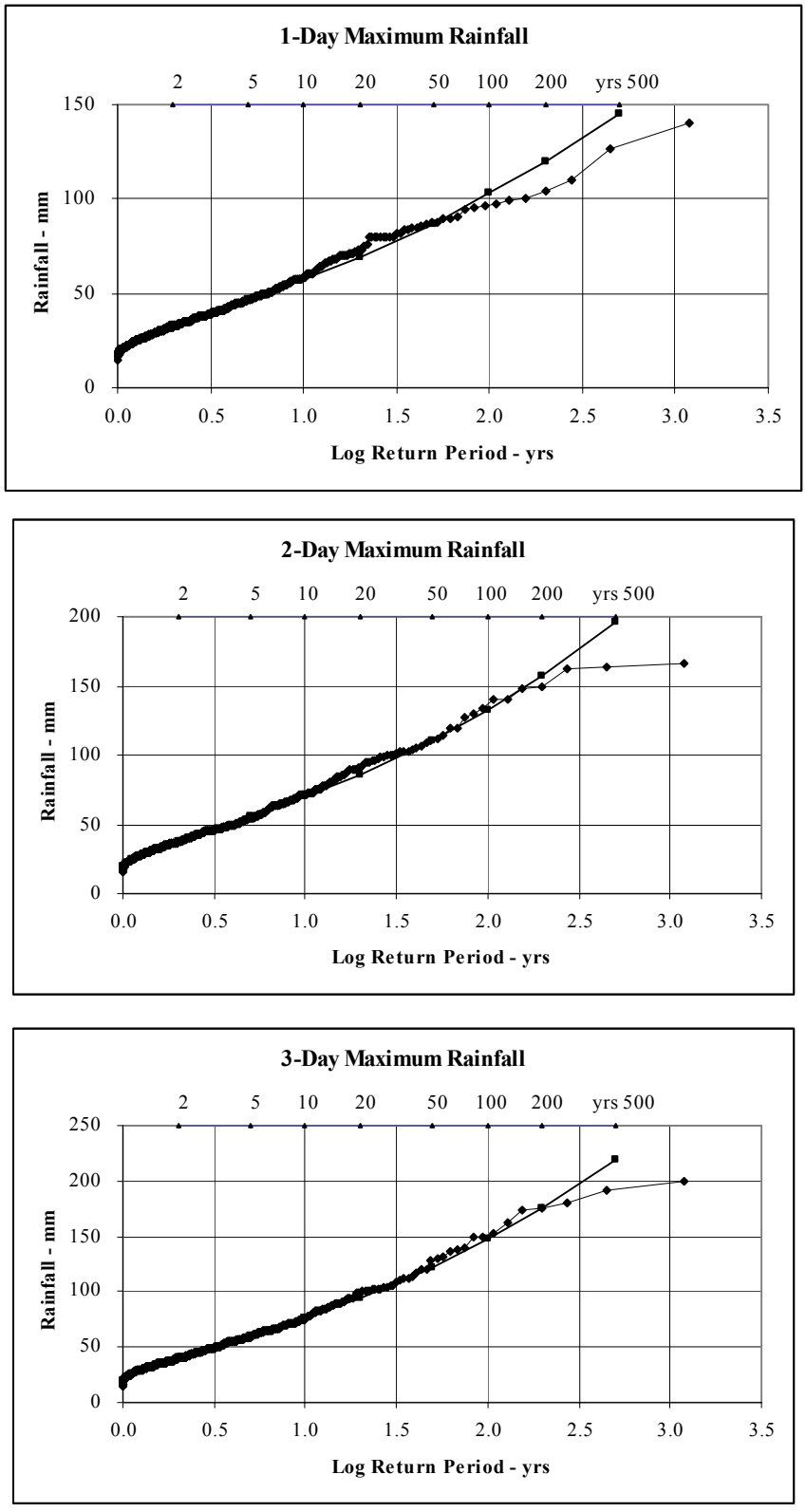


Figure 23.4-3 Maximum Rainfall Frequency Plots for Plain Areas of Northern Oman

Table 23.4-1 summarizes the maximum recorded 1-day rainfalls more than 100 mm in the northern and southern Al Batinah Region.

Table 23.4-1 Maximum Recorded 1-Day Rainfalls (>100 mm) in Al Batinah Region

Station	Basin	Elevation (m)	Max. Rain (mm)	Date
Shinas	Faydh	10	100	14/02/1982
Liwa	B Umar al Gharbi	15	104	17/02/1988
Majis	Suq	4	110	17/02/1988
Kitnah	Jizi	650	124	18/02/1988
Daqeeq	Jizi	840	105	18/02/1988
Hayl al Adhah	Jizi	430	113	14/02/1982
Hayl al Adhah	Jizi	430	108	18/02/1988
Al Khan	Jizi	420	122	18/02/1988
OMC	Jizi	275	105	18/02/1988
Ar Raqah	Hilti	197	134	18/02/1988
Adh Dharat	Hilti	160	111	18/02/1988
Sohar	Hilti	15	115	23/02/1988
Al Masarah	Ahin	910	162	29/03/1997
Ghushayn	Shafan	620	140	29/03/1997
Rahbah B Umar	Hawasinah	820	102	26/03/1997
Rahbah B Umar	Hawasinah	820	106	30/03/1997
Majzi 1	Hawasinah	475	104	30/03/1997
J Rustaq South	Fara	1810	109	22/07/1995

The adopted method for the estimation the expected number of closing days per year along Al Batinah Highway due to heavy rain falls can be summarized as follow:

1- Specify the catchment that can be considered as a representative sample for the Batinah Highway.
2- Determine the average number of rainy days for the selected wadi/catchment's (N_1).
3- Determine the ratio of the days that the rainfall intensity will exceeds the mean rain fall (R_1).
4- Determine the number of rainy days when the rainfall intensity exceeds the mean rainfall intensity (N_2) by the following equation:

$$N_2 = N_1 \times R_1$$

5- Estimate the storm coverage length.

6- Based on the estimated storm coverage length, estimate the ratio (R_2) and probability (P_r) that the road section under consideration will share the storm.
7- Calculate the number of closing days (D_c) by the following equation:

$D_c = N_2 \times R_2 \times P_r$

8- Assume that a fraction of closing day will be approximate to one full day.

The abovementioned procedure has been adopted to estimate the number of closing days along Al Batinah Highway as follows:

1- Al Jizzi catchment is selected as a typical case of Al Batinah Highway, Table 23.4-2.
2- The average number of rainy days $N_1 = 16$ days
3- The ratio of the days that the rainfall intensity will exceeds the mean rain fall $R_1 = 0.75$.
4- The number of rainy days when the rainfall intensity exceeds the mean rainfall intensity $N_2 = N_1 \times R_1 = 16 \times 0.75 = 12$ days
5- The storm coverage length is about 35 km.
6- Based on the estimated storm coverage length, the estimated ratio R_2 and probability P_r that the road section under consideration will share the storm are 0.75 and 0.60, respectively.
7- The number of closing days $D_c = N_2 \times R_2 \times P_r = 0.75 \times 0.60 \times 12 = 5.4$ days
8- Assume that a fraction of closing day will be approximate to one full day then the number of closing days is 6 days.

Table 23.4-2 Frequency Analysis for Rain Gauge Stations: Wadi Jizzi.

Rainfall Stations	Recorded Hydrological years	Mean Rainfall	No. of events exceeding mean Rainfall	No. of events below mean Rainfall
Hayl (DM271711AF)	18	111.7	7	11
Kitnah (DM260958AF)	18	113.2	7	11
Daqiq (DM264436AF)	14	163.8	5	9
Far (DM374569AF)	17	136.5	7	10
Al Hayl (DM382737AF)	16	102.1	7	9

Magnitude of depth can be evaluated on the basis normal and critical depths and velocities indicated in Appendix 23-1, Table 23-4.

Table 23.4-3 shows approximate estimated duration of flood peaks along Al Batinah Highway by utilizing Figure 23.2-2 (Frequency of Rainfall Intensities for Plain, Hills and Mountains) shown early in Section 3.2 and the calculated time of concentrations relevant to the ad hoc catchment's areas.

Based on Table 23.4-3 calculations, the estimated duration of flood peaks along Al Batinah Highway, reveals that flood is 18 hours at maximum in usual cases.

Table 23.4-3 Estimated Duration of Flood Peaks along Al Batinah Highway.

Crossing No.	Catchment's	Flood Peak at I.C (m^3/sec) 50 years R.P.	Critical Depth (m)	Depth (m)	Max. Rain fall (mm)	Duration of Flood Hours T_C
5	6 Wadi Bani Gafir	300	0.467	0.533	70	3-6
6		300	0.467	0.533	70	
9	9 Wadi Hawassinah	650	0.782	0.847	105	10-12
10		650	0.882	0.945	105	
11	10 Wadi Shafan	350	0.517	0.584	140	16-18
12		400	0.356	0.418	140	
13		450	0.612	0.68	140	
30	20 Wadi Bidah	650	1.023	1.08	100	10-12

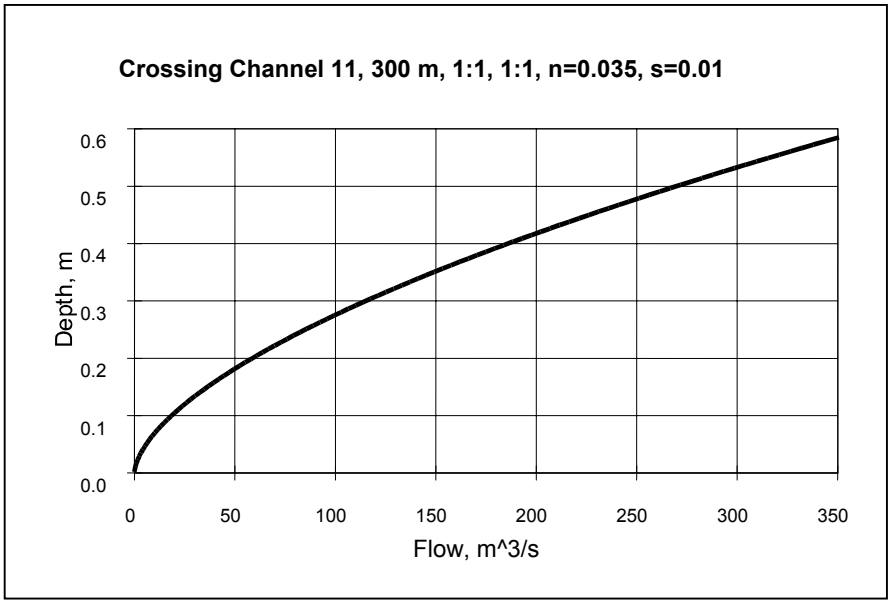
1 day maximum rainfall frequency, for 50 years return period is 80 mm for the plain areas.
2 day maximum rainfall frequency for 50 years return period is 112 mm for the plain areas.
3 day maximum rainfall frequency for 50 years return period is 150 mm for the plain areas.

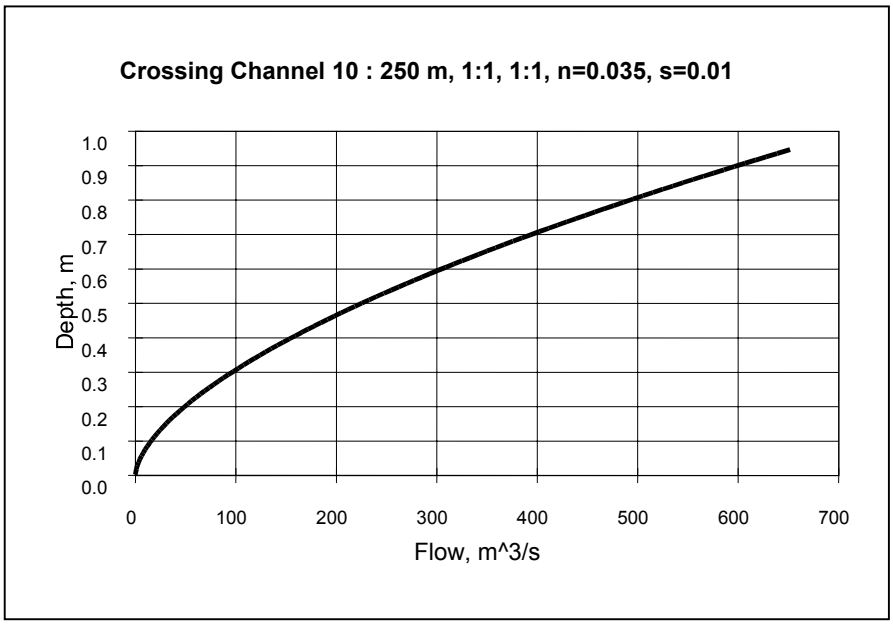
23.4.3 Calculation of Rating Curves

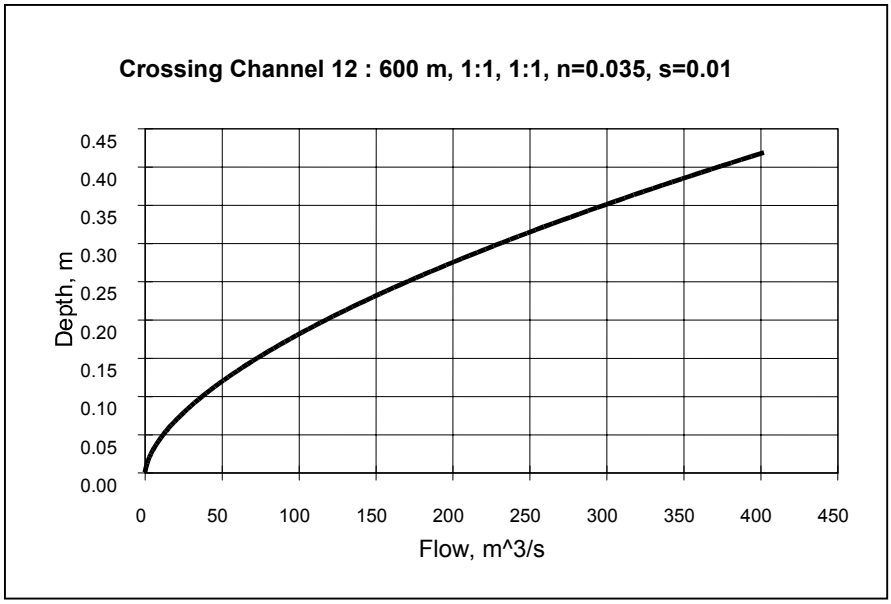
Manning Solver Programme has been used in order to evaluate the existing Irish Crossings hydraulic conditions. This software solves Manning Formula for irregular circular, trapezoidal, triangular and rectangular channels, and can either be solved for depth of water in the channel or flow.

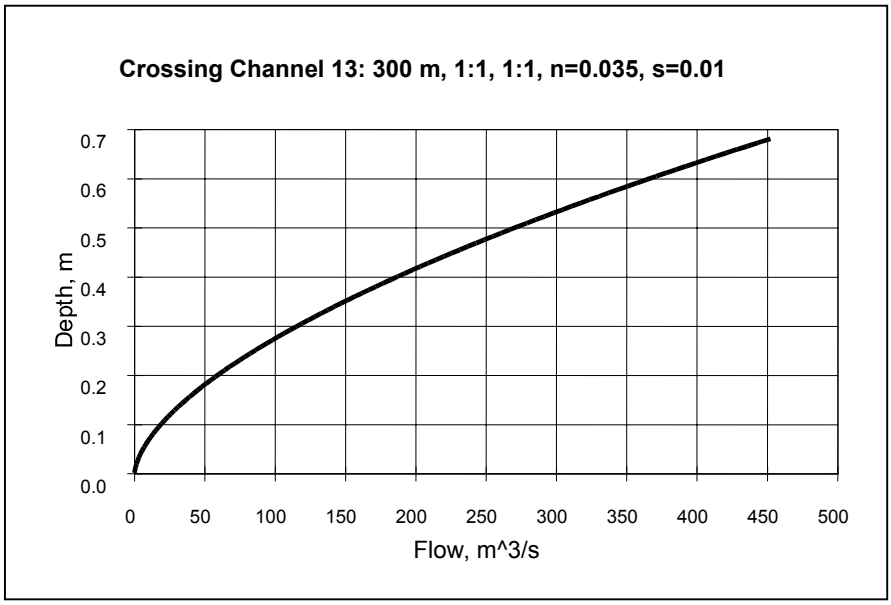
The calculation has been applied on the screened Irish Crossings in order to evaluate flow-depth relationship and velocities at downstream discharging points. The following figures illustrating the results of ad hoc calculation under assumed conditions as indicated on the Figure 23.4-4.

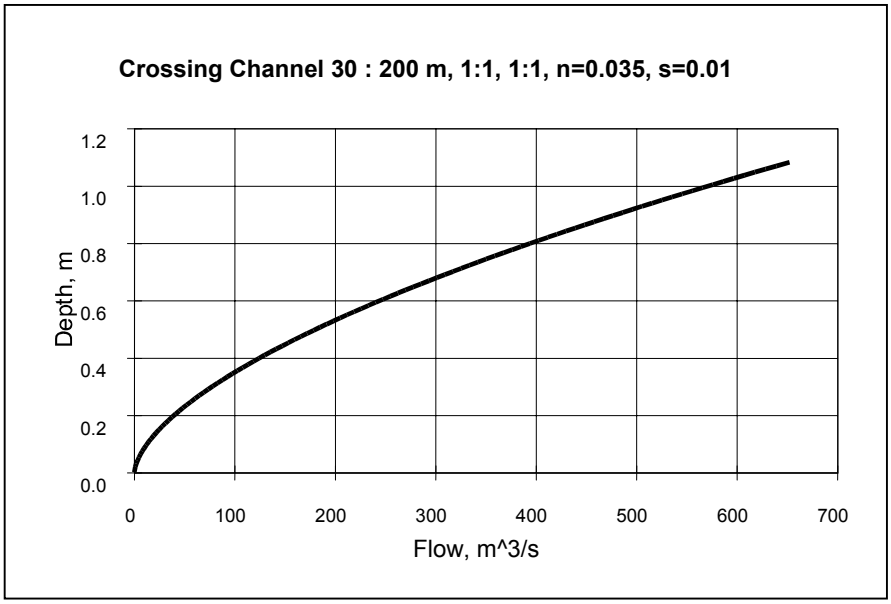
Upon detailed field investigations refinement to the parameters could be applied. The results of rating curves of the selected wadis can be used up to 1 meter depth. The discharge flow records could be used to find where wadis water depth exceeds a certain height as requested.

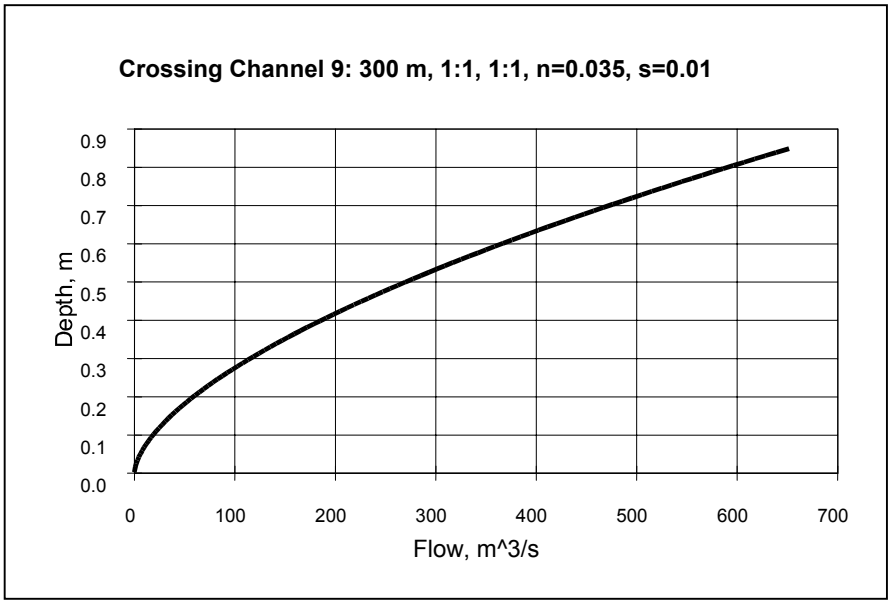

Crossing Channel 11, 300 m, 1:1, 1:1, n=0.035, s=0.01
Depth, m
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0
50
100
150
200
250
300
350
Flow, m^3/s


Crossing Channel 10 : 250 m, 1:1, 1:1, n=0.035, s=0.01
Depth, m
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0
100
200
300
400
500
600
700
Flow, m^3/s


Crossing Channel 12 : 600 m, 1:1, 1:1, n=0.035, s=0.01
Depth, m
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
50
100
150
200
250
300
350
400
450
Flow, m^3/s


Crossing Channel 13: 300 m, 1:1, 1:1, n=0.035, s=0.01
Depth, m
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
50
100
150
200
250
300
350
400
450
500
Flow, m^3/s


Crossing Channel 30 : 200 m, 1:1, 1:1, n=0.035, s=0.01
Depth, m
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
500
600
700
Flow, m^3/s


Crossing Channel 9: 300 m, 1:1, 1:1, n=0.035, s=0.01
Depth, m
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
100
200
300
400
500
600
700
Flow, m^3/s

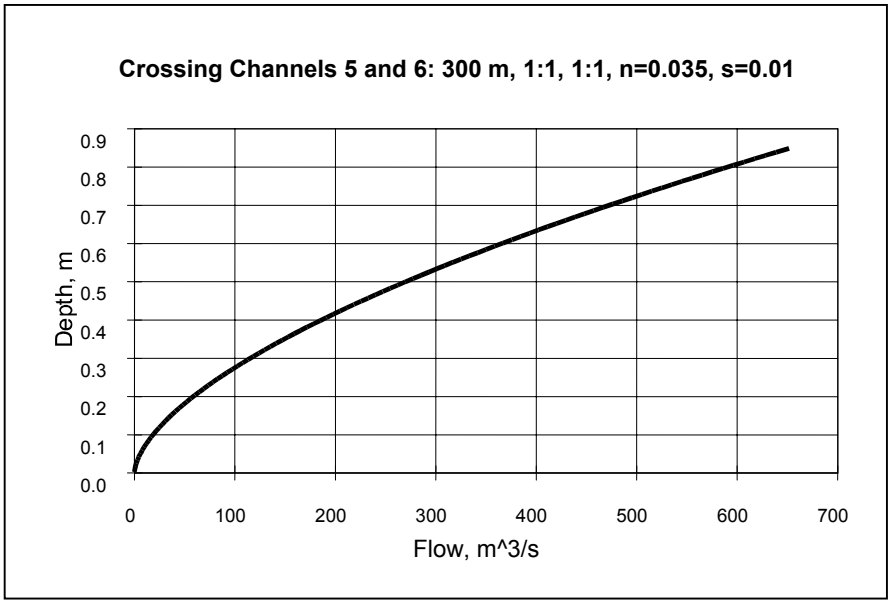


Figure 23.4-4 Results of Rating Curves of the Proposed Rehabilitative Irish Crossings of Al Batinah Region

23.5 MULTI-FUNCTION CULVERTS

23.5.1 Concept of Multi-Function Culverts

One of the major problems of Batinah Highway is crossings of pedestrians and vehicles, which constitutes one of major causes of traffic accidents. Main cause of crossings of pedestrians and vehicles is lack of proper crossing facilities.

