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WORKING PAPER 9
Initial Roads Study

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 **ARCADIS** EUROCONSULT

IN ASSOCIATION WITH





YEMENI ENGINEERING GROUP

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1 TERMS OF REFERENCE

The tasks for the initial roads study are to:

- Conduct a drive-over inspection of the existing roads in the two project areas
- Discuss with project staff about priorities and if any of the roads work will be carried out under the maintenance budget
- Prepare a strategy, priorities and possible work schedules for road improvements compatible with the current allocation of funds for this work
- Identify which roads would merit asphalt surfacing if funds permit
- Present a report in the form of a working paper on proposed road improvements.

2 SITE VISITS

2.1 WADI TUBAN

The roads listed below are considered priorities of the work to be done in Wadi Tuban. During this first mission only a first impression of the entire road network in the project area was obtained. The first priority ranking is given below. A map of the roads in the project area is displayed in Figure 2.1 at the end of this report.

Table 2.1 Roads listed as priorities in Wadi Tuban

	Name	Length (km)
1-	Al-Arais roads	10.0
2-	Ras Al Wadi roads	11.0
3-	Faleq Iadh roads	8.0
4-	Mujahid roads	6.0
5-	Al-What roads	4.0
6-	Beizag roads	8.0
7-	At Thaalab roads	2.0
8-	Al Manasira roads	4.0
9-	Obar Riyadh roads	2.0
Total		55.0

2.2 WADI ZABID

One of the priorities as seen by the PIU is the construction of an asphalt ring road. However, it is understood that the September 2002 World Bank mission proposed that any asphalt surfacing should be carried out by the World Bank funded Rural Roads Project. A map of the roads in the project area is displayed in Figure 2.2 at the end of this report.

Table 2.2 Roads visited in Wadi Zabid

Road No.	Length (km)
2	4.5
8	7.3
8-A	8.0
8-B	5.5
8-C	6.2
8-D	1.9
10	6.8
10-A	6.7
10-B	3.6
1	5.3
1-A	1.0
1-B	1.4
1-C	3.1
1-D	7.6
4	2.4
7	1.2
TOTAL	72.5

It was observed that Zabid has a more integrated overall road network compared with Tuban. These roads provide better overall coverage of the project area with few of the roads running along canals.

3 GENERAL APPROACH TO IMPROVEMENT

The following considerations are made during the formulation of recommended works for the roads:

Minimum Work

All the roads inspected require the following basic minimum work to ensure an extension of their current working life:

- Scarification of the existing surfacing
- Mixing of additional binder where needed
- Grading and compaction

Thickness of Gravel Surfacing

For most roads, additional gravel surfacing is proposed. This will either be 100mm or 200mm thickness according to the thickness of existing gravel surfacing still remaining and the traffic loading.

Road Width

The width of the existing roads is generally sufficient to meet the current traffic needs.

Earthworks

Additional earthworks are needed for Zabid roads 4, 8B and 10. A raise of 0.5 m of the embankment is necessary since this has been deteriorated by spate irrigation water.

Drainage Structures

During the visit to Wadi Tuban and Wadi Zabid all existing drainage structures were examined and some of the problems encountered are listed below:

- Drainage is blocked on purpose
- Structures need cleaning
- Several structures need protection work (Wadi Zabid, road 10)

New drainage structures in existing and non-existing roads will be based on the following information:

- Information from PIU representatives about the need for drainage in a certain road section.
- Information from farmers about the quantity of water passing during the wet season.
- Initial study of the catchment area

Asphalting

Asphalting will only be done if enough money is allocated for this purpose. The PIU manager of Wadi Zabid, Mr. Khaled Al-Attas suggested a ring road, comprising road 8, 8A, 8C, 1B, and 1D. After further inspection, road 10 and 10A are considered to be more suitable for asphalting, because of the larger farms located there. In case enough money is allocated for

construction of a ring road, a survey such as a traffic study should be conducted in advance, to recommend the most beneficial location.

Materials

Suitable material is available at both locations in the vicinity of roads. Screened gravel material of a maximum size of 50 mm is needed for gravelling.

