4.3. Pavement Design

Due to the absence of any Traffic information in addition to the fact that the original TOR for the Consultancy Services does not include carrying out any traffic counts and/or analysis, it is rather difficult to calculate the required thickness of the pavement layers. However, in the following sub–sections a reverse design will be carried out and checked where two different thicknesses of pavement layers are to be assumed. Each case shall be analysed separately to check the volume of traffic it can accommodate and the applied service life.

4.3.1. Pavement Structure

As for road design taking a service life of 20 years is a common practice not only in Jordan but also internationally.

(1) Traffic Distribution

<u>Traffic conditions</u>

In the case, the pavement layers are suitable for the traffic conditions:

- Service Period: 20 years.
- Average Daily Traffic in each direction: 5000 VPD.
- % of small buses: 15%
- % of big buses: 10%
- % of trucks: 2%

W_{18} = 4750(0.73x0.0007x0.15x0.0887 + 0.1x1.0421 + 0.02x2.453) = 794 per day

W_{18} (for 20 years) = 794x20x365 = 5.796 million standard axle load.

<u>Weight</u>

- Assuming the ave. weight of small vehicles: 2 tons
- The average weight of big buses: 6 tons
- The average weight of trucks: 15 tons
- The back axle: carrying 2/3 the weight.
- Using the equivalent 8.2 lane factors for: Pt = 2.5 and SN =3

(2) Evaluating Traffic Volume

Using the following basic design equation of AASHTO:

$$\log_{10} W_{18} = 9.36 \log (SN + 1) - 0.2 + \frac{\log\{(4.2 - Pt)/(4.2 - 1.5)\}}{0.40 + \{1094/(SN+1)^{5.19}\}} + \log \frac{1}{R} + 0.372(S_i - 3.0)$$

Where:

W18 = Total equivalent 18-kips single axle load applications during Service period.

SN = The pavement structural number which should be calculated

Si = Soil Support Value (average 6.0 for CBR = 15)

Pt = Terminal Serviceability Index (2.5)

R = Regional Factor (1.0)

Using the following equation:

SN = a1 D1 + a2 D2 + a3 D3

Where:

D1 = The Sub – Base Layer Thickness

D2 = The Base layer thickness

D3 = The bituminous surface layers thickness (total)

a1 = The structural number coefficient for sub – base layer.
= 0.11 for sandy gravel sub – base material

a2 = The structural number coefficient for base layer
= 0.11 for crushed stones base material

a3 = The structural number coefficient for bituminous surface layers
= 0.44 for plant mix bituminous surface layer.

SN = 0.11x20 + 0.11x20 + 0.44x5 + 0.44x5 = 8.8cm = 3.465 in.

Log W_{18} = 6.082 – 0.2 + (-0.2009/0.8639) + 0 + 1.116 = 6.765

W_{18} = 5.82 million standard axle load.

(3) Pavement structure

According to the above study, the pavement structure applied to the sub-project is as shown below:

- 5cm thick compacted bitumen Wearing Coarse.
- 5cm thick compacted bitumen Binder Coarse
- 20cm thick compacted crushed aggregate Base.
- 20cm thick sandy gravel Sub – Base Layer

As for the Bridge, the pavement structure applied as follows:

- 5cm thick compacted bitumen Wearing Coarse.
- Water proofing membrane
- 20cm thick of Deck slab

4.4. Cross–Section, At–grade Intersections and Other Road Facilities

4.4.1. Cross–Section Elements

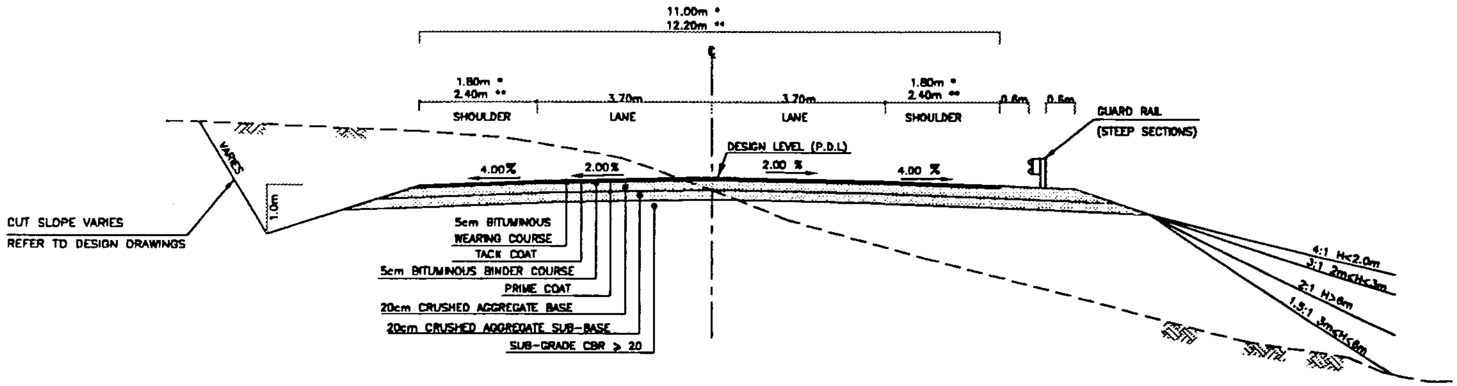
The cross section of the Dead Sea Parkway generally comprises of two lanes and two shoulders. The lane width is 3.7m while the width of the shoulder is 1.8m for the 30kph-design speed stretches and 2.4m for the 50kph-design speed stretches.

Normal crown is considered with 2.0% cross slopes for the road and 4.0% for the shoulders.

The type of surface used is hot asphalt mix (flexible). The shoulders are also paved with no drop in elevation between the edge of lane and the edge of shoulder. Paved ditches (grouted rip-rap) is considered and clearly marked especially in the steep slope sections.

Cut and fill slopes are determined depending on the material and the height of cut or fill. This is shown on the typical cross sections in Figure 4.6.

TYPICAL ROAD SECTION



* FROM STA. 0+000 TO STA. 5+540
& FROM STA. 10+595 TO STA. 11+643.70
** FROM STA. 5+540 TO 10+595

Source: JICA Study Team

Figure 4.6 Typical Cross Sections of Parkway

4.4.2. At-grade Intersections

Two at-grade intersections are designed at both the start and the end points of the Dead Sea Parkway.

The first is the intersection point between the Parkway and the Dead Sea Highway Route 65, called the Dead Sea Intersection. The second is the intersection with the Ma'in-Main Road, called the Ma'in Intersection.

(1) Dead Sea Intersection

The design is based on AASHTO Standards. The intersection angle is modified to become almost perpendicular as per the official request from MPWH.

Two additional lanes are proposed to increase the width of the existing Dead Sea Highway (3.7m lane for each direction) in order to accommodate traffic on both sides of the highway.

Traffic coming from the North direction and headed towards Ma'in will have an auxiliary lane of 45m in length in addition to the taper to provide for safe stopping prior to turning left. Traffic coming from the North and headed south on the Dead Sea Highway will have no stops due to the provision of the auxiliary lane for the use of traffic turning left.

The additional lane (for traffic coming from North) will end with a 90.0m taper as shown in Figure 4.7.

Traffic using the Dead Sea Highway and coming from the South and headed towards Ma'in can take the extreme right lane and continue in that direction without making any stops theoretically (through the provision of a 60m taper and a 120m deceleration lane). Traffic signs are provided at the intersection to give priority to traffic using the Parkway Road.

As for traffic using the Dead Sea Highway and headed north, it will examine no stops similar to the traffic in the other direction.

Traffic coming from Ma'in and headed North will utilise the additional 120m acceleration lane in addition to the 60m taper on the Dead Sea Highway. This additional lane will minimise the effects on the through traffic headed north. As for traffic coming from Ma'in and Headed South, a full stop shall be required giving priority for the through traffic using the Dead Sea Highway in both directions.

All curves at the intersection location are designed for big tourist buses.

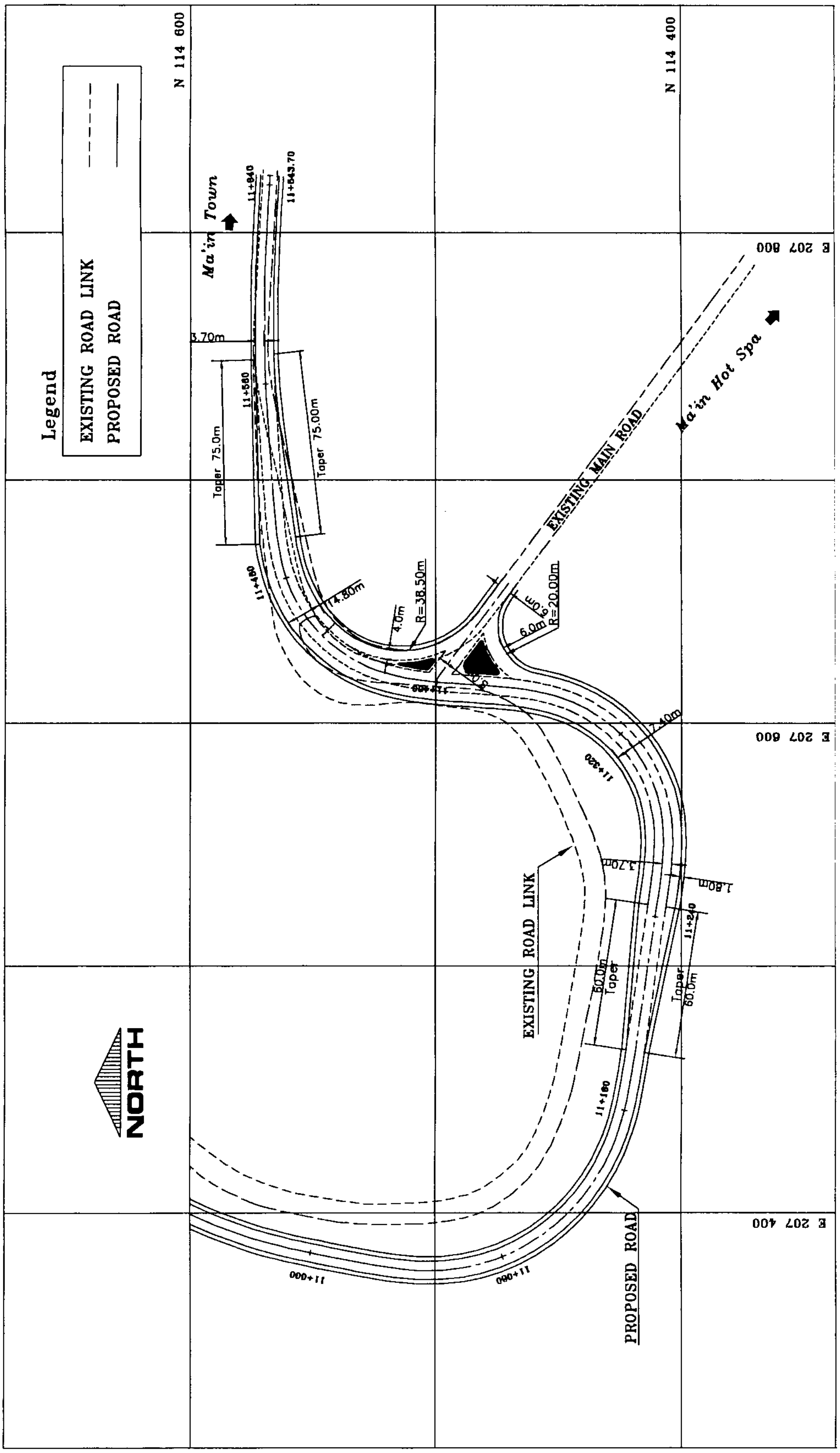
The design of marking and signing for the intersection is carefully done to ensure safety. All islands are provided with the proper signs and chevrons to insure good visibility even at night time.

Signs are properly placed so that the intersection hazards would be minimised. White, Yellow, Green and red Uni-Directional Cats Eyes in addition to Yellow – Red Bi-Directional Cats Eyes are used properly and in full coordination with the Traffic and Maintenance Directorate in MPWH.

Mountable curbstone is used for all islands in the intersection area to reduce the safety hazards for vehicles in all directions.

The layout of the Dead Sea intersection is shown in Figure 4.7.

Figure 4.7 Dead Sea Intersection



Source: JICA Study Team

(2) Ma’in Intersection

The design is based on AASHTO Standards. The main principles of the design can be summarised as follows:

- To consider this link as a continuation to the Madaba - Ma’in Road. It is expected that a considerable percentage of the traffic will use this link due to its accessibility to the Dead Sea Highway (Route 65) once the Dead Sea Parkway Road is being constructed. This new route will represent an alternative route for all passenger cars, tourist buses and light trucks headed towards the Dead Sea Highway and vica versa towards Madaba, Ma’in and even Amman.
- Re-align the existing link for better intersection location. This will be done both horizontally and vertically. The new Parkway is considerably lowered to meet the levels of the existing Ma’in – Hot Spa Road that will ease the vertical connection between the two roads. This will be clearly observed when designing the profile of the ramp serving the traffic coming from the Hot Spa and headed towards the Dead Sea and vica versa. Part of the existing Ma’in Main Road will be used as a ramp to serve traffic coming from the Hot Spa and headed towards Ma’in, Madaba and Amman.
- To consider the remaining stretch of the existing Ma’in – Hot Spa Road that connects with the Hot Spa as the minor road.

Taking all the above into consideration, the intersection is designed as shown in Figure 4.8.

In this design, it is proposed to make use of the existing flat area to introduce an additional lane with proper tapers to serve the concept of non-stopping traffic heading from Madaba towards the Dead Sea direction. As for traffic coming from Madaba and headed towards the Hot Spa, it will be forced to make a stop and give priority but within a separate lane before continuing towards the Hot Spa. This concept is raised depending on the assumption that the main traffic coming from Madaba will mostly be heading towards the Dead Sea and the Baptism Site.

As for traffic coming from the Dead Sea, the portion of it heading towards Madaba will require no stops. The other portion of traffic heading towards the Hot Spa will go through another ramp but will be forced to make a stop at the end of the ramp to give priority for other traffic in the existing road.

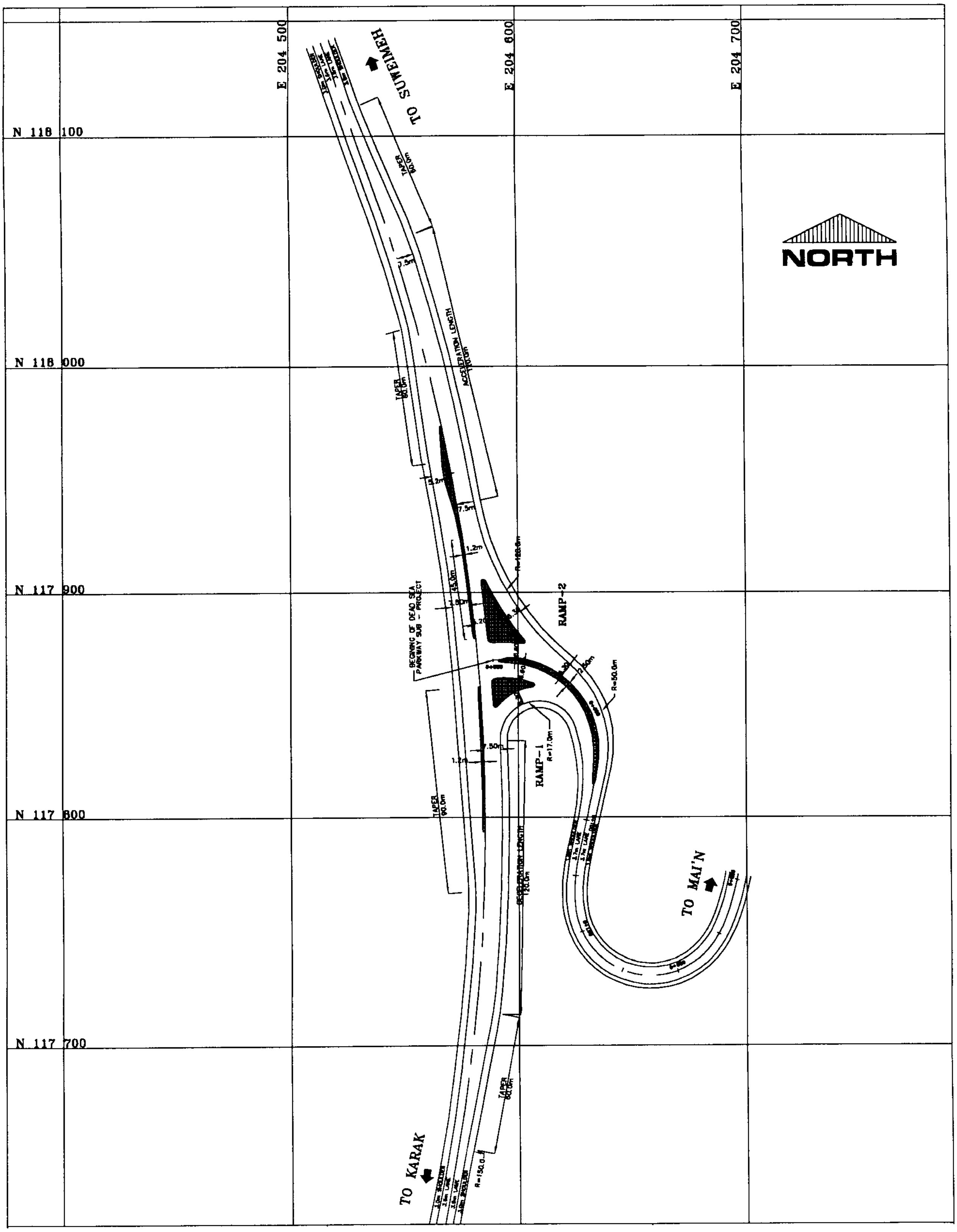
Traffic coming from the Hot Spa and heading towards the Dead Sea will have to make a stop at the channelised islands giving priority for the main traffic between Madaba and the Dead Sea and vica versa. As for the traffic coming from the Hot Spa and headed towards Ma’in and Madaba, part of the existing road is utilised ending with a taper to connect with the newly proposed road.

All curves at the intersection location are designed for big tourist buses. Traffic signs are provided at the intersection to give priority to traffic using the Parkway Road in the two directions.

The design of marking and signing for the intersection is carefully done to ensure safety. All islands are provided with the proper signs and chevrons to insure good visibility even at night-time. Mountable curb stone is used for all islands in the intersection area to reduce the safety hazards for vehicles in all directions.

The layout of the Ma’in intersection is shown in Figure 4.8.