On the section of Batinah Highway between Bait Al Barka R/A and Khatmat Milahah (UAE border), there is no pedestrian bridge or underpass. On this section, all the intersection, except roundabouts are at-grade intersections. Even at roundabouts, pedestrians have to cross carriageways.

In current practice, inner height of a usual box culvert is 1.5 m or less. If height of a culvert is 2 m or more, pedestrians can walk through the culvert. If the inner height is around 3 m or more and the inner width is around 3 m or more, ordinary small vehicles (passenger cars and small trucks) can pass through. Therefore, box culverts used as "Irish bridges" can have the functions of underpass for pedestrians and vehicles if the height and width of the culverts are larger. In this report, such culverts with functions as Irish bridge and underpass for pedestrians and/or vehicles are referred to as "**multi-function culverts**". Figure 23.5-1 shows schematic drawing of multi-function culverts.

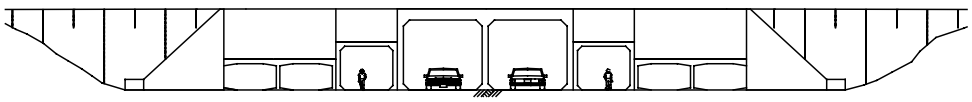


Figure 23.5-1 Schematic Drawing of Multi-Function Culvert

As explained later, increases of construction cost for 2.5 m (height) x 3.0 m (width) culverts for pedestrian crossing and 4.5 m x 4.0 m culverts for vehicle crossing, compared with that of ordinary 3.0 m x 1.5 m culverts, are estimated to be about 20 % and 30 %, respectively.

Based on the above consideration, constructing multi-function culverts, instead of ordinary Irish bridges, is discussed here.

23.5.2 Existing Irish Crossings

There are 31 Irish crossings on Batinah Highway between Bait Al Barka R/A and UAE border (Khatmat Milahah). Figure 23.5-2 shows location of these Irish crossings. Tabel 23.5-1 shows the width of wadi (length of the bottom section of Irish crossing), depth of wadi and lengths of approach sections on both sides of wadi at each Irish crossing.

23.5.3 Preliminary Cost Estimates

1) Basic Assumption

In estimating the cost of converting existing Irish crossing into culverts, the followings are assumed.

Types of culverts
Three types of culverts are assumed:

Type 1: W 3.0 m x H 1.5 m (conventional Irish bridge)
Type 2: W 3.0 m x H 2.5 m (pedestrian crossing)
Type 3: W 4.5 m x H 4.0 m (vehicle underpass)

Approach section on both side of culvert section

Since the depth of wadi is less than 2.5 m in many cases, the top of the culverts become higher than the elevation of adjacent road section. Accordingly, approach section need to be constructed on the both sides of the culverts. The grade of these approaches is assumed to be 3 %. Road structure of approach sections is embankment with 1:2.0 slope.

Unit cost
Unit costs of similar items used in other Pre-Feasibility Studies (Chapters 18 to 21) are used.

2) Comparison of Total Cost by Type of Culverts

Total cost of converting 31 Irish crossings into culverts is estimated based on the above assumptions. Table 23.5-2 shows the estimated total costs. Total costs are estimated for the following the three cases.

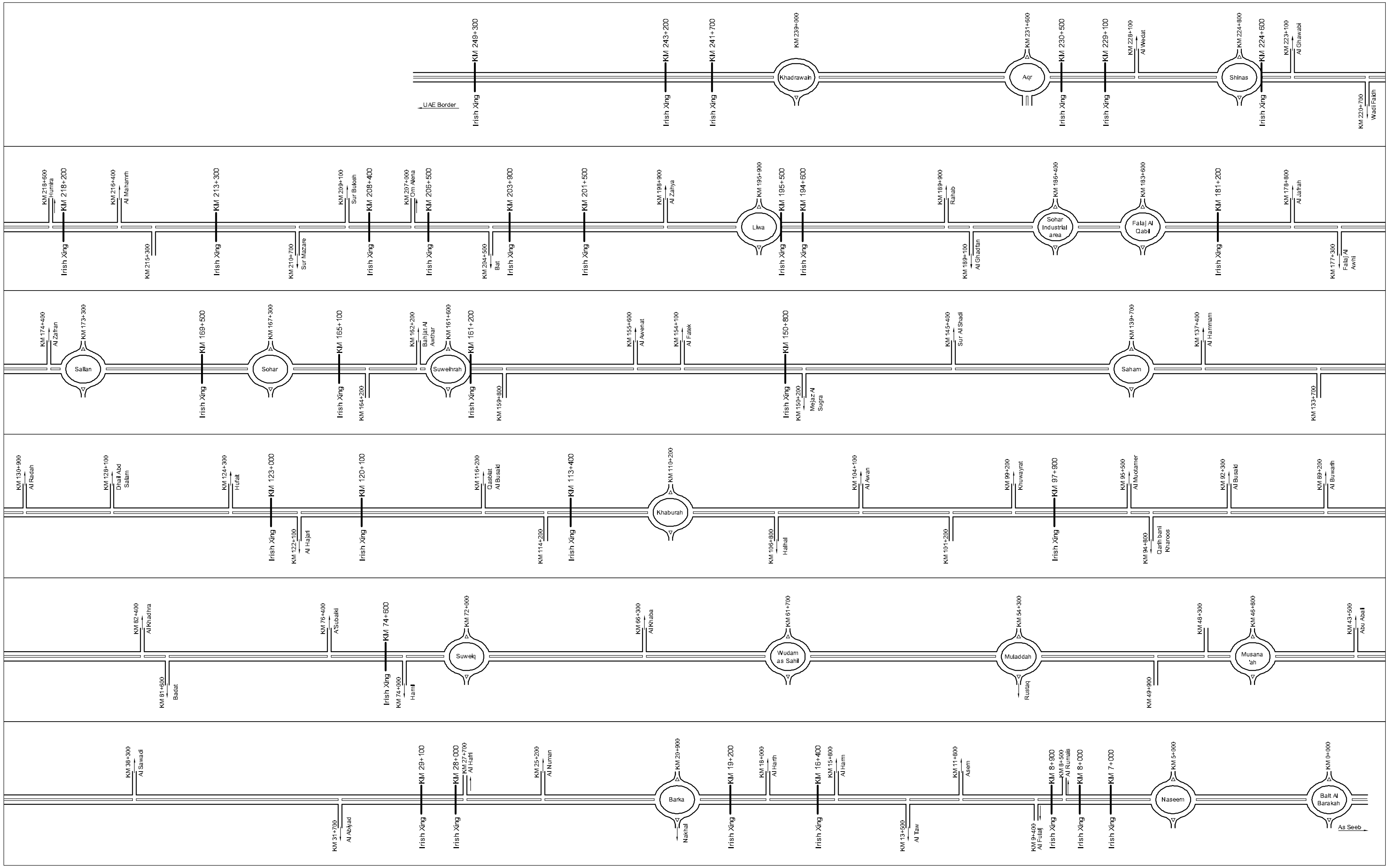
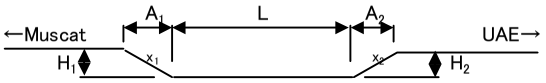
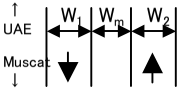


Figure 23.5-2 Location Map of Irish Crossing on Batinah Highway

Table 23.5-1 List of Irish Crossing on Batinah Highway





No.	Station	Irish crossing length, approach length and approach height					Slope Inclination		Road width (m)		
		A_1 (m)	L (m)	A_2 (m)	H_1 (m)	H_2 (m)	x1(%)	x2(%)	W_1	W_m	W_2
1	7+000	139	110	78	0.60	0.80	0.43	1.03	11.0	8.0	12.0
2	8+000	145	182	134	0.55	0.55	0.38	0.41	10.0	8.7	12.0
3	8+900	89	238	156	0.90	0.40	1.01	0.26	11.4	7.7	13.0
4	16+400	164	47	204	1.40	0.90	0.85	0.44	11.2	6.4	12.3
5	19+200	95	96	127	2.10	1.10	2.21	0.87	11.3	7.0	13.1
6	28+000	171	126	195	2.60	0.80	1.52	0.41	10.4	7.9	12.7
7	29+100	114	65	137	1.20	1.40	1.05	1.02	11.3	7.5	12.7
8	74+600	124	144	158	1.60	1.10	1.29	0.70	10.7	7.5	13.0
9	97+900	148	158	217	2.00	1.50	1.35	0.69	11.0	7.5	13.0
10	113+400	232	254	215	3.05	1.55	1.31	0.72	11.5	7.3	12.7
11	120+100	218	116	176	2.75	1.80	1.26	1.02	11.2	7.5	14.7
12	123+000	120	173	191	1.20	1.60	1.00	0.84	11.0	7.5	13.0
13	150+800	186	50	238	2.00	3.40	1.08	1.43	12.0	6.7	12.8
14	161+200	263	60	128	4.05	2.15	1.54	1.68	10.0	8.9	13.1
15	165+100	186	56	197	3.55	2.95	1.91	1.50	10.0	9.8	11.8
16	169+500	114	47	144	2.20	1.50	1.93	1.04	11.5	6.6	13.1
17	181+200	170	172	161	1.60	1.70	0.94	1.06	10.6	7.1	13.0
18	194+600	165	65	210	1.40	0.20	0.85	0.10	11.2	7.4	13.1
19	195+500	134	20	179	1.40	1.20	1.04	0.67	10.7	7.6	12.6
20	201+500	20	43	184	1.50	1.20	7.50	0.65	11.1	8.5	13.0
21	203+900	133	61	181	1.60	1.50	1.20	0.83	10.5	8.6	12.6
22	206+500	178	70	179	1.90	1.70	1.07	0.95	10.9	8.2	12.8
23	208+400	159	66	157	2.45	0.95	1.54	0.61	10.4	8.4	13.1
24	213+300	258	175	194	1.80	0.90	0.70	0.46	10.7	7.7	13.0
25	218+200	171	309	285	0.70	1.40	0.41	0.49	10.6	7.4	13.1
26	224+600	186	49	86	2.60	0.25	1.40	0.29	10.8	9.0	14.3
27	229+100	232	274	157	3.55	1.25	1.53	0.80	10.6	7.4	13.3
28	230+500	156	84	167	1.65	1.45	1.06	0.87	11.1	8.5	13.1
29	241+700	140	49	82	1.40	0.80	1.00	0.98	9.9	3.8	10.5
30	243+200	136	54	139	0.90	1.20	0.66	0.86	9.4	4.2	10.5
31	249+300	158	153	257	1.70	0.50	1.08	0.19	9.8	3.8	13.6
TOTAL		4,904	3,566	5,313					Ave. Road Width = 31.0m		

Case 1: Conventional Irish bridge

In this case, Type 1 culverts (3.0 m x 1.5 m) are assumed to be constructed at all the existing Irish crossings to let flood water pass Batinah Highway.

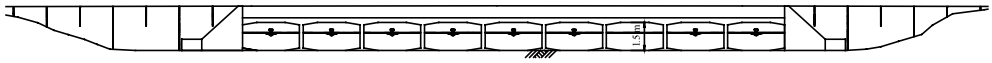
Case 2: Pedestrian underpass

In this case, Type 2 culverts (3.0 m x 2.5 m) are constructed for entire wadi width at all the existing Irish crossings to be used as pedestrian underpasses.

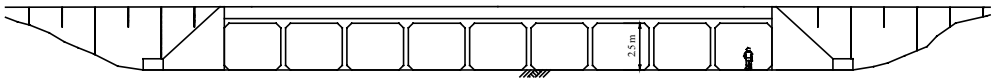
Case 3: Vehicle underpass

In this case, two cells of Type 3 culverts (4.5 m x 4.0 m) are constructed as vehicle underpasses. Type 2 culverts (3.0 m x 2.5 m) are constructed for the remaining section.

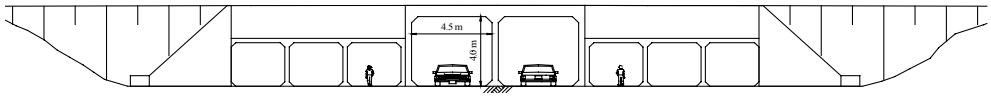
Figure 23.5-3 shows the concepts of these three cases.



(a) Case 1



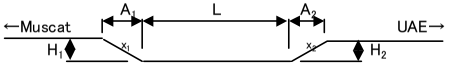
(b) Case 2

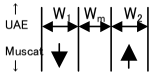


(c) Case 3

Figure 23.5-3 Conceptual Illustration of Three Cases

Table 23.5-2 Total Costs for Three Cases





No.	Station	Irish crossing length, approach length and approach height					Slope Inclination		Road width (m)			Project Cost (RO)		
		A_1 (m)	L (m)	A_2 (m)	H_1 (m)	H_2 (m)	x1(%)	x2(%)	W_1	W_m	W_2	Case-1	Case-2	Case-3
1	7+000	139	110	78	0.60	0.80	0.43	1.03	11.0	8.0	12.0	365,666	450,840	495,550
2	8+000	145	182	134	0.55	0.55	0.38	0.41	10.0	8.7	12.0	578,785	685,609	663,290
3	8+900	89	238	156	0.90	0.40	1.01	0.26	11.4	7.7	13.0	763,692	903,087	825,083
4	16+400	164	47	204	1.40	0.90	0.85	0.44	11.2	6.4	12.3	174,885	234,595	334,976
5	19+200	95	96	127	2.10	1.10	2.21	0.87	11.3	7.0	13.1	324,101	398,299	443,280
6	28+000	171	126	195	2.60	0.80	1.52	0.41	10.4	7.9	12.7	410,121	499,534	529,548
7	29+100	114	65	137	1.20	1.40	1.05	1.02	11.3	7.5	12.7	234,557	299,888	381,111
8	74+600	124	144	158	1.60	1.10	1.29	0.70	10.7	7.5	13.0	467,483	554,231	570,467
9	97+900	148	158	217	2.00	1.50	1.35	0.69	11.0	7.5	13.0	509,448	611,375	613,735
10	113+400	232	254	215	3.05	1.55	1.31	0.72	11.5	7.3	12.7	793,265	932,611	846,674
11	120+100	218	116	176	2.75	1.80	1.26	1.02	11.2	7.5	14.7	405,556	493,769	533,711
12	123+000	120	173	191	1.20	1.60	1.00	0.84	11.0	7.5	13.0	557,316	656,443	654,409
13	150+800	186	50	238	2.00	3.40	1.08	1.43	12.0	6.7	12.8	185,451	242,688	333,370
14	161+200	263	60	128	4.05	2.15	1.54	1.68	10.0	8.9	13.1	222,344	272,483	353,145
15	165+100	186	56	197	3.55	2.95	1.91	1.50	10.0	9.8	11.8	200,926	257,335	337,839
16	169+500	114	47	144	2.20	1.50	1.93	1.04	11.5	6.6	13.1	181,277	226,812	317,314
17	181+200	170	172	161	1.60	1.70	0.94	1.06	10.6	7.1	13.0	543,428	639,902	631,475
18	194+600	165	65	210	1.40	0.20	0.85	0.10	11.2	7.4	13.1	243,440	315,817	406,797
19	195+500	134	20	179	1.40	1.20	1.04	0.67	10.7	7.6	12.6	102,028	152,199	272,518
20	201+500	20	43	184	1.50	1.20	7.50	0.65	11.1	8.5	13.0	162,337	210,463	293,277
21	203+900	133	61	181	1.60	1.50	1.20	0.83	10.5	8.6	12.6	226,437	291,109	376,122
22	206+500	178	70	179	1.90	1.70	1.07	0.95	10.9	8.2	12.8	256,222	324,973	394,920
23	208+400	159	66	157	2.45	0.95	1.54	0.61	10.4	8.4	13.1	246,295	303,766	386,512
24	213+300	258	175	194	1.80	0.90	0.70	0.46	10.7	7.7	13.0	568,992	672,840	658,437
25	218+200	171	309	285	0.70	1.40	0.41	0.49	10.6	7.4	13.1	958,491	1,115,047	964,679
26	224+600	186	49	86	2.60	0.25	1.40	0.29	10.8	9.0	14.3	203,890	269,504	374,580
27	229+100	232	274	157	3.55	1.25	1.53	0.80	10.6	7.4	13.3	852,460	988,833	887,414
28	230+500	156	84	167	1.65	1.45	1.06	0.87	11.1	8.5	13.1	301,922	377,572	445,510
29	241+700	140	49	82	1.40	0.80	1.00	0.98	9.9	3.8	10.5	150,165	199,519	278,969
30	243+200	136	54	139	0.90	1.20	0.66	0.86	9.4	4.2	10.5	166,339	211,857	292,316
31	249+300	158	153	257	1.70	0.50	1.08	0.19	9.8	3.8	13.6	442,726	528,372	534,472
TOTAL		4,904	3,566	5,313					Ave. Road Width = 31.0m			11,800,042	14,321,372	15,431,500

Case-1 : Box 3.0*1.5
Case-2 : Box 3.0*2.5
Case-3 : 2-Box 4.5*4.0, 2-Box 3.0*2.5, Others : Box 3.0*1.5

Table 23.5-3 is summarized as Table 23.5-4 below:

Table 23.5-4 Summary of Total Cost

Case	Total Cost (RO mil.)	Comparison with Case 1
Case 1: Conventional Irish Bridge	11.80	-
Case 2: Pedestrian Underpass	14.32	+ 21.4 %
Case3: Vehicle Underpass	15.43	+ 30.8 %

As shown in the table, the increase of cost by constructing pedestrian-underpass-type culverts (2.5 m in inner height) is a little more than 20 % compared with the cost of constructing conventional type of culverts (1.5 m in inner height). The cost of constructing vehicle underpass is about 30 % higher than that of conventional culverts Irish bridge).

Considering relatively small difference of costs and large difference of functions between Types 1, 2 and 3, it is proposed that Type 1 is not constructed. In addition, crossing of pedestrians and vehicles will become more dangerous than present due to increase of traffic. Therefore, it is proposed that the minimum inner height of culverts be 2.5 m is used in the following discussions.

3) Proposed Type of Culverts

Table 23.5-5 shows the type of culvert to be constructed at each existing Irish crossing. These types are proposed based on the result of site survey on the conditions as listed below:

- Roadside land use
- Type of service (frontage) road
- Type of access road (road that runs parallel to wadi)
- Pedestrians or vehicles crossing Batinah Highway
- Others; such as nearby public facilities or shops and distance to nearby roundabouts

Figure 23.5-4 shows the site conditions of some of the existing Irish crossings where vehicle type culverts are proposed.

As shown in the table, the total construction cost of these culverts is approximately RO 14.67 million.

Figure 23.5-4 Condition of Site Where Vehicle Type Culvert is Proposed

4) Variation of Culvert Type

The arrangements of culverts described above are proposed based on the assumption that these culverts are not used during floods in wadi. There is a possibility that these culverts can be used during light wadi flows depending on the configuration of culverts and water channel in wadi. Figure 23.5-5 shows conceptual sketch of such configuration. However, careful consideration needs to be given to measures for entrance of flood water, during severe flood, to the culverts which is designed to be used by vehicles and pedestrians.

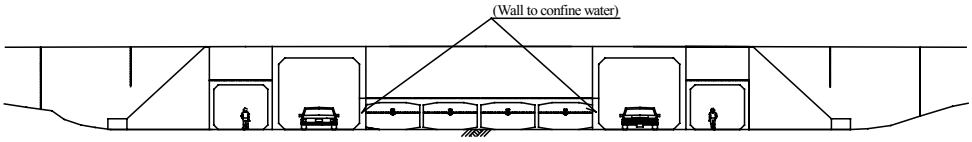


Figure 23.5-5 Conceptual Sketch of Multi-Function Culverts Usable During Light Flood

23.5.4 Provision of Underpass for Large Vehicles between Roundabout

In the future, at-grade intersections on Batinah Highway will become extremely hazardous due to increase of traffic volume. Even today, the existing at-grade intersections are supposed to be direct or indirect causes of traffic accidents. Therefore, it is recommended that DGR study possibility of prohibiting access to Batinah Highway at any other locations than roundabouts or grade-separated intersections with appropriate on-ramps and off-ramps.

When access to Batinah Highway is fully controlled, vehicles need detour to the grade-separated intersections. Where the structure of grade-separated intersection does not allow entrance of large vehicles, large vehicles have to detour to roundabouts. To avoid such situation, it is recommended to construct underpasses with sufficient clearance for large vehicles be constructed at appropriate locations. This kind of underpass (or overpass) will become necessary also when the New Batinah Expressway will be constructed and the traffic between the urbanized coastal area and the New Batinah Expressway will cross the existing Batinah Highway.

Such underpass can also provide U-turn way for the vehicles which want to go back for some reason.

Figure 23-5-6 shows concept of such underpass. Preliminarily estimated cost of such under pass is approximately RO 0.85 million/location. If such underpasses are to be constructed at an interval of 10 km, 17 underpasses are to be constructed. Accordingly, the total cost will become RO 14.45 million.