4 PROPOSED ROADWORK

Table 4.1 Proposed roadwork in Wadi Tuban

Road no.	Length (km)	Width (m)	Present status	Proposed work
A-1	10.0	5.0	Top gravel layer is washed away. Needs drainage	0.20 m of gravel to be laid Sub grade preparation for the first 2 km 2 Pipe culverts Ø 0.90 m 3 Pipe culverts Ø 0.75 m
A-2	11.0	5.0	Top gravel layer is washed away. Needs drainage	0.20 m of gravel to be laid. Sub grade preparation for the first 5 km 3 Pipe culverts Ø 0.90 m. 2 Pipe culverts Ø 0.75 m.
B1-1	8.0	3.5	No tracks	Clearing & grubbing Excavation (cut & fill) 0.20 m Sub grade Layer 0.20 m of gravel to be laid 5 box culverts 1.0mx1.5 m. 3 box culverts of 2 cells 3m x2.5 m
B1-2	6.0	3.5	No tracks	Clearing & grubbing Excavation (cut & fill) 0.20 m Sub grade layer 0.20 m of gravel to be laid 6 box culverts of 2 cells 2m x 2 m
B1-3	4.0	3.5	No tracks	Clearing & grubbing Excavation (cut & fill) 0.20 m Sub grade layer 0.20 m of gravel to be laid
B2-1	8.0	3.5	Top gravel layer is washed away. Needs drainage	0.20 m of gravel to be laid. 3 pipe culverts Ø 0.75m
B2-2	2.0	3.5	Top gravel layer is washed away.	0.20 m of gravel to be laid.
B2-6	4.0	3.5	Track road	Sub grade preparation for the first 2 km 0.20 m of gravel to be laid
B2-7	2.0	3.5	Top gravel layer is washed away.	0.20 m of gravel to be laid.

Table 4.2 Detailed roadwork in Wadi Tuban

Road no.	Length (km)	Width (m)	Clear & Grub (ha)	New box culvert	New pipe culvert	New Irish crossing	Regravelling to 0.20 m (km)	Sub grade prep. (m ²)	Fill (m ³)	Soil exc. (m ³)
A-1	10.0	5.0			2 Ø 0.90 m 3 Ø 0.75m					
A-2	11.0	5.0			2 Ø 0.75m					
B1-1	8.0	3.5		5(1 x 1.2m) 3 (2C x 3m x 2.5m)						
B1-2	6.0	3.5		6 (2C x 2m x 2m)						
B1-3	4.0	3.5								
B2-1	8.0	3.5			3Ø 0.75m					
B2-2	2.0	3.5								
B2-6	4.0	3.5								
B2-7	2.0	3.5								

Table 4.3 Proposed roadwork in Wadi Zabid

Road no.	Connecting area		Length (km)	Width (m)	Present status	Proposed works
	From	To				
1	Road No 1-0	Diversion weir no.1	5.3	3.5	Top gravel layer is washed away.	0.20 m of gravel to be laid
1-A	Road No 1-0	Applied research farm	1.0	3.5	Top gravel layer is washed away.	0.20 m of gravel to be laid
1-B	Road No.1	Diversion weir no.2	1.4	3.5	Top gravel layer is washed away.	0.20 m of gravel to be laid
1-C	Road No.2	Diversion weir no.3	3.1	3.5	Top gravel layer is washed away. Needs drainage	0.20 m of gravel to be laid. 3 new pipe culverts 1m dia. are needed.
1-D	Main road	TDA Wadi Zabid Camp	7.6	6.0	Top gravel layer is washed away. Needs drainage	0.20 m of gravel to be laid. 2 new pipe culverts 0.90 m dia. are needed.
4	Main road	Diversion weir no.4	2.4	3.5	50% of road embankment is damaged. Needs drainage	0.50 m of height to be raised, 50% of road length. 4Box culvert of 2 cells of 1m x 1.5m is needed. 0.20 m of gravel to be laid.
7	Main road	Diversion weir no.5	1.2	3.6	Top gravel layer is washed away.	0.20 m of gravel to be laid.