Figure 4.8 Ma'in Intersection



Source: JICA Study Team

4.4.3. Parkway Facility

Unique parking facilities were provided for the Parkway Sub – Project between Sta. 5 + 560 and Sta. 6 + 080 (See Figure 4.9) for several purposes, some of which are as follows:

- Give a chance for tourist traffic to enjoy the beauty of nature in that area in addition to the view overlooking the Dead Sea. As previously mentioned in the Ecology section in Chapter (2) of this report, this area is being considered as part of the Dead Sea Basin Ecosystem that is considered unique due to the dramatic drop in elevation and other features resulting from years of complex geophysical activity. The Dead Sea Basin Ecosystem is also considered very important for resident and migratory birds and endangered raptors.
- For traffic in general, it is considered as a rest area. Traffic coming from the Dead Sea climbing the first difficult 5.5km of the Parkway Road would find it necessary to have a rest before continuing towards Ma’in and /or Madaba. The same applies for the traffic in the other direction.

The Parkway Facility consists of two asphalt paved parking areas with two landscape areas accessed by two 4m roads (one for each direction). The parking in each direction is designed to accommodate at least ten cars in addition to separate parking spaces for buses. The access roads are smoothly and safely connected with the Parkway Road in both directions through the provision of adequate tapers.

Simple landscaping is applied in the designated areas consisting of trees (Acacia, Ice Plant and Phoenix), natural stone tiles, rock formation and some stone seating.

The design of the facility took into consideration providing three different levels. The upper level would be for the parking and landscape area to the left, the intermediate level would be for the Parkway Road while the lowest level would be for the parking and landscape area to the right side of the project. This is to integrate the facility with the surroundings with the minimum amount of earthworks needed causing minimum disturbance to the area. Additionally, this vertical design prevents the view of this magnificent area from being blocked.

Proper signing and marking are provided for the facility to ensure safety to the highest level for both pedestrians and vehicles.

4.4.4. Safety Measures

Selection of the safety measures

For the general safety measures on the road, a guardrail system is applied rather than the guard rope system based on the following comparison results:

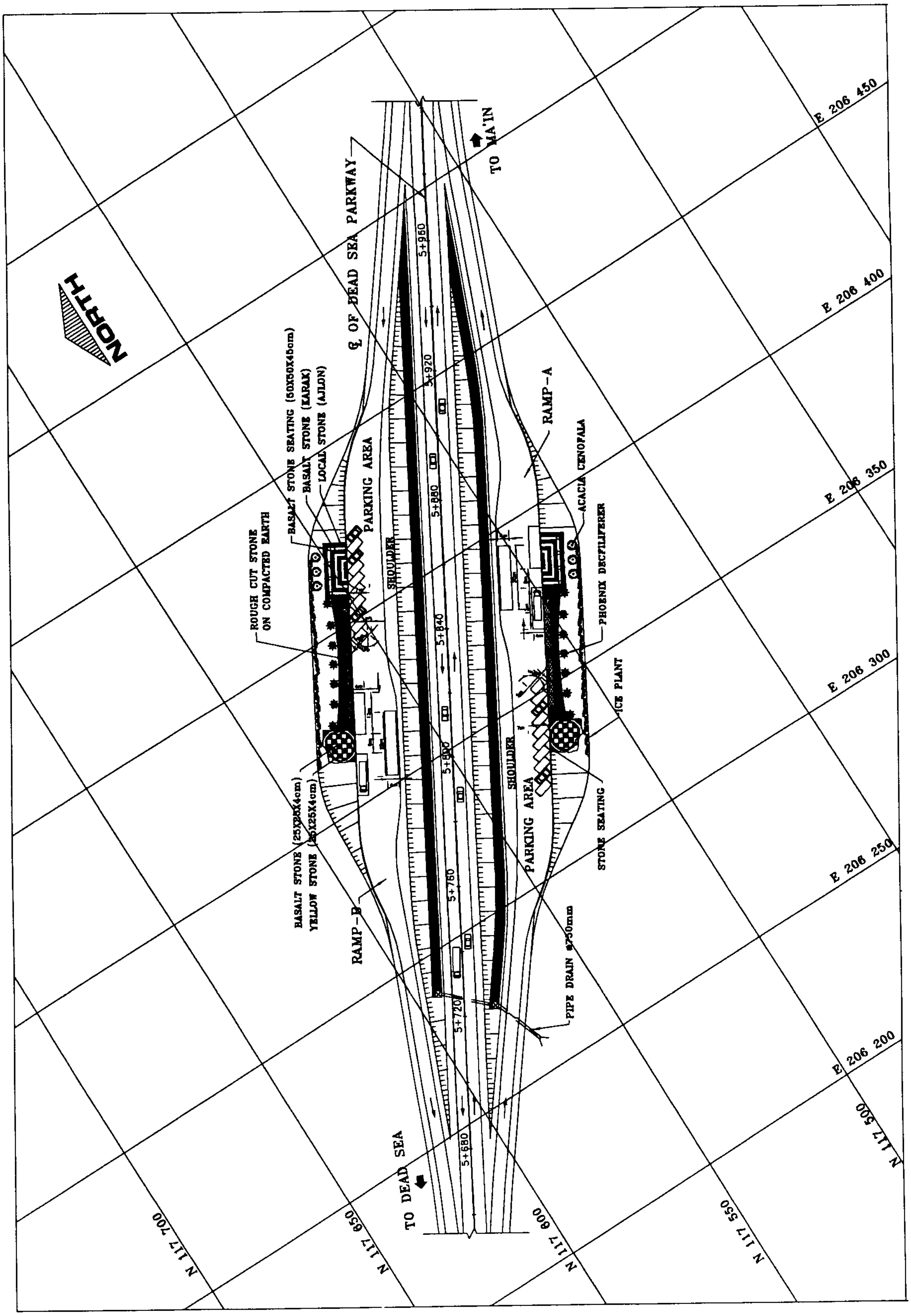
Table 4.3 Comparison of Guard rail and rope systems

Criteria	Guard rail system	Guard rope system
Curve applicable	Applicable for smaller curve	Applicable for larger curve
Repair of damage (maintenance)	Small part(4m long) can be replaced and cheaper	Long rope (approx. 500m long) is required to be replaced and is very expensive
Guiding sight line	Higher	Lower
Visibility	Lower	Higher
Construction cost	Lower	Very high

Source: JICA Study Team

Taking into account the cost factors for both maintenance and construction, the guard rail system is selected for the parkway.

Figure 4.9 Layout of Parkway Facility



Source: JICA Study Team

Installation guidelines

Installation of guardrails is determined according to the following guidelines:

- Sections with small radius curve and earth filling, in principle,
- Sections with large radius curve, but with high filling (more than 2.0m)

4.4.5. Delineation Facility

The area of the Parkway has no houses and other buildings giving some guide for the drivers, except for the Panoramic Complex, especially at night, therefore, the following delineation facilities are installed:

- Cats eyes along the centre line and both sides of the lanes. The intervals of the cat eyes is according to the Jordanian guidelines
- Chevron marker for the section with small radius curve

White, yellow, green and red uni-directional cats eyes in addition to yellow–red bi-directional cats eyes are used properly and in full coordination with the Traffic and Maintenance Directorate in MPWH.

4.4.6. Signage

Installation of road signs along the Parkway is planned according to the road sign installation standards of MPWH. The standards are similar to international standards such as AASHTO, etc.

The design of signing for the intersection is carefully done to ensure the safety of vehicles and guiding drivers. The signs provided on the Parkway are as follows:

- Directional; at intersections and before intersections
- Recreational; guide to the Panoramic Complex, etc.,
- Warning; stone falling, curves, steep slopes, etc. , and
- Regulatory signs; speed control, etc.

These are properly placed so that the intersection hazards would be minimised in full coordination with the Traffic and Maintenance Directorate in MPWH.

4.4.7. Emergency Escape Ramp

Two Emergency Escape Ramps were placed at the steep section of Part-A (at STA. 1+800 and at STA. 4+000), where the gradient of the road continue to exceed more than 10% in the straight sections. The structure and scale of the ramp is as follows:

- Width of the ramp is 7.0 m at the entry point and 5.0 m at the end of the ramp.
- Total length of the ramp is 80.0 m (40.o m for .
- Structure of the ramp formed by 1.0 m thick of compacted sand with the formation of 1.5 m interval of humps which raised 0.25 m to create a bumpy effect to dissipate the speed of uncontrolled vehicle.
- Speed dissipation method is also applied by creating opposing angle to the descending road with 5% at the initial section for 30.0 m and 20 % at the end section for 10.0 m.
- Guardrail is installed along the ramp to control any vehicle not to drop off from the ramp.

4.5. Drainage Design

The study area comprises the natural drainage catchment for side wadis flanking the Dead Sea. A detailed investigation of the hydrology of the area has been carried out, to define both the quantity and distribution of surface water originating from within these catchment areas, in order to assess the implications for the road works.

4.5.1. Peak Discharge

There is no stream flow data available for the basins inside the project area. Wherever stream flow observations are not available, estimation should be made by using the appropriate method.

The rational method is applied to estimate the peak discharge since the catchment areas are limited to a maximum of 12.277 km^2 for wadi Hamara as shown in Table 4.4. The Rational method, which can be traced back to the mid-nineteenth century, is still probably the most widely used method for design of cross-drainage works. The peak discharge Q can be estimated conservatively by:

$$Q = 0.278 C\ I\ A$$

where

C = Rational method runoff coefficient which is estimated according to catchment conditions, slope and return period.

I = Rainfall Intensity, in mm/hr using the developed I-D-F curves of Madaba rainfall station.

A = Catchment area, in km^2

The rainfall intensity is selected on the basis of the design rainfall duration and return period. The return period of 25-Yr for design and 50-Yr for checking are selected due to the importance of the road illustrated in Figure 4.10. The design duration is equal to the time of concentration for each drainage area. In literature, there are a number of equations and methods to estimate the time of concentration with different boundary conditions. The most applicable equations representing small watersheds are selected to estimate the time of concentration and the minimum is considered in Table 4.4. The following equations are used:

Kirpich

$$t_c = 0.0078\ (3.281L)^{0.77} S^{-0.385}$$

California Culvert

$$t_c = 60\ (11.9(l/1609.3)^3/(3.281H))^{0.385}$$

Federal Aviation

$$t_c = 1.8\ (1.1 - C)(3.281L)^{0.5}/(100S)^{0.333}$$

where:

t_c = Time of concentration, in min.

L = Length of longest watercourse, in m.

S = Slope of flow path, in m / m.

H = Elevation difference between divide and outlet, in m.

The Federal Aviation is probably the most valid for small watersheds where sheet flow and overland flow dominate.

I-D-F curves are developed using data from the Ministry of Water and Irrigation of 27 years, from 1970/71 to 1998/1999 (with 2 years missing). Gumble External Type I distribution is found the best fit distribution to the actual data through a comprehensive comparison with other distributions using the software HFA and FRAH. The comparison is presented in Figure 4.11 while the I-D-F curves and estimated rainfall intensity are exhibited in Figure 4.12

and Table 4.6 respectively.

The rainfall intensity depending on the time of concentration should be read from curves. In order to reduce the error in reading the curves two different formulae are developed for calculating the intensity out of the estimated rainfall intensity. These formulae are in the following format:

$$I = \frac{a}{t^h}$$

and

$$I = \frac{a}{t + b}$$

where:

a and *b* = Parameters for each return period.

t = Duration, in min.

The first equation is used due to high R^2 value, as shown in Figure 4.10. The calculated peak flows are presented in Table 4.4, which are considered in the design of the cross-drainage structures and the protection works.

Surface flow along the road corridor is encouraged with open channels and road culverts as cross drainage structures as stated earlier. The final design of the culverts, protection works, and lined channels is carried out to define in detail the size of each culvert and the flow characteristics according to the flow design estimated in the above table. Seven box and eight pipe culverts are designed with a number of relief pipe culverts. The two largest crossings at wadi Abu El-Asal and wadi Hamara are fitted with two bridges. Although culverts can be a cheaper drainage option, they will not fulfil other road and environment requirements. The design flows through these bridges are conveyed safely using reinforced concrete lined trapezoidal channels. The design of these structures are presented through this section and detail drawings are submitted in the design drawing volume.

4.5.2. Planning and Design Criteria

Every cross drainage structure performs an operative function determined by hydrology and hydraulics, and a load-carrying function determined by structural considerations and construction procedures.

The design, therefore, involves two independent design problems: ***hydraulic*** design and ***structural*** design. The intent of the hydraulic design is to determine the most economical installation by realistically anticipating the effects of hydrology in establishing satisfactory hydraulic operation. The intent of the structural design is to assure the construction of an installation with sufficient strength to support the loads without adversely affecting the hydraulic operation.

The economics of culvert design is greatly influenced by ***location and alignment***. The culvert should be placed so as to achieve maximum economy, utility, and safety. Therefore, all culverts are located to maintain the natural drainage in alignment and grade, in order to minimise head losses and erosion. Natural drainage is maintained by following the original drainage grade. Necessary channel relocations are exercised to maintain the natural drainage grade. Care is practised in the latter case because of the possibility of introducing objectionable secondary effects and even interfering with desirable hydraulic operating characteristics.

The ***entrance*** structure was properly designed using end walls and wing walls to prevent bank erosion and improve the hydraulic characteristics of the culvert. It was also provided with erosion-resistant aprons (flexible and concrete) for the accelerating flows approaching the culvert. No drop inlet culvert was designed to obviate the blockage of the entrance by transported sediments. The culvert sill length was designed sufficiently to discharge the design flow with a reasonable head water level.

A proper device is provided at the ***outlet*** to prevent the downstream erosion of the bed, the slopes of the embankment, and undercutting of the culvert barrel. The geologic condition of almost all wadis are stable with sound rock beds. For high outlet discharge velocities, a provision for dissipating the energy of the outflow is designed with sufficient details for construction which are presented in the design drawings.

The end of the energy dissipater is protected against scour holes (undermining) which develops progressively adjacent to the concrete section during high flows. The protection is materialised by concrete and flexible aprons of sufficient length and size. Full details are presented and discussed through this report.

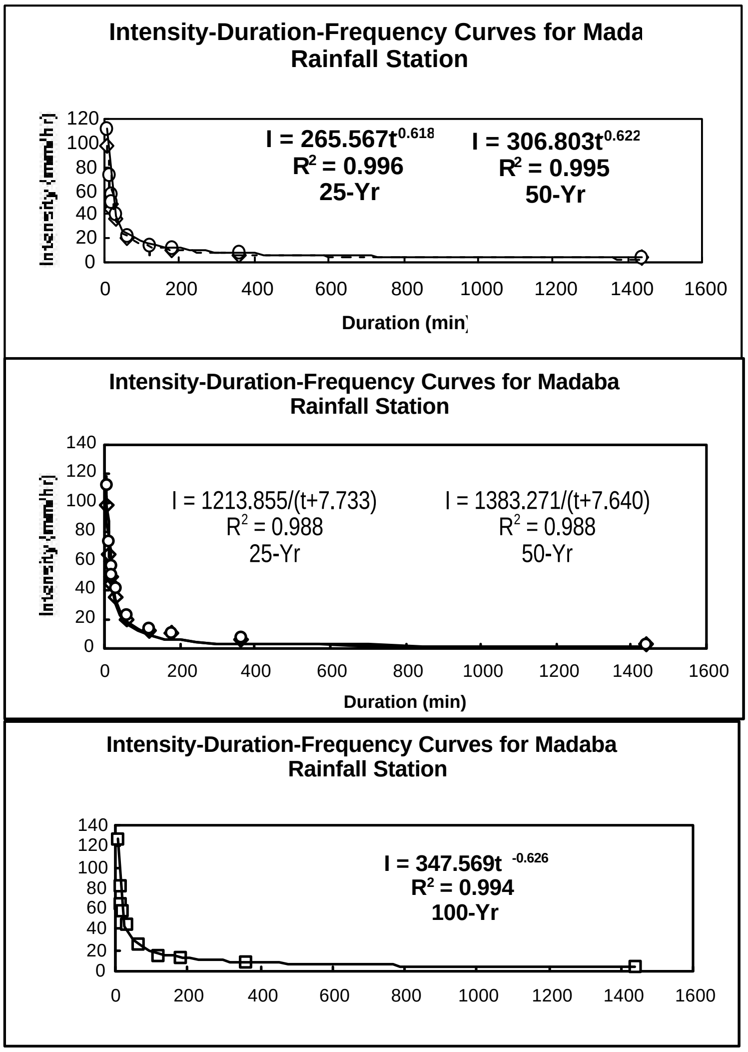
Design rainfall intensities are provided by the last progress report as rainfall intensity equations. These equations are developed for ***return periods*** of 25, 50, and 100 years. These

Table 4.4 Peak Flow and Characteristics of the Catchment Areas

Wadi	Area (km^2)	Lgth of Water course	Ground Elevation (m.a.s.l.)		Time of Concent ration	Rainfall Intensity (mm/hr)			Runoff Coefficient			Peak Flow (m^3/s)		
#		(km)	Divide	Outlet	(min)	25-Yr	50-Yr	100-Yr	25-Yr	50-Yr	100-Yr	25-Yr	50-Yr	100-Yr
1	1.028	1.69	213	-180	9.6	65.5	74.9	-	0.45	0.48	-	8.411	10.267	-
2	0.375	0.25	140	-140	5.0	98.2	112.7	-	0.45	0.48	-	4.602	5.633	-
3	0.588	0.85	213	100	7.6	75.6	86.6	-	0.45	0.48	-	5.554	6.786	-
4	0.140	0.30	183	150	5.0	98.2	112.7	-	0.45	0.48	-	1.718	2.103	-
5	3.735	3.50	500	135	24.0	37.3	42.5	47.7	0.45	0.48	0.52	17.403	21.162	25.718
6	0.110	0.30	203	170	5.0	98.2	112.7	-	0.45	0.48	-	1.350	1.652	-
7	12.277	9.20	771	110	59.4	21.3	24.1	27.0	0.45	0.48	0.52	32.633	39.531	47.905
8	0.826	2.05	405	120	14.4	50.9	58.2	-	0.45	0.48	-	5.260	6.410	-
9	0.263	1.05	300	160	9.0	68.4	78.3	-	0.45	0.48	-	2.248	2.745	-
10	0.456	1.30	300	130	10.7	61.5	70.3	-	0.45	0.48	-	3.505	4.276	-
11	0.777	1.85	380	130	12.7	55.3	63.2	-	0.45	0.48	-	5.372	6.549	-