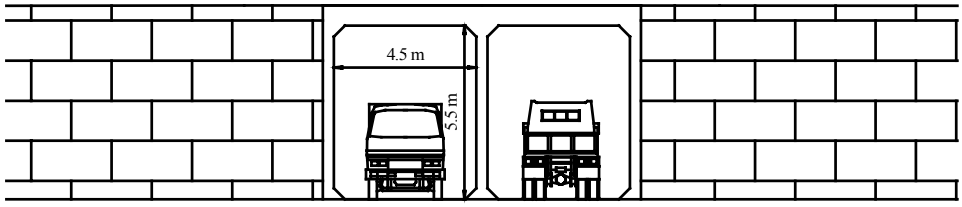


Figure 23.5-6 Conceptual Drawing of Underpass for Large Vehicles

Table 23.5-5 List of Proposed Culvert Type (1 / 3)

*) **Objective** ; V : Vehicle, P : Pedestrian, W : Water

No.	Station	L (m)	Ave. Depth(m)	Condition								Culvert type		Cost
				Land use		Service road		Access road		Road crossing pedestrian	Other condition	Objective*	Size	
				Left	Right	Left	Right	Left	Right					
1	7+000	110	0.7	Small shops	House, unused	Unpaved	Paved	Paved	Truck	Some	None	W	□ : 2-4.0*4.5 □ : 2-3.0*2.5 ■ : Multi-3.0*2.5 □ : Multi-3.0*1.5	450,840
2	8+000	182	0.6	Unused	Unused	Paved	Paved	Truck	Paved 100m	None	Natural off ramp for RUMAIS EXCHANGE(Oman Tel) at right side Traffic is heavy at right service road	V	■ : 2-4.0*4.5 ■ : 2-3.0*2.5 □ : Multi-3.0*2.5 ■ : Multi-3.0*1.5	663,290
3	8+900	238	0.7	Farm, unused	Building, house	Paved	Paved	Truck	None	None	Water flows under the fence Left side deep wadi Government office right side	W	□ : 2-4.0*4.5 □ : 2-3.0*2.5 ■ : Multi-3.0*2.5 □ : Multi-3.0*1.5	903,087
4	16+400	47	1.2	Farm	Farm	Unpaved	Paved	None	None	None	Deep wadi	V	□ : 2-4.0*4.5 □ : 2-3.0*2.5 ■ : Multi-3.0*2.5 □ : Multi-3.0*1.5	234,595
5	19+200	96	1.6	Unused	Unused	Paved	Paved	None	None	None	Barka Factory for Omani Sweet at right side Near Barka R/A Strong protection indicating wadi flow Heavy traffic on service road	W	□ : 2-4.0*4.5 □ : 2-3.0*2.5 ■ : Multi-3.0*2.5 □ : Multi-3.0*1.5	398,299
6	28+000	126	1.7	Unused	Unused	Paved	Paved	Unpaved	Paved	None	Road coming from right side Heavy dump truck using U-turn lane before wadi Heavy traffic on left side truck road Strong protection for Irish crossing	V	■ : 2-4.0*4.5 ■ : 2-3.0*2.5 □ : Multi-3.0*2.5 ■ : Multi-3.0*1.5	529,548
7	29+100	65	1.3	Unused	Unused	Unpaved	Paved	None	Truck	None	Strong protection for Irish crossing	W	□ : 2-4.0*4.5 □ : 2-3.0*2.5 ■ : Multi-3.0*2.5 □ : Multi-3.0*1.5	299,888
8	74+600	144	1.4	Unused	Unused	Paved	Being paved	Truck	Truck	None	None	V	■ : 2-4.0*4.5 ■ : 2-3.0*2.5 □ : Multi-3.0*2.5 ■ : Multi-3.0*1.5	570,467
9	97+900	158	1.8	Unused	Unused	Paved	Paved	None	None	None	Strong protection for Irish crossing, also service road Building at Sohar side	W	□ : 2-4.0*4.5 □ : 2-3.0*2.5 ■ : Multi-3.0*2.5 □ : Multi-3.0*1.5	611,375
10	113+400	254	2.3	House	Farm	Paved	Paved	Truck	None	None	Both side farm land with fence before 1km to wadi Water channel is defined by both side fences	W	□ : 2-4.0*4.5 □ : 2-3.0*2.5 ■ : Multi-3.0*2.5 □ : Multi-3.0*1.5	932,611
11	120+100	116	2.3	Unused	Unused	Paved	Paved	Truck	Truck	None	Both side farm land with fence before 1km to wadi Continuous fence at right side Strong protection for Irish crossing	W	□ : 2-4.0*4.5 □ : 2-3.0*2.5 ■ : Multi-3.0*2.5 □ : Multi-3.0*1.5	493,769

Table 23.5-5 List of Proposed Culvert Type (2 / 3)

*) **Objective** ; V : Vehicle, P : Pedestrian, W : Water

No.	Station	L (m)	Ave. Depth(m)	Condition								Culvert type		Cost
				Land use		Service road		Access road		Road crossing pedestrian	Other condition	Objective*	Size	
				Left	Right	Left	Right	Left	Right					
12	123+000	173	1.4	Unused	Farm	Paved	Paved	Paved	Paved	None	Both side farm land with fence before 1km to wadi Electric Pole protected by gabion HAFIT Exchange(Oman Tel) at right side Many access roads Government office before 300m to wadi Wide wadi at upstreami Near R/A	W	□ : 2-4.0*4.5 □ : 2-3.0*2.5 ■ : Multi-3.0*2.5 □ : Multi-3.0*1.5	656,443
13	150+800	50	2.7	House	House	Paved	Paved	Truck	Paved	None	Mosk, houses and shops before wadi Entrance of Sohar after wadi School bus coming from left side truck road 2 paved access road at right side	V	■ : 2-4.0*4.5 ■ : 2-3.0*2.5 □ : Multi-3.0*2.5 ■ : Multi-3.0*1.5	333,370
14	161+200	60	3.1	Unused	Mosk	Paved	Paved	None	None	None	1 km before Sweihrah R/A Maybe together with grade separation Sweihrah R/A Bus stop	W	□ : 2-4.0*4.5 □ : 2-3.0*2.5 ■ : Multi-3.0*2.5 □ : Multi-3.0*1.5	272,483
15	165+100	56	3.3	House, unused	House	Paved	Paved	Truck	None	None	Aquafina signboard Stadium near Automobil show room	W	□ : 2-4.0*4.5 □ : 2-3.0*2.5 ■ : Multi-3.0*2.5 □ : Multi-3.0*1.5	257,335
16	169+500	47	1.9	Farm	House, Mosk	Paved	Paved	Truck	None	None	Football ground at right side Off ramp to the right before wadi Service road protected for irish crossing	V	■ : 2-4.0*4.5 ■ : 2-3.0*2.5 □ : Multi-3.0*2.5 ■ : Multi-3.0*1.5	317,314
17	181+200	172	1.7	Farm , desert	Farm , desert	Unpaved	Paved	Truck	None	None	Wide wadi Service road protected for irish crossing	W	□ : 2-4.0*4.5 □ : 2-3.0*2.5 ■ : Multi-3.0*2.5 □ : Multi-3.0*1.5	639,902
18	194+600	65	0.8	Small shops	Small village, House	Paved	Unpaved	Truck	Truck	Some	Both side farm land before 1 km to wadi Bus stop right side before wadi	V	■ : 2-4.0*4.5 ■ : 2-3.0*2.5 □ : Multi-3.0*2.5 ■ : Multi-3.0*1.5	406,797
19	195+500	20	1.3	Semi-urban	Semi-urban	Paved	Paved	Truck	None	Some	1 km before R/A Service road protected for irish crossing Irish crossing protection broken at downstream side Semi urban area	W	□ : 2-4.0*4.5 □ : 2-3.0*2.5 ■ : Multi-3.0*2.5 □ : Multi-3.0*1.5	152,199
20	201+500	43	1.4	Small village	Small village	Unpaved	Paved	None	None	None	A' Rumilah 3km	W	□ : 2-4.0*4.5 □ : 2-3.0*2.5 ■ : Multi-3.0*2.5 □ : Multi-3.0*1.5	210,463
21	203+900	61	1.6	House	House	Unpaved	Paved	Truck	Truck	None	Government office before 1 km to wadi	W	□ : 2-4.0*4.5 □ : 2-3.0*2.5 ■ : Multi-3.0*2.5 □ : Multi-3.0*1.5	291,109
22	206+500	70	1.8	Farm	Farm	Unpaved	Unpaved	None	None	None	None	W	□ : 2-4.0*4.5 □ : 2-3.0*2.5 ■ : Multi-3.0*2.5 □ : Multi-3.0*1.5	324,973

Table 23.5-5 List of Proposed Culvert Type (3 / 3)

*) **Objective** ; V : Vehicle, P : Pedestrian, W : Water

No.	Station	L (m)	Ave. Depth(m)	Condition								Culvert type		Cost
				Land use		Service road		Access road		Road crossing pedestrian	Other condition	Objective*	Size	
				Left	Right	Left	Right	Left	Right					
23	208+400	66	1.7	Small village	Small village	Unpaved	Paved	None	None	None	Service road protected for irish crossing	W	□ : 2-4.0*4.5 □ : 2-3.0*2.5 ■ : Multi-3.0*2.5 □ : Multi-3.0*1.5	303,766
24	213+300	175	1.4	Small village	Small village	Paved	Paved	None	None	None	Service road protected for irish crossing Water level pole partly removed for crossing	V	■ : 2-4.0*4.5 ■ : 2-3.0*2.5 □ : Multi-3.0*2.5 ■ : Multi-3.0*1.5	658,437
25	218+200	309	1.1	Unused	Small village	None	None	None	Truck	None	Skew wadi	P	□ : 2-4.0*4.5 □ : 2-3.0*2.5 ■ : Multi-3.0*2.5 □ : Multi-3.0*1.5	1,115,047
26	224+600	49	1.4	Building, house	Building, house	Paved	Paved	None	Truck	None	Including Sinas R/A Narrow wadi before R/A	W	□ : 2-4.0*4.5 □ : 2-3.0*2.5 □ : Multi-3.0*2.5 ■ : Multi-3.0*1.5	269,504
27	229+100	274	2.4	Unused, farm	Unused, farm	Unpaved	Paved	None	None	None	Service road protected for irish crossing	W	□ : 2-4.0*4.5 □ : 2-3.0*2.5 ■ : Multi-3.0*2.5 □ : Multi-3.0*1.5	988,833
28	230+500	84	1.6	Small village	Small village	Unpaved	Paved	None	Truck	None	On ramp for inbound direction	V	■ : 2-4.0*4.5 ■ : 2-3.0*2.5 □ : Multi-3.0*2.5 ■ : Multi-3.0*1.5	445,510
29	241+700	49	1.1	Unused, farm	Unused, farm	None	Unpaved	None	None	None	Narrow service road	W	□ : 2-4.0*4.5 □ : 2-3.0*2.5 ■ : Multi-3.0*2.5 □ : Multi-3.0*1.5	199,519
30	243+200	54	1.1	Unused, farm	Unused, farm	None	Unpaved	None	None	None	U-turn lane before and after wadi	W	□ : 2-4.0*4.5 □ : 2-3.0*2.5 ■ : Multi-3.0*2.5 □ : Multi-3.0*1.5	211,857
31	249+300	153	1.1	Small village	Small village	None	None	None	None	None	None	W	□ : 2-4.0*4.5 □ : 2-3.0*2.5 ■ : Multi-3.0*2.5 □ : Multi-3.0*1.5	528,372
Total		3,566	-	-	-	-	-	-	-	-	-	-	-	14,671,001

ANNEX 23-1

DRAINAGE STUDIES

Annex 23-1

DRAINAGE STUDIES

DGR, NESPAK and followed by the current study activities of JICA 2004 have carried out a detailed visual condition surveys of the existing drainage structures along the entire Al Batinah Highway. During the surveys the reaches prone to pond of water were noted keeping in view the condition of culvert protection works, type and extents of scour at culvert and adjoining embankment areas.

It is reported that water pond and overtopping along Al Batinah highway has been generally originated due to the following phenomena's:

- Inadequate capacity of the drainage structures
- Rerouting of discharge due to man made obstructions upstream of the highway such as houses, roads, dams and garden dykes in the wadi beds
- Instability of natural channels resulting in change of flow patterns. This phenomenon has been discussed in detail in the next section

The following two sorts of problems are prevailing:

1. Overtopping of highway resulting in scour and damage to upstream and downstream protection works and embankments. This is generally attributed to inadequate size of structure at the specific location. Flow of traffic is also disrupted due to this type of problem.
2. Generation of considerable flow parallel to embankment at upstream resulting in erosion of embankment and overloading of adjoining drainage structures. This is generally attributed to upstream obstructions, diversions and changes in flow pattern.

Consequently, the above types of problems are resulting in a severe pond of upstream area; water imposes threat to safety of inhabitants and their property.

This section is dealing with estimating the need for additional drainage structures, the probability that the road will becomes impassable and the duration of this event. The estimation of the duration that the road becomes impassable per year is a major parameter for assessment the feasibility of the road upgrading by converting the highly

overtopped (water height > 25 cm) Irish Crossings into Box Culverts wherever the results are calling for.

23.1 FLOOD SYSTEM ALONG AL BATINAH HIGHWAY

In the section from Al-Aqr roundabout to Bait-al-Barka roundabout the highway runs parallel to Gulf of Oman traversing through Al Batinah plains. Numerous wadis emerge from Al Hajar-al Gharbi Mountains and cross the highway before dispersing into the sea. Floods emerging from the hills catchments get divided into multiple channels while crossing the alluvial plains before reaching the highway. However, the portion of the highway from Al Wajaja to Al-Aqr runs parallel to Wadi-Al-Hatta crossing its minor tributaries only.

Figure 23-1 presents a 3D outline sketch of the wadi sub-system of Al Batinah highway.

Four wadis (catchments) relating to 8 Irish Crossings having insufficient drainage capacities as will be indicated and discussed in the following section appear from the available mapping to disperse into a total of 30 channels upstream of the Highway. It has not been possible to carry out a survey of these 30 channels or therefore to assess the likely division of flood flows among them.

However, it can be said that these channels tend to be unstable and they are subjected to changing during major flood events. Floods arriving at Highway crossings are also affected by upstream man-made effects such as Hawasinah Dam and Wadi Bani Umar al Charbi diversion at Bayda (recently breached by citizens). Flood frequencies at the highway are therefore very difficult to predict with lasting accuracy and they are subjected to changes as channels and upstream developments dictate.

Some of the highway stations have only crest-stage indicators, which have the disadvantage of catching most but not all of the flood peak series. Furthermore, highway stations are bypassed by other channels and therefore become only of limited (generally indicative) value in frequency analyses.

Therefore, more confidence can be placed in the flood frequencies computed for hill/mountain catchments upstream of the Highway. Flood peaks generally can be computed here for the entire natural wadi flow without bypassing channels or man-made influences. These hill/ mountain floods represent the predominant portion of the flood carried through to the Highway. The flat plains contribute downstream being relatively small and slow to run off. The plains can generally be expected to cause some reduction in the emerging hill/mountain flood peaks through the spreading of the floods

over the wide alluvial plains and arid through infiltration but this effect is greater for small floods than large ones.

Flood frequencies have been computed for the hill/mountain portions of each of the Irish Crossing catchments. These are considered to represent the upper limit of flood flows likely to reach the Highway. They would be expected to disperse into a number of channels. The current channel numbers and relative capacities seem to be the best means to estimate the likely division.

In cases when catchments contain large proportions of plain area, significant flood routing effects (or hill/mountain flood peak reduction) could be expected to occur. However, where the plain area is only a small proportion of the total catchment such as for Wadi Hawasinah, effectively all of the hill/mountain flood peak should be expected to reach the Highway at least for longer return periods.

In all cases, the resulting design floods can only be regarded as approximate and channels are unavoidably subject to change during major floods involving inevitable risks of flood and maintenance problems in the long term. Major and minor wadi channels as they cross Al Batinah Highway can and do vary as severe floods occasionally changing the predominant channel courses.

Furthermore, man-made developments upstream of gauging stations can affect the floods recorded at the stations and this is the case for Wadi Hawasinah at Khaburah, which is affected by the Hawasinah Dam, constructed 7 km upstream. Wadi Bani Umar al Gharbi at Bayda is affected by an embankment 0.6 km upstream of the station that was constructed more than 14 years ago by the Ministry of Communications to sensibly direct flood flows towards one major Irish Crossing on the Highway at Liwa rather than being dispersed through many different Highway crossings. It is understood that because of downstream complaints of loss of water resources the embankment has been breached so that floods can now bypass the wadi gauging station and recharge areas to the southeast towards Majis.

The full frequency analysis that was previously impossible now has enabled more realistic results to be proposed and the hill/mountain floods set out in the accompanying table are all much lower than would be derived from the FFCO.

The hill area frequencies represent the general order of upper limit for the flood peaks at the proposed Irish locations. The plain areas downstream of the hill areas vary from 18% of the catchment to the Highway (Wadi Hawasinah) to 47% (Wadi Mabrah/Diyan). In general, larger the proportion of downstream plain area, greater the potential for

flood peak reduction by flood storage routing and infiltration. Flood peaks crossing the Highway from Wadi Hawasinah would therefore be expected to be in total (summing the various channels) more severe than those for Wadi Mabrah/Diyan.

The hill floods are divided among various distributaries as they cross the plain towards Al Batinah Highway. It is very difficult to assess what proportion of a hill flood will pass along any of these alternative channels. As mentioned above, the present predominant channel if it can be identified may not remain the predominant channel after the next major flood that may change the overall drainage path configuration. Only reliable diversions or collector drains constructed to confine flood flows to specific and dedicated Highway crossings can overcome this "Variable Flood Path" problem.

23-2 ESTIMATION OF DESIGN DISCHARGES

Catchment's areas of all major wadis crossing the project highway were calculated using 1:100,000 scale maps. The design discharges were calculated using these areas and other physiographic characteristics of all wadi sub systems. The catchment's areas and design discharges of flood peaks of 50 years return period of the catchments are given in Table 23-1.

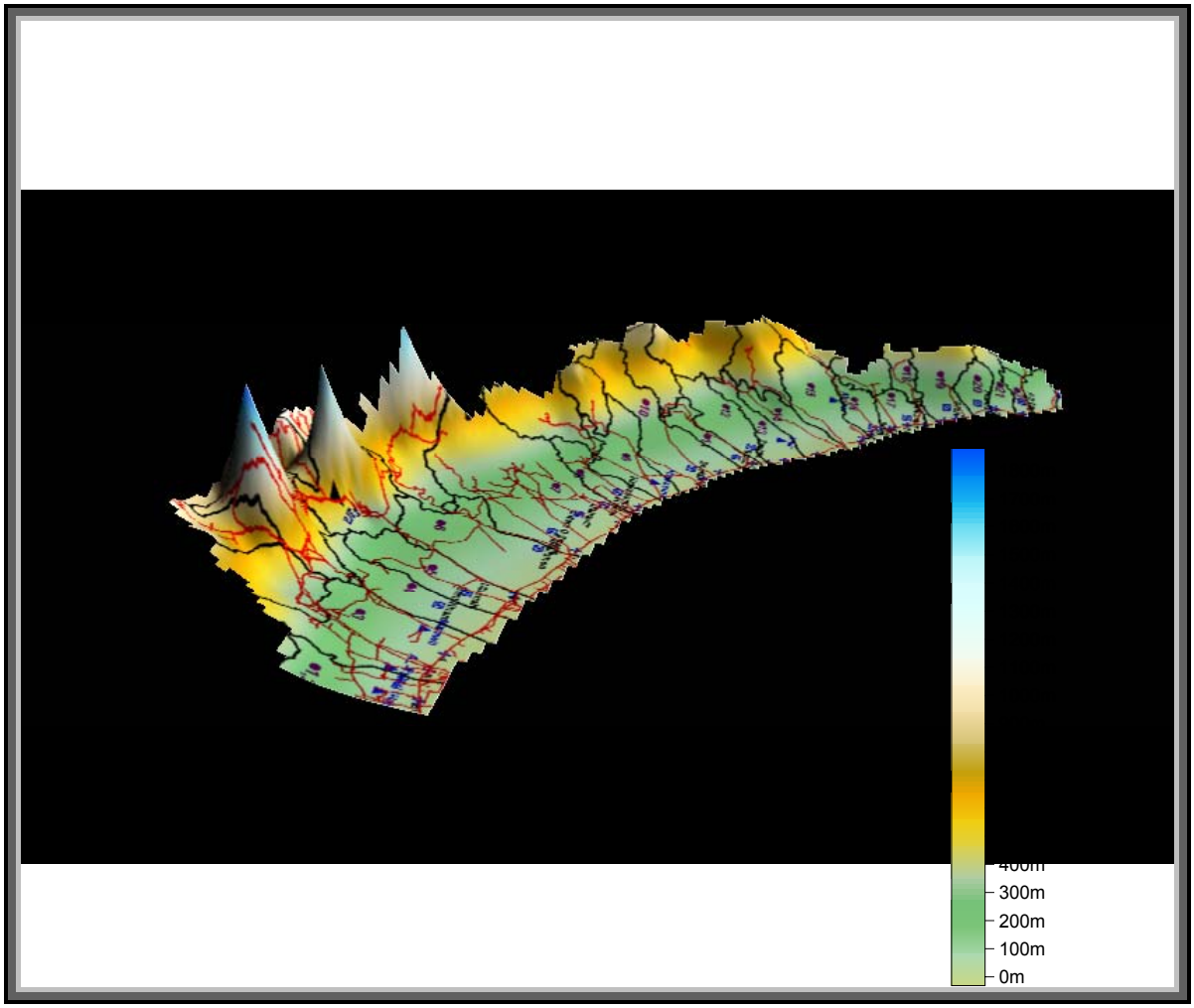


Figure 23-1 3-Dimensional Map of the Wadi Sub-System
(Irish Crossings of Al Batinah Region)

Table 23-1 Flood Peak Frequencies of 50 Years Return Period of Al Batinah Catchment's Areas along the Highway

Wadi Name	Catchment No.	Catchment Area (km^2)	Flood Peak 50 years return period (m^3/sec)
WADI KHOUD	1	1863	2000
WADI TAWW	2	173	275
WADI MAAWIL	3	708	800
WADI BANI KHARUS ABYAD	4	1539	1450
WADI FARAH	5		
WADI BANI GHAFIR	6	1785	1600
WADI ALMAAYAH, MABRAH	7	531	800
WADI MASHIN	8		
WADI HAWASINAH	9	1512	2190
WADI SHAFAN	10	362	985
WADI SARAMI	11	452	650u/s,150d/s
WADI SAKHIN	12	373	450
WADI AHIN	13	462	500
WADI HILTI	14	644	700
WADI AL JIZZI	15	1046	900
WADI SUQ	16	165	350
WADI BANI OMAR GH	17	488	500
WADI FIZH	18	357	600
WADI ALRAJMI	19	397	650
WADI BIDAH	20	137	500
WADI ALFAYD	21	121	250
WADI HATA	22	560	750

Note: u/s: upstream, d/s: downstream

23.3 CAPACITIES OF EXISTING DRAINAGE SYSTEMS

Culvert capacities have been worked out by (DGR,) on the basis of Nomographs provided in Highway Design Manual (HDM, Figures No. 11.7 & 11.8) under inlet control conditions for head water depth ratio of 1.20 for non-skew culverts (very few culverts along the entire highway are at skew angle).

Capacities of Irish Crossings have been determined using broad weir formula given in Highway Design Manual and reproduced below.

$Q = 1.69\ B\ (H)^{1.5}$

Where,

B = Length of wadi crossing

H= Specific energy head including average water depth and velocity head

Since the Irish Crossings and Irish Bridges are the most predominant drainage structures contributing to the drainage capacity of the Highway, an accurate assessment has been attempted at each individual location. Drainage capacity of culverts within the Irish Bridges has been worked out under the headwater conditions corresponding to maximum discharge. Calculated capacities for each Irish Crossing and culverts within each stretch corresponding to individual wadi are given in Table 23-2.

Table 23-2 Capacities of Existing Structures, of Al Batinah Highway

Wadi Name	Catch. No.	Bridges capacity (m^3/sec)	Pipe Culverts Capacity (m^3/sec)	Box culverts Capacity (m^3/sec)	Irish crossings Capacity (m^3/sec)	Irish Bridges Capcity (m^3/sec)	Culverts within irish Br. (m^3/sec)	Total capacity of the reach (m^3/sec)
Wadi Khoud	1		23.45	70.40	234.22	216.40	780.0	1324.47
Wadi Taww	2		5.95	40.00	229.94			275.89
Wadi Maawil	3		6.65	32.00	843.44			882.09
Wadi Bani Kharus Abyad	4		28.15	48.00		714.14	665.60	1455.89
Wadi Farah	5							
Wadi Bani Ghafir	6		32.90	140.00	493.26	59.69	390.00	1115.85
Wadi Almaayah Mabrah	7	600.00	28.00	40.00				668.00
Wadi Mashin	8							
Wadi Hawasinah	9		29.40	176.00	1412.48			1617.88
Wadi Shafan	10		31.15	108.00	305.28			752.00
Wadi Sarami	11		14.00	68.00		39.77	124.80	246.57
Wadi Sakhin	12		8.75	4.00		559.84	400.40	972.99
Wadi Ahin	13		10.15	28.00	640.88			679.03
Wadi Hilti	14	350.00	17.15	56.00	1332.56			1755.71
Wadi Al Jizzi	15		16.75	96.00	118.34	561.93	700.00	1493.02
Wadi Suq	16		3.15	52.00	331.21			386.36
Wadi Bani Omar Gh	17		15.05	220.00	272.80			507.85
Wadi Fizh	18		11.20	120.00	719.77	73.67	104.0	1028.64
Wadi Alrajmi	19		7.00	68.00	597.72	202.92	114.4	990.04
Wadi Bidah	20		11.20	116.00	85.29			212.49
Wadi Alfayd	21		12.60	48.00	44.31	114.97	26.0	245.88
Wadi Hata	22		4.20	76.00	835.00	692.95	476.0	2084.44

23.4 SHORTFALL IN DRAINAGE CAPACITIES

Comparison of the calculated design discharges according to the current JICA Study versus the existing capacities of all the drainage structures in each catchment has revealed a shortfall of moderate to severe order in the capacity of structures in four (4) catchment's, (6, 9, 10 and 20) including eight (8) Irish Crossing locations.