Table 4.3 Proposed roadwork in Wadi Zabid cont'd

Road no.	Connecting area		Length (km)	Width (m)	Present status	Proposed works
	From	To				
2	Garahi	Road C	4.5	3.5	Top gravel layer is washed away. Needs drainage	0.20 m of gravel to be laid. 1 box culvert of 2 cells of 1m x 2m is needed.
8	Zabid	Toraibah	7.3	6.0	Top gravel layer is washed away.	0.20 m of gravel to be laid.
8-A	Toraibah	Road no. 8-C	8.0	6.0	Top gravel layer is washed away. Culvert & Irish crossing are needed.	0.20 m of gravel to be laid. 2 Irish crossings of 50 m are needed. One pipe culvert of Ø0.75 m is needed
8-B	Toraibah	Zaribah	5.5	3.5	50% of Road embankment is washed away by spate irrigation water. Needs drainage	Road embankment to be reconstructed for 50% of total length. 3 Irish crossing length 40 m are needed. 0.20 m of gravel to be laid.
8-C	Road no. 8-A	Amer	6.2	3.5	Top gravel layer is washed away.	0.20 m of gravel to be laid.
8-D	Road no. 10-A	Qurrah	1.9	3.5	Top gravel layer is washed away.	0.20 m of gravel to be laid. One pipe culvert of Ø0.75 m is needed.
10	Zabid	Zaribah	6.8	3.5	50% of Road embankment is washed away. Top gravel layer is washed away. Needs drainage	Raise embankment by 0.50m. 4 Box culverts are needed of 2 cells of 1m x1.5 m.
10-A	Zaribah	Road no. 8-D	6.7	3.5	Top gravel layer is washed away.	0.20 m of gravel to be laid.
10-B	Zaribah	Mahal Sheikh	3.6	3.5	Completely washed away by spate irrigation.	Replacement by new road.

Table 4.4 Detailed roadwork in Wadi Zabid

Road no.	Length (km)	Width (m)	New box culvert	New pipe culvert	New Irish crossing	Regravelling to 0.20 m depth (km)	Raise embankment (km)	Reconstruction of road (km)
1	5.3	3.5				5.3		
1-A	1.0	3.5				1.0		
1-B	1.4	3.5				1.4		
1-C	3.1	3.5		3 Ø 1.0 m		3.1		
1-D	7.6	6.0		2 Ø 0.90 m		7.6		
4	2.4	3.5	4 (2C x 1m x 1.5m)			2.4	3.5 by 0.5	
7	1.2	3.6				1.2		

Table 4.4 Detailed roadwork in Wadi Zabid (Cont'd)

Road no.	Length (km)	Width (m)	New box culvert	New pipe culvert	New Irish crossing	Regravelling into 0.20 m depth (km)	Raise embankment (km)	Reconstruction of road (km)	
2	4.5	3.5	1 (2C x 1m x 2m)			4.5			
8	7.3	6.0				7.3			
8-A	8.0	3.5		1 Ø 0.75m	2 (L=50 m)	8.0			
8-B	5.5	3.5			3 (L=40 m)	5.5		2.8	
8-C	6.2	3.5				6.2			
8-D	1.9	3.5		1 Ø 0.75m		1.9			
10	6.8	3.5	4			6.8	3.5 by 0.5		
10-A	6.7	3.5				6.7			
10-B	3.6	3.5	construct new road						3.6
Total	50.5							6.4	

5 COST ESTIMATES

The availability of suitable building materials is researched, and the prices of the Ministry of Public Works and concerned authorities in Yemen are compared to private sector prices. Based on this information and a study of both wadis, a proper cost estimate is made, and displayed in the following tables in paragraph 5.1 and 5.2.

5.1 COST ESTIMATES FOR WADI TUBAN

Table 5.1 Estimated quantities and costs in YR for gravelling of roads in Wadi Tuban

Road no.	Length (km)	Width (m)	Area (m ²)	Gravelling depth (m)	Gravelling (m ³)	Cost - 700YR/m ³
A-1	10.0	5.0	50,000	0.2	10,000	7,000,000
A-2	11.0	5.0	55,000	0.2	11,000	7,700,000
B1-1	8.0	3.5	28,000	0.2	5,600	3,920,000
B1-2	6.0	3.5	21,000	0.2	4,200	2,940,000
B1-3	4.0	3.5	14,000	0.2	2,800	1,960,000
B2-1	8.0	3.5	28,000	0.2	5,600	3,920,000
B2-2	2.0	3.5	7,000	0.2	1,400	980,000
B2-6	4.0	3.5	14,000	0.2	2,800	1,960,000
B2-7	2.0	3.5	7,000	0.2	1,400	980,000
Total	55.0		224,000		44,800	31,360,000

Table 5.2 Estimated quantities and costs in YR for clearing and grubbing roads in Wadi Tuban

Road no.	Length (km)	Width (m)	Area (m ²)	Total Cost - 80,000YR/m ²
B1-1	8.0	5.0	40,000	320,000,000
B1-2	6.0	5.0	30,000	240,000,000
B1-3	4.0	5.0	20,000	160,000,000
Total	18.0	10.0	90,000	720,000,000

Table 5.3 Estimated quantities and costs in YR for box culverts for roads in Wadi Tuban