Source: Madaba Rainfall Station

Figure 4.10 Intensity-Duration-Frequency Curves



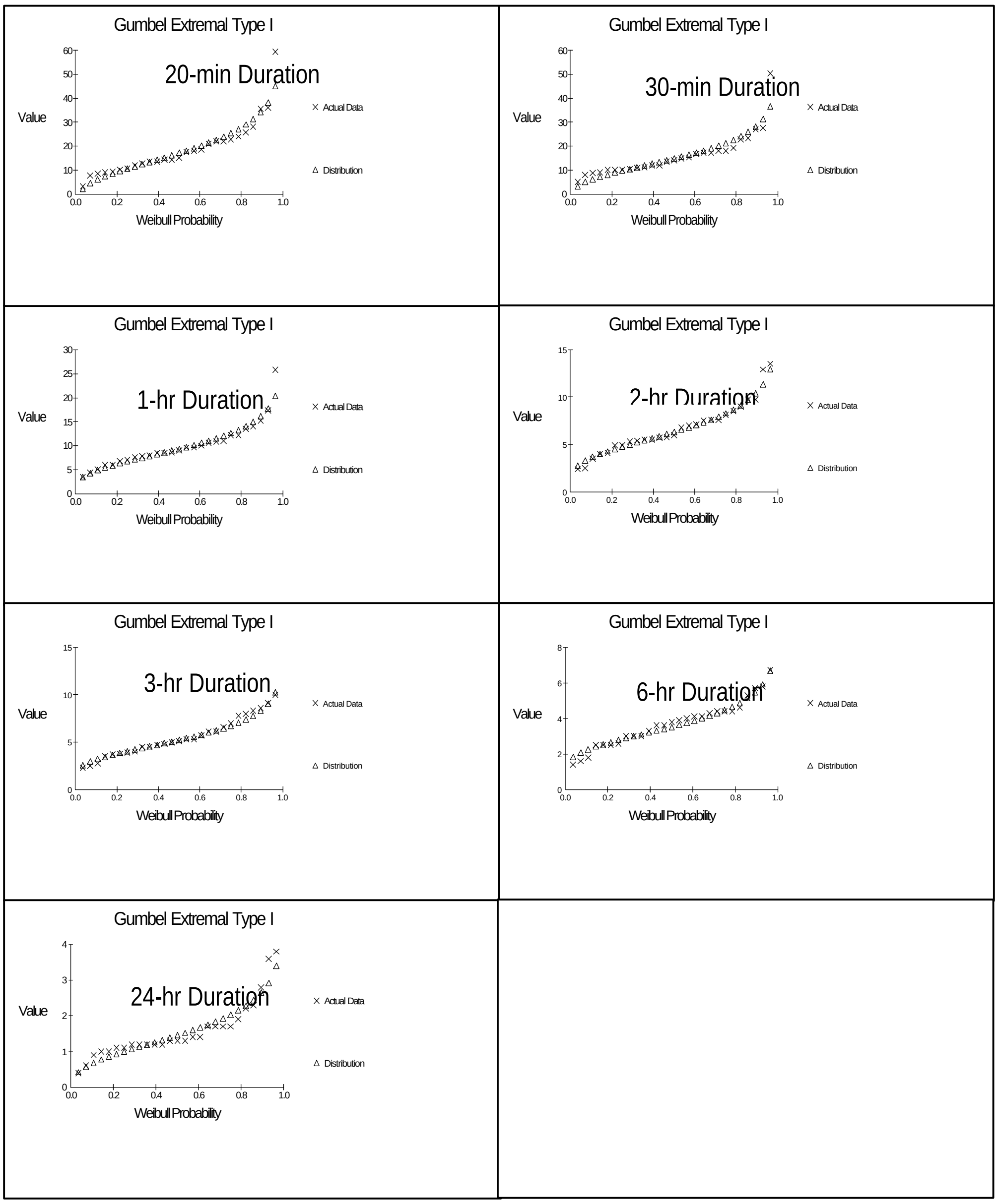
Source: Madaba Rainfall Station

Table 4.5 Rainfall Intensity, Madaba

Duration (Min)	**Intensity (**mm/hr) **25-Yr**	**50-Yr**	**100-Yr**
5	98.2	112.7	127.0
10	64.0	73.2	82.3
15	49.8	56.9	63.9
20	43.9	50.6	57.2
30	35.7	40.9	46.0
60	20.0	22.7	25.3
120	12.7	14.2	15.8
180	10.1	11.3	12.5
360	6.6	7.3	8.1
1440	3.3	3.8	4.2

Source: Madaba Rainfall Station

Figure 4.11 Distribution Comparison Plots according to Duration for Rainfall Intensity Record



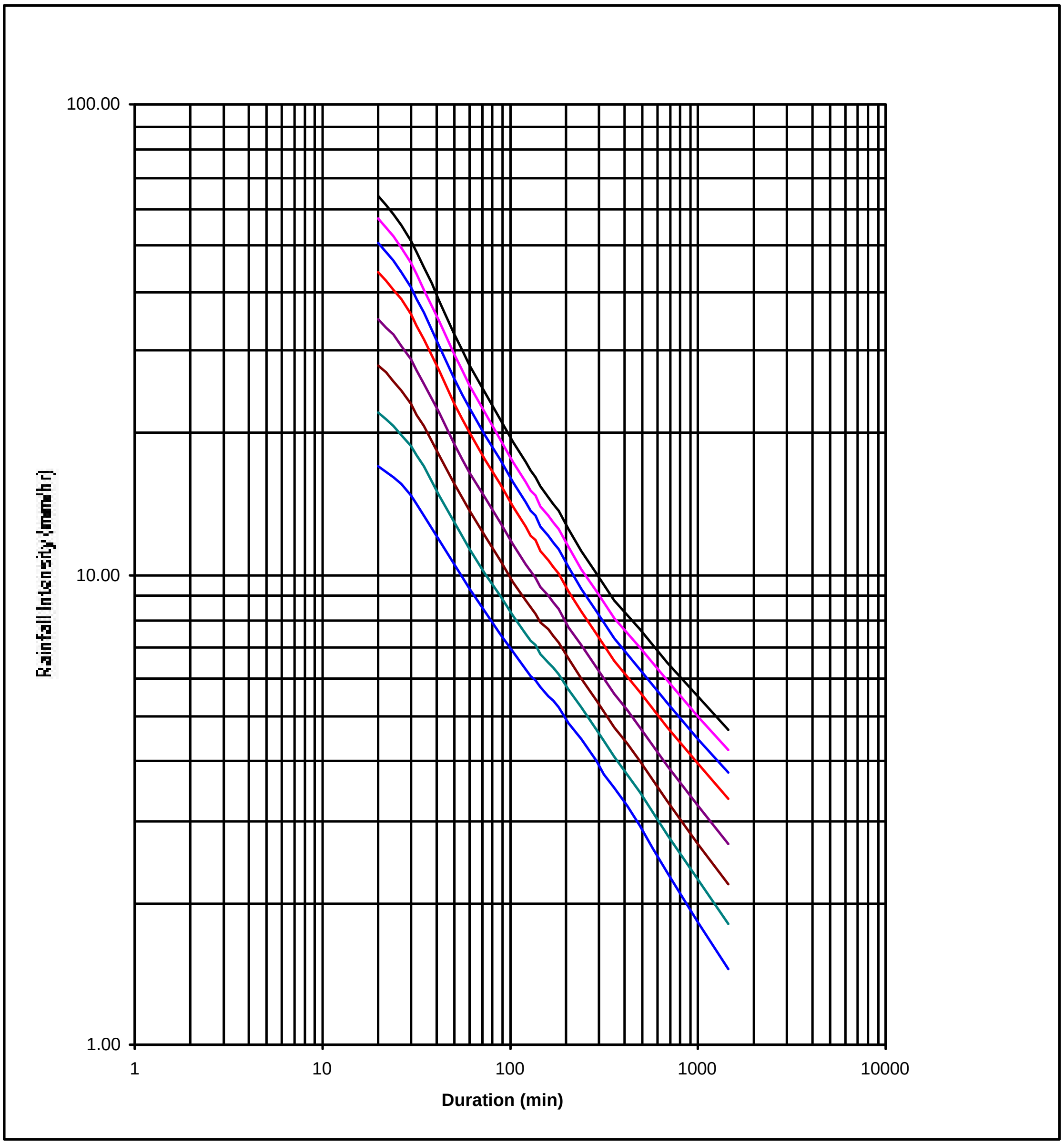
Source: Madaba Rainfall Station

Table 4.6 Rainfall Intensity (mm/hr) according to Duration and Return Period

Return	Duration						
Period-Yr	20-min	30-min	1-hr	2-hr	3-hr	6-hr	24-hr
200	63.80	51.16	27.93	17.35	13.66	8.79	4.70
100	57.21	46.03	25.30	15.80	12.47	8.05	4.24
50	50.59	40.87	22.67	14.23	11.28	7.30	3.78
25	43.93	35.68	20.01	12.66	10.08	6.55	3.32
10	34.94	28.68	16.43	10.53	8.45	5.54	2.69
5	27.83	23.14	13.60	8.85	7.17	4.73	2.20
3	22.18	18.74	11.35	7.52	6.15	4.10	1.81
2	17.09	14.78	9.32	6.31	5.23	3.52	1.45

Source: Madaba Rainfall Station

Figure 4.12 I-D-F Curves



Source: Madaba Rainfall Station

equations are used in the Rational formula to calculate the design flow. The return period is reflected by the average recurrence interval. This measure determines the magnitude of a design runoff event with which the system can cope. The return period was specified according to the following table (Table 4.7) to be 25-years for culverts considering high traffic due to road importance, but the 50-year return period is adopted for checking the performance of the system and the design of the protection works with more restrictive storm. The return period for bridges was specified as 50-years considering the primary system due to the same reason, and 100-year return period is used for checking the lined channels capacity with more restrictive storm also.

Table 4.7 Generalised Design Criteria for cross drainage structures:

Type of Structure	Return Period (Year)
** Highway crossroads drainage (culverts)*	
Low Traffic (< 400 ADT)	5 - 10
Intermediate (400 - 1700 ADT)	10 - 25
High Traffic (1700 - 5000 ADT)	25 - 50
Very High Traffic (> 5000 ADT)	50 - 100
** Highway Bridges*	
Secondary System	10 - 50
Primary System	50 - 100

Source: JICA Study Team

4.5.3. Hydraulic Design

The culvert's purpose is to provide a water channel through the road embankment. Proper design requires compatibility inflow and allowable headwater elevation at normal and extreme operating conditions (50-Yr flood). This was assured through the hydraulic analysis considering all of the factors controlling flow through the culverts.

Obtaining accurate solutions for culvert hydraulics can be a formidable computational task. Culverts act as a significant constriction to flow and are subject to a range of flow types including both gradually varied and rapidly varied flow.

It is this mix of flow conditions and the highly transitional nature of culvert hydraulics that make the hydraulic solutions so difficult. For this reason, the documented approach is to simplify the hydraulics problem and analyse the culvert system using two different assumptions of flow control. All culverts on the wadis are analysed using computer models.

- ***Outlet control*** assumption - Computes the upstream headwater depth using conventional hydraulic methodologies that consider the predominant losses due to the culvert barrel friction as well as the minor entrance and exit losses; the effect of the tail-water condition during the design storm has an important affect on the culvert system.
- ***Inlet control*** assumption - Computes the upstream headwater depth resulting from the constriction at the culvert entrance while neglecting the culvert barrel friction and other minor losses.

The controlling headwater depth is the larger value of the computed inlet control and outlet control headwater depths. Because the culvert system may operate under inlet control conditions for a range of flow rates and under outlet control conditions for another range of discharges, calculations are performed for both control conditions for all culverts.

Two computer models are used for the design; Culvert Master from Haestad Methods and Dodson Hydrocalc Hydraulics V1.2 for Windows. The following assumptions are considered for extreme conditions and practical execution:

- Reinforced concrete pipe or box culvert (Manning's roughness coefficient n-value 0.013);

single or multiple with following sizes: 750-mm and 900-mm diameters; 1.5 and 2-m span; 1.5-m rise

- Pipe with headwall or headwall with wing walls-square-edge (square cut end of pipe) Loss coefficient - 0.5
- Box with headwall parallel to embankment-square-edged on three edges. Loss coefficient- 0.5

4.5.4. Dimensions and Capacities

The new road alignment crosses eleven wadis where wadi #2 is crossed six times and wadi # 10 and 11 two times. These crossings are indicated by numbers and letters. Wadi # 5 and 7 are major wadis with large crossing spans, therefore, they are planned to be crossed by bridges, although there is no hydraulic necessity due to high rises as discussed earlier.

All culverts are designed using computer models and sizes are selected from common practices. The sizes are narrowed to two pipe diameters; 750- and 900-mm, and two box rise and span sizes; 1.5x1.5m and 1.5x2m. The 750-mm pipe culvert is used only as a relief drainage structure for limited flow. Dimensions, elevations and other characteristics of culverts are listed in Table 4.8. The table is self explanatory with full details of the culverts, e.g. station, flow, type, size, elevations, headwater depths, maximum velocities, drop height and stream training length if any, together with the type of outlet and the maximum embankment cover above culvert barrel.

The flow rate is calculated against headwater depth up to the maximum flow rate, which is greater than the 50-Yr flood.

The road cross drainage at Wadi # 5 and Wadi # 7 is provided with bridges due to excessive span. The flood flow is planned to drain through reinforced concrete lined open channel with the same alignment and location as the natural stream in both wadis. The channel is 4-m bottom width and 1-m depth with side slopes of 1H:1V and 3H:1V for Wadi #5 and Wadi #7 respectively. The side slopes are selected according to the flow size and the economic fit of the wadi section.

4.5.5. Energy Dissipater and Protection Works

Downstream erosion varies widely, depending upon the characteristics of the stream section material, the depth of flow in the stream, and the velocity distribution. All wadis will flow with high velocities due to steep slopes of the natural streams. The streams are of rocky channels which can stand high flow velocities without scour. Each culvert is checked for scoring and sedimentation and proper measures are developed.

Various types of outlet structures have been used to control erosion below culverts, but no type of structure meets all requirements. In the case of moderate velocities, a simple endwall and apron can provide ample protection. Channel erosion below culverts is due to the kinetic energy of the water. If the kinetic energy can be transformed to potential energy or dissipated, the erosion potential will be either eliminated or substantially reduced.

Energy Dissipation is the destruction of a large part of the kinetic energy. As a result of the large energy losses that occur in energy dissipation structures, the erosive potential of the culvert discharge is substantially reduced. A characteristic of energy dissipation, but not a necessary feature is the transition from shallow to deep flow. This transition is usually characterised by a sudden and violent churning action that must be contained at least in part on a concrete apron.

Table 4.8 Drainage Crossing Structure

Wadi #	Station (m)	Peak Flow (m³/s) 25-Yr	50-Yr	Structure Type	Cells or Pipes(#)	Size (m)	Skew Angle (°)	Invert Elevation(m from sea level) Upstream	Road CL	Dwnstream
1	1+856.50	8.411	10.267	DCBC	1	1.5x2 [4]	119.5	-184.50	-192.40	-196.00
2A	2+210.00	Small [6]	Small	DCPC [2]	1	0.900 [5]	80.3	-163.85	-167.00	-192.35
2B	2+321.30	1.151	1.409	DCPC	1	0.900	82.0	-151.40	-152.17	-155.50
2C	2+402.75	3.068	3.756	DCBC	1	1.5x1.5	104.0	-145.78	-148.95	-160.60
2D	2+400.00	1.534	1.878	// Chan.[10]	D.L.Channel	T0.5x1[10]	Parallel	-143.00	-	-145.78
2E	2+730.70	1.151	1.409	DCPC	1	0.900	63.0	-112.54	-113.35	-120.63
2F	2+826.00	1.151	1.409	DCPC	1	0.900	113.5	-107.25	-112.05	-115.20
3	5+246.00	5.554	6.786	DCBC	1	1.5x2	97.0	92.91	91.95	76.75
4	5+870.80	1.718	2.103	CPC [3]	2	0.900	118.5	147.47	144.45	140.47
5 [9]	6+280.00	21.162	25.718	Bridge	L.Channel	T1.0x4 [8]	-	132.60	131.90	130.63
6	6+864.00	1.350	1.652	CPC	2	0.900	68.0	163.62	162.88	162.16
7 [9]	7+278.00	39.531	47.905	Bridge	L. Channel	T1.0x4 [8]	-	103.00	102.51	101.69
8	7+495.14	5.260	6.410	DCBC	1	1.5x2	-	121.63	115.46	106.12
9	8+107.50	2.248	2.745	CBC[1]	1	1.5x1.5	33.0	148.00	147.08	146.19
10A	8+514.30	3.505	4.276	DCBC	1	1.5x1.5	113.0	128.76	126.84	124.83
10B	8+267.80	Small	Small	CPC	1	0.900	41.0	141.22	140.67	140.00
11A	9+207.00	5.372	6.549	CBC	1	1.5x2	98.0	120.00	117.05	113.00
11B	8+976.50	Small	Small	CPC	1	0.900	61.5	126.07	124.82	123.43

Wadi #	Station (m)	Culvert Length (m)	Culvert Slope (%)	Headwater Depth (m) 25-Yr	50-Yr	Max. Water Velocity (m/s) 25-Yr	50-Yr	Stream Training (m)	Drops* Height (m)	Max. Cover (m)	Outlet
1	1+856.50	53.3	12.150	2.117	2.603	11.275	12.021	22	5*1.0	8.65	ED[11]
2A	2+210.00	95.2	15.756	-	-	-	-	-	9*1.5	8.12	-
2B	2+321.30	26.5	7.925	1.082	1.292	5.449	5.738	-	2*1.0	3.60	ED
2C	2+402.75	52.5	13.943	1.103	1.284	9.002	9.613	-	5*1.5	6.69	ED
2D	2+400.00	28.5 RCL[7]	2.737	0.277	0.311	4.331	4.598	15	2*1.0	-	-
2E	2+730.70	48.5	7.402	1.000	1.210	5.186	5.486	15	3*1.5	5.34	ED
2F	2+826.00	60.5	5.702	1.008	1.218	4.723	4.998	30	3*1.5	12.04	ED
3	5+246.00	57.5	10.713	1.411	1.632	9.417	10.072	-	5*2.0	8.22	ED
4	5+870.80	93.5	7.483	0.801	0.932	4.825	5.102	-	-	4.25	ED
5 [9]	6+280.00	40 RCL[7]	4.925	0.497	0.558	9.472	10.112	-	-	-	-
6	6+864.00	27.8	5.261	0.688	0.789	3.977	4.209	-	-	3.62	ED
7 [9]	7+278.00	40 RCL[7]	3.275	0.717	0.793	8.964	9.47	-	-	-	-
8	7+495.14	119.3	8.813	1.370	1.580	8.257	8.816	-	5*1.0	23.20	ED
9	8+107.50	50.3	3.598	0.948	1.092	5.153	5.493	-	-	3.94	ED
10A	8+514.30	35.5	5.437	1.283	1.478	5.675	6.018	-	2*1.0	5.80	ED
10B	8+267.80	34.3	3.557	-	-	-	-	15	-	2.05	-
11A	9+207.00	105.7	6.623	1.408	1.622	7.937	8.469	-	-	18.54	ED
11B	8+976.50	59.3	4.452	-	-	-	-	-	-	9.14	-

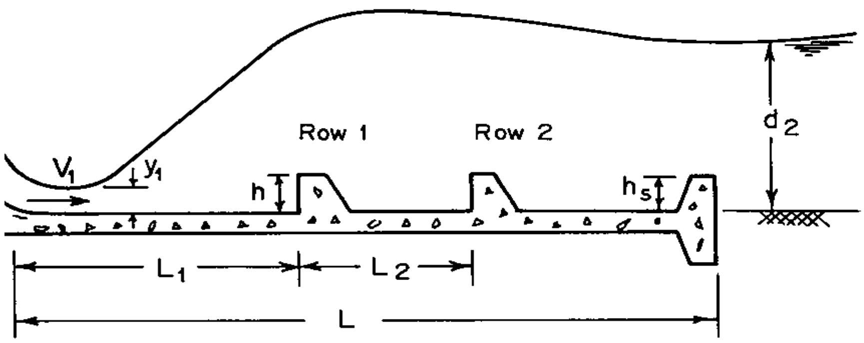
Note:
[1] CBC: Concrete Box Culvert
[2] DCPC or DCBC: Drop Concrete Pipe or Box Culvert
[3] CPC: Concrete Pipe Culvert
[4] 1.5x2: Cell Size 1.5 m Rise x 2 m Span
[5] 0.900: Inside Pipe Diameter
[6] Small: Small Peak Flow to be estimated
[7] RCL: Reinforced Concrete Lined Channel
[8] T1.0x4: Trapezoidal Channel with Side Slopes 1H for wadi-5 3H for wadi-7:1V, Bottom Width 4 m and 1.0 m Depth
[9] Wadi # 5 and 7: the Return Periods are 50- and 100-Yr
[10] // Chan.: Parallel to the Road, Reinforced Concrete Channel, Trapezoidal 1H:1V, Bottom Width 1 m and 0.5 m Depth
[11] ED: Energy Dissipate

Source: JICA Study Team

Although stepped culvert is used, the flow still contains high energy. Therefore, the flow velocities downstream from the culverts are high, as shown in Table 4.9. These velocities may cause serious scour and erosion of the downstream wadi if proper precautions are not taken. For this purpose, energy dissipaters are provided to dissipate a sufficient amount of energy before water enters the downstream wadi.