Capacities of existing structures are shown early in Table 23-2 .Deficiencies in discharge volumes of existing drainage structures are presented in Table 23-3. Finally, Table 23-4 shows the locations of wadis having under capacities and the crossing where overtopping of Irish Crossings are expected. The estimated water depth and flow speed

at those crossings are also presented. It is worth mentioning that additional drainage structures are recommended at these locations or to be converted into Irish Culverts and to be distributed according to the number of channels. Further detailed site investigation should be carried out to precisely determine allocated structures at each location.

Figure 23-2 shows locations of shortfall in discharge capacities of the existing structures along Al Batinah Highway needs rehabilitation and the highest flood peak zones coinciding with the highly flooded areas observed in the region.

A total shortfall of about 1579 m^3/sec has been estimated in these reaches. Severe inadequacies of drainage capacities were found relating to catchments 6 and 9, where as moderate shortfalls for catchments 10 and 20. Incidentally, most of the drainage problems especially overtopping have also been noticed in the same reaches. This required additional drainage structures to be constructed in these reaches. Furthermore, embankment protections are also required where parallel flows are generated due to diversion of water.

Table 23-5 presents the detail of total number of box drainage cells (size 2m x 1m) that will be required to take the excess water at the specified overtopped I/C and also the estimated required costs.

Table 23-3 Deficiencies in Discharge Volumes of the Existing Drainage Structures

Wadi Name	Catch. No.	Total capacity of the reach (m^3/sec)	Flood Peak 50 years R.P. (m^3/sec)	Deficiency in Discharge (m^3/sec)
Wadi Khoud	1	1324.47	d/s 450.00	
Wadi Taww	2	275.89	d/s 275.00	
Wadi Maawil	3	882.09	800.00	
Wadi Bani Kharus Abyad	4	1455.89	1450.00	
Wadi Farah	5			
Wadi Bani Ghafir	6	1115.85	1600.00	486.00
Wadi Almayyah, Mabrah	7	668.00	650.00	
Wadi Mashin	8			
Wadi Hawassinah	9	1617.88	2190.00	573.00
Wadi Shafan	10	752.00	985.00	233.00
Wadi Sarami	11	246.57	u/s 650.00 d/s 150.00	
Wadi Sakhin	12	972.99	450.00	
Wadi Ahin	13	679.03	500.00	
Wadi Hilti	14	1755.71	700.00	
Wadi Al Jizzi	15	1493.02	900.00	
Wadi Suq	16	386.36	350.00	
Wadi Bani Omar Gh	17	507.85	500.00	
Wadi Fizh	18	1028.64	600.00	
Wadi Al Rajmi	19	990.04	650.00	
Wadi Bidah	20	212.49	500.00	287.00
Wadi Alfayed	21	245.88	250.00	
Wadi Hata	22	2084.44	750.00	

Providing additional structures with adequate drainage capacity necessitates the followings:

- Provision of individual box culverts of size 2m x 1m adjacent to the existing Irish crossings.
- Provision of Irish Crossings at suitable locations (keeping in view the geometry of the highway and location of the Wadis) and providing individual box culverts for the excess discharge.
- Provision of Irish Bridges in place of existing Irish Crossings at above mentioned locations (required number of cells will be grater than the figures shown in Table 23-5 to accommodate the total flood discharge).

  This is the only alternative can guaranty all weather road. Since this corridor is the most important corridor in the Sultanate of Oman road network, it is recommended as the optimum solution.

Table 23-4 Locations of Irish Crossings of Excess Discharge

Locations of Irish Crossings of Excess Discharge											
X	Y	Crossing No	Length (m)	Altitude (m)	Station	Deficiency in Discharge (m^3/sec)	Catchment's No.	Flood Peak at I.C. (m^3/sec) 50 yr. R.P.	Critical Depth	depth	Velocity (m/s)
560935.48	2626931.80	5	300	28	052+600	486	6	300	0.467	0.533	1.87
559206.08	2626758.80	6	300	21	053+700			300	0.467	0.533	1.87
517869.83	2644746.00	9	300	22	099+300	573	9	650	0.782	0.847	2.55
514756.75	2645956.70	10	250	24	102+300			650	0.882	0.945	2.74
500055.55	2658755.50	11	300	22	123+100	233	10	350	0.517	0.584	1.99
497288.20	2659274.30	12	600	14	125+500			400	0.356	0.418	1.6
493310.16	2662733.30	13	300	18	130+200			450	0.612	0.68	2.2
444709.80	2732088.30	30	200	20	221+100	287	20	650	1.023	1.08	2.99

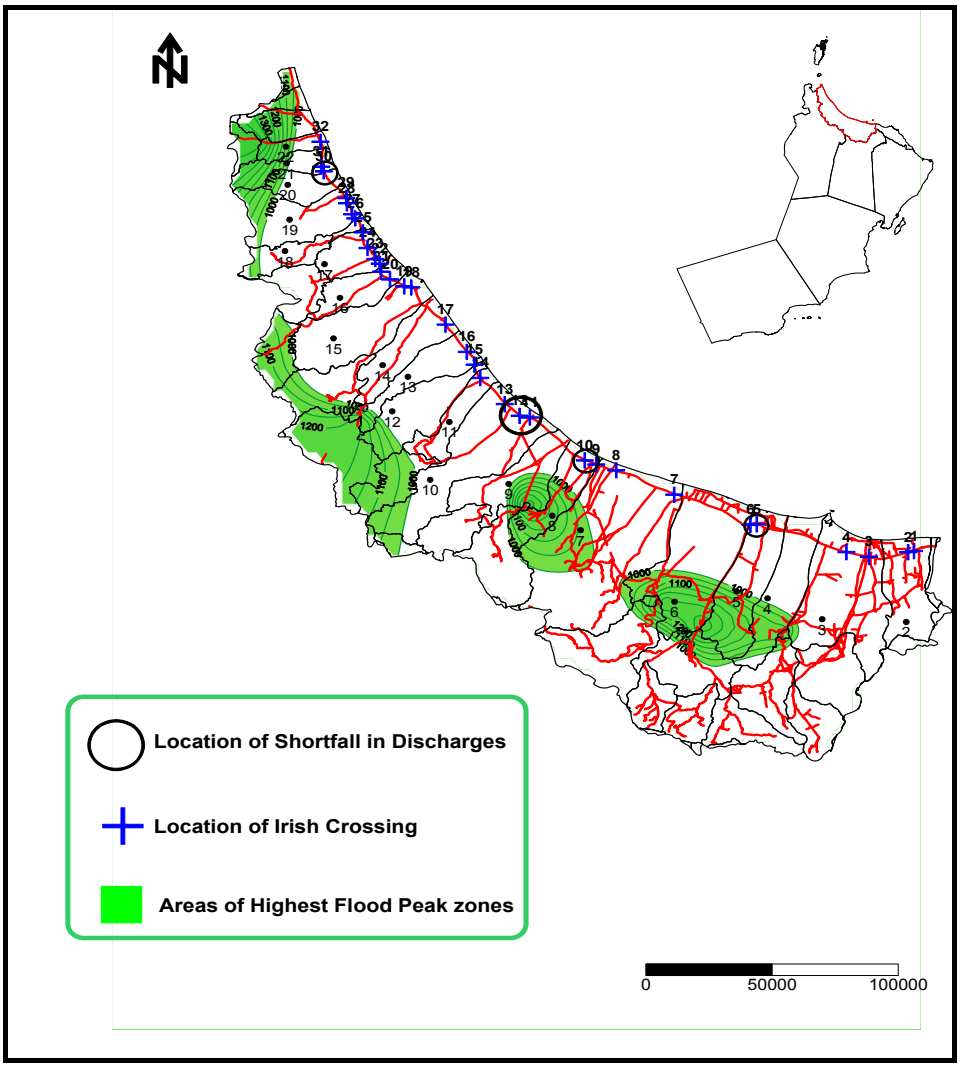


Figure 23-2 locations of Shortfall in Discharge Capacities of the Existing Irish Crossings along Al Batinah Highway

Table 23-5 Estimated Deficiency, Required Structures and Cost

Catchment's, no	Length of Reach (Km)	Deficiency in Discharge (m^3/sec)	Required No of 2m x 1m cells	Cost Estimate (million R.O)
20	7.5	287	72	0.446
10	11	233	59	0.365
9	23	573	142	0.881
6	25.5	486	122	0.756
Total		1579	395	2.448

CHAPTER 24

MANAGEMENT STUDY ON NEW BATINAH EXPRESSWAY

CHAPTER 24

MANAGEMENT STUDY ON NEW BATINAH EXPRESSWAY

24.1 INTRODUCTION

24.1.1 Study Perspective

1) Purpose of the Study

The purpose of this study is to reevaluate the economic and financial feasibility of the New Batinah Expressway as a Toll-Road. Peculiarity of this study is to evaluate the feasibility of the Expressway based on total traffic flow of intra Oman and of international traffic as well, and to be able to explore the possibility of applying various types of private investments (private sector company) in thanks to the Royal Decree No. 77/2004 which declares losing the effect of the previous Royal Decree No. 42/1996.

2) Flow of the Study

a. Initial condition setting up

The study consists of the five steps as shown in Figure 24.1-1. This section 24.1 compromises the initial conditions such as construction costs, maintenance costs, implementation program, demand forecast, vehicle operating unit cost, travel time unit cost, equity, loans, service costs, general costs, income tax and dividend, depreciation, and inflation.

As a synthesis of these initial conditions, the financial statements at the start of service are prepared.

b. Toll studies

Reasonable toll rate is studied from five points of views. The first is the rates assumed in a previous study, which are distributed in the range of 10 to 15 Baisas per km (passenger car case, hereinafter all of the output referred to is limited to the application to a passenger car).

The second is the economic benefit caused by the passing on New Batinah Expressway (NBE) comparing to the passing on the Existing Batinah Highway (EBH). The economic benefit passing on NBH to EBH is mostly negative due to the longer distance on NBH for Muscat – Batinah coastal area traffic.

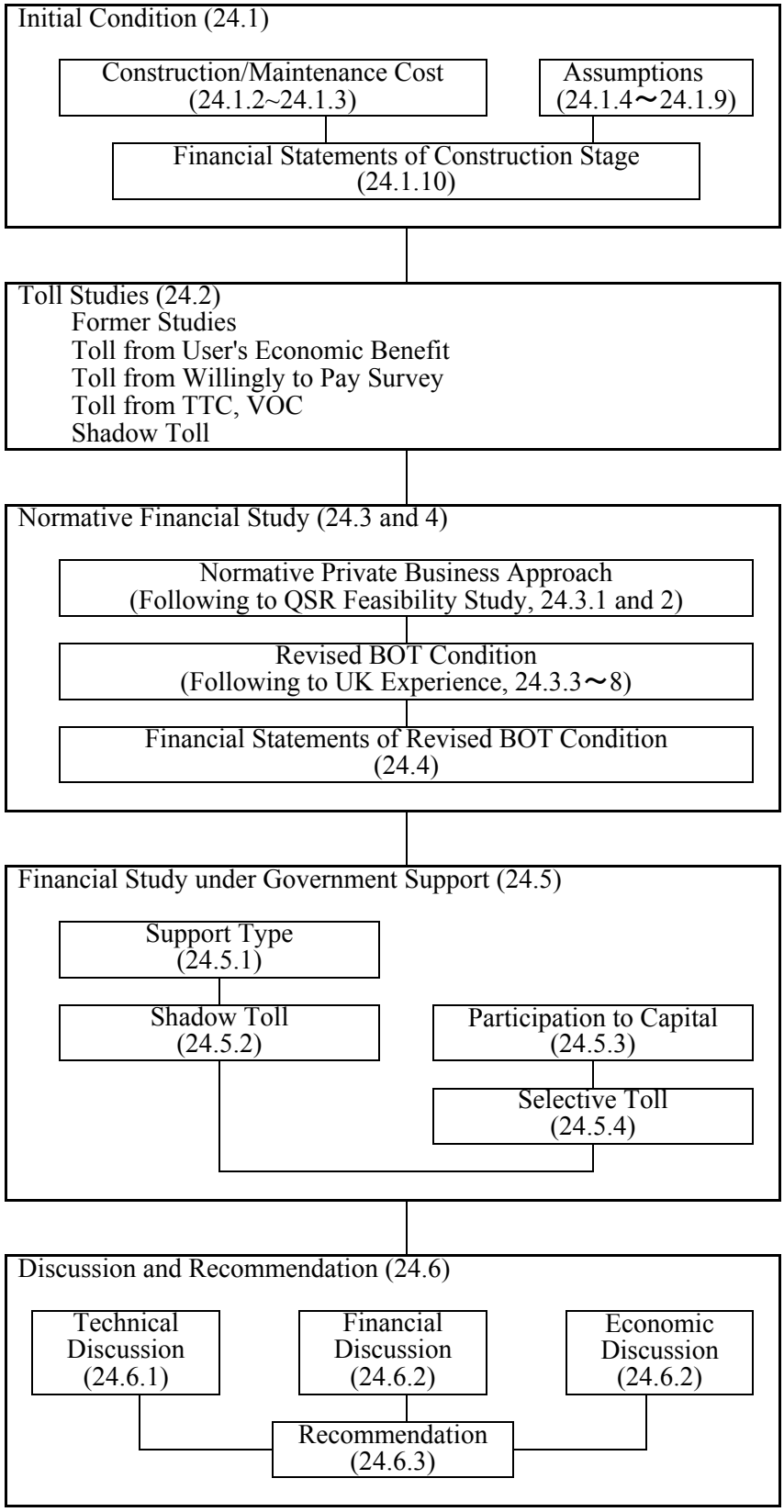


Figure 24.1-1 Study Flow

The third is the interview results on the concept of "willingly to pay" to passenger car users. A 203 Baisas per km is the most profitable toll rate from the product of expected number of users and toll rate point of views.

The fourth is the rate induced from assignment results for different toll rates in the range of RO 2 and RO 8 per the total length of 246.3 km. The most profitable rate is RO 6 per 266.3 km, which means 244 Baisas per km.

The fifth is applying a shadow toll. Economic benefit of NBE in 2025 is calculated as RO 4,730,194. It means the maximum shadow toll of 2025 is RO 4,730,194.

c. Normative financial study

Financial statements are prepared based on the initial conditions explained in step a. The initial conditions are normative for the private business but not for toll road business. The results show that a concessionaire can not survive.

Initial conditions are revised to fit the toll road business by introducing UK experience. The financial statements of the revised initial condition case, however, also arre not attractive for any concessionaire.

d. Financial study under Governmental support

In order to attract a concessionaire to the NBE toll road business, the support of the Omani Government is necessary based on the results of studies mentioned above. In this step, two types of Governmental support are examined, one is the shadow toll and the other is capital participation.

At first, it is studied that at least how much shadow price is necessary to attract a concessionaire to the NBE toll road business, and at second how much capital participation also at least is necessary.

As an application of capital participation, selective toll system (toll from truck only) is examined.

e. Discussion and recommendation

The proposed two types of Governmental supports are compared from financial point of views and also from economic point of views. Finally, the shadow toll system is recommended to be applied.

24.1.2 Physical Outline of New Batinah Expressway

1) Alignment

The alignment of New Batinah Expressway was subjected to several alternatives. In this Study, the applied alignment is the last recommended alignment by the Supreme Committee for Town Planning (SCTP). This alignment is the third one recommended by its Technical Committee, as presented in Figure 24.1-2. The proposed right of way is 500m in order to consider future required widening of the expressway and also to accommodate the proposed railway tracks that connect Gulf countries in the future.

The alignment is shifted to the east direction about 10 to 15 km from the proposed alignment by the Batinah Regional Plan. Shifting of the alignment resulted in more reasonable and less severe mountainous terrain. This alignment has also the advantage of traversing wadis at narrow channels rather than at wide catchments near the coast.

The estimated total length is about 246 km. This length has been classified among flat, rolling and mountainous terrains based on the investigation of the topographical conditions from area photo maps and satellite images.

The expressway has intersections with 11 major roads where interchanges should be constructed. The drainage of wadis can be done by PC or BC as proposed by a previous preliminary study. To eliminate any possible community separation that may be caused by the construction of the expressway and to provide access to residential areas on both sides, overpasses have to be constructed. The preliminary investigation shows that about 19 overpasses will be constructed.

2) Major Design Standard

The applied major design standards are as follows:

Carriageway: 4-lane divided highway
Lane Width: 3.6m
Shoulder Width: 2m
Median Width: 10m
Design Speed: 120 km/hr
Intersection Type: Diamond Interchange

3) Terrain

A preliminary terrain investigation along the proposed alignment shows that there are:

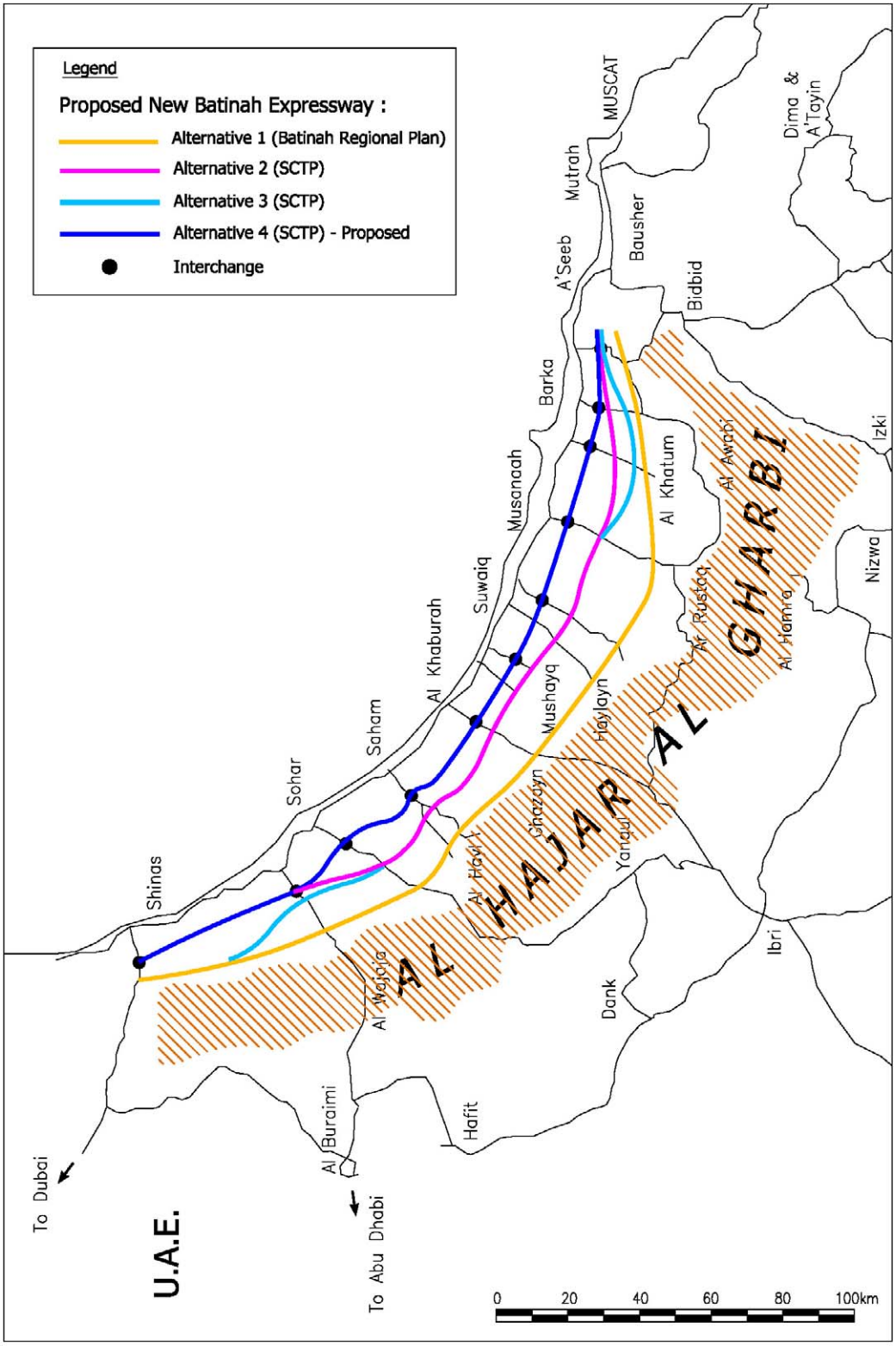


Figure 24.1-2 Proposed Alignment of New Batinah Expressway

148.30 km on flat terrain,
70.80 km on rolling terrain; and
27.20 km on mountainous terrain

24.1.3 Cost Features

1) Construction costs

Construction costs were estimated under the following assumption.

Pavement and Earthwork:
The cost per km based on the terrain condition was estimated. The estimated unit costs are utilized to obtain the total cost. The estimated costs are:

Flat Terrain	RO 154,000 / km
Rolling Terrain	RO 270,000 / km
Mountainous Terrain	RO 539,000 / km

Main Structure:
The required structures along the expressway have been determined as:

- Interchanges: 11 locations, of which four (4) Interchanges are of three (3) legs and seven (7) Interchanges are of four (4) legs
- Overpass: 19 locations

Fencing:
An average unit cost of RO 10,000 per km was assumed to estimate the fencing cost. Based on the HDM Standard and considering the proposed alignment, the estimated length of fencing is about 500 km.

Access to Residential Areas:
Grade-separation structures are considered at all minor at-grade crossing roads to secure no interruption for the through traffic. The access roads to residential areas will be designed on a higher level (overpass) over the new expressway therefore; major traffics and pedestrians will needs to use the overpass.

Toll Facilities:
Toll gates will be installed at ramps of the interchanges. The installation of toll plazas, each plaza has two manual processing gates and two Electronic Toll Collection (ETC) gates, is estimated at about RO 4,000,000.

Engineering Cost:
It is estimated to be about 2% for DD and 4% for C/S of the construction cost.

Contingency Cost:

It is assumed as 10% of the total of construction cost and engineering cost.

Land Acquisition:

The alignment almost passes through unused land. The land acquisition does not represent an issue for the road construction or compensation. The estimated cost for the land acquisition can be considered later under more comprehensive F/S since it is not included in the estimated construction cost. In a previous study on the Batinah Regional Plan Alignment (1998), the estimated cost is about RO 2.5 million.