Road no	Width (m)	Type 1 (1mx2m)		Type 2: 2 CELLS (3m x2.5m)		Type 2: 2 CELLS (2m x2m)		Total Cost
		No.	Tot. Cost	No.	Tot. Cost	No.	Tot. Cost	
B1-1	3.5	5.0	2,750,000	1.0	1,560,000			4,310,000
B1-2	3.5					6.0	5,940,000	5,940,000
Total			2,750,000		1,560,000		5,940,000	10,250,000

Table 5.4 Estimated quantities and costs in YR for pipe culverts for roads in Wadi Tuban

Road no.	Width (m)	Type 1 Ø 0.75		Type 2 Ø		TYPE 2 Ø		Total Cost
		No.	Tot. Cost	No.	Tot. Cost	No.	Tot. Cost	
A-1	5.0	5.0	1,110,000					1,110,000
A-2	5.0	5.0	1,095,000					1,095,000
B2-1	3.5	3.0	540,000					540,000
Total			2,745,000					2,745,000

Table 5.5 Estimated quantities and costs in YR to subgrade layers for roads in Wadi Tuban

Road No.	Length (km)	Width (m)	Area (m ²)	Layer height (m)	Subgrade (m ³)	Total Cost - 700YR/m ³
B1-1	8.0	3.5	28,000	0.2	5,600	3,920,000
B1-2	6.0	3.5	21,000	0.2	4,200	2,940,000
B1-3	4.0	3.5	14,000	0.2	2,800	1,960,000
Total	18.0	10	63,000		12,600	8,820,000

Table 5.6 Estimated quantities and costs in YR for cut and fill of roads in Wadi Tuban

Road no.	Length (km)	Cut width (m)	Area (m ²)	Cut height (m)	Soil exc. (m ³)	Cost of cut - 150YR/m ³	Cost of fill - 180YR/m ³	Total cost
B1-1	8.0	2.0	16,000	1.5	24,000	3,600,000	1,440,000	5,040,000
B1-2	6.0	2.0	12,000	1.5	18,000	2,700,000	1,080,000	3,780,000
B1-3	4.0	2.0	8,000	1.5	12,000	1,800,000	720,000	2,520,000
Total	18.0		36,000		54,000	8,100,000	3,240,000	11,340,000

Table 5.7 Total costs in YR for roads of Wadi Tuban

Description	Cost
Clearing and grubbing	720,000
Cut	8,100,000
Fill	3,240,000
Subgrade layer	8,820,000
Box culverts	10,250,000
Pipe culverts	2,745,000
Gravelling	31,360,000
Sub total Cost	65,235,000
Total cost in USD (1 USD =182 YR)	358,434

5.2 COST ESTIMATES FOR WADI ZABID

Table 5.8 Estimated quantities and costs in YR for gravelling of roads in Wadi Zabid

Road no.	Length (km)	Width (m)	Area (m ²)	Gravelling depth (m)	Gravelling (m ³)	Total Cost - 700YR/m ³
1	5.3	3.5	18,550	0.2	3,710	2,597,000
1-A	1.0	3.5	3,500	0.2	700	490,000
1-B	1.4	3.5	4,900	0.2	980	686,000
1-C	3.1	3.5	10,850	0.2	2,170	1,519,000
1-D	7.6	6	45,600	0.2	9,120	6,384,000
4	2.4	3.5	8,400	0.2	1,680	1,176,000
7	1.2	3.6	4,320	0.2	864	604,800
2	4.5	3.5	15,750	0.2	3,150	2,205,000
8	7.3	6	43,800	0.2	8,760	6,132,000
8-A	8.0	3.5	28,000	0.2	5,600	3,920,000
8-B	5.5	3.5	19,250	0.2	3,850	2,695,000
8-C	6.2	3.5	21,700	0.2	4,340	3,038,000
8-D	1.9	3.5	6,650	0.2	1,330	931,000
10	6.8	3.5	23,800	0.2	4,760	3,332,000
10-A	6.7	3.5	23,450	0.2	4,690	3,283,000
10-B	3.6	3.5	12,600	0.2	2,520	1,764,000
Total	72.5		291,120		58,224	40,756,800

Table 5.9 Estimated quantities and costs in YR for embankment of roads in Wadi Zabid

Road no.	Length (km)	Width (m)	Area (m ²)	Embankment raise (m)	Embankment vol. (m ³)	Total Cost - 700YR/m ³
4	1.2	3.5	4,200	0.5	2,100	1,470,000
8-B	2.75	3.5	9,625	0.5	4,813	3,368,750
10	3.4	3.5	11,900	0.5	5,950	4,165,000
10-B	3.6	3.5	12,600	0.5	6,300	4,410,000
Total	11		38,325		19,163	13,413,750