The hydraulic jump is used for energy dissipation in a stilling basin. A concrete apron is provided for the length of the jump. Long apron lengths are needed for such a stilling basin. For economic reasons as well as to make the stilling basin operate efficiently over a wide range of flows, accessories are provided to stabilise the jump, and to reduce the length of the jump. These accessories are baffle blocks and end sills, see the Figure 4.13 below.

Figure 4.13 Section of Apron



Source: JICA Study Team

The dimensions of the basin and of the appurtenances are determined from the following relationships:

$$L_1 = 1.5y_2 \rightarrow F_{r1} \leq 4.6$$

$$L_1 = \left[1.5 + \frac{1}{11}(F_{r1} - 4.6)\right]y_2 \rightarrow F_{r1} > 4.6$$

$$L_2 = 2.5h$$

$$h = \frac{y_2}{6} \rightarrow F_{r1} \leq 4.6$$

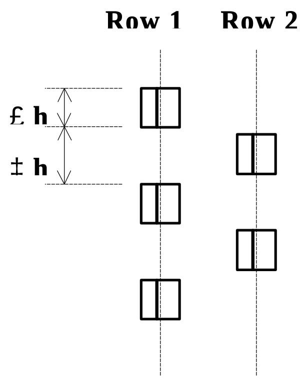
$$h = [1 + 0.13(F_{r1} - 4.6)]y_1 \rightarrow F_{r1} > 4.6$$

$$h_s = \frac{h}{2}$$

$$d_2 \geq 0.85y_2 \cong y_2$$

$$L \geq L_1 + y_2$$

$$L \geq 4y_2$$



where

F_{r1} = Froude Number at section 1 (culvert outlet), and all other variables are shown in the figure above.

Baffle block rows 1 and 2 are staggered and the baffle block width is less than or equal to h. The spacing between the blocks is to be at least equal to the baffle block width. The design calculations are developed in Table 4.9 and a typical plan and sections are presented in the design drawings.

Table 4.9 Flow Characteristics and Dimensions of Energy Dissipaters

Wadi #	Maximum Flow	Cell or Pipe #	Culvert Span	Flow per unit Width	Outlet Velocity	Outlet Depth	Froude #	Sequent Depth
1	10.267	1C	2.0	5.134	12.021	0.427	5.87	3.340
2B	1.409	1P	0.9	1.566	5.738	0.387	2.94	1.430
2C	3.756	1C	1.5	2.504	9.613	0.260	6.02	2.087
2E	1.409	1P	0.9	1.566	5.486	0.382	2.83	1.352
2F	1.409	1P	0.9	1.566	4.998	0.410	2.49	1.254
3	6.786	1C	2.0	3.393	10.072	0.337	5.54	2.477
4	2.103	2P	0.9	1.168	5.102	0.324	2.86	1.159
6	1.652	2P	0.9	0.918	4.209	0.312	2.41	0.917
8	6.410	1C	2.0	3.205	8.816	0.364	4.67	2.226
9	2.745	1C	1.5	1.830	5.493	0.333	3.04	1.274
10A	4.276	1C	1.5	2.851	6.018	0.474	2.79	1.649
11A	6.549	1C	2.0	3.275	8.469	0.387	4.35	2.193

Wadi	Stilling Basin Dimensions							Remarks
#	**L_1**	**L_2**	**L**	**h**	**h_s**	**d_2**	**Slope**	
1	5.396	1.244	13.359	0.498	0.24884418	2.83875044	13.5 : 5.0	
2B	2.145	0.596	5.719	0.238	0.11915163	1.21534664	6.0 : 0.5	
2C	3.400	0.770	8.348	0.308	0.15398424	1.77398607	8.5 : 2.0	
2E	2.028	0.563	5.407	0.225	0.11265357	1.14906645	5.5 : 1.5	
2F	1.882	0.523	5.018	0.209	0.10453932	1.06630104	5.0 : 1.0	
3	3.927	0.945	9.908	0.378	0.18907855	2.10537838	10.0 : 6.0	
4	1.739	0.483	4.637	0.193	0.0966036	0.9853567	4.75 : 0.25	
6	1.375	0.382	3.668	0.153	0.07641185	0.77940089	3.75 : 0.25	
8	3.353	0.918	8.906	0.367	0.18354673	1.89252322	9.0 : 2.25	
9	1.912	0.531	5.098	0.212	0.10619928	1.08323262	5.25 : 0.25	
10A	2.473	0.687	6.595	0.275	0.13739406	1.40141941	6.75 : 0.40	
11A	3.290	0.914	8.773	0.366	0.18276772	1.8642307	9.0 : 0.40	

Note:
L_1 Distance between Outlet and Row 1 of Baffle Blocks
L_2 Space between Row 1 and Row 2 of Baffle Blocks
L Stilling Basin Total Length
h Baffle Block Height
h_s End Sill Height
d_2 Downstream Water Depth

Source: JICA Study Team

Protection Works – During high flows the wadi bed will be scoured both on the upstream and downstream sides of the culvert, and large scour holes developed progressively adjacent to the concrete aprons; the foundation may slip into these scour holes, thus undermining the structure. The minimum stable width of an alluvial channel is given by the regime equation:

$$B = 4.75\sqrt{Q}$$

where:
B = The water way, in m.
Q = The maximum flood discharge, in m^3/s.

The regime scour depths, R_s, may be estimated by the following formulae:

$$R_s = 0.475(Q/f)^{1/3}$$

if the actual water way provided is greater or equal to the regime width, and

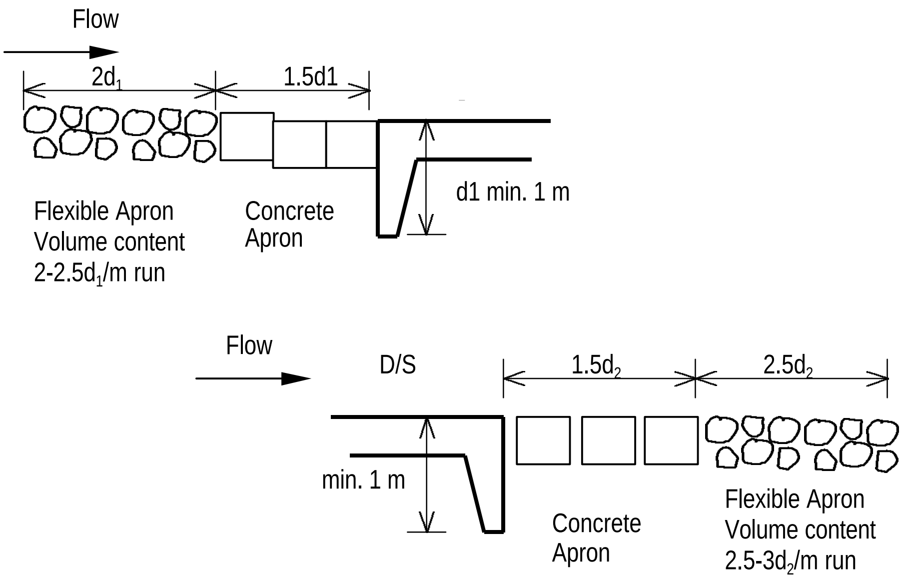
$$R_s = 1.35(q^2/f)^{1/3}$$

if the water way provided (basin width in Table 4.10) is less than the regime width, which is the case in all the culverts.

where
R_s = Measured from the high flood level.
f = Lacey's silt factor = 1.75 $d^{1/2}$ (can be taken as 1).
d = Mean diameter of the bed material.
q = Discharge per unit width.

Culvert failure due to scour can be prevented by using a concrete apron and flexible (launching) apron, as shown in the Figure 4.15 below.

Figure 4.15 Section of In-take and Out-let Portions of Culvert



Source: JICA Study Team

The concrete aprons are of plain concrete blocks of about 1x1.5x0.75 m deep, cast in situ. The downstream apron is laid with 70-100 mm open joints filled with broken stones, so that the uplift pressure is relieved. An inverted filter of well graded gravel and sand is placed under the concrete apron in order to prevent the loss of soil through the joints. The upstream is laid watertight so that the uplift pressure and downward flow is reduced.

Flexible aprons of boulders or stones are laid upstream and downstream of the concrete aprons with minimum stone size of:

$$d \cong k\frac{V^2}{2g}$$

where d = Stone diameter, in mm.
k = 1 and 1.4 for calm and high turbulent flow respectively.
V = Flow velocity, in m/s.
g = Gravitational acceleration = 9.81 m/s^2.

or/

$$d = 0.032(S_s - 1)^{1/2} V^{9/4}$$

where S_s = Relative density of the material.

The largest d is selected which is presented together with all design dimensions in Table 4.10.

Table 4.10 Design calculations of the Protection Works

Wadi #	Maximum Flow	Cell or Pipe #	Culvert Span	Flow per unit width	Outlet Velocity	Outlet Depth	Froude #	Sequent Depth	D/S Depth	D/S Velocity
1	10.267	1C	2.0	5.134	12.021	0.427	5.87	3.340	2.839	0.603
2B	1.409	1P	0.9	1.566	5.738	0.387	2.94	1.430	1.215	0.580
2C	3.756	1C	1.5	2.504	9.613	0.260	6.02	2.087	1.774	0.706
2E	1.409	1P	0.9	1.566	5.486	0.382	2.83	1.352	1.149	0.613
2F	1.409	1P	0.9	1.566	4.998	0.410	2.49	1.254	1.066	0.661
3	6.786	1C	2.0	3.393	10.072	0.337	5.54	2.477	2.105	0.806
4	2.103	2P	0.9	1.168	5.102	0.324	2.86	1.159	0.985	0.711
6	1.652	2P	0.9	0.918	4.209	0.312	2.41	0.917	0.779	0.707
8	6.410	1C	2.0	3.205	8.816	0.364	4.67	2.226	1.893	0.847
9	2.745	1C	1.5	1.830	5.493	0.333	3.04	1.274	1.083	0.845
10A	4.276	1C	1.5	2.851	6.018	0.474	2.79	1.649	1.401	0.763
11A	6.549	1C	2.0	3.275	8.469	0.387	4.35	2.193	1.864	0.878

Wadi #	Basin Width	**B**	**RS**	**d2**	**1.5 d2**	**2.5 d2**	Min. stone Size (mm)	Remarks
1	6.000	15.220	4.0	5.196	7.794	12.990	25.93	
2B	2.000	5.638	1.8	2.425	3.638	6.063	23.98	
2C	3.000	9.206	2.5	3.205	4.807	8.012	35.54	
2E	2.000	5.638	1.8	2.491	3.737	6.228	26.82	
2F	2.000	5.638	1.8	2.574	3.861	6.435	31.15	
3	4.000	12.374	3.0	3.991	5.987	9.978	46.33	
4	3.000	6.888	1.5	2.010	3.015	5.024	36.11	
6	3.000	6.105	1.3	1.770	2.656	4.426	35.62	
8	4.000	12.026	2.9	3.977	5.965	9.942	51.16	
9	3.000	7.870	2.0	2.956	4.434	7.391	50.91	
10A	4.000	9.822	2.7	4.027	6.040	10.067	41.52	
11A	4.000	12.156	3.0	4.090	6.134	10.224	55.04	

Note:
B Minimum Stable Width
R_S Regime Scour Depths
d_2 Downstream Cutoff Depth
1.5 d_2 Concrete Apron Length
2.5 d_2 Launching Apron Length

Source:

Sedimentation problem is managed through the design of check dams upstream of the culverts. Two types of check dam are designed; rock fill check dam and concrete section check dam. Details are developed in the design drawings. Upstream wadi # 1, a check dam is located in front of the stream training section. Other streams are left for the engineer to select the narrowest section with stable banks. The rock fill section is designed for stable rocky sites and the concrete section is developed for sites with unstable loose material. The dams are deigned to stop the transport of the bed load to the entrance of the culvert. At the same time, they work to ease the stream bed slope through the accumulation of sediments upstream of the dam. This eventually leads to a great deal of flow velocity reduction.

4.5.6. Overall Function of the Drainage System

The different parts of the drainage system are planned to function as one integral system. Therefore, the culverts and drainage ditches are designed to drain the road site and dispose the storm water with the running springs and base flow efficiently out of the corridor. Drainage ditches are designed along the edges of the roadway to receive the runoff from the pavement surfaces and the surrounding areas. These ditches will serve as interceptor channels to drain storm water away from the roadbed. Also, the base flow is collected and diverted by the drainage ditches downstream of the road embankment in order to protect it and to minimize the adverse impact against the surrounding environment. Plate 1 and 2 show a spring and base flow running within the road corridor. The surrounding area consists of higher ground, and as in the cut, water may flow towards the roadway. A ditch constructed in the back slope near the top of the cut, or on benches in the cut slope, will intercept and carry the water away. A typical section is presented in the design drawings.

Water collected in the interceptor ditches from cuts and fills and from all longitudinal drainage is discharged into existing drainage streams at proper intervals according to topography, ditch capacity, and location of the natural drainage stream. These outlets are fixed on the plan-profile sheets in design drawings volume. All ditches on grades exceeding 2% are lined and a typical section is designed and presented in design drawings volume. The lined ditch provides positive drainage and also controls erosion, plus other desirable characteristics such as hydraulic efficiency, durability, and minimal maintenance. The Manning equation is the most frequently used and widely accepted method of determining channel capacity. This method will give a reliable estimate of the velocity of the flow and discharge as long as the channel cross-section, roughness, and slope is relatively uniform.

The Manning equation for discharge is:

$$Q = \frac{A}{n} R^{2/3} S^{1/2}$$

Where Q = Discharge Rate, in m^3/s.
A = Cross-Sectional Area, in m^2.
n = Manning Roughness Coefficient.
R = Mean Hydraulic Radius, in m.
= Area of Section/Wetted Perimeter.
S = Longitudinal Slope, in m/m.

The estimated capacity of 0.50 m depth of the lined drainage ditch will be more than 0.5 m^3/s, depending on the bed slope (grade).

4.5.7. Design Policy

For the design of drainage components, the following policy was applied:

(1) Box and pipe culvert

- To install the culverts keeping the existing alignment and longitudinal gradient of the wadis as much as possible
- To set the in-take of the culvert at right angles to the stream line of the existing wadi
- To avoid bending the culvert
- To set a check dam in the up-stream side of the in-take in order to avoid damage to the culvert caused by flowing down of soil, sand and rocks.

(2) Road side ditch at cut portion

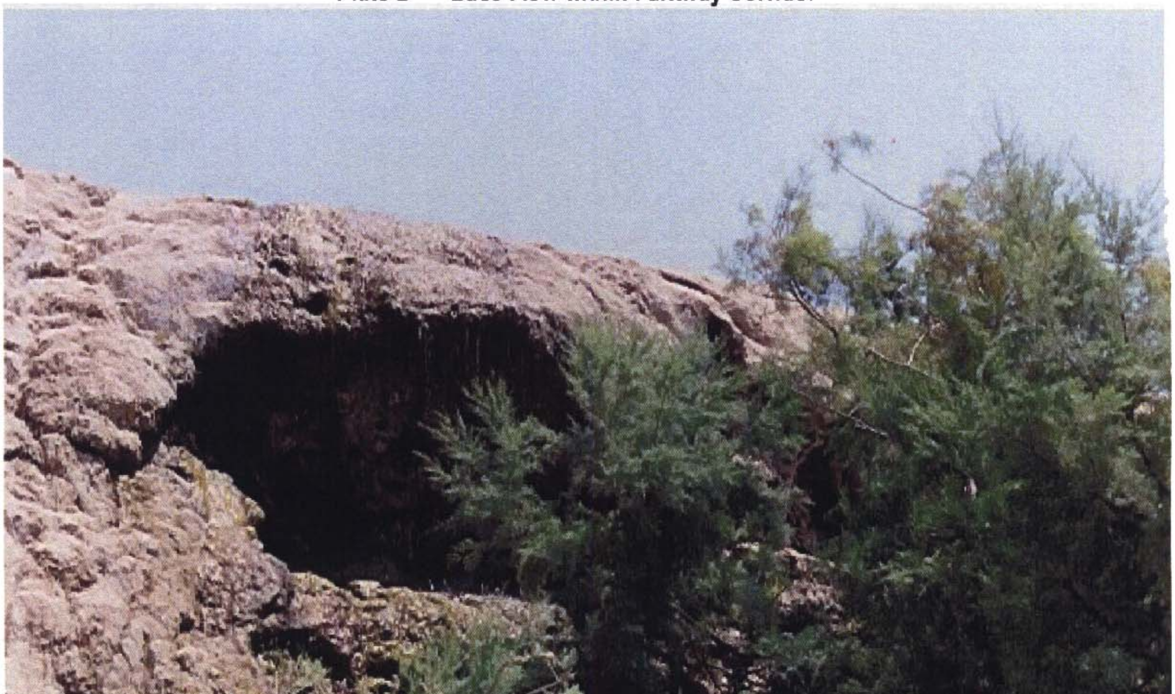
- To apply surface protection (rip-rap) for all road side ditches at both cut and fill portions. It is assumed that the ditches will be damaged by heavy rainfall conditions, which are characteristics of the area, without such protection, although no protection is stipulated in the Jordanian standards for ditches with gradients of less than 5%.