The total construction cost of the expressway project is estimated at about RO 132 million. The break-down of this estimated cost is presented in Table 24.1-1.

Table 24.1-1 Cost of New Batinah Expressway

Item	Classification	Quantity	Unit Cost (RO 1,000)	Cost (RO 1,000)
Pavement and Earth Work	F Terrain	148.3 km	154	22,838
	R Terrain	70.8 km	270	19,116
	M Terrain	27.2 km	539	14,661
Sub Total				56,615
Main Structures	I/C, 3-Legs	4	3,000	12,000
	I/C, 4-Legs	7	4,000	28,000
	Overpass	19	400	7,600
Sub Total				47,600
Fencing		500 km	10	5,000
Toll Facilities				4,000
Subtotal				113,215
Engineering				6,793
Sub Total				120,008
Contingency 10%				12,001
Total Construction Cost		*246km*		132,009
Land Acquisition				2,500
Maintenance				
Routine			80 / year	80
Periodical				
Interchange		11	100	1,100
Overpass		19	10	190
Pavement	F Terrain	148.3	44	6,525
	R Terrain	70.8	53	3,752
	M Terrain	27.2	57	1,550
Periodical Maintenance				13,117

2) Maintenance Cost

Two types of maintenance systems; routine and periodical maintenance, are considered. The cost of routine maintenance is estimated to be about RO 80,000 per year to start on the following year to the opening. The periodical maintenance is consisting of asphalt overlay every 10 years and maintenance to interchanges. The maintenance cost per bridge or interchange is estimated in average RO 100,000. The overlay will be estimated applying a unit rate of asphalt for 4-lane/km as: RO 44,000 Flat Terrain, 53,000 Rolling Terrain and 57,000 Mountainous Terrain. Results are shown in Table 24.1-1.

3) Implementation Program

Construction contracts are divided into five packages, as shown in Tables 24.1-2 and 24.1-3. The total construction cost of RO 132,009 is deployed in seven years.

24.1.4 Demand Forecast

OD Tables prepared for the Master Plan Study (see details in Chapter 7) are used for this study without any changes. The changes of traffic demand caused by toll are handled in the model (JICA STRADA).

24.1.5 Vehicle Operating Cost and Travel Time Cost

Vehicle Operating Unit Cost and Travel Time Unit Cost provided for the Master Plan Study (see details in Chapter 9) are also used for this study without any changes.

24.1.6 Regulatory Preparation for Privatization

The Royal Decree No. 42/1996 effective until the Royal Decree No. 77/2004 was issued ruled that:

- Maximum tariffs shall be set by the Government and can only be changed with its approval.
- Companies which are set up for privatization projects will be public joint stock company (SAOG's) which has to offer a minimum 40% of their shares to the public. Omani participation will not be less than 51%.
- The maximum level of profit which can be earned by a company holding a concession is 20% p.a. of paid up capital over the average of a three year period. Any excess shall be shared with the Government.
- The Government shall not grant any soft or interest-free loans to privatized projects except in limited circumstances.

Table 24.1-2 Implementation Plan of New Batinah Expressway

Item	Year	1	2	3	4	5	6	7	8	9	Remarks
		2011	2012	2013	2014	2015	2016	2017	2018	2019	
1	Detailed Design										
2	Land Acquisition*										
3	Bidding and Mobilization Package 1										58
4	Construction of Package 1										km
5	Construction of Toll Gate of Package 1										
6	Bidding and Mobilization Package 2										59.5
7	Construction of Package 2										km
8	Construction of Toll Gate of Package 2										
9	Bidding and Mobilization Package 3										53.2
10	Construction of Package 3										km
11	Construction of Toll Gate of Package 3										
12	Bidding and Mobilization Package 4										26.3
13	Construction of Package 4										km
14	Construction of Toll Gate of Package 4										
15	Bidding and Mobilization Package 5										49.3
16	Construction of Package 5										km
17	Construction of Toll Gate of Package 5										
Total Cost (1000RO)		2,492	*2500**	9,821	20,292	30,136	24,967	22,364	13,075	8,862	*132,009*

Note *: The cost does not include Land Acquisition in year 2012.

Table 24.1-3 Cost Estimate per Package (RO 1,000)

Package No.	1	2	3	4	5	Total
Length (km)	58.0	59.5	53.2	26.3	49.3	246.3
Construction	24,541	25,176	22,510	11,128	20,860	104,215
Fencing	1,177	1,208	1,080	534	1,001	5,000
Toll Gate	942	966	864	427	801	4,000
Detailed Design	2,265					2,265
Construction Supervision	1,066	1,094	978	484	906	4,528
Subtotal	29,992	28,444	25,432	12,573	23,568	120,008
Contingency (10%)	2,999	2,844	2,543	1,257	2,357	12,001
Total Cost	32,991	31,288	27,975	13,830	25,924	132,009

Based on the experience of the consultant, these conditions let the foreign investor lose the investment interest. In the occasion of abolition of the Royal Decree No. 42/1996 and enactment of the new privatization law, the consultant tries to explore more attractive rule not only for investors but also for the Government.

24.1.7 Equity and Loans

Conditions of equity and loans are vital for the management of the company. The same condition as stated in Quriyat – Sur Road Feasibility Study, Dept Equity Ratio of 2:1 is used.

24.1.8 Other Cost Assumptions

1) Cost of Services

Maintenance costs described on section 24.1.3 are only considered as cost of service.

2) General and administration costs

It includes personnel costs of administration staff, RO 96,000 for 20 personnel, road patrol, RO 14,400 for 6 personnel, collection staff, RO 594,000 for 165 staff assumed 2 manual booths and 2 automatic booths in each toll plaza, and other miscellaneous costs, RO 40,000.

3) Corporate income tax and Dividend policy

Assuming the corporate income tax policy dictated in the RD No. 42/96 may not be changed in the new law to be acted, tax rate to the company wholly owned by Omani is used in this study. The rule applied is to exempt till the first RO 30,000 of the taxable income and levy 12% in excess of the taxable income mentioned above. Twenty percent of profit after tax payment is assumed as dividend.

4) Depreciation cost

Concession period is assumed the same as Quriyat – Sur Road FS; 25 years. In consideration of financial difficulty in the loan return period, 25 years fixed amount depreciation method is applied.

24.1.9 Inflation

Annual inflation rates during the last 7 years are stagnant as seen from Table 24.2-2. Based on such unsteady movement estimation of interest rate in 25 years long is impossible.

Items excluding paid-up capital, loan repayments and interest payments are escalated by inflation in the same extent. In addition repayments of loan and payments of interest become easier by inflation effect. The ignorance of inflation is considered to issue no substantial problems and to locate judgment in safety side. Due to these reasons in this Charter inflation effects are disregarded.

24.1.10 Financial Statements of Construction Stage

Detailed design starts in 2011 based on the Master Plan Schedule. Construction completes in 2019. The financial statements of the New Batinah Expressway Company, until the end of 2019, are estimated by each two years as shown in Table 24.1-4.

The balance sheet in Table24.1-4 shows that the company has to have RO 75 millions capitals and RO 150 millions loans for the start.

24.2 TOLL STUDY

24.2.1 Toll of Previous Studies

There are three toll studies on Oman roads available for reviewing, which are: New Batinah Expressway (NBE), Quriyat - Sur Road (QSR) and Bowshar – Al Armarat Road (BAR). Tolls proposed in the studies are summarized as shown in Table 24.2-1.

These tolls are based on 1997 or 1998 current price. However, because of stable price fluctuation (see Table 24.2-2), tolls shown in Table 24.2-1 can be referred without adjustment.

Based on the traffic assignment result applying RO 3 for the 246.3km NBE, it means that 122 Baisas/km, annual toll becomes RO 773,223 (Table 24.2-9), but based on the interview result, the annual toll becomes RO 1,266,523 in 2025 (Table 24.2-7).

Table 24.1-4 Financial Statement of Expressway Company - Construction Stage (RO 1,000)

Year	2011	2013	2015	2017	2019
Statement of Income (Loss)					
Revenue	0	0	0	0	0
Toll sales	0	0	0	0	0
Expenses	80	80	80	80	80
Cost of services	0	0	0	0	0
General and admin. exp.	80	80	80	80	80
Depreciation	0	0	0	0	0
Income from operation	-80	-80	-80	-80	-80
Other income	0	1,183	864	752	1,166
Interest income	0	1,183	864	752	1,166
Other expenses	0	0	3,000	15,000	13,419
Interest expenses	0	0	3,000	15,000	13,419
Net income for the period	-80	1,103	-2,216	-14,328	-12,332
Corporate income tax	0	129	0	0	0
Balance carried over	0	924	2,796	-6,014	-34,244
Dividend	0	0	0	0	0
Cumulative profit for the period	-80	1,898	581	-20,342	-46,576
Balance Sheet					
Assets					
Current assets	72,429	62,085	40,340	92,086	10,712
Cash on hand/ in banks	72,429	62,085	40,340	92,086	10,712
Fixed assets	2,492	14,813	65,241	112,572	134,509
Road property	2,492	14,813	65,241	112,572	134,509
Total Assets	74,920	76,898	105,581	204,658	145,221
	0	0	0	0	0
Liabilities and equity	0	0	30,000	150,000	116,797
Loan payable	0	0	30,000	150,000	116,797
Stockholder's equity					
Paid-up capital	75,000	75,000	75,000	75,000	75,000
Retained earnings	-80	1,898	581	-20,342	-46,576
Total equity	74,920	76,898	75,581	54,658	28,424
Total liabilities & equity	74,920	76,898	105,581	204,658	145,221
Statement of Cash Flow					
Cash flow from operating activities					
Income from operation	-80	-80	-80	-80	-80
Depreciation	0	0	0	0	0
Interest receivable	0	1,183	864	752	1,166
Interest payable (long term)	0	0	3,000	15,000	13,419
Interest payable (short term)	0	0	0	0	0
Tax and dividend	0	129	0	0	0
Net cash from operation	-80	974	-2,216	-14,328	-12,332
Cash flow from investing activities					
Additions of property	2,492	9,821	30,136	22,364	8,862
Sale of property	0	0	0	0	0
Net cash from investment	-2,492	-9,821	-30,136	-22,364	-8,862
Cash flow from financing activities					
Issue of bond	0	0	0	0	0
Redemption of bond	0	0	0	0	0
Addition to loans	0	0	30,000	78,000	0
Payment to loans	0	0	0	0	17,392
Net cash from finance	0	0	30,000	78,000	-17,392
Total cash flow	-2,572	-8,847	-2,352	41,308	-38,586
Cash balance					
Beginning of the year	75,000	70,932	42,692	50,778	49,298
End of the year	72,429	62,085	40,340	92,086	10,712

Table 24.2-1 Tolls of Former Studies (Baisas/km)

Type of Cars	NBE Alt. 1	NBE Alt. 2	QSR	BAR Alt 1	BAR Alt 2	BAR Alt 3
Passenger Car, 4 Wheeler	12	15	11	7	14	22
Pick-up, Minibus	12	15	13	7	14	22
Medium Goods Vehicle	12	15	16	7	14	22
Heavy Goods Vehicle, Large Bus	12	15	22	14	22	43

Table 24.2-2 Price Index between 1997 and 2003

Year	1997	1998	1999	2000	2001	2002	2003*
Price Index	100.0	99.5	100.0	98.8	97.8	97.1	96.7

Note: *provisional value

24.2.2 Toll induced from User's Economic Benefit

There are two toll settlement systems, which are "repayment feasible" and "economic benefit dependable". There are four countries out of twelve countries surveyed are adopting in "economic benefit dependable" policy, as presented in Table 24.2-3.

Table 24.2-3 Toll Statement System by Country

Country	Repayment Feasible	Economic Benefit Dependable	Comment
USA	Yes*		Referring to the optimum diversion rate
UK		Rather Yes*	Adopting Shadow Rate (described later)
France	Yes		
Italy		Yes*	50% of Economic Benefit in average
Spain	Yes		
Hungary	Rather Yes*		Profitability is prioritized
Indonesia		Yes*	50% of Economic Benefit by law
Philippines		Yes*	Based on Economic Benefit on policy
Thailand	Yes*		Must be lower than 100% of Eco. Benefit
Hong Kong	Rather Yes*		Profitability is prioritized
China	Yes		
Japan	Yes		

Economic benefit of New Batinah Expressway passenger-car user of total length of 246.3 km is shown in Table 24.2-4, comparing to the Existing Batinah Highway of total 232.5 km. In this calculation, the following data are applied:

- OD Table: in 2025
- Base Network: The Master Plan Network in 2025

New Batinah Expressway does not show positive benefits to vehicle users compared to the case of running through Existing Batinah Highway. The excess cost is around RO 2

in case of running the section between Muscat and Sohar. This result means toll induced from user's economic benefit is not applicable.

Table 24.2-4 Economic Benefit per Car of New Batinah Expressway - 2025

Items	New Batinah Exp. Way			Exist. Batinah Highway		
	P. Car	Bus	Truck	P. Car	Bus	Truck
Average Running Hours (Hr)*	2.525	2.525	2.525	2.530	2.530	2.530
Running Kilometers	246.3	246.3	246.3	232.5	232.5	232.5
Travel Time Cost (RO.)	3.21	14.52	0.00	3.21	14.55	0.00
VOC** subject to hour (RO)	2.75	4.63	6.72	2.75	4.64	6.73
VOC** subject to km (RO)	12.73	13.36	14.87	10.93	11.39	12.79
Total Economic Cost	18.68	32.51	21.59	16.89	30.59	19.52
Economic Benefit of NBE user	-1.79	-1.92	-2.07			

Note: *: Traffic assignment result
**: Abbreviation of Vehicle Operating Cost

24.2.3 Toll from Field Interview

"Repayment feasible" toll policy is adopted in 8 countries out of the 12 countries studied, as shown in Table 24.2-3. Based on the recently abolished Royal Decree 42/1996, Omani Government also supported this policy.

Needless to say, even though repayment feasible price policy is installed, the price must be in the limit of willingly to pay price. Willingly to pay price was explored by an interview survey to the users of the Existing Batinah Highway.

Number of interviewees is 371, of which male drivers 255 and female drivers 116, Omani drivers 345 and Expatriate drivers 26, and in teens 3, in twenties 145, in thirties 148, in forties 69 and in fifties 6, as presented in Table 24.2-5.

Table 24.2-5 Interviewee Attributes

Total	371	Total	371	Total	371
Male	255	Omani	345	In teens	3
Female	116	Expatriate	26	In twenties	145
				In thirties	148
				In forties	69
				In fifties	6

Results of the interview survey are summarized as follows:

- A 55% of interviewees answered "no pay" and only 14% affirmative to pay RO 2 or more for the whole length of 246.3 km.
- There is no remarkable difference by gender.

- A 38% of expatriates answered “agree to pay RO 2 or more” but 12% of Omani answered yes (Table 24.2-6A).

The third fact may show that expatriates are accustomed to use toll roads but Omani is not. If so, we can expect the attitude of Omani will be changed after they are accustomed to pay toll.

Table 24.2-6B shows younger ages are rather flexible for toll than older. As a whole, 14% of interviewees answered “willingly to pay RO 2 for 246.3 km” and 8% of them “willingly to pay RO 5”.

Table 24.2-6A Summary of Interviews (%)

Toll	Male	Female	Both Gender	Omani	Expatriate	Both National
No Pay	55	55	55	56	35	55
Less Than RO 1	24	25	24	25	19	24
RO 1	6	7	7	7	8	7
RO 2	5	5	5	4	15	5
RO 3	1	2	1	1	0	1
RO 4	0	0	0	0	0	0
RO 5 or More	9	6	8	7	23	8
Total	100	100	100	100	100	100

Table 24.2-6B Summary of Interviews(continued) (%)

Toll	Teen Age	Twenties	Thirties	Forties	Fifties	All Age
No Pay	0	56	55	52	83	55
Less Than RO 1	33	19	26	32	17	24
RO 1	33	7	7	6	0	7
RO 2	0	7	3	4	0	5
RO 3	0	2	1	0	0	1
RO 4	0	0	0	0	0	0
RO 5 or More	33	9	8	6	0	8
Total	99	100	100	100	100	100

From the interview results and traffic demand assignments, the expected toll sales are obtained as shown in Table 24.2-7.

Higher toll rate realizes the higher sales in spite of decreasing number of users. The highest sales, RO 2.4 millions a year is expected in the case of Toll RO 5 in 2030.

Table 24.2-7 Expected Toll Sales induced from Interview Survey

		Daily Usage			Yearly Sales*
Year/Toll*	Willingly to pay rate(%)	Passenger car (car-km)	Bus (bus-km)	Truck (truck-km)	All type of vehicles (RO)
2020		1,745,717**	56,720**	987,932**	
RO 1	21	1,455	47	823	848,737
RO 2	14	1,940	63	1,098	1,131,649
RO 3	9	1,870	61	1,058	1,091,233
RO 4	8	2,217	72	1,255	1,293,313
RO 5	8	2,771	90	1,568	1,616,642
2025		1,877,769**	63,704**	1,297,227**	
RO 1	21	1,565	53	1,081	985,104
RO 2	14	2,086	71	1,441	1,313,473
RO 3	9	2,012	68	1,390	1,266,563
RO 4	8	2,384	81	1,647	1,501,112
RO 5	8	2,981	101	2,059	1,876,389
2030		2,180,798**	72,446**	1,943,816**	
RO 1	21	1,817	60	1,620	1,276,606
RO 2	14	2,423	80	2,160	1,702,141
RO 3	9	2,337	78	2,083	1,641,350
RO 4	8	2,769	92	2,468	1,945,304
RO 5	8	3,462	115	3,085	2,431,630

Note: *Toll/246.3km, it is used after conversion to Toll/km.
** Case of "no pay"

24.2.4 Tolls induced from User's Logical Behaviors

In this model, the time value by type of vehicle is pre-input (Table24.2-8, refer to economic benefits in Chapter 9 for details). These values are compared to the expected shorten travel time value and distinguished automatically whether to use toll road or not. In the different way of expression, the model expects reasonable behavior of car users. Results are summarized in Table 24.2-9.

Because of the completion of the Coastal Road, the expected sales amount of 2030 is lower than that of 2025. The toll of RO 6 in 2025 for the total length of 246.3km shows the largest sales amount. It means that the difference of VOC and TTC between EBH and NBE is equivalent to RO 6 for 246.3km.

The annual earnings of this case are around RO 1.0 million in 2025.

Table 24.2-8 Time Value -2005 (RO/hr)

	Passenger car	Bus	Truck
VOC subject to running hours	1.09	1.84	2.66
Vehicle base travel time cost	1.27	5.75	-
Total	2.36	7.59	2.66

Table 24.2-9 Expected Sales assumed Time Value Reasonable Behavior (RO)

2025							
Type 1/Toll*	2	3	4	5	6	7	8
Vehicle km	66,112	66,046	50,454	45,016	40,872	40,738	32,112
Toll	537	805	820	915	997	1,159	1,044
Type 2/Toll*	4	6	8	10	12	14	16
Vehicle km	127	51	51	51	51	34	12
Toll	2	1	2	2	2	2	1
Type 3/Toll*	6	9	12	15	18	21	24
Vehicle km	46,738	35,854	30,525	25,951	24,678	17,695	15,780
Toll	1,140	1,312	1,489	1,582	1,806	1,511	1,540
Yearly Toll	613,019	773,223	843,536	912,276	1,023,842	975,178	943,374
2030							
Type 1/Toll*	2	3	4	5	6	7	8
Vehicle km	24,414	16,922	8,540	1,656	1,374	1,338	550
Toll	198	206	139	34	34	38	18
Type 2/Toll*	4	6	8	10	12	14	16
Vehicle km	1,010	570	455	368	296	232	64
Toll	16	14	15	15	14	13	4
Type 3/Toll*	6	9	12	15	18	21	24
Vehicle km	1,294	384	267	56	0	0	0
Toll	32	14	13	3	0	0	0
Yearly Toll	89,963	85,519	60,840	19,002	17,502	18,716	8,048

Note: * Toll of RO of total length of NBE

24.2.5 Shadow Toll

Because it is difficult to collect toll from the road users in the U.K., the Government developed the way to pay reasonable economic amount to the concessionaire instead of collecting toll. The shadow toll is requested in general to be calculated and proposed by each concessionaire candidate. But it is commonly understood that the shadow toll must be in the range of economic benefit of the project.

Table 24.2-10 shows the economic benefit amounts of the NBE for the years 2020, 2025 and 2030. The table shows that the economic benefit caused by VOC-km is negative because of the longer distance of NBE than the EBH but benefit caused by VOC-hr and TTC is positive because faster traveling speed on NBE than EBH (see Chapter 9 on details of VOC-km, VOC-hr and TTC).

In 2020, traffic volume is comparatively small and benefit caused by VOC-hr and TTC cannot cover the negative benefit caused by VOC-km. In 2025, the traffic demand environment changes and benefit caused by NBE becomes positive. But in 2030 the amount of benefit becomes 60% of 2025 due to completion of the coastal road running

in parallel to NBE. After 2030, it is expected that the increase of benefit in proportional to the increase of traffic demands.

Table 24.2-10 Economic Benefit of New Batinah Expressway (RO)

	W/O NBE	W/ NBE	W/O – W/	Yearly Benefit
2020				
VOC-km	889,785	907,441	-17,656	-6,444,476
VOC-hr	364,148	360,337	3,811	1,391,117
TTC	225,289	222,814	2,475	903,344
Total	1,479,222	1,490,592	-11,370	-4,150,016
2025				
VOC-km	1,165.543	1,173,900	-8,357	-3,050,211
VOC-hr	490,676	476,479	14,197	5,181,908
TTC	253,516	246,396	7,119	2,598,498
Total	1,909,734	1,896,775	12,959	4,730,194
2030				
VOC-km	1,602,207	1,626,626	-24,419	-8,912,907
VOC-hr	712,036	690,347	21,689	7,916,475
TTC	303,959	293,670	10,289	3,755,539
Total	2,618,202	2,610,643	7,559	2,759,107

24.2.6 Summing up of Toll Systems

Three ways of toll are considerable, which are “willingly to pay” base toll, “reasonable behavior” base toll and shadow cost. Table24.2-11 are summing up of the former discussed toll systems.

Table 24.2-11 Summary of Tolls

Nature of Toll	Toll Amount*	Expected Yearly Sales**
Feasibility Studies	RO 3***	RO 1,266,563
“Willingly to pay” base	RO 5	RO 1,876,389****
“Reasonable behavior” base	RO 6	RO 1,023,842
Shadow cost base	-	RO 4,730,194

Note: * Tolls to achieve the maximum sales expected are selected
** Sales of 2025
*** Standard case
**** RO 2,431,630 in 2030 and RO 1,616,642 in 2020

24.3 PRELIMINARY FINANCIAL STUDY

24.3.1 Initial Assumptions

Under this financial feasibility, the applied initial assumptions are listed up in Table 24.3-1 (there is some duplication to the contents written in 24.1)

Table 24.3-1 Initial Assumptions for Preliminary Feasibility Study

Item	Condition
Construction	
Year of construction start	The year 2011
Necessary years for construction	9 years
Total cost including land acquisition cost	RO 134,509,000
Toll collection	4 gates (2 ETC, 2 manual) per toll plaza
Financial condition	
Equity : Loan ration	1 : 2
Loan	Commercial loan of 10% p.a., 10 years return period with 3 years grace period.
Capital	Paid-up
Concession period	25 years
Depreciation	4% p.a. in corresponding to c.p.*
Road facilities transfer condition	Transfer without value after c.p.*

Note: * concession period

24.3.2 Financial Statements of each Five Years

The financial statements of each five years are prepared by pulling out from the year by year financial statements projection after nine years construction period, as presented in Tables 24.3-2. In the tables, borrowing and repaying of short term loans making up the yearly deficit is not recorded considering the transaction which does not exceed a year, and interest caused by those loans are recorded as short term loan interest.