Table 5.10 Estimated quantities and costs in YR of box culverts for the roads in Wadi Zabid

Road no.	Width (m)	Type 1 (1mx2m)		Type 2 (2 cells of 3mx2.5m)		Type 2 (2 cells of (2mx2m))		Total costs
		No.	Tot. Cost	No.	Tot. Cost	No.	Tot. Cost	
2	3.5	1.0	550,000					550,000
10	3.5	4.0	2,200,000					2,200,000
Total								2,750,000

Table 5.11 Estimated quantities and costs in YR of pipe culverts for the roads in Wadi Zabid

Road no.	Width (m)	Type 1 Ø 0.75 m		Type 2 Ø 0.90m		Type 2 Ø		Total costs
		No.	Tot. Cost	No.	Tot. Cost	NO	T.cost	
1-C	3.5			3	585,000			585,000
1-D	6.0			2	480,000			480,000
8-A	6.0	1	225,000					225,000
8-D	3.5	1	180,000					180,000
Total		2	405,000	5	1,065,000			1,470,000

Table 5.12 Estimated quantities and costs in YR of Irish crossings for the roads in Wadi Zabid

Road no.	Width (m)	Data				Total cost - 30,000 YR/m ³
		No.	Thickness (m)	Length (m)	Volume (m ³)	
8-A	3.5	2	0.25	50	87.5	2,625,000
8-B	3.5	3	0.25	40	105	3,150,000
Total					192.5	5,775,000

Table 5.13 Total costs in YR for roads of Wadi Zabid

Description	Cost
Box Culverts	2,750,000
Pipe Culverts	1,470,000
Embankment	13,413,750
Gravelling	40,756,800
Irish Crossings	5,775,000
Subtotal Cost	64,165,550
Total costs in USD (1 USD =182 YR)	352,558

5.3 TOTAL COSTS OF ROAD WORK

Table 5.14 total costs in YR of road work

	Total Costs
Wadi Tuban	65,235,000
Wadi Zabid	64,165,550
Total	129,400,550
Total (USD)	710,992

6 RECOMMENDATIONS

6.1 WADI TUBAN ROAD NETWORK

The current proposals for improvement of roads in the Wadi Tuban area appear to be focussed on providing access along canals, rather than providing wider benefits to the community. Some, but not all, the canal roads already provide important transport links.

It is therefore recommended that further study and consultation is needed for the Wadi Tuban area to ensure that investment in road improvements will provide the greatest possible benefits to the farmers. This will include both access for irrigation infrastructure operation and maintenance purposes and the provision of better links between farms and markets.

6.2 SURVEY WORK

Detailed design can proceed for improvement of the road network in Zabid as soon as the surveys are completed. Survey work for existing roads will not take much time since all roads are flat. With a total station instrument, a surveyor can take cross sections at 50 m intervals with readings at the centre, left and right, which could result in an surveyed area of 4-5 km per day. For existing roads this method of surveying would be convenient.

For non-existing roads, full survey work must be done, which includes PI's, cut and fill of cross-section and bench marking. 20 - 25 m sections should be taken, and 1 – 2 km could be surveyed daily since the roads are flat. In the light of the above, surveying must be done during the execution of work by the contractor, to monitor these activities at the same time.

LIST OF APPENDICES

A. PHOTOGRAPHS OF ROADS IN WADI TUBAN

B. PHOTOGRAPHS OF ROADS IN WADI ZABID

A. PHOTOGRAPHS OF ROADS IN WADI TUBAN

Al Arais Road



Al Arais Road



Al Arais Road



Branch road from Al Arais



Ras Al Wadi Road



Ras Al Wadi Road











Starting point of Al Faqih
Road (Track is 200 m long)



Al Faleq Road
(No track)



Al Faleq Iadh Road (No track)



Al Faqih Road



Al Faleq Road



Al Faleq Road



Al Wahat Road



Al Wahat Road



Al Wahat Road





Mujahed Road



Mujahed Road



Mujahed Road



Mujahed Road



B. PHOTOGRAPHS OF ROADS IN WADI ZABID



Road no. 1 (Start)



Road no. 1



Road no. 1



Road no. 1



Road no. 2



Road no. 2



Road no. 8-D



Road no. 8-D



Road no 8-C (End)



Road no. 8-D



Road no. 8-D



Road no. 8-D



Road 8-C



Road 8-C



Road 8-C



Road no. 8-A



Road no. 8-A



Road no. 8-A



Road no. 8-A



Road no. 8



Road no. 8