(3) Protection of slope

- To apply slope protection for the following:
  - high fill portion
  - low earth filling, but where rain water will flow down from a shoulder in the cut portion

Plate-1 Spring Water within Parkway Corridor

Plate-2 Base Flow within Parkway Corridor



4.6. Bridge Design

4.6.1. Alternatives for Crossing Wadis

In the study on the alignment of the Parkway one of the important criteria is how to reduce the number and size of wadi crossings. The selected alignment has 2 wadi crossings.

It was proposed and eventually agreed to provide bridges at the two locations, in order to avoid the construction of high embankments (more than 30m). Embankments have a disastrous effect on the environment and bio-diversity especially in the Wadi Himara area due to the width required for embankment construction, while the bridges can minimise the effect of such massive earthworks

4.6.2. Bridge Design

The locations and the length of the bridges are as shown below:

- Wadi Abu El-Asal Bridge, 90m long, at Sta. 6 + 000 approximately, and
- Wadi Hammara Bridge, 120m long, at Sta. 7 + 000 approximately.

The selection of superstructure and substructure of the bridge in any particular site depends on technical and economic considerations (i.e. number and length of span, alignment and site layout, method of construction, materials and construction techniques available).

Considering the above mentioned factors, several bridge types and arrangements are analysed and evaluated, with economy and constructibility being the most important factors considered in the selection and evaluation process. It is recommended to use the arrangement of:

- Pre-stressed pre-cast girders with a cast-in-place slab deck for the super-structure of the bridge.
- Hammerhead shaft piers for the substructure of the bridge.

The above arrangement eliminates the need for the construction of false work, which reduces cost. In addition, the same girder section can apply for the two bridges to reduce the cost of mobilization associated with form work required for girders casting.

The configurations of the pier section designed suits the height of the piers and locations adjacent to the wadis.

The layout and section of Wadi Hammara Bridge are shown in Figure 4.16.

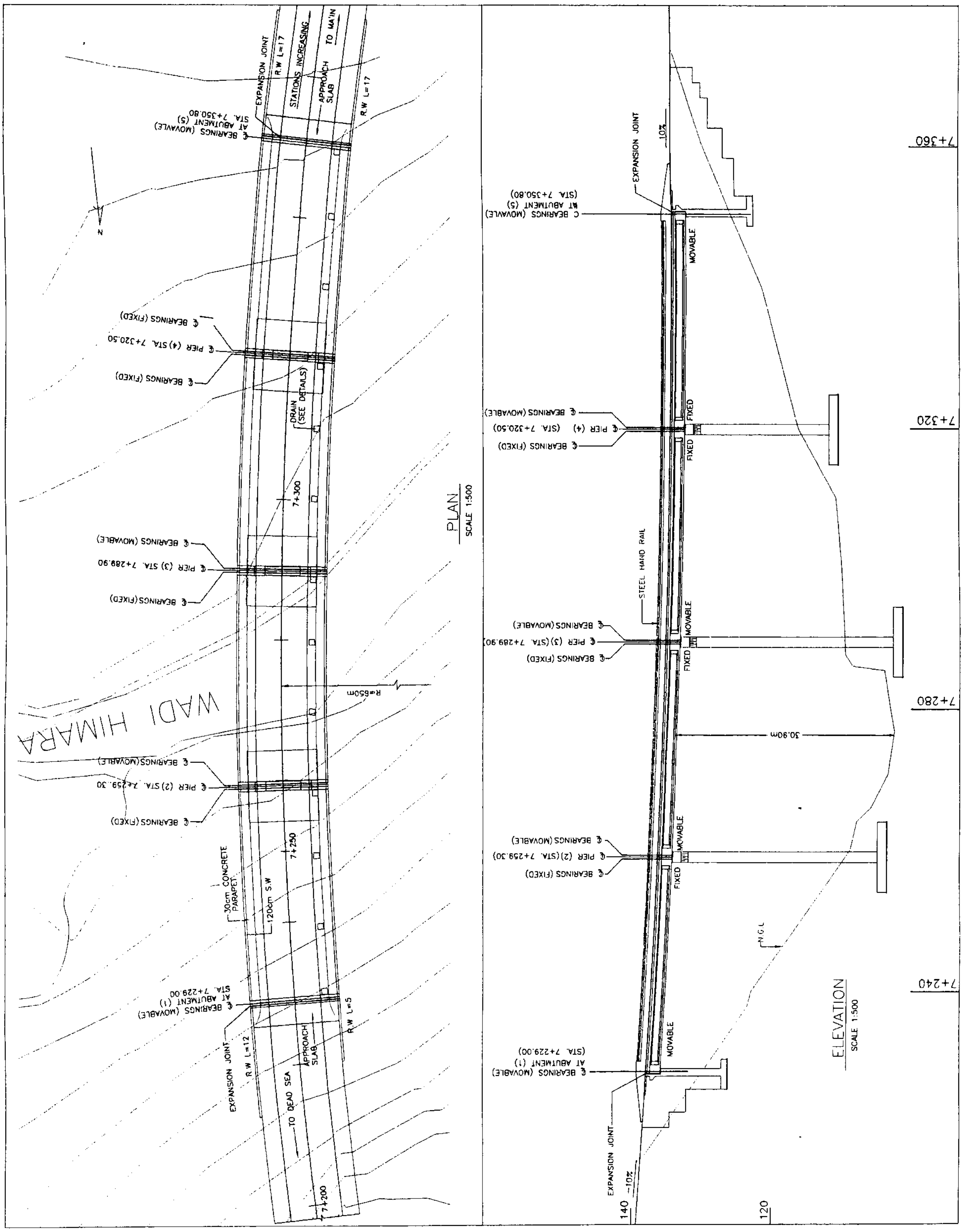
4.7. Design Elements with Geotechnical Considerations

<u>Geotechnical Visual Evaluation</u>

A geo-technical survey including an intensive desk study on the available data and site walkover visits were conducted along the sections of Part-A and B for a length of 9.4 km. In the walkover surveys, critical areas with respect to geotechnical factors (such as potential areas of instability, areas of deep cuts and bridge sites) were identified.

Based upon the study of existing information and the walkover survey, it is possible to lay down broad guidelines for the design of earthworks and foundations. The site investigation provides further data at particular locations.

Figure 4.16 Layout and Section of Wadi Hammara Bridge



Source: JICA Study Team

Thorough geotechnical investigation including stability analysis covering the last 2.25km of Part-C was carried out. Another geotechnical investigation was carried out covering the route from Sta. 5 + 500 to 9 + 400 approximately.

According to the results of the geotechnical evaluation, design is made for the following elements:

4.7.1. Earthworks

(1) Natural Slopes

Although no instability (existing or potential landslides) is identified along the route, shallow seated surface failures may appear within the Lisan Marl Formation outcropping over the route between sta. 1 + 350 and sta. 2 + 650, and rock falls from the weathered and intensively jointed sandstone surfaces of the steep escarpments and steep sided wadis, especially at several locations as shown in the detailed design drawings.

These possible surface failures and rock falls will not endanger the safety of the road if the site clearance is properly done and the locations where the Lisan Marl outcrops are properly flattened.

(2) Excavation Side Slopes (Cuttings)

On the basis of observation of the strata along the route and their long-term performance in existing natural slopes, three categories have been adopted, namely; weathered and jointed rock, (WR); highly weathered and/or intensively jointed and fractured rock (HWR), and soil (S)-Lisan marl gravel. While classification is generally relatively simple, there are cases where adverse orientation of discontinuities and unfavourable dipping will require slopes flatter than those proposed in the design. These factors are to be the subject of further study during the detailed site investigation phase (during construction) especially for the first 5.5km of the route.

(3) Method of Excavation

Selection of proper excavation method should be based on the soil properties obtained during the detailed site investigation phase, on which a Rock Mass Rating can be built up. However, on the evidence of the visual observations, a classification is presented below:

Table 4.11 Classification of Method of Excavation

Method	Material	Remarks
Scrape	Lisan Marl (from sta. 1+350 to sta. 2+650) and top soil deposits which cover a significant part of the route along section B (i.e. from sta. 5+600 to 9+400)	Conventional excavation equipment such as loaders and bulldozers. Jack hammers and rock breaker may also be required for excavation through the strongly cemented Lisan marl forming rock crust and for excavation of the large boulders encountered within the top soil.
Rip	Sandstone from Umm Ishrin, Main, Dardur and Kumub Formations.	Pneumatic equipment such as jack hammers and rock breakers and rippers successfully breakout these rock formations (although they may cause high bit wear). These sandstone are generally weathered and intensively jointed which make it easily ripped and scraped.
Blast (if it is permitted)	Sandstone as above.	In order to minimise the expected high bit wear and to increase the excavation rate especially for the sandstone of Umm Ishrin, Main and Dordur Formations exposed approximately along the route from sta. 0+000 to 1+350 and from sta. 2+650 to 4+250..

Source: JICA Study Team

(4) Suitability of Site Materials for Construction Purposes

The materials which will be excavated from the site are considered suitable for earthfill construction and pavement layers (except for base course layers and aggregates for the asphalt layer(s)). However, the materials need to be processed by crushing, storing, mixing, etc, in order to meet the requirement of the Standard Specifications for Construction of Roads and Bridges, Ministry of Public Works and Housing (MPWH), Jordan, 1991.

The final decision shall be taken during construction based on the results of laboratory testing provided during the quality control program.

4.7.2. Embankments

Since the route generally crosses relatively strong materials the stability of embankment is dependant upon the strength of the compacted fill materials. For the materials obtained from the project site and provided that the requirements of the above mentioned MPWH specification are followed (gradation, physical and mechanical properties, compaction criteria, etc), fill slopes of three horizontal to two vertical (3H:2V) may be adopted for embankments up to 6m high but flatter (e.g. 2H:1V) slopes would be required for embankments in excess of this height.

4.7.3. Foundation and Retaining Structures

(1) Foundations

Based upon inspection of ground conditions along the route (especially at both bridge sites), it is anticipated that shallow foundations shall be adopted. The bearing capacity values for exact locations of bridge foundations should be determined following more detailed site investigation.

(2) Retaining Structures

If the previously advised side slopes (for the cut areas and embankments) can not be achieved because of space limitation or for any other reasons, both reinforced concrete and gabion walls may be adopted, the latter being particularly favoured for long sections and within the areas of steep natural side slopes and sleep sided wadis to accommodate possible lateral movements.

For reinforced concrete, particular attention is paid to the drainage conditions to ensure that accumulation of water does not occur behind the wall. Granular backfill shall be provided immediately behind the wall with appropriate weep holes, etc.

Chapter 5. Construction Planning

5.1. Project Site

The contractor will be handed over the construction site of the sub-project, and the contractor shall be responsible for the site for the whole of the construction period.

5.2. Temporary Works

All temporary works are the responsibility of the contractor. Program of all temporary works should be submitted to and approved by MPWH and/or relevant agencies prior to commencing the actual implementation of the temporary works on site.

5.2.1. Temporary Facilities

(1) Construction access road

An existing road extended from Madaba-Ma'in Spa road toward the Dead Sea is the only possible access road for construction of the Parkway at the northern end, although the road has been badly damaged and is steep, and is to be improved as part of this Project. The National Highway Route 65 is another access for the southern end of the Parkway, but also this access is steep. In Part-A the site construction road should be carefully planned since the area is environmentally sensitive; having important plants and archaeological sites. It is considered as an option that the alignment of the construction road would be the same alignment as the Parkway itself, for which EIA has been applied..

(2) Contractor's office, workshop, material storage, parking, etc.

The contractor can select a suitable area as the temporary facility site, but subject to the acceptance of MPWH and relevant agencies. The sites for temporary facilities are recommended as shown in Figure 5.1, although this should be studied and determined by the contractor according to the construction method and schedule.

<u>Specific Note</u>

The location of the sub-project is in a remote area and in the same location where the Dead Sea Panoramic Complex is to be constructed as a component of this Project. It is essential that the contractors for the Parkway and Panoramic Complex cooperate in the operation of some plant, such as concrete mixing plant and asphalt plant, and large size/capacity equipment and machines, in order to reduce the costs of the temporary works. Furthermore, it is recommended that the 2 sub-projects should be combined into one package in order to more effectively reduce costs of the temporary works. This may be possible, since the tender management and construction supervision are conducted by MPWH.

(3) Testing room and equipment

In Amman there are public and private laboratories where the tests can be conducted. The contractor can select a laboratories. The brochure of the laboratories selected and items tested by the laboratories should be submitted to MPWH for its acceptance prior to the conduct of the tests.

(4) Utility Services for the construction works

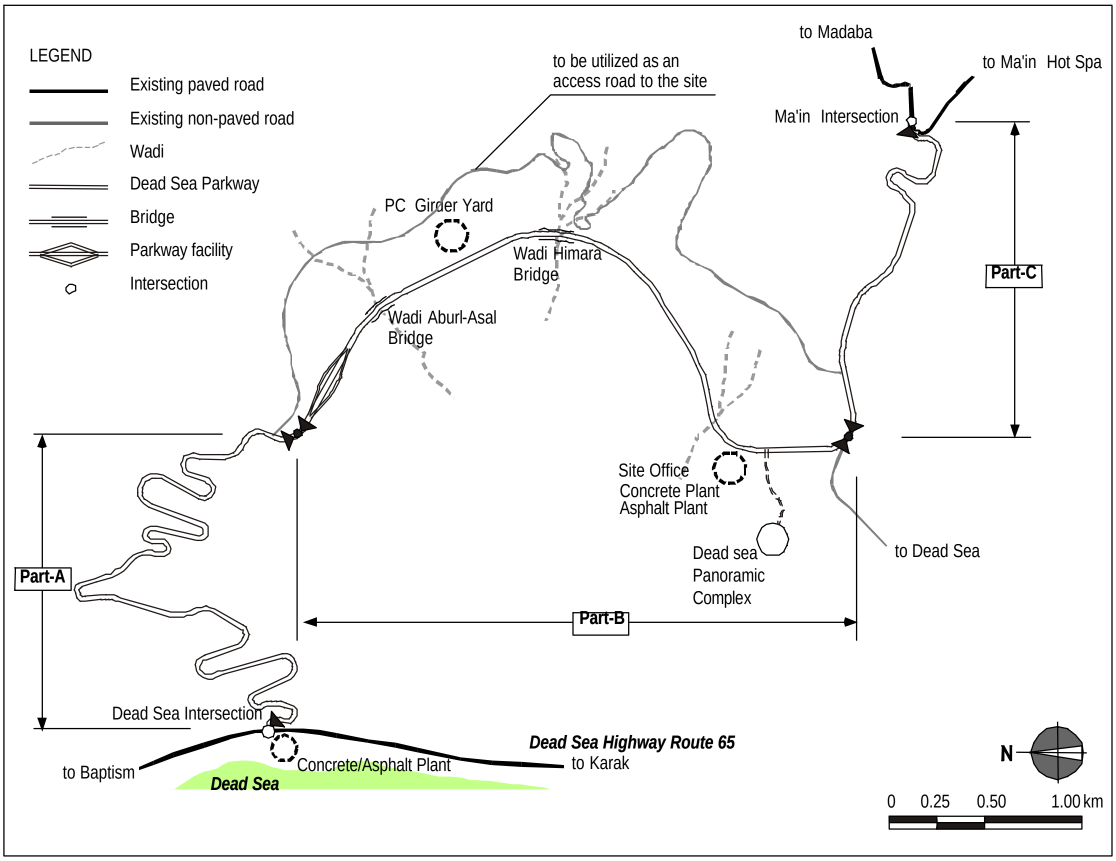
1) Water supply

Since there is no existing water supply system to the location, the contractor is responsible for securing a water supply. As an option the water can be brought from the Madaba Municipality by tank lorry, but the contractor should provide a water reservoir.

2) Electrical supply

Electrical supply is also not available in the location at this moment. However, power will become available from the new cable installation from the transmission line along the section of Madaba-Ma'in, The cable can be utilized for the temporary power supply if the construction sequence is well managed.

Figure 5.1 Sub-project and Temporary Facility Site proposed



Source: JICA Study Team

3) Telecommunications

As for the telephone line, it may be practical to utilize mobile telephones. However, cable lines are required for the facsimile line and also internet/e-mail lines. Permanent telephone lines for the Panoramic Complex are also to be installed, being branched from the Main line along the Madaba-Ma'in Spa road. If the construction sequence is properly coordinated, this telephone line could be utilized.

4) Sewerage

The sewage should be carefully treated in this location, since it is an environmentally sensitive area. There are two alternative solutions: 1) shipped out with a vacuumed car from Madaba Municipality from a cesspool to be constructed; and 2) to provide a sewerage treatment plant to meet the Jordanian standards and regulations. The discharge point of the treated water to a wadi should be coordinated with Jordan Valley Authority. An overall plan of the sewage treatment system should be submitted to and approved by the agencies prior to construction on site.

5) Normal solid waste disposal from the contractor's office

The contractor should apply an appropriate system and measures by his responsibility, and the measures should be accepted by Jordan Valley Authority.

6) Disposal of excess soil and debris

The excess soil and debris should be disposed to an area(s), which should be designated under coordination with Jordan Valley Authority, with proper manners. The necessary measures to mitigate environmental impacts should be taken by the contractor.

The final solutions of the utility services accepted by the relevant agencies should be submitted to MPWH in written form prior to construction on site.

5.2.2. Traffic Control Measures

There are no severe problems found on the traffic control during the construction, since the location is remote and has low traffic volume on the Section of Madaba-Ma'in, except the tourist traffic to Ma'in Spa. However, a proper traffic control measure should be applied for the access from the National Highway Route 65, on which cars are running at high speeds.

5.2.3. Safety and Security Measures

No specific safety measures for people are required since no residents are living in the area. However, some security measures should be required in order to protect construction materials and equipment from thefts under the contractor's responsibility.

5.3. Construction Method and Construction Schedule

The contractor should plan the most appropriate construction method and construction schedule. They should be submitted to MPWH for its approval prior to the commencement of the work on site.

5.3.1. Construction Method

The contractor should submit construction methods for particular work items as well as the general methods including utilisation plan of construction machines as well as labour force.

The following are the items to be taken into consideration in the construction method:

(1) Construction roads

Alignment and construction of roads for delivery of materials (construction roads) should be carefully planned by the contractor due to the area being environmentally sensitive. The following are standards for the roads to protect the environment and to maintain construction safety.

- Capacity: 10t dump truck
- Width: lane 3.0m, shoulder 0.5m both sides, total 4.0m
- Longitudinal gradient: Maximum 15%
- Pavement: Asphalt pavement of 3.0cm thickness to be adopted for the steep gradient portion (more than 12%)

<u>Part-A</u>

The existing trails can not be used as the construction road due to the steep gradients. Since Part A crosses steep slopes, the construction road needs many temporary culverts and retaining walls similar to the permanent facilities. These temporary culverts and retaining walls will obstruct the construction of permanent facilities, therefore, it is recommended to construct the permanent facilities in advance. The construction road should avoid locations of the archaeological site and environmental impacts.

Part-B

For Part-B the existing trails (non-paved trails for the afforestation in the area) along the Parkway alignment can be utilised as the construction road. The trails would be constructed to the standards shown above. From this road the construction could be started from any point within Part-B including the bridges, as well the upper side of Part B.