Table 24.3-2 shows the company may not survive. It is fatal that the estimate of revenue RO 1,617,000 in 2020 but depreciation RO 5,380,000. This tendency does not change until the end of operation. The revenue of RO 4,065,000 p.a. in the end of service year, which is increased in corresponding to increase of traffic demand, is still not coping with the depreciation cost RO 5,380,000 p.a.

Reflecting on the said facts, income statements shows negative without exception. It indicates the longer concession period is necessary. The ratio of depreciation over toll sales in 2020 is 3.3 and 2025 is 2.9. It means depreciation period must be prolonged in three (3) times of the present 25 years, it means 75 years concession period.

Table 24.3-2 Financial Statements of each Five Years (RO 1,000)

Year	2020	2025	2030	2035	2040	2044
Statement of Income (Loss)						
Revenue	1,617	1,876	2,431	2,921	3,510	4,065
Toll sales	1,617	1,876	2,431	2,921	3,510	4,065
Expenses	6,205	6,205	6,205	6,205	6,205	6,205
Cost of services	80	80	80	80	80	80
General and admin. exp.	744	744	744	744	744	744
Depreciation	5,380	5,380	5,380	5,380	5,380	5,380
Income from operation	-4,588	-4,329	-3,774	-3,284	-2,695	-2,139
Other income	495	0	0	0	0	0
Interest income	495	0	0	0	0	0
Other expenses	11,680	2,078	2,523	2,703	2,848	2,962
Interest expenses	11,680	2,078	2,523	2,703	2,848	2,962
Net income for the period	-15,772	-6,407	-6,297	-5,986	-5,543	-5,101
Corporate income tax	0	0	0	0	0	0
Balance carried over	-46,576	-109,005	-154,223	-185,346	-227,352	-249,055
Dividend	0	0	0	0	0	0
Cumulative profit for the period	-62,349	-115,411	-160,520	-191,332	-232,895	-254,156
Balance Sheet						
Assets						
Current assets	-18,812	-142,639	-160,846	-164,757	-179,418	-179,158
Cash on hand/ in banks	-18,812	-142,639	-160,846	-164,757	-179,418	-179,158
Fixed assets	129,128	102,227	75,325	48,423	21,521	0
Road property	129,128	102,227	75,325	48,423	21,521	0
Total Assets	110,317	-40,413	-85,521	-116,334	-157,896	-179,158
Liabilities and equity	97,666	0	0	0	0	0
Loan payable						
Stockholder's equity						
Paid-up capital	75,000	75,000	75,000	75,000	75,000	75,000
Retained earnings	-62,349	-115,411	-160,520	-191,332	-232,895	-254,156
Total equity	12,651	-40,411	-85,520	-116,332	-157,895	-179,156
Total liabilities & equity	110,317	-40,413	-85,521	-116,334	-157,896	-179,158
Statement of Cash Flow						
Cash flow from operating activities						
Income from operation	-4,588	-4,329	-3,774	-3,284	-2,695	-2,139
Depreciation	5,380	5,380	5,380	5,380	5,380	5,380
Interest receivable	495	0	0	0	0	0
Interest payable (long term)	11,680	0	0	0	0	0
Interest payable (short term)	0	2,078	2,523	2,703	2,848	2,962
Tax and dividend	0	0	0	0	0	0
Net cash from operation	-10,392	-1,026	-917	-606	-162	279
Cash flow from investing activities						
Additions of property	0	0	0	0	0	0
Sale of property	0	0	0	0	0	0
Net cash from investment	0	0	0	0	0	0
Cash flow from financing activities						
Issue of bond	0	0	0	0	0	0
Redemption of bond	0	0	0	0	0	0
Addition to loans	0	0	0	0	0	0
Payment to loans	19,131	0	0	0	0	0
Net cash from finance	-19,131	0	0	0	0	0
Total cash flow	-29,523	-1,026	-917	-606	-162	279
Cash balance						
Beginning of the year	10,712	-141,613	-159,930	-164,151	-179,255	-179,437
End of the year	-18,812	-142,639	-160,846	-164,757	-179,418	-179,158

Because of continuance of net loss for the period, cumulative loss continues to increase and reaches RO 254,156,000 at the end of operation of 2044. The company shall be closed with deficits of RO 179,158,000 (balance of retained loss and paid-up capital) and with the record of no dividend payments in the whole period, though fixed assets (road facilities) are transferred to the Government without charge (fully depreciated).

Cash flow statements show negative figures during whole period though the amount of negative decreases year by year. On the computation, short term loan of equally amount of shortage is assumed to be financed with same interest rate of the long term loan.

Table 24.3-2 induces the conclusion of no company has interested in this project. How to attract them, meaning how increases the Government contribution to the project, will be examined in the following sections.

24.3.3 Reconsideration of Revenue

The biggest problem of the income statements is that revenue cannot cover the expenses. The road network in Batinah is well developed and provides agreeable driving environment. In that environment, generally speaking, car user doesn't like to use toll road.

As mentioned in Section 24.2.5, the road network of U.K. is also well developed and road user commonly feels reluctant to pay toll. After the construction of three toll bridges under BOT, all the attempts to construct toll road under BOT have been failed.

It was widely recognized in U.K. that the road development benefit does not limit to road users but land owners and other entrepreneurs, and that it is unfair policy to burden all of the costs to road users.

After the bitter experiences, U.K. decided to quit BOT financed from toll collection but to adopt the shadow toll system paid by Government. This system was well developed as shown in Table 24.3-3 and called as PFI (*Private Finance Initiative*).

In consideration of the road network environment in the Sultanate, the adoption of the shadow toll concept for the NBE must be one of advisable alternatives. Reasonable shadow toll is considered equal to or below than RO 4.73 million a year, which is equivalent to the economic benefit of NBE based on the calculations in Section 24.2.5.

Hereafter, there is a brief explanation of PFI system attached for reference use.

1) PFI – concept

PFI concept consists of; a. Value for Money (VFM), b. Optimal Risk Management (ORM), c. Competition and d. Transparency.

a. VFM
   VFM concept is that the Government must provide the most valuable service for tax payers. PFI must be adopted only in the case that private entrepreneur can assure more effective and higher quality service in the stable condition than public sector can do.
b. ORM
   The entity that can manage a risk in smaller cost and in more proper manner must handle that risk.
c. Competition
   Introduction of competition rule is necessary to achieve better VFM.
d. Transparency
   PFI means a private entrepreneur serves some public service exclusively. Transparency in the process of selection is definitely important.

2) PFI – purpose

As purposes of PFI, three items are highlighted; a. Suppression of public expense coping with demand of that public service, b. Achievement of higher level of VFM and c. Off balance sheet effect.

a. Suppression of public expense coping with demand of that public service
   In fact PFI is a kind of deferred payment. Especially in case the actual payment is lower than estimated economic benefit, PFI can discount the payment.
b. Achievement of higher level of VFM
   Competition on bidding assures the achievement of higher level of VFM.
c. Off balance sheet effect.
   PFI aims not only to suppress public cash outflow but also to suppress public stock (debt).

3) PFI - effectiveness

Major effectiveness of PFI is described in the part of PFI-purpose. In addition of these three effects, six derivative effects are counted.

a. Transformation of capital expenditure to current expenditure
   In PFI, initial large investment shall be done by the private entrepreneur and later Government pays comparatively small facility rental fee. As a result, Government can invest that initial investment to other projects.
b. Decrease of Government employees

Transferring public service to private sector means decrease of Government employees or stop to recruit new employees for that service.

c. Creation of new business chance, new business industry
   Through PFI, the markets so far monopolized by the Government are open to private entrepreneurs. New markets create new business chances/new industries.

d. Acceleration of technical innovation
   Competition on bidding produces technical innovation especially when bidding includes designing stage.

e. Practical use of project financing
   Private companies also try to avoid that assets/liability recorded on their balance sheets. They tend to establish a special purpose company for the PFI project and finance by project financing method.

f. Enlargement of financing opportunity
   PFI is in nature high risk high return business in the long project period. Financing opportunity of money looked for such kind of investment opportunity is enlarged.

4) Applied Field

PFI has been well developed in various fields as shown in Table 24.3-3.

24.3.4 Reconsideration of Project Start

Economic benefit of NBE in 2020 is –RO 4,150,016 but in 2025 shows RO 4,730,194 (see Table 24.2-10). It means the start of the project is too early from the economic point of views. As a strategic road in the future network, it is scheduled to be implemented during the 8th Plan to support economic diversification.

24.3.5 Reconsideration of Construction Period

The interest of loan based on the proposed construction schedule is RO 53,619,000. If the proposed five packages can start at the same time, construction period could be shortening in five years. In the revised case, a total of five years is applied as three years for construction, one year for D/D and bidding, and one year for land acquisition,.

24.3.6 Reconsideration of Depreciation Costs

In the calculations of the financial statements above, depreciation period is considered the same as the concession period, and the concession period is 25 years following Quriyat – Sur Road feasibility study. The concession period, however, shall be decided by competition. The case of Severn bridge BOT project in U.K. ruled that concession is terminated when accumulated revenue (fixed price) does exceed £957 million (two times of total loan and capital) but it is not less than 30 years after the contract starts.

Based on the discussion in Section 24.3.2, the concession period must be extended to 75 years.

Table 24.3-3 PFI Application Field

Application Field	Facility applied
Transportation	Ordinal road
	Toll Bridge
	Streetlight
	Interchange
	Railway
	LRT
	Airport Terminal
	Parking Space/Building
	Subway Rolling Stock
House	Public House
Sanitation	Water and Filtration
	Sewer and Sewage
Military	Training Facility
	Military Facility
Prison and similar Facilities	Prison
	Rehabilitation Facility
Medical or Welfare Facilities	Hospital
	Clinic
	Medical Disposal Treatment
	Medical Instrument
	Recuperation Facility
	Care House
Education	University
	School Building
	School Meal
	Athletic Facility
Power	Power supply to Public House
	Power supply to Subway
Information System	
Public Facilities	Police Station
	Small Firearms Training Facility
	Horse Riding Training Facility for Policeman
	Police Radio communication Facility
	Fire Station
	Fireman Training Facility
	Courthouse
	Embassy House
	Library
	Museum
	Training Institute
	Leisure Facility
	Salt Storage Space
	Effective Use of Public owned Land or Building
	Public cars and its Maintenance Facility

24.3.7 Reconsideration of Loan Condition

Loan condition of Qiruyat – Sur Road feasibility study was 10 years loan period and 10% interest p.a. The financing scheme of the said BOT project in U.K. was quite different from Qiruyat - Sur FS as shown in Table 24.3-4.

Table 24.3-4 Financing Scheme of Severn Bridge

Financing Group	Amount	Period	Interest
Europe Investment Bank	£ 150 millions	19 years	-
Financing Bank Group	£ 190 millions	Roll over until 2007	
Capital Gain Bond	£ 131 millions	20 years	6%+accumulated inflation rate

The project started in1992. Rolling over until 2007 means 15 years loan period. Project financing type long term loan (20 years or more) and capital appreciation bond shall be considered in stead of 10 years commercial loan.

24.3.8 Reconsideration of Paid-up Capital

Debt Equity Ratio of 2:1 was used for Qiruyat – Sur Road feasibility study. It is reasonable in the ordinal industry, but not applicable to the type of the toll road business. In the case of Severn Bridge Project, its Debt Equity Ratio was £ 100,000 capital to £ 471,000,000 loan (1 : 4710).

24.4 FINANCIAL STUDY UNDER REVISED CONDITIONS

24.4.1 Assumptions

Based on the knowledge obtained in the Section 24.3, the project conditions are reassumed as summed up in Table 24.4-1.

Table 24.4-1 Assumption Revised

Change Items	Contents of Change	Comments
Project Start Period	2025 operation starts	To wait higher shadow toll is expected
Concession Period	Seventy five (75) years	To decrease annual depreciation cost and result in positive income from operation
Construction Period	Five years including DD, Bidding and Land acquisition	To minimize interest during construction period
Equity	RO 262,000	Round number of 1/4710 of the total costs
Shadow Toll	2025 shadow toll;	To apply fixed 2025 shadow toll in the all service year
Loan Condition	20 years, 6%, with 3 years grace period	To apply the project finance method.

24.4.2 Financial Reports

Financial projection based on the revised assumption is simulated and the results are shown in Table 24.4-2. Improvement of financial status is not satisfied as a result.

Income from operation is changed to positive in thanks of small amount of depreciation due to the extension of concession period. But six (6) % p.a. of interest rate is heavy burden for the company even though loan period extended from 10 years to 25 years including the grace period during construction stage. Net profits for the period do not show positive figures.

The final retained loss of the operation is RO 1,384,380 notwithstanding no dividend pays during 75 years.

24.5 FINANCIAL FEASIBILITY STUDY WITH GOVERNMENT SUPPORT

24.5.1 Considerable Type of Support

The conclusion of the precedent section is the company does not liable, because the revenue does not meet to the interest payment.

From the said fact, Government support is expected for: a) increasing the shadow toll to balance the expenditures including interest payment; or b) investing to the company as much extent as the company can survive by itself.

In the following two sub-sections, qualitative answers are explored. In these studies, the other conditions are considered as same as used in the Section 24.4. The differences between the two cases are summarized as follows:

a. Construction cost
   In shadow toll case, no construction cost of toll collection facilities is considered.
b. Operation cost
   In shadow toll case, no operation cost of toll collection is considered.
c. Toll
   In shadow toll case, no toll collection from user is considered. In Government investment case, toll is collected as 21 Baisas per km (RO 5.0 for 246.3km) for passenger car and 32 Baisas (RO 7.5 for 246.3km) for bus and truck.

Table 24.4-2 Financial Reports of Revised Assumption Case

Year	2025	2035	2045	2055	2070	2085	2099
Statement of Income (Loss)							
Revenue	4,730	4,730	4,730	4,730	4,730	4,730	4,730
Toll sales	4,730	4,730	4,730	4,730	4,730	4,730	4,730
Expenses	1,966	1,966	1,966	1,966	1,966	1,966	1,901
Cost of services	80	80	80	80	80	80	80
General and admin. exp.	150	150	150	150	150	150	150
Depreciation	1,736	1,736	1,736	1,736	1,736	1,736	1,671
Income from operation	2,764	2,764	2,764	2,764	2,764	2,764	2,829
Other income	138	0	0	0	0	0	0
Interest income	138	0	0	0	0	0	0
Other expenses	24,000	22,619	18,020	14,471	17,585	21,552	26,262
Interest expenses	24,000	22,619	18,020	14,471	17,585	21,552	26,262
Net income for the period	-21,098	-19,855	-15,256	-11,707	-14,821	-18,788	-23,434
Corporate income tax	0	0	0	0	0	0	0
Balance carried over	-19,946	-239,011	-434,168	-570,663	-780,456	-1,055,36	-1,360,94
Dividend	0	0	0	0	0	0	0
Cumulative profit	-41,044	-258,866	-449,424	-582,370	-795,278	-1,074,14	-1,384,38
Assets							
Current assets	-16,446	-318,775	-674,397	-898,411	-1,085,28	-1,338,12	-1,624,11
Cash on hand/ in banks	-16,446	-318,775	-674,397	-898,411	-1,085,28	-1,338,12	-1,624,11
Fixed assets	128,373	111,017	93,660	76,304	50,269	24,234	-0
Road property	128,373	111,017	93,660	76,304	50,269	24,234	-0
Total Assets	111,927	-207,758	-580,737	-822,108	-1,035,01	-1,313,88	-1,624,11
Liabilities and equity	152,709	50,846	-131,574	-240,000	-240,000	-240,000	-240,000
Loan payable	152,709	50,846	-131,574	-240,000	-240,000	-240,000	-240,000
Stockholder's equity							
Paid-up capital	262	262	262	262	262	262	262
Retained earnings	-41,044	-258,866	-449,424	-582,370	-795,278	-1,074,14	-1,384,38
Total equity	-40,782	-258,604	-449,162	-582,108	-795,016	-1,073,88	-1,384,11
Total liabilities & equity	111,927	-207,758	-580,737	-822,108	-1,035,016	-1,313,887	-1,624,118
Statement of Cash Flow							
Cash flow from operation activities							
Income from operation	2,764	2,764	2,764	2,764	2,764	2,764	2,829
Depreciation	1,736	1,736	1,736	1,736	1,736	1,736	1,671
Interest receivable	138						
Interest payable (long term)	24,000	18,234	7,908	0	0	0	0
Interest payable (short term)	0	4,385	10,112	14,471	17,585	21,552	26,262
Tax and dividend	0	0	0	0	0	0	0
Net cash from operation	-19,363	-18,120	-13,521	-9,971	-13,085	-17,052	-21,763
Cash flow from investing activities							
Additions of property	0	0	0	0	0	0	0
Sale of property	0	0	0	0	0	0	0
Net cash from investment	0	0	0	0	0	0	0
Cash flow from financing activities							
Issue of bond							
Redemption of bond							
Addition to loans	0	0	0	0	0	0	0
Payment to loans	7,291	13,057	23,382	0	0	0	0
Net cash from finance	-7,291	-13,057	-23,382	0	0	0	0
Total cash flow	-26,653	-31,176	-36,903	-9,971	-13,085	-17,052	-21,763
Cash balance							
Beginning of the year	10,207	-287,598	-637,494	-888,440	-1,072,19	-1,321,06	-1,602,35
End of the year	-16,446	-318,775	-674,397	-898,411	-1,085,28	-1,338,12	-1,624,11

24.5.2 Shadow Toll

A total of RO 8,437,000 p.a. is the shadow toll at the break even point of the retained earnings through the whole period, as shown in Table 24.5-1. Shadow toll is in common sense to be under the economic benefit caused by the toll road. In this case under discussion, the economic benefit of NBE is RO 4,730,000 p.a. and necessary shadow toll is RO 8,437,000, which is 1.8 times of the economic benefit. Some justification of RO 8,437,000 shadow toll is necessary.

Table 24.5-1 Shadow Toll and Retained Earning (RO 1,000)

Shadow Toll	8,300	8,400	8,437	8,500	9,000	9,500
Retained Earnings	-13,437	-3,655	0	6,126	54,858	103,028
Dividend Total	40,873	42,780	43,493	44,686	54,257	63,942
Max. Shortage of Cash	-192,567	-189,763	-188,714	-186,959	-173,035	-159,427
Corporate Income Tax	24,524	25,688	26,096	26,812	32,544	38,365
Paid-up capital	262	262	262	262	262	262
Ave. Dividend to Capital	1.95	2.04	2.08	2.13	2.59	3.05

Before exploring of the economic meaning of RO 8,437,000, the rate of growth is assumed. The Master Plan Study period is from 2005 till 2030. In the other hand, the economic evaluation of NBE shadow toll is from 2025 till 2099. Under this Study, the growth rate after 2030 is assumed as average growth rate of OD volume between 2005 and 2030, as shown in Table 24.5-2.

The maximum traffic of the link in NBE is 23,610 vehicles per day in 2030. Assume the maximum link capacity as 80,000 vehicles per day for four lanes, then traffic can be increased until 2056 in corresponding to the average increase of OD volume between 2005 and 2030, but will hit the ceiling in 2062. After 2062, a flat traffic volume is assigned.

The value of economic benefit is also stopped in 2062 and flatted after 2062.

Table 24.5-2 Growth Rate from 2005 till 2030

Year	2005	2010	2015	2020	2025	2030
Daily OD	107,398	133,331	151,055	185,280	218,741	277,949
Yearly Increase		1.044	1.025	1.042	1.034	1.049
Average Increase	1.039					

The economic analysis results of shadow toll are summarized in Table 24.5-3. Shadow toll case in range of RO 8,437 and less than RO 9,500 shows Government economic feasible and company financial feasible.

The concessionaire receives some retained earnings, in the case of shadow toll is higher than RO 8,437, but a big amount of shortage of cash in hand in the long period is expected. Only a concessionaire supported by sufficient fund can manage the project, and such a concessionaire generally requires high return.

How to evaluate "transferred fixed asset" is an another issue. It was fully depreciated and so remained value is zero from financial point of views. But from economic and engineering points of views, it is still physically usable.

As supporting evidence, daily vehicle-km in 2025 is projected as 3,238,700. Annual shadow toll of RO 8,437,000 means 7.14 Baisas per vehicle per km. It is cheaper than other toll discussed in the section 24.2.

Table 24.5-3 Economic Analysis of Shadow Toll (RO 1,000)

Shadow Toll	8,300	8,400	8,437	8,500	9,000	9,500
Government Benefit						
NBE Economic Benefit	543,016	543,016	543,016	543,016	543,016	543,016
Corporate Income Tax	24,524	25,688	26,096	26,812	32,544	38,365
Transfer of Fixed Asset	130,509	130,509	130,509	130,509	130,509	130,509
Total Gain	698,049	699,213	699,621	700,337	706,069	711,890
Government Expenses						
Shadow Toll Payment	622,500	630,000	632,775	637,500	675,000	712,500
Total Expenses	622,500	630,000	632,775	637,500	675,000	712,500
Government Benefit	75,549	69,213	66,846	62,837	31,069	-610

Total traffic volume of NBE in 2025 without toll is 1,182 millions. If RO 8.437 millions is paid for that traffic, shadow toll per vehicle per km becomes 7.14 Baisas and if RO 9.5 millions, the shadow toll is 7.93 Baisas.

24.5.3 Government Participation to Capital

The 100% Government participation case is studied at first. The results are shown in Table 24.5-4. Even with enough capital support, business faces retained loss in long period, but cash in hand is maintained in positive.

In the range of RO 135,000,000 and RO 145,000,000, Government benefit is positive and company is viable. Capital cost is considered as 6% p.a. interest and 75 years loan period. Results are summarized in Table 24.5-5.

Table 24.5-4 Government Investment and Retained Earning (RO 1,000)

Paid-up Capital	135,000	140,000	145,000	150,000	155,000	160,000
Retained Earnings	141,183	148,971	156727	164,441	172,088	179,685
Dividend Total	58,928	60,794	62,664	64,540	66,425	68,319
Min. Cash Position	5,626	10,853	16,080	21,307	26,535	31,762
Corporate Income Tax	35,357	36,476	37,598	38,724	39,855	40,922
Years counted Ret. Loss	20	18	15	12	10	8

Table 24.5-5 Economic Analysis of Government Investment (RO 1,000)

Equity Amount	135,000	140,000	145,000	150,000	155,000	160,000
Government Benefit						
Dividend Total	58,928	60,794	62,664	64,540	66,425	68,319
NBE Economic Benefit	285,440	285,440	285,440	285,440	285,440	285,440
Corporate Income Tax	35,357	36,476	37,598	38,724	39,855	40,922
Return of Investment	135,000	140,000	145,000	150,000	155,000	160,000
Transfer of Fixed Asset	134,509	134,509	134,509	134,509	134,509	134,509
Total Benefit	649,234	657,219	665,211	673,213	681,229	689,190
Government Expenses						
Loan and Interest Payment	615,283	638,071	660,859	683,648	706,436	729,224
Total Expenses	615,283	638,071	660,859	683,648	706,436	729,224
Government Benefit	33,951	19,148	4,352	-10,434	-25,207	-40,034
Reference: Retained Earnings	141,183	148,971	156,727	164,441	172,088	179,685
Return of Investment	135,000	140,000	145,000	150,000	155,000	160,000
Cash in Hand at end of Business	6,183	8,971	11,727	14,441	17,088	19,685

Though 100% Government capital is assumed, the project is managed by a private company. Due to this, Government capital enjoys dividend but retained earnings shall be given to the company. On the possibility of private capital participation, the cases of private share from 5% up to 50% are studied. The private capital participation from 5% till 20% is viable, as shown in Table 24.5-6.

The impact of private participation to Government economic evaluation is explored in case of private participation rate is 5%, 10% or 20%.

24.5.4 Selective Toll

The case of collecting toll only from truck was studied in response to the Omani side request. This case is the variation of the case discussed in Section 24.5.3. Difference between both cases is to collect toll from all of car users or only from truck users. For the convenience of comparison, the study results are described in the same step as in Section 24.5.3.

Table 24.5-6 Company Financial Analysis

Equity Amount	%*	135,000	140,000	145,000	150,000	155,000	160,000
A: Company Earnings (Retained Earnings + Company Share, right, Dividend)	50	170,647	179,368	188,059	196,711	205,301	213,845
	40	164,754	173,289	181,793	190,257	198,658	207,013
	30	158,861	167,209	175,526	183,803	192,016	200,181
	20	152,969	161,130	169,260	177,349	185,373	193,349
	10	147,076	155,050	162,993	170,895	178,731	186,517
	5	144,129	152,011	159,860	167,668	175,409	183,101
B1: Company Capital Expenses (10%, 75 years Case)	50	574,148	595,413	616,678	637,943	659,207	680,472
	40	459,319	476,330	493,342	510,354	527,366	544,378
	30	344,489	357,248	370,007	382,766	395,524	408,283
	20	229,659	238,165	246,671	255,177	263,683	272,189
	10	114,830	119,083	123,336	127,589	131,841	136,094
	5	57,415	59,541	61,668	63,794	65,921	68,047
B2: Company Capital Expenses (6%, 75 years Case)	50	375,141	389,036	402,930	416,824	430,718	444,612
	40	300,113	311,228	322,344	333,459	344,574	355,690
	30	225,085	233,421	241,758	250,094	258,431	266,767
	20	150,057	155,614	161,172	166,730	172,287	177,845
	10	75,028	77,807	80,586	83,365	86,144	88,922
	5	37,514	38,904	40,293	41,682	43,072	44,461
C1: Company Net Profit (10%, 75 years Case, A-B1)	50	-403,501	-416,045	-428,619	-441,232	-453,907	-466,628
	40	-294,564	-303,042	-311,550	-320,097	-328,708	-337,365
	30	-185,628	-190,039	-194,481	-198,963	-203,509	-208,103
	20	-76,691	-77,035	-77,411	-77,828	-78,310	-78,840
	10	32,246	35,968	39,658	43,306	46,889	50,422
	5	86,715	92,469	98,192	103,874	109,489	115,054
C2: Company Net Profit (6%, 75 years Casen A-B2)	50	-204,494	-209,668	-214,871	-220,113	-225,417	-230,768
	40	-135,359	-137,940	-140,551	-143,202	-145,916	-148,677
	30	-66,223	-66,212	-66,232	-66,291	-66,415	-66,587
	20	2,912	5,516	8,088	10,619	13,086	15,504
	10	72,048	77,243	82,407	87,530	92,587	97,594
	5	106,615	113,107	119,567	125,986	132,337	138,640
D1: Profitability (10%, 75 years Case, C1/Private Investment)	50	-0.080	-0.079	-0.079	-0.078	-0.078	-0.078
	40	-0.073	-0.072	-0.072	-0.071	-0.071	-0.070
	30	-0.061	-0.060	-0.060	-0.059	-0.058	-0.058
	20	-0.038	-0.037	-0.036	-0.035	-0.034	-0.033
	10	0.032	0.034	0.036	0.038	0.040	0.042
	5	0.171	0.176	0.181	0.185	0.188	0.192
D2: Profitability (6%, 75 years Case, C2/Private Investment)	50	-0.040	-0.040	-0.040	-0.039	-0.039	-0.038
	40	-0.033	-0.033	-0.032	-0.032	-0.031	-0.031
	30	-0.022	-0.021	-0.020	-0.020	-0.019	-0.018
	20	0.001	0.003	0.004	0.005	0.006	0.006
	10	0.071	0.074	0.076	0.078	0.080	0.081
	5	0.211	0.215	0.220	0.224	0.228	0.231

As the first step was the study of 100% Government participation case. The results are shown in Table 24.5-8. When comparing with Tables 24.5-4 and 24.5-8, the difference is clear. In case of selective toll, the last retained earning is negative in any case calculated.

Table 24.5-7 Economic Analysis for Company Participation Case (RO 1,000)

Equity Amount	140,000	140,000	140,000	150,000	150,000	150,000
of which, Government	133,000	126,000	112,000	142,500	135,000	120,000
Private	7000	14000	28000	7500	15000	30000
Note: Government Share	95%	90%	80%	95%	90%	80%
Government Benefit						
Dividends	57,754	54,715	48,635	61,313	58,086	51,632
Economic Benefit from NBE	285,440	285,440	285,440	285,440	285,440	285,440
Corporate Income Tax	36,476	36,476	36,476	38,724	38,724	38,724
Transfer of Fixed Assets	134,509	134,509	134,509	134,509	134,509	134,509
Dividends	57,754	54,715	48,635	61,313	58,086	51,632
Return of Investments	133,000	126,000	112,000	142,500	135,000	120,000
Government Benefit Total	647,179	637,140	617,060	662,486	651,759	630,305
Government Costs						
Loan and Interest Payment	606,167	574,264	510,457	649,465	615,283	546,918
Government Balance (B - C)	41,012	62,876	106,603	13,021	36,476	83,387

Table 24.5-8 Government Investment and Retained Earning (RO 1,000)

Paid-up Capital	135,000	140,000	145,000	150,000	155,000	160,000
Retained Earnings	-96,455	-87,213	-78058	-68,982	-59,966	-51,071
Dividend Total	5,639	7,212	8,807	10,422	12,057	13,711
Min. Cash Position	-9,077	-1,844	5,389	12,621	19,854	27,052
Corporate Income Tax	3,383	4,327	5,284	6,253	7,234	8,227
Years counted Ret. Loss	72	72	72	71	71	70

24.6 DISCUSSION AND RECOMMENDATION

24.6.1 Technical Issues

1) Growth Rate after 2030

The Master Plan Study period is until 2030. In this Study the average growth rate of OD trips between 2005 and 2030 are applied after 2030 without any adjustment or increase. Regarding the traffic handled by NBE, the maximum traffic volume is limited to a maximum of 80,000vehicle/day. This growth rate is an expedient and further updating study before the start of the project is necessary.

2) Retained Earning

In this feasibility study, the assumption is that a private company manages this business. It means all of profit or loss is resulted in that private company activities.

3) Transfer of Fixed Asset

Financially the road facilities are depreciated in order to transfer it without cost to the Government. It means no value on the book. However from the economic point of view it is usable but not new. In the Study, construction cost is considered as value of the asset because it is the same as the toll collectable when it starts.

4) Intra-zone Traffic

OD volume used in this Study is inter-zonal only. It means intra-zonal traffic (practically traffic in the same Wilayat) is not counted for toll collectable trip.

5) Long Concession Period

Seventy five (75) years concession period is seemingly too long. However, no investor interests in the project without assurance of profitability. In Severn project case, open ended concession is the assurance of profitability. Here, because many assumptions are adopted, concession period is set to be as enough long periods (seventy five years) but it is advisable to set the concession period ended by the maximum profit.

6) Inflation

Generally speaking inflation gives positive effect to business of large initial investment with long term return period. In the Study, all of the revenue and some costs, cost of

service and general/administration costs are impacted inflation in the same extent, but depreciation which is a part of cost is not affected by the inflation. In addition, the value of fixed asset decreases in proportion to inflation rate.

It is impossible to estimate the average rate of inflation in seventy five (75) years from 2030 but assumption of no inflation set the financial analysis in the safety side. Due to this, under this Study no inflation is assumed.

7) Project Start

If the Government is willing for early implementation and earlier start of the project and agrees to pay shadow toll from 2020, the financial statement for the concessionaire will not be harmed by that decision. This decision only affects to the economic return which shows keen increase in 2025.

24.6.2 Comparison of Two Government Supporting Systems

1) Company Viability

Figure 24.6-1 shows the final amount of profit at the end of operation of Shadow Toll Case and 100% Capital Support Case. For the convenience of understanding capital investment is converted to annual payment of 75 years, 6% loan base. From the figure, obviously the Shadow Toll Case is more profitable than Capital Support Case. From the company viability point of views, shadow Toll Case shall be chosen.

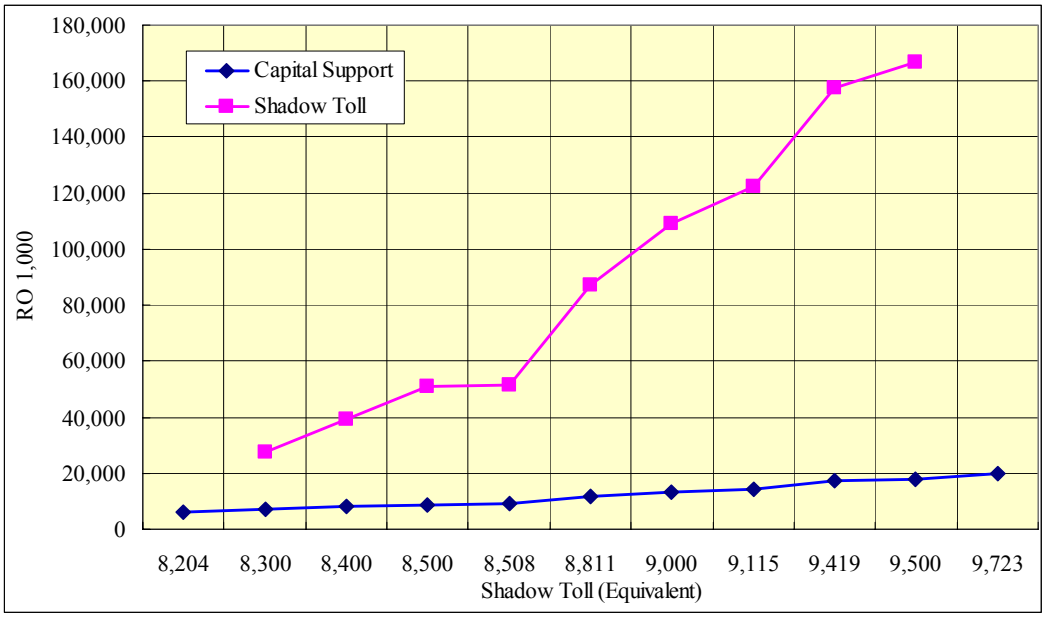


Figure 24.6-1 Final Profit by Type and Volume of Subsidies

2) Attractiveness to Concessionaires

Profitability and safety are the points to attract concessionaires. From the profitability point of views, as discussed above, Shadow Toll Case is superior to Capital Support Case.

From safety point of views, Capital Support Case is definitely good. In Figure 24.6-2, the annual cash balance of two types of company is shown. Shadow Toll of the figure case is RO 9,419,000 and Capital Case is RO 145,000,000 paid-up, both cases show the small positive figures of Government economic benefit.

"Capital before" in the Figure means usual cash balance. "Capital after" means cash balance when business was closed (after returning capital to the Government). In Shadow toll case, a company owns the capital by itself.

Huge periodical maintenance cost by ten years results in the periodical gap shown in the figure. Any case shows ascending pattern.

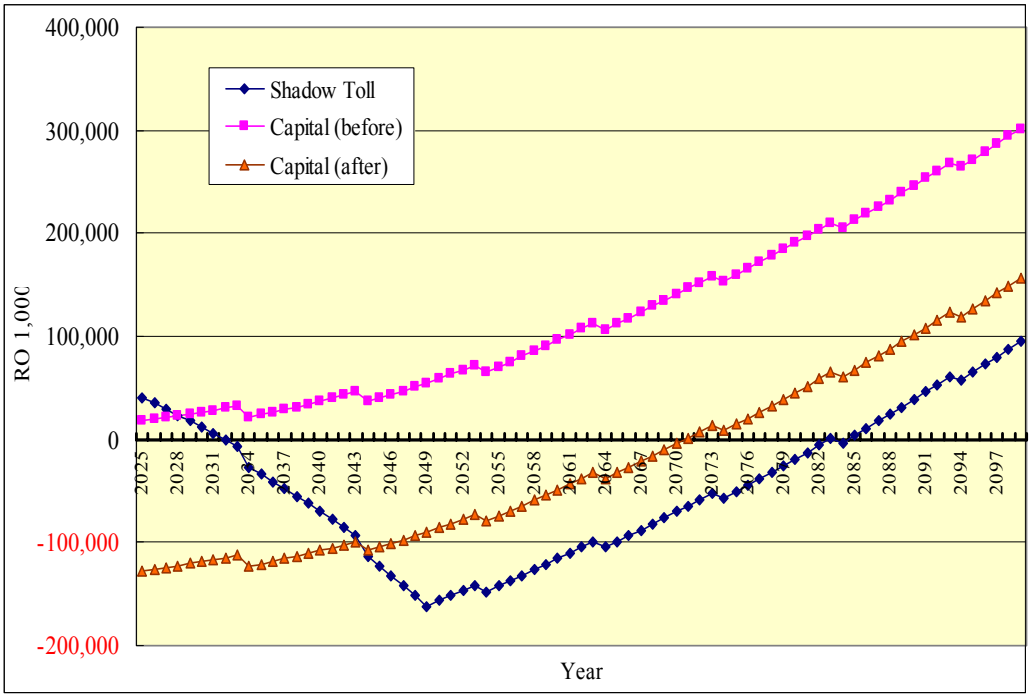


Figure 24.6-2 Cash Position

3) Government Economy

From the economic benefit point of view, both cases have big difference (Figure 24.6-3). As a tendency both have ascending pattern, but the Shadow Toll Case starts from approximately zero against that Shadow Toll Case stays in negative due to the large amount of loan repayment.).

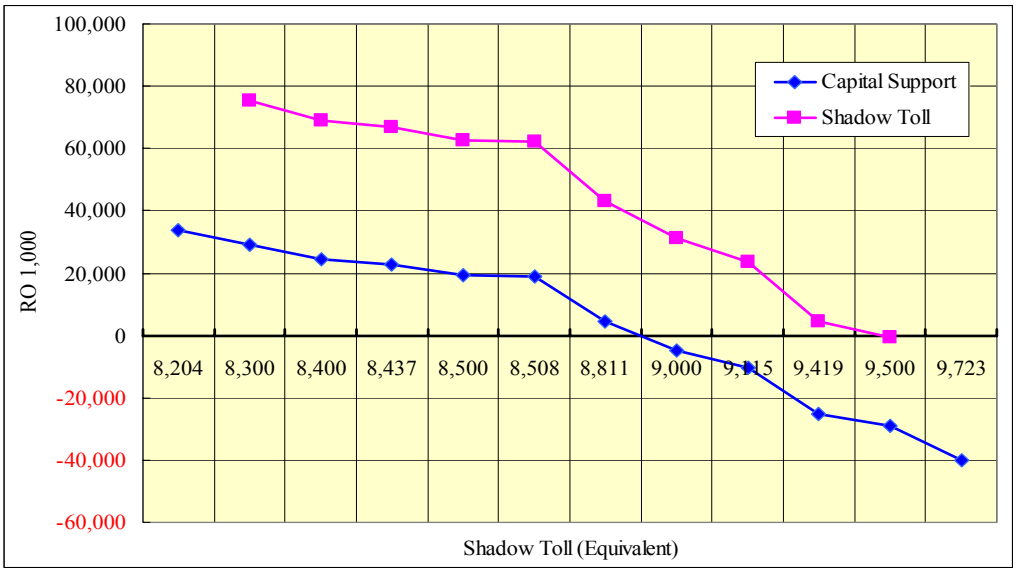


Figure 24.6-3 Economic Benefit

4) Diversification of Economy

The toll road business is natured to be really huge and long term return period. If the profitable character is given to, the business contributes to diversification of Omani economy. Referring to Section 24.1.2, a checking list is summarized and the results are shown in Table 24.6-1. From the table, Shadow toll system gives more impact to the Omani economy and its diversification effort.

24.6.3 Recommendations

From the above discussion, the consultant advises the Omani Government to study Shadow Toll System as PFI, and decides to adopt Shadow Toll System if the system is applicable to the Sultanate environment. There is enough time to prepare the necessary environment because the implementation of the expressway is scheduled to be during the 8th Plan from the year 2011. Careful implementation steps are highly required.

The major purpose of this chapter is to introduce beneficial nature of Shadow Toll Concept by applying complete figure on financial analysis, and advise to study in concrete the application of this system. This purpose is realized, and in spite of many uncertain assumptions due to the fact that most years of project period are out of the Master Plan period and many remained issues without discussing due to the out of scope of the pre-feasibility study, the difference of Shadow Toll and Government Capital Subsidy was clearly shown.

Finally, the financial statement of the RO 9,500 Shadow Toll case in the selected years is shown as an example of the recommended case in Table 24.6-2.

Table 24.6-1 Summary of Shadow Toll and Capital Support Cases

Measure	Shadow Toll Case	Capital Support Case
Suppression of public expenses	No need to invest big money at once but only need to pay shadow toll (ex. RO 9.5 million)	Need big money (ex. at least 90% of investment, RO 144 million).
Achievement of higher level of VFM*	Higher Economic Benefit means higher VFM	Lower Economic Benefit means lower VFM
Off balance sheet effect	Because the concessionaire provides capital, it is Off Balance	Because the Government provides capital, it is On Balance
Transformation of capital expenditure to current expenditure	Shadow toll payment means “current expenditure”	Capital support means “capital expenditure”
Decrease of Government employees	Managed by the concessionaire means no increase of Government employees in this project	Managed by the concessionaire means no increase of Government employees in this project
Creation of new business chance	The market so far monopolized by the Government is open to private entrepreneurs	The market so far monopolized by the Government is open to private entrepreneurs
Acceleration of technical innovation	Competition on bidding produces technical innovation especially bidding includes designing stage.	Competition on bidding produces technical innovation. If bidding does not include designing stage, that is probable because the role of concessionaire is operator in the 100% Government support case, the extent of effect is limited comparing to the Shadow toll case.
Practical use of project financing	Without project financing, Shadow toll case does not materialize. Project finance is only available when assured income from Government agreement on the shadow toll.	No use of project financing technique because no shortage of cash due to enough capitals
Enlarging of financing opportunity	Shadow toll project (PFI) is in nature high risk high return business of long term project period. It gives opportunity to the money looking for such an opportunity.	No financing is necessary

Note: * Value for Money

Table 24.6-2 Financial Statement of RO 9,500 Shadow Toll in Selected Years (RO 1,000)

Year	2025	2035	2045	2055	2070	2085	2099
Statement of Income (Loss)							
Revenue	9,500	9,500	9,500	9,500	9,500	9,500	9,500
Toll sales	9,500	9,500	9,500	9,500	9,500	9,500	9,500
Expenses	1,966	1,966	1,966	1,966	1,966	1,966	1,901
Cost of services	80	80	80	80	80	80	80
General and admin. exp.	150	150	150	150	150	150	150
Depreciation	1,736	1,736	1,736	1,736	1,736	1,736	1,671
Income from operation	7,534	7,534	7,534	7,534	7,534	7,534	7,599
Other income	598	0	0	0	0	77	1,510
Interest income	598	0	0	0	0	77	1,510
Other expenses	12,000	9,117	3,954	23410	1239	0	0
Interest expenses	12,000	9,383	10,637	23410	1239	0	0
Net income for the period	-3,868	-1,855	1,896	5,193	6,295	7,611	9,109
Corporate income tax	0	0	224	620	752	910	1,089
Balance carried over	-23,212	-65,728	-83,256	-67,196	-20,365	28,497	96,824
Dividend	0	0	373	1,033	1,253	1,516	1,816
Cumulative profit for the	-27,080	-67,584	-81,957	-63,655	-16,075	33,682	103,028
Assets							
Current assets	41,164	-32,915	-121,142	-139,697	-66,081	9,710	103,290
Cash on hand/ in banks	41,164	-32,915	-121,142	-139,697	-66,081	9,710	103,290
Fixed assets	128,373	111,017	93,660	76,304	50,269	24,234	-0
Road property	128,373	111,017	93,660	76,304	50,269	24,234	-0
Total Assets	169,537	78,102	-27,482	-63,393	-15,813	33,944	103,290
Liabilities and equity	196,355	145,423	54,213	0	0	0	0
Loan payable	196,355	145,423	54,213	0	0	0	0
Stockholder's equity							
Paid-up capital	262	262	262	262	262	262	262
Retained earnings	-27,080	-67,584	-81,957	-63,655	-16,075	33,682	103,028
Total equity	-26,818	-67,322	-81,695	-63,393	-15,813	33,944	103,290
Total liabilities & equity	169,537	78,102	-27,482	-63,393	-15,813	33,944	103,290
Statement of Cash Flow							
Cash flow from operation activities							
Income from operation	7,534	7,534	7,534	7,534	7,534	7,534	7,599
Depreciation	1,736	1,736	1,736	1,736	1,736	1,736	1,671
Interest receivable	598	0	0	0	0	77	1,510
Interest payable (long term)	12,000	9,117	3,954	0	0	0	0
Interest payable (short term)	0	272	1,683	2,341	1,239		
Tax and dividend	0	0	597	1,652	2,005	2,426	2,905
Net cash from operation	-2,133	-120	3,035	5,276	6,026	6,921	7,874
Cash flow from investing activities							
Additions of property	0	0	0	0	0	0	0
Sale of property	0	0	0	0	0	0	0
Net cash from investment	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
Cash flow from financing activities							
Issue of bond							
Redemption of bond							
Addition to loans	0	0	0	0	0	0	0
Payment to loans	3,645	6,528	11,691	0	0	0	0
Net cash from finance	-3,645	-6,528	-11,691	0	0	0	0
Total cash flow	-5,778	-6,648	-8,656	5,276	6,026	6,921	7,874
Cash balance							
Beginning of the year	46,942	-26,267	-112,486	-144,973	-72,107	2,789	95,416
End of the year	41,164	-32,915	-121,142	-139,697	-66,081	9,710	103,290

CHAPTER 25

IMPLEMENTATION PLAN FOR PRE-F/S PROJECTS

CHAPTER 25

IMPLEMENTATION PLAN FOR PRE-F/S PROJECTS

25.1 PROJECT IMPLEMENTATION PROGRAM

25.1.1 Introduction

The Road Network Development Study covers the period from the 7th 5-Year Development Plan (2006-2010) up to the 11th 5-Year Development Plan (2025-2030). The Pre-F/S projects are selected based on the prioritization criteria and consultation with concerned officials within the DGR. Table 25.1-1 presented the list of the selected projects together with their major characteristics.