Part-C

The existing road will be utilised as the construction road for Part-B as well as Part-C.

(2) Temporary facility distribution plan

The temporary facility layout plan should be prepared and proposed to MPWH and agencies concerned for their approval. The following are the details to be considered.

Site office, staff accommodation , concrete and asphalt plant

The flat area at the southern part of the far east wadi and western side of the parkway in the site could be recommended for the main temporary facility area including main office, concrete plant, asphalt plant and material stock yard.

It may also be required to provide other concrete and asphalt plants at the bottom area of cliff in the Dead Sea Intersection in order to start construction of Part-A from both ends to shorten the construction period. The concrete of this plant would be supplied to the construction of Part-A.

The asphalt plant would be required later, and the concrete plant site can be used for the asphalt plant.

PC Girder Yard

The PC girder yard for the bridges would be provided in between the two bridge construction sites in order to shorten the shipping distance. The concrete would be supplied from the concrete plant on the plateau.

(3) Starting point of Construction

It is recommended that the construction should be started from each end of Parts-A, B and C. Since additional geological survey by the contractor is required for Part A and the commencement of the site work may be delayed, it may be necessary to apply measures to catch up such delay in Part A

5.3.2. Construction Schedule

A construction schedule indicating the major work items, recommended by the Study Team, is shown in Figure 5.2. The total construction period is estimated as 24 months with the defect liability (guarantee) period of one-year.

The actual construction schedule should be prepared in CPM by the contractor taking into consideration temporary works and construction methods as well as other conditions of the site, material and labour supply plan, etc. The construction schedule should be submitted to MPWH for its approval prior to the commencement of the work.

The rainy season (from December to February) should be taken into consideration for the preparation of the construction schedule.

Permanent lines for electrical supply and telephones could be used if the construction sequence is well managed.

5.4. Specific issues to be taken for Tender Package

<u>Combining with the Dead Sea Parkway Sub-project</u>

The site location is remote from the supply points of construction materials and labour force as well as construction machines and equipment. In this case, costs of the temporary works become higher in general. However, there is another sub-project, the Dead Sea Panoramic Complex, in the same area. The Ministry of Public Works and Housing is the employer and also manages the tendering for both the Dead Sea Panoramic Complex and Dead Sea Parkway. In this situation it is strongly suggested to combine both sub-projects into one tender and construction package in order to save temporary works costs.

If the sub-projects are combined, the Complex contractor would get materials such as concrete and pavement materials from plants of the Parkway contractor. The Complex contractor should co-ordinate with the Parkway contractor and should prepare the construction plan and schedule to meet the operation and material supply timing and capacity of the Parkway contractor's plant.

5.5. Environmental Consideration

The Dead Sea Parkway Development is a sub-project of The Tourism Sector Development Project, comprising the construction of a two lane road linking Ma'in Hot Springs and Zara (Dead Sea) areas. The construction site of the Parkway is located on a rocky plateau which has specific environmental and archaeological aspects. It is considered that construction activities of a road connection will inevitably result in some large changes of the existing condition along the road alignment and influence the natural and human environment. An Environmental Impact Assessment (EIA) Survey has been conducted for this Parkway project by the Jordanian consultants, namely the Consolidated Consultants Engineering and Environment including experts from the University of Jordan.

5.5.1. Methodology

According to the principles of the OECF Environmental Guidelines, the JICA Study Team (JST), in general, should comply with an EIA procedure of the recipient country, if the country has sufficient EIA procedures and regulations. In case Jordan does not have such procedures, JST shall apply an EIA procedure to projects, taking into consideration the Environmental Consideration Guidelines of JICA, OECF and the World Bank.

The EIA Survey which has been conducted is composed of the two parts: Natural Environment Survey, and Human Environment Survey.

The Natural Environmental survey was focused on botanical, zoological and ecological issues within the study area. The on-site surveys were carried out, using maps and a Global Positioning System (GPS) for navigation. In addition, some laboratory specimens were also taken, and traps were set up. The findings were used to evaluate a relative level of ecological sensitivity/importance of areas within the study area. In order to evaluate ecological sensitivity and importance, several factors were considered and analysed including presence of rare, endangered and indigenous species, sensitivity of vegetation and soil cover, habitat density, biodiversity, and vegetal succession. Both concepts, sensitivity and importance, are subjective, however, in order to comprehensively identify areas where careful environmental mitigation should be undertaken, these two concepts are combined and rated comparatively, based upon the best professional judgement of experts from the University of Jordan and NGOs, etc.

On the other hand, the objective of the Human Environment Survey is to identify possible adverse impacts on socio-economic activities, archaeological sites and cultural heritage sites. This objective was mainly achieved through database searches, literature reviews, and a walking survey.

5.5.2. Findings of Natural Environment Survey

The study area falls within the greater Dead Sea Basin Ecosystem that is considered unique due to the dramatic drop in elevation and other features resulting from years of complex geophysical activity. The Dead Sea Basin Ecosystem is also considered very important for resident and migratory birds and endangered raptors. Further, seasonal variations and literature reviews to determine potential survey findings during other times are taken into consideration.

Table 5.1 Summary of Ecological Importance of the Study Area

Ecotype	Micro-ecosystems: Habitat/Niche	Ecological Importance of Micro-ecosystems	Overall Ecological Importance of Ecotypes
A: Plateau	Rocky Outcrops, Crevices & Caves	Low	Low
	Stony/sandy areas	Low	
B: Slopes	Rocky Outcrops, Crevices & Caves	High	Medium
	Stony/scree areas	Low	
C1: More temporarily flowing wadis	Sandy Areas	Medium	Medium
	Rocky Outcrops, Crevices & Caves	Medium	
	Seasonal Water Courses	Medium	
C2: More permanently flowing wadis.	Permanent Pools (C2)	High	High
	Permanent Water courses (C2)	High	
	Palm trees/dense vegetation	High	
	Rocky Outcrops, Crevices & Caves	Medium	
	Sandy Areas	Medium	
	Reed beds	Medium	

Source: JICA Study Team

5.5.3. Findings of Human Environment Survey

Findings indicate that the hilltops above the project area have always had the concentration of urban development and agriculture because of the favourable soil conditions, climate, availability of water and good trade routes, while the lower Rift Valley margin has traditionally been difficult to access. This fact, coupled with the semi-arid conditions, means that the study area has never been heavily exploited by humans. However, there are permanent and semi-permanent water sources that have provided the means of survival for travellers, nomadic herders, and hunters in the past as they still do today.

The fieldwork identified several findings, which are classified under different types. Under each type, the findings are categorized according to their significance. A surprising number of sites were located during the field survey. The sites fall into nine basic site types:- 1)settlements, 2) stone enclosures and circles (some including graves), 3) small stone shelters, 4)walls and fields, 5)dams and water harvesting terraces, 5) large cairn tombs, 6)cemetery, 7)single graves, 8)flint scatter, and 9) a part of the Roman Road. The archaeological sites identified have been divided into three categories based on various criteria (refer to Section 2.6)

5.5.4. Impacts and Mitigation

Potential impacts on both the natural and human environments that may result during construction phase were identified. Negative and positive impacts were identified for construction phase and were categorised as either direct or indirect. Mitigation measures that could minimise the significance, extent, and likelihood of adverse impacts, were also proposed. The tables below summarise the potential impacts and proposed mitigation measures.

One mitigation measure already completed is the ranking of route options while bearing in mind the locations of archaeological sites and sensitive ecological areas. This resulted in selection of a favoured route option.

Table 5.2 Potential impacts

factors	actions	impacts	stage	term	type
Water Pollution	- wastewater from plant, temporary facilities and accommodation - landslide from slope of cut and embankment	- water pollution in the wadis by wastewater and landslide - negative effects on the aquatic invertebrates	construction	short	direct
Waste Pollution	- construction materials	- generation construction wastes - increase of tourist litter	construction	Short	direct
Landscape	- construction of structures and road etc.	- deterioration of landscape	construction	Short	Direct
Ecology	- earthwork and construction work - establishment of temporary facilities and road	- damage to vegetation around the proposed alignment - impacts on vegetation along wadis	construction	short	direct
Archaeological remains	- earthwork - place temporary road and facilities etc. - transport work	- damage to existing archaeological remains and newly discovered sites	construction	short	direct

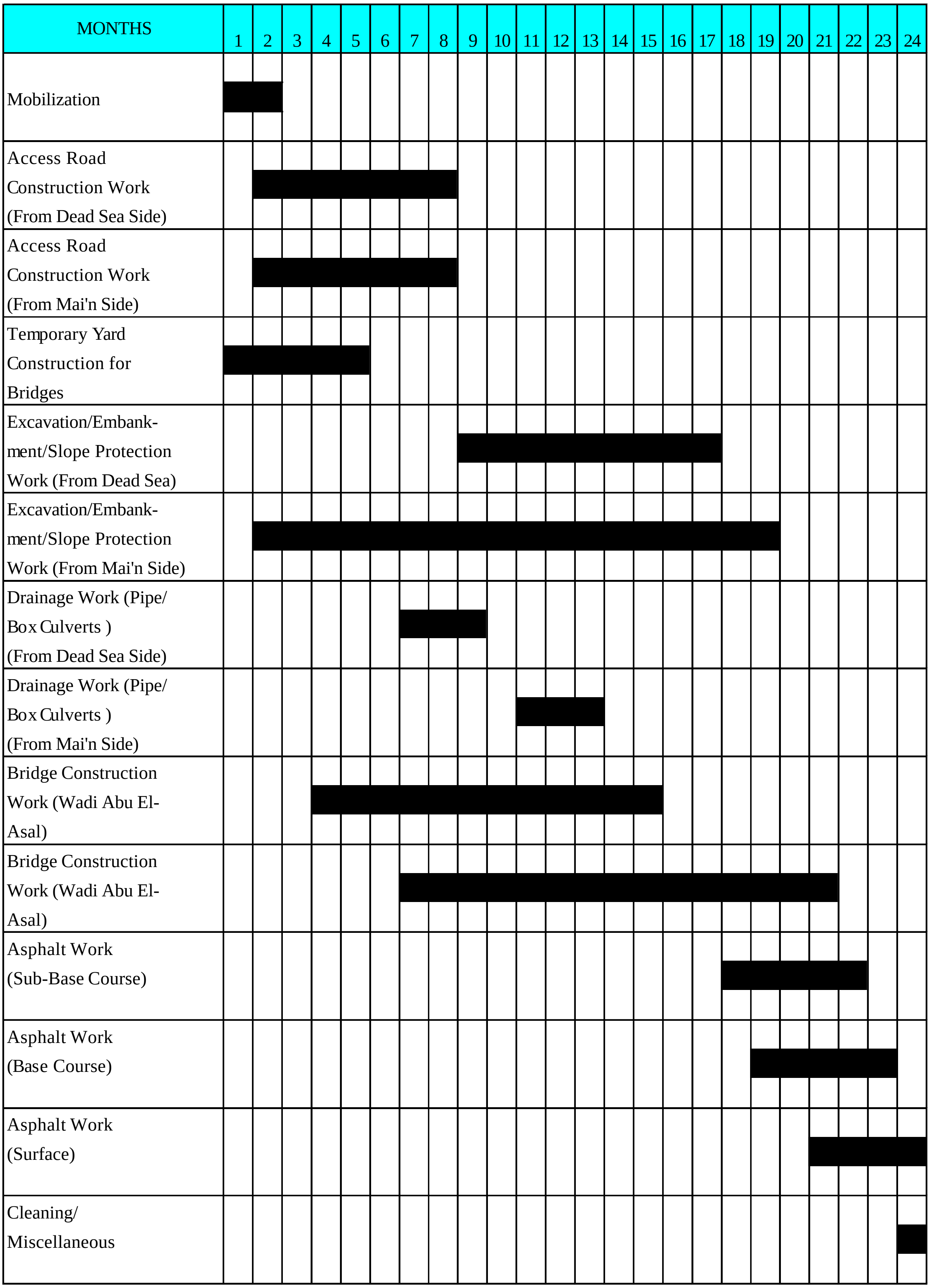
Source: JICA Study Team

Table 5.3 Proposed mitigation measures

	impacts	countermeasures	N.B.
Countermeasures should be clarified in the Tender Document	Archaeological remains	- work plans including temporary facilities and road should be admitted by MPWH and DOA as normal construction works - observe in consultation with experts of DOA to avoid direct impact on potential archaeological remains	
	Waste pollution	- ensure disposal site for construction wastes	
	Water pollution	- avoid rainy season - avoid using water from wadis - avoid direct discharge of non-treated waste water	There is no legal requirement for the control of wastewater from construction works.
Others	Landscape	- careful attention to be paid to height, colour, and feature of construction to alleviate drastic landscape changes	
	Ecology	- use bridge/culvert for water courses - avoid rainy season as much as possible - provide passes for animal trails and Bedouin's stock routes, if any	

Source: JICA Study Team

Figure 5.2 Construction schedule



Source: JICA Study Team

Chapter 6. Tender and Contract Documents

6.1. Components for the Tender

This tender is conducted in one package including the following components:

1) Construction of a new road of 11.35 km in total
2) Parkway Facility

6.2. Tender Administration

6.2.1. Agency Responsible for this Tender

The tendering for the Dead Sea Parkway with the procurement method of LCB is conducted by the Government Tenders Directorate (GTD) of the Ministry of Public Works and Housing (MPWH). GTD in MPWH will organize a Tender Committee composed of staff of the GTD. The various works related to the tender will be assisted by a Project Management Consultant (PMC) selected for the management of implementation of this sub-project.

The signer (the Employer) of the contract with the Contractor will be the Minister of MPWH.

6.2.2. Procurement Method

According to the guidelines of JBIC this sub-project should adopt International Competitive Bidding (ICB), since the construction cost is estimated at not less than 900,000,000 Japanese Yen (approximately 6 million JD). In the case of ICB, the pre-qualification procedure should be applied before the tender procedure.

Regarding ICB, the procedures of procurement of the contractor are as shown below and procedures 6) , 14) and 18) are the specific requirements of JBIC

1) Before making advertisement/notification of the pre-qualification, review and concurrence are required by JBIC on the "Pre-qualification Evaluation Criteria"
2) Making advertisement/notification with international media
3) Delivery of pre-qualification documents
4) Preparation of pre-qualification proposals by attending firms
5) Selection of pre-qualified firms
6) When pre-qualified firms have been selected, review and concurrence by JBIC on the "Result of Pre-qualification" with the selection procedures, reasons for the choice made, attaching relevant documents are required.
7) Issuance of Invitation to Tender
8) Delivery of Tender Documents to Tenderers
9) Conduct Pre-tender Conference by MPWH
10) Preparation of Tender by each of the Tenderers
11) Submission of Tender and Tender Opening
12) Tender evaluation
13) Decision by tender committee

14) After the tendering, before sending a notice of award to the successful tenderer, review and concurrence are required by JBIC on the "Analysis of the Tenders and Proposal for Award" with other documents related to the award, tender documents, etc. as requested by JBIC.

15) Issuance of Notice of Award

16) Negotiation

17) Signing Contract

18) After executing a contract, review and concurrence are required by JBIC on the "Contract" with a duly certified copy of the contract.

6.3. Pre-qualification and Tender Documents

6.3.1. Pre-qualification Documents

(1) Pre-qualification documents

6.3.2. Composition of the Documents

The tender documents are composed of Invitation to Tender and five(5) volumes of documents as shown below:

(1) Invitation to Tender

(2) Volume -I: Instructions to Tenderers

Form of Tender

1) Appendices

Appendix A:	Schedule of Time, Rates and Conditions
Appendix B:	Form of Agreement
Appendix C:	Form of Tender Security
Appendix D:	Form of Performance Security
Appendix E:	Foreign Currency Requirement
Appendix F:	Form of Advance Payment Security
Appendix G:	Drawing List
Appendix H:	General Construction Schedule
Appendix I:	Temporary Facility Location Map
Appendix J:	Site Investigation Report
Appendix K:	Query Form
Appendix L:	Tender Acknowledgement
Appendix M:	List of Eligible Countries

2) Enclosures

Enclosure No.1:	Power of Attorney
Enclosure No.2:	Certification of Submission of Tender Guarantee
Enclosure No.3:	Joint Operation Agreement
Enclosure No.4:	Letter of Association
Enclosure No.5:	Affidavit of Site Inspection
Enclosure No.6:	Basic Program of the Work
Enclosure No.7:	Contractor's Organisation Chart
Enclosure No.8:	Outline Construction Plan and Proposed Layout Plan for Temporary Works

Enclosure No.9: List of Contractor's Equipment to be used on the Works
Enclosure No.10: List of Major Materials and Plant for the Works
Enclosure No.11: List of Sub-Contractors/ Suppliers
Enclosure No.12: Detailed Monthly Cash Flow of Anticipated Contract Payments
Enclosure No.13: Breakdown of Major Rates
Enclosure No.14: MOTA and Engineer office and equipment

(3) Volume -II: Specifications

PART-1: General Requirements
PART-2: Technical Specifications

(4) Volume -III: Bill of Quantities

(5) Volume -IV: Drawings

(6) Volume -V: Conditions of Contract

PART-1: General Conditions of Contract
PART-2: Special Conditions of Contract

6.3.3. Status of Tender Documents

The tender documents are prepared by the JICA Study Team under the contract with JICA as a technical assistance scheme of the Japanese Government. The documents will be granted to the Jordanian Government after the completion of appraisal by JICA, and the Jordanian Government should legalize and formalize the documents for use in the implementation of the Project.

6.3.4. Priority Order of the Documents

The priority among the documents is as follows:

1) Contract Agreement
2) Letter of Acceptance
3) Tender and Notice to Tenderer/Appendix
4) Conditions of Contract Part (II)-Special Conditions
5) Conditions of Contract Part (I)-General Conditions
6) Specifications
7) Drawings
8) Priced Bill of Quantities

6.4. Type of Tendering

In principal, a “Unit Price Base Contract” contract shall be adopted for this sub-project.

6.5. Specific Issues to be considered for Tender Package

Combining with Dead Sea Parkway Sub-project

The site location is remote from the supply points of construction materials and labour force as well as construction machines and equipment. In this case, costs of the temporary works become higher in general. However, there is another sub-project, the Dead Sea Panoramic Complex, in the same area. The Ministry of Public Works and Housing is the employer and also manages the tendering for both the Dead Sea Panoramic Complex and Dead Sea Parkway. In this situation it is strongly suggested to combine both sub-projects into one tender and construction package in order to save temporary works costs.

Chapter 7. Cost Estimates and Implementation Plan

7.1. Conditions of Cost Estimates

(1) Definition of Cost Estimate Condition

The unit prices which are approved by the Ministry of Public Works and Housing are used in the cost estimation of the Dead Sea Parkway sub-project, referring to similar projects in Jordan.

(2) Cost Estimation Currency

Jordanian Dinar (JD) is used for the cost estimation currency in accordance with that of the SAPROF Report.