Table 25.1-1 Major Characteristics of Pre-F/S Projects

Region	Project Name	M/P Project No.	Length (km)	Cost (1,000 RO)	Plan
Batinah	Al Hamra – Rustaq	N27	28	8,417	7th
	Batinah Highway (Wadi Study)	U1	253	29,120	8th
	New Batinah Expressway (Management Study)	N1	246	132,009	8th
Musandam	Madha - Dafta	N30	15	5,146	7th
Al Wusta	Al Hij - Film	N47	19	1,767	7th
Ash Sharqiya	Mahla - Ismaiya	N36	38	6,283	7th
Dhofar	Hasik - Shuwaymia (Environmental Study)	N7	114	39,026	8th

Note: N: new project; U: upgrading of existing road

As can be recognized from Table 25.1-1 four of the Pre-F/S Projects are scheduled in the 7th 5-Year Development Plan and three projects are scheduled in the 8th Plan. It should be noticed that some of the construction packages are extended to the following plan in order to balance the annual budgets in an approximately constant manner.

Table 25.1-2 shows the required fund and the estimated constructed length of the Pre-F/S Projects for each of the 7th and 8th 5-Year Development Plans. The table shows that the estimated required fund in the 7th Plan is about 61 million RO and in the 8th Plan is about 161 million RO. No cost is assigned in the 9th –Plan based on the New Batinah Expressway cost will be totally allocated during the 8th -Plan.

Table 25.1-2 Length and Required Fund of Pre-F/S Projects

Plan	Projects	Length (km)	Financial Cost (RO 1,000)
7th	N27, N30, N47 and N36	100	21,613
8th	U1, N1 and N7	613	200,155
Total		713	221,768

Note: budget for New Batinah Expressway is allocated in the 8th –Plan

25.1.2 Feasibility Study

Under this Study, only pre-feasibility studies are carried out. Before the implementation of the Projects further comprehensive F/S studies are required. Therefore, the time schedule to carry out the F/S study for each project is included in the proposed implementation plan.

With the existing of these Pre-F/S studies, it can be assumed that about a half year can be considered as a reasonable duration to carry out the F/S study for any of the four Pre-F/S Projects under the 7th Plan. As for projects under the 8th Plan, which are New Batinah Expressway, Batinah Highway and Hasik–Shuwaymia Road, a minimum of one year is required as these are large-scale projects with special conditions.

25.1.3 Environmental Impact Assessment

The preliminary environmental impact assessments (EIA) for each of the Pre F/S Projects were carried out within the scope of this Study. However, further assessment will be needed in the future for the real implementation of these projects. Chapters 18 to 24 are the Chapters specified for the selected seven Pre F/S Projects. At the end of each chapter except Chapters 23 and 24, an Annex for the EIA is attached that include the recommended implementation plan to carry out the required EIA. The EIA in Chapters 23 and 24 which deal with the existing Batinah Highway and New Batinah Expressway respectively were out of the scope of this Study. This Study was concentrated in the wadi problem and management of expressways.

The proposed durations to carry out the EIA as mentioned in each of the Pre-F/S Project chapters are considered in preparing the project implementation plans. As shown in the TOR of EIA, an average of 14 months is required. In the case of Batinah Highway and New Batinah Expressway, a reasonable duration for the EIA Study is assumed as one year.

25.1.4 Detail Design, Tendering, Bidding and Mobilization

The required duration to carry out the detailed design, preparation of tender documents, bidding and mobilization is estimated based on the investigations on current conditions in the Sultanate of Oman and considering previously executed similar projects.

The length of the project road and the topographical conditions are almost the main factors that govern the required duration to carry out these tasks. The tendering documents are usually prepared by the consultant, and reviewed by DGR, during the detail design stage. Bidding and mobilization of the contractor usually require one year for large-scale projects.

25.1.5 Land Acquisition

The issue of land acquisition can be assessed as a mild issue based on the preliminary results of the carried out Pre-F/S studies. Therefore, it can be assumed that if land acquisition is required, the process can be undertaken within the duration of bidding and mobilization that assumed to take about one year.

25.1.6 Construction

Length of the road, topographical conditions and locations of resource materials are the major factors that govern the required duration to carry out this task. The availability of the construction materials and the facilities owned by the contractor also has recognizable effects. It is assumed that the Pre-F/S Projects will be carried out by highly qualified contractors who have enough capabilities to execute such projects within the reasonable assigned construction duration.

Previous experiences in the Sultanate of Oman show that, in average, one year will be required to construct a road length of about 50 to 60 km. However, in mountainous terrain twice or more of this duration may be required. Therefore, in case of mountain terrain construction of 30 km per year is considered as reasonable.

It should be clarified here that it is out of the scope of this Pre-F/S Study to investigate the availability of the resource materials. The locations of the resource materials can significantly affect the duration of construction. As mentioned early, it is highly recommended in future to carry out a more comprehensive F/S that includes an investigation on the availability of the resource materials.

25.2 BUDGET AND FUND ALLOCATION

As shown early in Section 25.1-1, the estimated required fund in the 7th and 8th 5-Year Development Plans are RO 22 and 200 million, respectively. Table 25.2-1 shows the estimated future road investments of roads projects as estimated early in Chapter 14, Table 14.2-2. In the Table 25.2-1 the ratio of the required fund allocation for the Pre F/S Projects to the total estimated future investments are presented.

Table 25.2-1 Ratio of Pre F/S Projects Fund to Estimated Future Road Investments

Plan	GDP (million RO)	Road Investment (million RO)	Fund for Pre F/S Projects (million RO)	Ratio of Pre F/S Projects to Road Investments (%)
7th 5-Year Plan 2006 - 2010	49,395	263.2	22	8.4
8th 5-Year Plan 2011 – 2015	58,957	326.0	200	61.3

As can be recognized from Table 25.2-1 that the ratio of Pre F/S Projects to the estimated road investments during the 7th and 8th 5-Year Development Plans are about 8.4% and 61.3%, respectively. The ratios seem reasonable and the ratio of the 8th Plan is coinciding with the M/P policy that the large-scale Pre-F/S Projects are implemented within this Plan. Therefore, it can be expected that DGR can carry out these projects on the implemented development plans.

25.3 IMPLEMENTATION PLANS

25.3.1 Al Hamra – Rustaq Road (N27)

This road is located in Al Batinah Region; with a length of 28 km for Phase IV that is under the Pre-F/S. This means that the project can be constructed under only one package. Table 25.3-1 presents the proposed implementation plan of this project.

Table 25.3-1 Implementation Plan of Al Hamra – Rustaq Road (N27)

Item	Task	2006	2007	2018	2009	2010	Total
1	Feasibility Study						
2	Environmental Impact Assessment						
3	Detail Design and Bidding		236				
4	Tendering and mobilization						
5	Land Acquisition			----			
6	Construction and C/S				8,181		
7	Required Fund (1,000 RO)	236			8,181		8,417

25.3.2 Madaha – Dafta Road (N30)

This road is located in Musandam Region; with a length of 15 km. This means that the project can be constructed under only one package. Table 25.3-2 presents the proposed implementation plan of this project.

Table 25.3-2 Implementation Plan of Madaha – Dafta Road (N30)

Item	Task	2006	2007	2018	2009	2010	Total
1	Feasibility Study						
2	Environmental Impact Assessment						
3	Detail Design and Bidding		144				
4	Tendering and mobilization						
5	Land Acquisition			-----			
6	Construction and C/S				5,002		
7	Required Fund (1,000 RO)	144			5,002		5,146

25.3.3 Al Hij – Film Road (N47)

This road is located in Al Wusta Region; with a length of 19 km. This means that the project can be constructed under only one package. Table 25.3-3 presents the proposed implementation plan of this project.

Table 25.3-3 Implementation Plan of Al Hij – Film Road (N47)

Item	Task	2006	2007	2018	2009	2010	Total
1	Feasibility Study						
2	Environmental Impact Assessment						
3	Detail Design and Bidding		50				
4	Tendering and mobilization						
5	Land Acquisition			----			
6	Construction				1,717		
7	Required Fund (1,000 RO)	50			1,717		1,767

25.3.4 Mahla – Ismayia Road (N36)

This road is located in Ash Sharqiya Region. The total length is 38 km that means the project can be considered under only one construction package. Table 25.3-4 presents the proposed implementation plan of this project.

25.3.5 Hasik – Shuwaymia Road (N7)

This road is located in Dhofar Region; with a total length of 114 km. This means that the project is better to be divided into construction packages. Based on the selected alignment, it is recommended to divide the project into three packages. Package I from station 0+000 to station 20+680 (about 21 km along the coastline), Package II from

station 20+680 to station 69+310 (about 48 km) and Package III from station 69+310 to station 113+170 (about 45 km). Table 25.3-5 presents the proposed implementation plan of this project.

Table 25.3-4 Implementation Plan of Mahla – Ismayia Road (N36)

Item	Task	2007	2018	2009	2010	Total
1	Feasibility Study					
2	Environmental Impact Assessment					
3	Detail Design and Bidding		175			
4	Tendering and mobilization					
5	Land Acquisition			-----		
6	Construction and C/S				6,108	
7	Required Fund (1,000 RO)	175			6,108	6,283

Table 25.3-5 Implementation Plan of Hasik - Shuwaymia Road (N7)

Item	Task	2006	2007	2008	2009	2010	Total
1	Feasibility Study						
2	Environmental Impact Assessment						
3	Detail Design and Bidding		1,170				
4	Tendering and mobilization Pac. I						
	Tendering and mobilization Pac. II						
	Tendering and mobilization Pac. III						
5	Land Acquisition			----			
6	Construction and C/S Package I				*21 km*		
	Construction and C/S Package II				*48 km*		
	Construction and C/S Package III				*45 km*		
7	Required Fund (1,000 RO)	1,170			37,856		39,026

25.3.6 Batinah Highway Upgrading (U1)

This project is located in Al Batinah Region. The project aims to convert the existing Irish Crossing at selected 31 locations into box culverts utilizing the multi-function culvert concept, in addition to the provision of grade separation structures at the at-grade junctions and intersections along the highway. The locations are scattered along the road length of about 253 km. It seems difficult to assign the whole project to only one contractor unless this contractor will have the enough power to manage such big project volume. In the implementation of the project, it is more practical to divide the project into three almost equal construction packages. Based on the investigation of the proposed construction locations, the packages are considered as follows:

Package I	from station 00+000	to station 99+200	including 10 locations,
Package II	from station 99+200	to station 204+500	including 11 locations
Package III	from station 204+200	to Emirates border	including 10 Locations

Table 25.3-6 presents the proposed implementation plan of this project.

Table 25.3-6 Implementation Plan of Batinah Highway (U1)

Item	Task	2011	2012	2013	2014	2015	Total
1	Feasibility Study						
2	Environmental Impact Assessment						
3	Detail Design and Bidding		874				
4	Tendering and mobilization Pac. I						
	Tendering and mobilization Pac. II						
	Tendering and mobilization Pac. III						
5	Land Acquisition			--			
6	Construction and C/S Package I				*99 km*		
	Construction and C/S Package II				*105 km*		
	Construction and C/S Package III					*49 km*	
7	Required Fund (1,000 RO)	874			28,246		29,120

25.3.7 New Batinah Expressway (N1)

The implementation plan of this project is presented in details in Table 24.1-2 of Chapter 24, Section 24.1.

25.4 OVERALL IMPLEMENTATION SCHEDULE

The separately implementation plans of the Pre F/S Projects are utilized to create the Overall Implementation Schedule of these projects. Table 25.4-1 presents the proposed Overall Implementation Schedule.

The overall schedule clarifies the duration required to carry out the different tasks of implementing the Pre-F/S Projects and also clarifies the required yearly fund to be allocated to undertake the construction activities.

Table 25.4-1 Overall Implementation Schedule of Pre F/S Projects

Project No.	Project	Region	Plan	Length (km)	Cost (1,000 RO)	7th-Plan					8th-Plan					9th-Plan			
						2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
N27	**Al Hamra-Rustaq Road**	Batinah	7	28.0															
	F/S					↔													
	EIA					↔													
	DD and Bidding						↔												
	Tendering and Mobilization							↔											
	Land Acquisition							↔											
	Construction and C/S								↔										
	Required Fund (1,000 RO)				8,417	79	79	79	8,181										
N30	**Madaha-Dafta Road**	Musanadm	7	15.0															
	F/S					↔													
	EIA					↔													
	DD and Bidding						↔												
	Tendering and Mobilization							↔											
	Land Acquisition							↔											
	Construction and C/S								↔										
	Required Fund (1,000 RO)				5,146	48	48	48	5,002										
N47	**Al Hij-Film Road**	Al Wusta	7	19.0															
	F/S					↔													
	EIA					↔													
	DD and Bidding						↔												
	Tendering and Mobilization							↔											
	Land Acquisition							↔											
	Construction and C/S								↔										
	Required Fund (1,000 RO)				1,767	17	17	17	1,717										
N36	**Mahala-Ismyia Road (1,000 RO)**	A'Sharqiya	7	38.0															
	F/S						↔												
	EIA						↔												
	DD and Bidding							↔											
	Tendering and Mobilization								↔										
	Land Acquisition								↔										
	Construction and C/S									↔									
	Required Fund (1,000 RO)				6,283		58	58	58	6,108									
N7	**Hasik-Shuwaymia Road**	Dhofar	7	114.0															
	F/S					↔													
	EIA					↔													
	DD and Bidding						↔												
	Tendering and Mobilization (P I)			*21.0*				↔											
	Tendering and Mobilization (P II)			*48.0*				↔											
	Tendering and Mobilization (P II)			*45.0*					↔										
	Land Acquisition							↔											
	Construction and C/S (P I)									↔									
	Construction and C/S (P II)									↔									
	Construction and C/S (P III)										↔								
	Required Fund (1,000 RO)				39,026		390	390	390	18,928	18,928								
U1	**Batinah Highway**	Batinah	8	253.0															
	F/S										↔								
	EIA										↔								
	DD and Bidding											↔							
	Tendering and Mobilization (P I)			*99.0*									↔						
	Tendering and Mobilization (P II)			*105.0*									↔						
	Tendering and Mobilization (P II)			*49.0*										↔					
	Land Acquisition												↔						
	Construction and C/S (P I)													↔					
	Construction and C/S (P II)													↔					
	Construction and C/S (P III)														↔				
	Required Fund (1,000 RO)				29,120						291.3	291.3	291.34	14,123	14,123				
N1	**New Batinah Expressway**	Batinah	8/9	246.0															
	DD										↔								
	Land Acquisition											↔							
	Tendering and Mobilization (P I)			*58.0*								↔							
	Construction and C/S (P I)												↔		↔				
	Construction of Toll Gate (P I)														↔				
	Tendering and Mobilization (P II)			*59.5*									↔						
	Construction and C/S (P II)													↔	↔				
	Construction of Toll Gate (P II)															↔			
	Tendering and Mobilization (P III)			*53.2*										↔					
	Construction and C/S (P III)														↔	↔			
	Construction of Toll Gate (P III)															↔			
	Tendering and Mobilization (P IV)														↔				
	Construction and C/S (P IV)			*26.3*												↔	↔		
	Construction of Toll Gate (P IV)																↔		
	Tendering and Mobilization (P V)															↔			
	Construction and C/S (P V)			*49.3*													↔	↔	↔
	Construction of Toll Gate (P V)																		↔
	Required Fund (1,000 RO)				132,009						2,492		9,821	20,292	30,136	24,967	22,364	13,075	8,862
5-Year Development Plan No.						7th-Plan					8th-Plan					9th-Plan			
Year						2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total Required Fund (1,000 RO)						143	592	592	15,349	25,036	21,711	291	10,112	34,415	44,259	24,967	22,364	13,075	8,862
Grand Total Required Fund (1,000 RO)					**221,768**			**60,639**					**161,129**						

CHAPTER 26

CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 26

CONCLUSIONS AND RECOMMENDATIONS

26.1 PRE-F/S PROJECTS UNDER 7th PLAN

- The four road projects will provide important links as basic transport facilities in the road network to strengthen its function, will improve the living standards of people, and will promote regional and rural development.

- The roads, for which Pre-F/S is conducted, are basically significant projects in line with the policy, objectives and concept of the nationwide road development Master Plan. They are justified technically, socially and environmentally for the early implementation. EIA is required for some projects in order to provide mitigating measures for any anticipated negative environmental impact.

- Al Hamra - Rustaq Road:

  - The Project aims to strengthen the road network function in Northern Oman by providing connections across Al Hajar Al Gharbi Mountain Range between the two parallel routes of East-West Corridor on both sides of the mountain. It will improve the standard living of people along the Project Road and support the development of tourism sector in the area.

  - Two alternative plans for the Project are established and justified to be technically, environmentally and economically feasible with the following indicators:

	Without Bridge Plan	With Bridge Plan
Financial Cost:	RO 8,417 million	RO 11,495 million
NPV:	RO 34.1 million	RO 37.8 million
B/C:	4.95	4.24
EIRR:	27.3%	23.9%

  - It is proposed that "Without Bridge" plan be implemented as the first stage to meet the short-term traffic demand while the construction of the proposed bridge can be considered with the increase in traffic volume in the future.

- Madha - Dafta Road:

  - The Project aims to provide basic road infrastructure within Wilayat Madha area

without passing through UAE territory, to facilitate the access to Dubai and other UAE areas, to improve the social welfare of residents in the Wilayat and strengthen the unity of the nation.

- The project is technically and environmentally feasible but the direct economic benefits are low (based on the discounted rate of 6%), as follows:

Financial Cost:	RO 5.146 million
NPV:	RO 465,600
B/C:	1.13
EIRR:	7.1 %

- Al Hij – Flim Road:

- The Project aims to provide proper access road for people who are living in this coastal area of Al Wusta Region. It will support development of tourism of Mahawt Island and surrounding areas, and improve the access of local fishery to the markets in the north (Sinaw, Muscat, UAE, etc.).

- The Project is technically and environmentally feasible but economic analysis results do not show high indicators, as follows:

Financial Cost:	RO 1.767 million
NPV:	RO - 74,000
B/C:	0.95
EIRR:	5.5 %

- The Project is recommended to be constructed from view point of alleviation of regional disparity and improvement of social welfare. It will contribute to the development of fishery industry and will promote tourism activities.

- Mahla - Ismaiyah Road:

- The Project aims to strengthen the road network function in Northern Oman by providing connections across Al Hajar Ash Sharqi Mountain Range and to support development of agriculture and tourism in the north-western areas. It will improve also the living environment of local residents by providing access to schools and other public services.

- The Project is technically, environmentally and economically feasible with the following indicators:

Financial Cost:	RO 6.283 million
NPV:	RO 2.4 million
B/C:	1.45
EIRR:	9.1 %

- It is recommended to carry out a partial Environmental Impact Assessment as the Project is anticipated to exert some impacts on the natural environment including eco-system, flora and fauna.

26.2 PRE-F/S PROJECTS UNDER 8th PLAN

- Hasik – Shuwaymiyah Road: Different alignments are investigated in which the most realistic alignment is along the coastline in the southern half, and then it goes inland to the north. In general it is found that the shorter the route alignment, the higher the cost. Close consultations with MRMEWR on road structure, method of construction and mitigation measures are required to be held before the alignment is finally decided. An EIA is required as both sides of sea and mountains are environmentally critical areas.

- Batinah Highway: Replacing Irish Crossings at wadi locations along the highway with multi-function culverts is justified economically, environmentally and technically. In addition, the elimination of at-grade junctions through the provision of underpasses for vehicles will upgrade the highway function and improve its safety level. High EIRR values of 18.7% for replacing the Irish crossings and 15.2% for the construction of underpasses are estimated. Considering the high economic returns and "unquantifiable benefits", such as reduction of traffic accidents, it is recommended that these projects are implemented.

- New Batinah Expressway: This is a major project in the M/P that will promote economic diversification, detouring of Batinah Highway, international transport and will play a very important role in supporting the function of Sohar Port. To apply private financing schemes, considerable Government participation is required by applying shadow toll system concept or in capital investment. The shadow toll system will satisfy requests from the Government on positive economic benefit and from concessionaire on positive profitability. However, the project requires a more comprehensive study on environmental, technical and economic aspects to facilitate its successful implementation.

26.3 RECOMMENDATIONS

Project Authorization and Implementation:

- Projects subject to the Pre-F/S are urgent projects and should be included in the 7th and 8th Five Year Development Plans to secure required funds and to assure the development of the road network based on the established schedule for the smooth implementation and maximum efficiency.

- The implementation program of the Pre-F/S projects is formulated based on a comprehensive prioritization multi-criteria integrated with the financial resources and budgetary limitations. However, future comprehensive studies for 8th Plan projects on route selection, environmental impact assessment as well as technical, economical and financial analysis with fund planning, especially on New Batinah Expressway, are required and requesting technical assistance by JICA may be considered.

Administration and Legislation:

- To introduce new concepts in road financing, management and operation (including toll collection systems, built-operate and transfer (BOT), public-private participation (PPP) and roadside land development schemes), it is required to establish the legislation system that can attract private sector investments and provide high level of service for road users.

- The administration systems of DGR and DGC are based on the small-size organization principle. As there are many other agencies involved in activities related to road operation and management, the establishment of a coordination body is required.

Organization and Institution:

- Taking into account the DGR small-organization principle, it should be strengthened by establishing new Engineering Department with experts for bridges and structures, transport economy, road environment and other related fields.

- To enhance administration for the developed road network, function and capacities of DGR Regional Offices should be strengthened for regional-base road network development activities.

Maintenance and Management:

- The construction of new roads will increase the tasks and activities of Maintenance Department under DGR in the near future. This Department should be ready for the increasing tasks and work volumes by the early establishing of a road maintenance management system.

- Human capacity building programs for maintenance engineers and technicians is a major task that should be strongly established to develop required experience through on-the-job training and other systemized training programs.

Environmental Consideration:

- The Pre-F/S projects aim to keep both natural and social environmental conditions with minimum negative impact. Alignments with negative impact potential are modified to avoid environmentally protected areas. Environmental Impact Assessment (EIA) will be required for some projects which should be prepared in advance during the design stage of the projects.

- When implementing projects in areas where land acquisition is required, it is important to prepare land acquisition and resettlement schemes in early stages together with the allocation of required fund.

Coordination with other related Projects and Agencies:

- To provide optimum integration and maximum benefits, implementation of the Pre-F/S projects should be carried out as scheduled and in complete coordination with other infrastructure and socioeconomic development plans and major projects.

- The two projects of Batinah Highway and New Batinah Expressway, which are subject to Pre-F/S, are directly connected with the road network under Muscat Governorate. Full coordination between DGR and Muscat Municipality is required for the smooth implementation of the projects.

- Good understanding and supporting by policy makers and budgeting agencies are indispensable for successful implementation of the Master Plan. DGR and DGC should exert full effort to obtain understanding of those people and agencies.