(3) Exchange Rate

The official exchange rate of Jordanian Dinar and US dollar is 0.708 JD, which has not been changed in the past three years. As for the exchange rate of Japanese Yen and US Dollar, the average TTB rate for the past six months (from September 1, 1999 up to February 29, 2000) is ¥106.08. (Source: The Bank of Tokyo-Mitsubishi)
Therefore, the exchange rates to be applied are as follows:

1 US$ = 0.708 JD

1 JD = ¥ 150

(4) Cost items to be excluded

Land acquisition costs and contingency costs are not included in the estimation.
Service tax, Overhead cost and Profit are included in the estimation, based on a series of discussions with Ministry of Public Works and Housing and normal practice of road construction projects in Jordan.

7.2. Confirmation of Project Cost

7.2.1. Direct Cost

The unit prices used in this sub-project have already acquired approval from the Ministry of Public Works and Housing in Jordan as mentioned in Section 1. However, whether the unit prices could be applicable for International Competitive Bidding is studied below.
As in other sub-projects, the compound costs for main construction works are set based on unit prices issued by MPWH (as of 1998) and market prices in Jordan in reference with the standard rates of Japan.

According to the study of the compound cost list, it is confirmed that the unit prices adopted in the agreement with MPWH are appropriate.

(1) Compound Price

1) The Unit Price for Construction Materials

The unit rates issued by MPWH (as of 1998) and market prices based on the local survey are taken into consideration.

2) Working Hours

The working hours of workers in the construction field is from 8 o'clock in the morning

to 5 o'clock in the afternoon including 2 hours of lunch break. Therefore, a duration of 7 hours is adopted as the working hours for this sub-project in the calculation of compound cost.
Generally the working hours is 8 hours in Jordan. However, the site of the sub-project is located in a remote area, and it is assumed to cause difficulty in labour force supply and increase in costs such as transportation fuels and others. Therefore, the work efficiency and overhead cost are adjusted by reducing the working hours to 7 hours.

3) Efficiency of Local Labour

The efficiency of local labour, the figure for which is obtained by comparing work cost in Jordan and work cost estimated for Japan, is calculated as a percentage for each work item. The main work items are as follows:

Item	Efficiency of Local Labour
Excavation	145% of work efficiency is adopted in consideration of the difference of climate between Jordan Dead Sea Area and Japan, and the site location which is on undeveloped hillside with complicated land grades.
Backfilling	120% of work efficiency is adopted in consideration of the difference of climate between Jordan Dead Sea Area and Japan.
Pavement work	120% of work efficiency is adopted in consideration of the difference of climate between Jordan Dead Sea Area and Japan.
Concrete work	120% of work efficiency is adopted in consideration of the difference of climate between Jordan Dead Sea Area and Japan.
Re-bar work	Work efficiency is same as in Japan.
Guardrail work	110% of work efficiency is adopted since this is fine work.

4) Since this sub-project, unlike other sub-projects, includes indirect cost in unit prices of each item, 24.3% should be added in unit prices same as that of other sub-projects. However, 19.9% is to be added to compound price for evaluation purpose, since about 4.4% is already added in BILL OF QUANTITIES, BILL NO.1: General Provisions.

5) The other conditions are considered the same as for other sub-projects.

(2) Bill of Quantities

A quantity take-off is carried out for this sub-project, and the Bill of Quantities is studied and confirmed for its appropriateness as follows:

1) Excavation and Back filling

Cross sectional computer analysis at 20m intervals is carried out for calculation of excavation and back filling. By this method, actual quantity difference should be within ±5%.

2) Road Pavement and Base Work

The quantity is calculated by the computer based on the road width, length and thickness of pavement and bases. To check the quantities, the verification is carried out every 200m.

3) Concrete Work

Quantity take-off is carried out based on the drawings and the detail of retaining wall details. The figures are studied again by JST.

4) Road Accessories (Signage, guardrail, etc)

Likewise, the accuracy of the length and quantity calculated by the computer is checked.

5) Bridge Work

The structure quantities, which were computed in Jordan, are re-checked in Japan.

7.2.2. Indirect Cost

As aforementioned, indirect cost is included and computed in unit prices based upon discussions with MPWH as well as normal practice for road construction projects in Jordan. However, only site direct cost (cost for the Owner side and Geological survey cost for this project) is incorporated in Bill No. 1 of the Bill of Quantities.
The site direct cost includes owner’s site office, its furniture and maintenance as well as transportation vehicles and drivers for staff of the Owner and supporting staff of its site office, and accommodation facilities for the Owner’s staff.

The portion of site direct cost to the total contract amount is about 4.4%.

After all the above conditions are considered, is concluded that the quantities and the unit prices confirmed with MPWH are applicable for International Competitive Bidding.

7.3. Construction Cost

The construction cost of this sub-project is not specified in this report primarily due to the public availability of this report and the confidentiality of the construction cost prior to the tender. The detailed information on the construction cost, however, has been described in a separate edition, which has been supplied only to the Agencies and Ministries concerned.

7.4. Project Implementation Plan

7.4.1. Execution of the Sub-project

Items to be fulfilled for the overall implementation period of this sub-project, which is categorised as an ICB type of procurement method, are as shown below:

(1) Completion of the JICA Study

JICA plans to complete the Final Report and Tender Documents at the end of August and they may be transferred to the Jordanian Government as soon as possible after finalising the internal procedures of the Japanese Government.

(2) Procurement of Project Management Consultant (PMC)

A Project Management Consultant (PMC) should be procured before the tender documents are transferred to the Jordanian side by JICA in order to maintain a smooth transition to the implementation stage under the JBIC Loan from the JICA D/D Stage.

(3) Review and confirmation of the tender documents

The tender documents should be reviewed and updated if any changes are made by the Jordanian side on the contents, such as: tender packaging, scope, and employer address. For the review, if required, 0.5 ~ 1 month is allocated.

(4) Tender period

This is categorised in the sub-projects for which procurement method is ICB. The procurement procedures are stipulated in the JBIC Guideline as follows, but applying omission of the pre-qualification procedure:

1) Before making advertisement/notification of the pre-qualification, review and concurrence are required on the "Pre-qualification Evaluation Criteria" by JBIC.
2) Preparation and submission of the pre-qualification proposals by the contractor.
3) When pre-qualified firms have been selected, review and concurrence by JBIC on the "Result of Pre-qualification" with the selection process, reasons for the choice made, attaching relevant documents are required.
4) Issuance of the Invitation to Tender to the pre-qualified tenderers.
5) Pre-tender conference
6) Preparation of tenders by the tenderers
7) Tender opening
8) Evaluation of Tenders
9) After tendering, before sending a notice of award to the successful tenderer, review and concurrence are required by JBIC on the "Analysis of the Tenders and Proposal for Award" with other documents related to the award, tender documents, etc. as requested by JBIC.
10) Sending the notice of award to the successful tenderer
11) Negotiation
12) Signing the contract
13) After executing a contract, review and concurrence are required by JBIC on the "Contract" with a duly certified copy of the contract.

For the above procedures 10 months are scheduled for the tender period.

(5) Construction and As-built drawings

As shown in Figure 5.2, the construction period of this sub-project is estimated at 24 months. The contractor should prepare and submit a set of as-built drawings to MPWH within 1.5 months after the completion of the construction works (issuance of the completion certificate).

(6) Defect liability (Guarantee) period

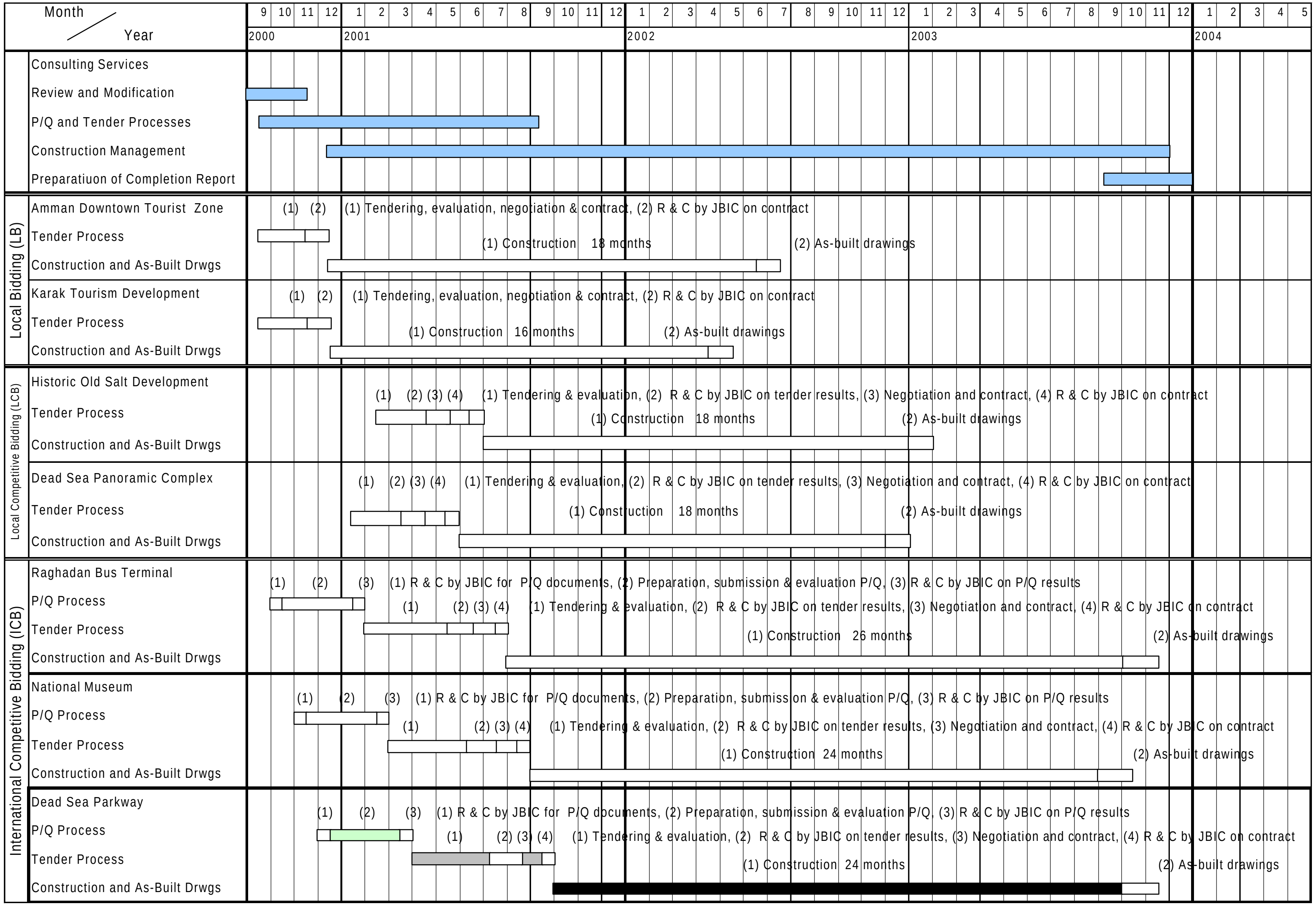
The period for defect liability is 365 days (one year).

(7) Completion Report

Within 3 months after the completion of the construction works a completion report should be prepared and submitted by the Consultant to MPWH.

An overall project implementation schedule prepared is shown in Figure 7.1

Figure 7.1 Overall Project Implementation Plan



Source: JICA Study Team

Chapter 8. Operation and Maintenance Plan

The operation and maintenance plan for the Dead Sea Parkway is basically handled by the existing organization, Road Maintenance Department of MPWH. Therefore, an explanation of the organization are as follows.

8.1. Existing Situation in Operation and Maintenance of Roads

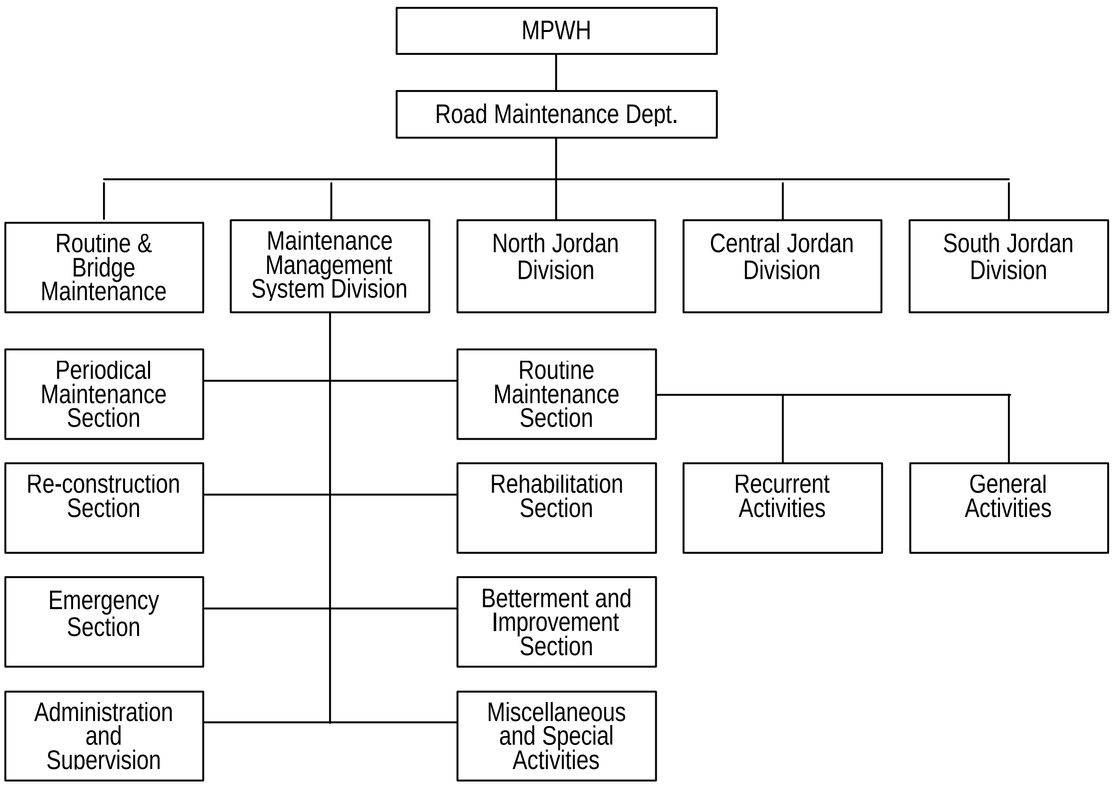
8.1.1. Organization Structure

MPWH has an organization named Road Maintenance Department, which consists of the following five (5) divisions:

1) Routine & Bridge Maintenance Division
2) MMS (Maintenance Management System) Division
3) North Jordan Division
4) Central Jordan Division
5) South Jordan Division

The organization chart of the Department is shown in Figure 8.1, and focussed on the MMS Division which may be the most important and closest related to the maintenance of the Dead Sea Parkway.

Figure 8.1 Organization Structure of Road maintenance Department of MPWH



Source: JICA Study Team based on the information given by MPWH

8.1.2. Staff

The road maintenance department, MPWH has the following number of staff according to the information given by MPWH in June 1999;

1)	Engineers:	499
2)	Administrative staff:	1,813
3)	Labourers:	5,234
4)	Total	7,546

Although the head of each division as well as the section chief are permanent positions, most of the staff do not belong to a specific division. The staffs are divided into several groups, and rotate periodically to other divisions.

8.1.3. Function and Roles

MPWH is fully responsible for maintaining all of the National Roads demarcated by the responsibility of the Municipalities, and each of the Municipalities is fully responsible for maintenance of all of the Local Roads in the municipal area.

The above MMS Division of the Road Maintenance Department carries out the following maintenance work:

(1) Routine Maintenance

This is the normal daily maintenance work, such as repairs, cleaning, reconditioning, and/or replacements that are necessary to be carried out once or more times a year to preserve the roads and to provide adequate levels of service and safety to the road users. This Division comprises the following 2 sections:

<u>Recurrent Activities</u>

Work includes pothole patching, deep patching, crack sealing, shoulder maintenance, mechanical ditch cleaning, repair of drainage structures, guard rail repair, traffic signs maintenance, minor repair of expansion joints and bridge seats, minor repair of bridge hand railing, deck curbing and approach pavement, repairing and replacing riprap.

<u>General Activities</u>

General activities such as washing, sweeping, trimming bumps, removal of trash, rocks, silt and other debris from the road surface, ditches, culverts, catch basins, inlets and outlets to maintain adequate drainage, clean traffic signs, paint guard rails and posts, removal of unauthorised signs, right-of-way cleaning and litter pick-up, disposing of debris, dead animals, tires, bush and tree cutting, spot moving and hand trimming, fence repairs, bridge hand sweeping, cleaning drain holes, debris removal from expansion joints, waterway openings, vegetation control and removal of writing and painting on the structures, etc.

(2) Periodic Maintenance

Periodic maintenance activities are more involved tasks than routine maintenance, and they should be carried out periodically in order to maintain the original roadway characteristics which are gradually lost due to action of age, traffic, weather, and accidents. This includes:

- Sealing,
- Resurfacing,

- Surface Treatment, and
- Pavement Marking, etc.

(3) Rehabilitation

Rehabilitation of roadway sections that have some failures in upper layers only, whereas its lower layers are still in good condition. This requires removal of the failed layers, reconditioning the remaining layers as necessary, then replacement with new layers.

This category includes roads under condition “1” according to road inventory results and 50% of roads under condition “2”.

Rehabilitation also includes shoulders and other roadway features on those roads as necessary.

(4) Re-construction

Reconstruction of roadway sections that have severe deterioration in all layers, from top pavement and base layers, all the way down to subgrade layer which cannot be maintained.

This category includes roads under condition “1” according to road inventory results and 50% of roads under condition “2”.

Reconstruction also includes shoulders and other roadway features on those roads as necessary.

A laboratory field test of road layers is required to determine the depth of the deterioration in order to decide whether to go for rehabilitation or reconstruction.

(5) Betterments and Improvements

Under this category are activities to improve the original roadway conditions, such as improve roadway capacity, increase safety, prevent recurrent problems, and/or to correct a construction-design deficiency. This includes:

- Road & Shoulder Widening,
- Drainage Betterments,
- Retaining Walls,
- Gabion Walls, and
- Slope Protection, etc.

(6) Emergencies

These are random road maintenance activities, characterised by the need for immediate action and the allocation of resources to restore the traffic flow to safe and efficient conditions. This includes:

- Snow Removal & Ice Control,
- Landslide Removal, and
- Emergency Drainage Structure Repair, etc.

(7) Miscellaneous and Special Activities

The road maintenance activities, which are not directly connected with the road, but rather related to support and enhance the remaining activities. These activities include:

- Material Stockpiling & Classification,
- Cold & Hot Mix Production, and
- Training of Personnel, etc.

(8) Administration and Supervision

Maintenance works related to administration and supervision activities include: coordination and distribution of work tasks on maintenance crews, preparing work reports, secretarial and clerical work, scheduling and monitoring personnel leave time, vehicles and equipment's servicing, and maintenance and transfer between work sites.

The re-construction and rehabilitation of the roads are normally executed by contractor through direct tendering. Other types of maintenance of the road are executed directly by the divisions of MPWH.

8.1.4. Budget for Road Maintenance

The budget of Operation and Maintenance of roads is allocated by the Government of Jordan and the amount of budget allocated for the Operation and Maintenance in the last ten years are as follows;

Table 8.1 Road Maintenance Budget for 1990 - 1999

Year	(1) Road Length (km)	(2) Budget of MPWH (mil. JD)	(3) Budget per km (JD)	(4) Change of (3) (%)
1990	6,041	3.95	653.9	-
1991	6,158	4.60	747.0	14.2
1992	6,318	11.13	1,761.6	135.8
1993	6,468	7.00	1,082.3	-38.5
1994	6,650	6.01	903.8	-16.5
1995	6,780	6.80	1,002.9	19.0
1996	6,872	3.95	574.8	-42.7
1997	7,022	9.60	1,367.1	137.8
1998	7,133	11.00	1,542.1	12.8
1999	7,133	12.00	1,682.3	9.1

Source: JICA Study Team based on the information given by MPWH

8.1.5. Examination

Based on the above information, the following conclusions are made.

- The number of staff for the Road Maintenance Department is 7,546 persons, while the total length of the national roads is 7,133 km in 1999. Therefore the ratio of maintenance staff to road length exceeds 1 person/km.
- Although the structure for the road maintenance is considered reasonable an intensive study on road maintenance may be necessary, since the number of staff is very high. If the government is trying to reduce staff numbers, an alternative study may be essential because the maintenance staff will be direct government employees.
- The budget for road maintenance fluctuates from year to year due to changes in national budget allocation. However, the required budget should be allocated annually since roads are the most important transport means in Jordan

8.2. Operation, Management and Maintenance (OMM) Plan for the Dead Sea Parkway

Based on the situation of the existing organization and Maintenance and Management System of the Road Maintenance Department, MPWH, this Section discusses a basic plan of Operation, Traffic Management and Maintenance System, which should be adopted for the Dead Sea Parkway networks.

The Dead Sea Parkway OMM system has three goals, which have been identified as follows: ensuring "traffic safety", "smooth traffic flow" and "user comfort" on the Dead Sea Parkway.

The Dead Sea Parkway OMM system is defined in terms of its own basic functions, "Traffic Management and Operations" and "Road Maintenance and Operations". The various components, which constitute these functions are identified and the tasks performed under these components are discussed in this Section.

The definitions and functions for the Dead Sea Parkway OMM system are shown in Figure 8.2.

8.2.1. Traffic Management and Operations Function

The functional roles of traffic management and operations are indicated as follows:

Maintaining safe and smooth traffic flow on the Dead Sea Parkway. Preventing unusual conditions such as traffic accidents and traffic congestion which impact traffic flows.

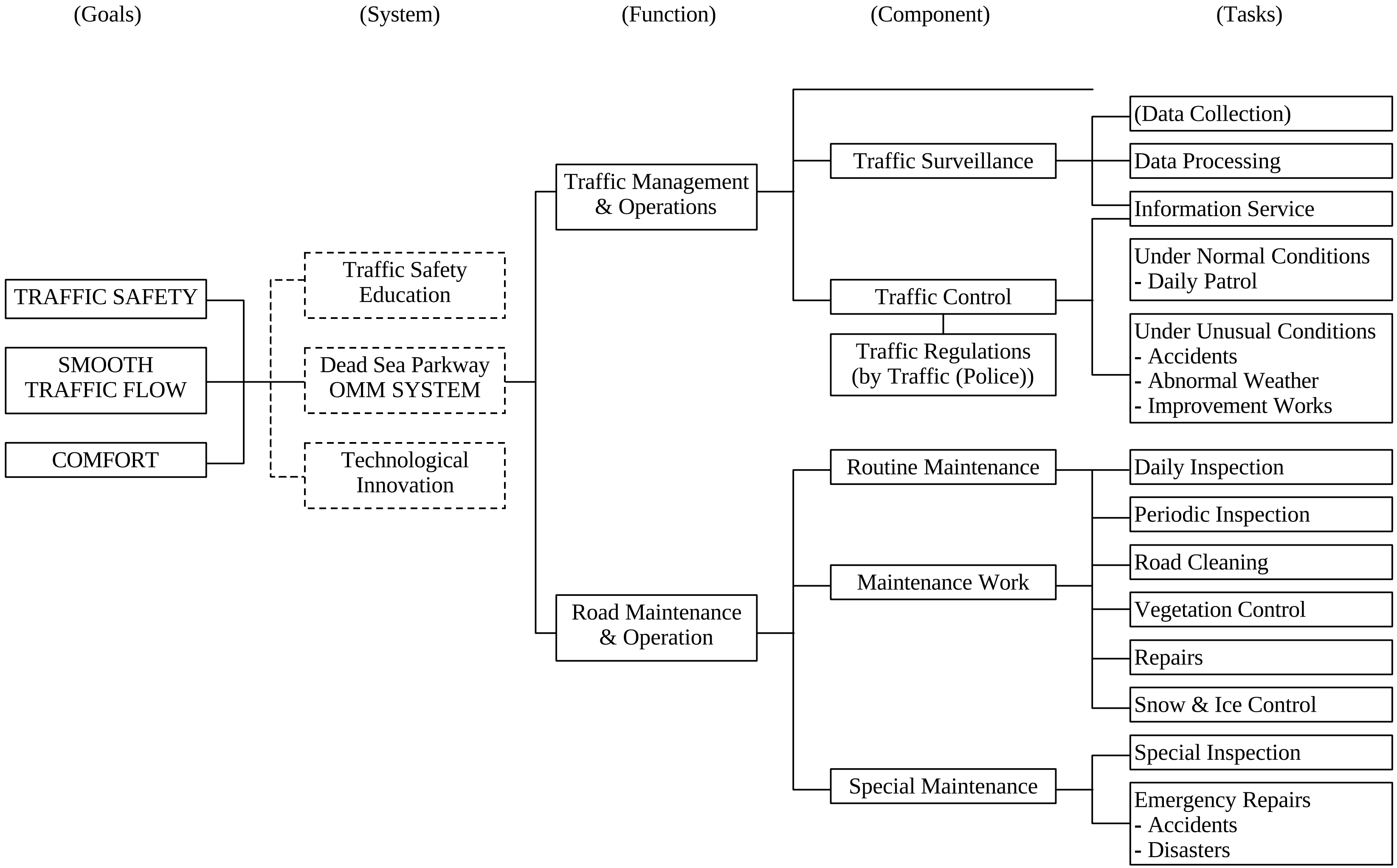
Recovering from traffic accidents and traffic congestion to normal traffic flow as quickly as possible for avoiding any unnecessary stoppage for tourists coming by tour bus and rental car.

The traffic management and operations function has three components as shown Figure 8.1. They are as follows:

- Traffic surveillance
- Traffic control
- Traffic regulation

Traffic surveillance is the process of obtaining information regarding traffic performance on the Dead Sea Parkway and determining existing traffic conditions by using special equipment and other means such as patrol cars, cooperative motorists, etc. Some of this information will provide quantitative data while others will provide information regarding traffic incidents or level of service. Traffic information is analysed by traffic engineers and conveyed to the traffic patrol or traffic police for traffic control purposes.

Figure 8.2 Definition and Function of the Dead Sea Parkway OMM System



Source: JICA Study Team

Traffic control includes not only general traffic control on the Dead Sea Parkway under normal conditions (as carried out by the traffic patrol or traffic police patrol units), but also emergency measures taken for the purpose of controlling traffic under unusual conditions. These unusual conditions may include traffic accidents, unusual weather (heavy rain or snow, strong wind, dense fog, etc.) or conditions generated by construction of future connections to the Dead Sea Parkway. Traffic control also performs a very important task that of providing information services. Traffic conditions or weather information gathered by relevant offices in the field are conveyed to other offices and patrol units via radio, dedicated or public telephone, variable message signs, and to other broadcasting services.

Traffic regulations (the jurisdiction of the traffic police) legitimise traffic control measures, such as maximum/minimum speed limit control or temporary closure of a lane or a section of the Dead Sea Parkway during an emergency.

8.2.2. Basic Concept for Establishing Traffic Management and Operations Levels

The purpose of providing traffic management and operations facilities on the Dead Sea Parkway is to maintain traffic safety and convenience for Dead Sea Parkway users through the activities of MPWH and other concerned agencies. This is done through the installation and operation of appropriate facilities along the Dead Sea Parkway and its vicinity. These facilities include both the hardware and software aspects of traffic management. Facilities for the Dead Sea Parkway can be divided into two groups. The first group consists of permanent facilities such as lighting, signs, emergency telephones, etc. The second group is related to traffic surveillance and control equipment to deal with the changing conditions of the road, traffic, and the weather.

Establishing traffic management and operations levels are dictated by organisational activity and the utilisation of special facilities to improve the movement of traffic. It is obviously most important to eliminate existing problems and issues. As an example, it is not possible to warn motorists of potential new hazards without the necessary facilities, such as variable message signs.

As a matter of practicality, however, the implementation of traffic management and operations systems is a costly venture, and it would be best to stage and prioritise the implementation of a system, so that MPWH can get the most benefit for the money spent. For example, it would be beneficial to have variable message signs installed at all segments of the Dead Sea Parkway so that motorists might be notified of any change of driving conditions. However, for the majority of Dead Sea Parkway segments away from the population centres, the traffic volumes would be so low and the occurrence of traffic incidents so seldom that it would not be a worthwhile expense (capital and operational).

Because of this, several different service levels have been established for the provision of traffic management and operations on the Dead Sea Parkway. This multiple service level method allows the logical implementation of traffic control devices where they are needed, and provides the best use of MPWH's budget. Service levels are established so that they can change as traffic conditions change, and facilities can be upgraded to provide for the new situation. This allows the staged implementation of traffic management and operations facilities as they are needed. This method of staging serves to reduce the financial burden on MPWH by providing only those facilities that are needed at that time.

8.2.3. Road Maintenance and Operations Function

Other than traffic safety, smooth traffic flow, and riding comfort, the other major requirement on the Dead Sea Parkway is to provide road maintenance and operations. The maintenance and operations function of the Dead Sea Parkway can be divided into three (3) components, as follows:

- Routine maintenance
- Periodic maintenance
- Special maintenance

Routine maintenance includes daily inspection of the road, structures and other related facilities. Items of inspection include pavement, embankment, bridge, fence, guardrail, signboard, etc. This daily inspection is for early detection of defects, damages, and wear and tear of structures or other facilities on the Dead Sea Parkway. Inspection results are reported for follow-up repair.

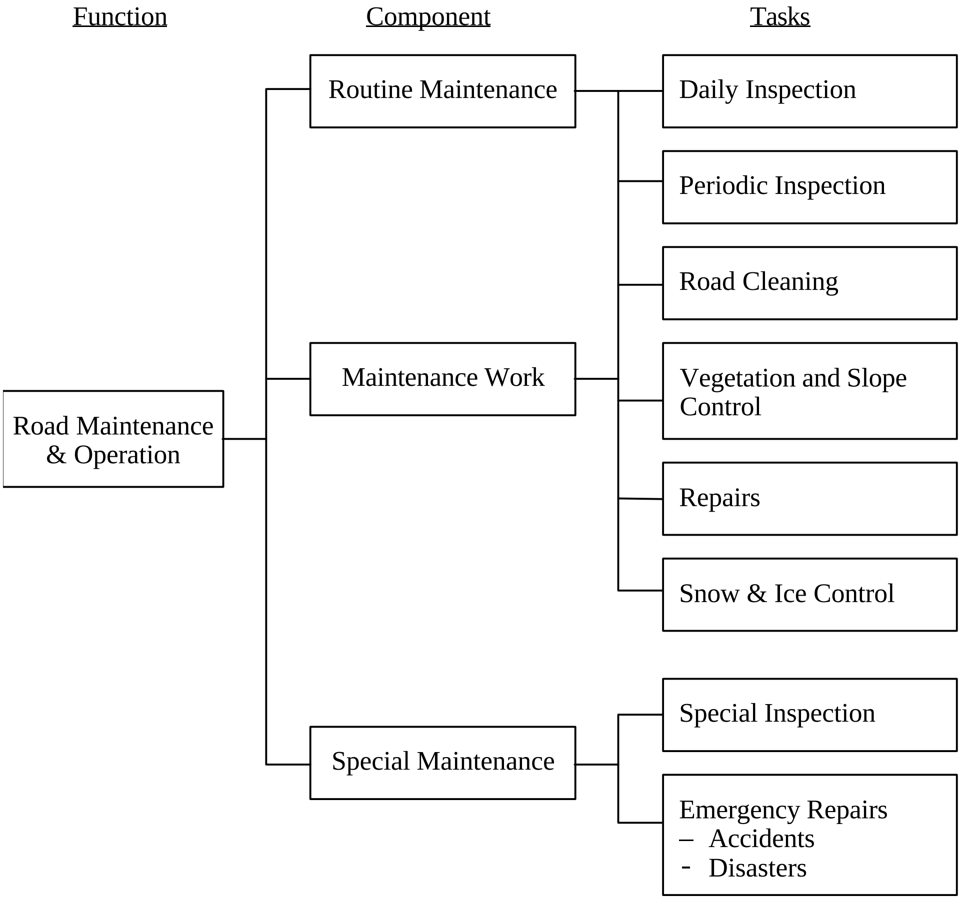
Periodic maintenance is performing detailed inspection, and checking and testing the condition of various facilities at fixed timed intervals. Periodic maintenance is performed at fixed cycles such as annually, semi-annually, monthly, or weekly, depending upon the type of facilities and the items to be inspected. When detected, problems are reported for necessary repairs. Periodic maintenance also includes pavement, cleaning, signs, guardrails, vegetation and slope control, painting of structures, etc.

8.2.4. Basic Plan for Road Maintenance and Operations

The purpose of maintenance and operations is to upkeep the roads and facilities as constructed or as improved, so that traffic safety, smooth traffic flow and riding comfort will be achieved.

Maintenance and operations are illustrated in Figure 8.3:

Figure 8.3 Components and Tasks of Road Maintenance & Operation



Source: JICA Study Team

The tasks of road maintenance and operations are described as follows:

(1) Inspections

Inspections are performed so that repairs can be made and the Dead Sea Parkway maintained and no hindrance to traffic will occur. In particular, steep slopes, culverts, foundation of retaining walls, bridges and shoulders of road should be carefully inspected after heavy rains.

(2) Road Cleaning

Road cleaning involves removing dirt, stones, rocks and trash from the road, adjacent facilities and slopes to eliminate traffic obstructions.

(3) Vegetation and Slope Control

Vegetation control consists of planting new growth, maintaining established vegetation, and removing old vegetation so that grass, shrubs and trees can grow without obstruction and provide a pleasing respite for drivers, and help controll slope stability.

Slope control is to maintain stability of slopes from erosion, weathering and sliding.

(4) Repairs

Repairs include repairing the pavement, roadside earth repair, and repainting traffic control facilities, bridges, tunnels, etc.

<u>Asphalt</u>

Asphalt overlay and/or repairs are required because of cracking and rutting caused by heavy traffic and sudden stopping. An evaluation method shall be established for the overlay required, based on a survey and analysis of the existing pavement roughness, cracking ratio and depth of rutting.

<u>Minor Repair</u>

- Pothole repairing, crack sealing and patching of local damage and adjustment of roadway surface differences
- Traffic control equipment, guard-rails, signs and road markings
- Slopes, embankment control, drainage and removal of fallen rock and debris
- Expansion joints and shoes for bridges and viaducts

<u>Maintenance of Road Fixtures, Fittings and Equipment</u>

This item includes the daily inspection, maintenance and repair of structure, machinery, and electrical equipment as well as communication facilities.

(5) Restoration of Traffic Accident Damage

Typical damage caused by traffic accidents is the damage to guardrails, curbs, sign poles, pavement, and box culverts and gabions, etc.

(6) Restoration Work for Damage Caused by Unforeseen Natural Disasters

Slope failures, culvert and bridge damage caused by heavy rainfall and/or earthquakes. Slope failures are normally related to heavy rainfall or providing inadequate drainage of surface and seepage water.

8.2.5. Service Level of Road Maintenance and Operations

This section discusses and recommends the frequency of inspection works and types of works with required and/or appropriate equipment in order to define the service level of road maintenance and operations, considering the service levels for the existing national highways in Jordan.

(1) Inspections

Roadways inspections are one of the most important maintenance activities in that they are necessary to determine the conditions of the road as well as traffic conditions.

The types of inspections to be conducted are divided into three categories: routine inspection, periodic inspection and special inspection.

1) Routine Inspection is defined as the investigation which is conducted to identify road conditions. It is normally done by visual inspection from a moving patrol vehicle, and augmented occasionally by observation on foot, and normally is comprised of two inspectors.

2) Periodic Inspection is defined as the detailed investigation of structures such as asphalt pavements, drainage, bridges and slopes, and is normally done on foot. Periodic inspections shall be conducted by specially trained inspectors, made up of both engineers and non-engineers.

3) Special Inspection is defined as the supplementary inspection conducted in addition to the routine and periodic inspection described above when necessary due to possible damage due to storms, heavy rain, or other unusual conditions.

The frequencies for the three types of inspection mentioned above are as follows:

Routine Inspection .... Once/2 weeks
Periodic Inspection........................ Once/year
Special Inspection......................... As necessary

The objectives of inspection are shown in Table 8.2. In each category, the inspections are further classified into the following four categories: full inspection, partial inspection, additional inspection, and no inspection.

Table 8.2 Objectives of Inspection

Functional Category	Classification of Structure	Routine Inspection	Periodic Inspection	Special Inspection
Road Surface	Pavement	F	A	If necessary
	Curb	F	A	
	Expansion Joint	P	F	
Slope	Vegetation Slope	P	F	
	Slope Protection Works	P	F	
	Masonry	P	F	
	Retaining Wall	P	F	
Drainage Facilities	Road Surface	P	F	
	Slope	P	F	
	Bridge	P	F	
Bridge	Concrete Structure		F	
	Concrete Sub-structure		F	
	Steel Structure		F	
	Galvanizing and Painting		F	
	Shoe		F	
	Railing and Curb	P	F	
Culvert	Reinforced Concrete Box		F	If necessary
	Reinforced Concrete Pipe		F	
	Other		F	
Traffic Safety Facilities	Traffic Barrier (Guard Rail, Guard Pipe, Concrete Barrier)	P	F	
Traffic Control Facilities	Traffic Signs	P	F	
	Markings	F		
	Delineators (Guard Posts)	F		
	Kilo Post	F		
Frequency		every other day	yearly	If necessary

F : Inspect the facility fully
P : Inspection the facility Partially
A : Additional Inspection to "F" if necessary
Blank : No Inspection required

Source: JICA Study Team

The specific items of inspection and their ratings for asphalt pavement are classified as shown in Table 8.3.

Table 8.3 Inspection Items and Ratings for Asphalt Pavement

Item	Rating	AA	A	B
1.	Obstacle on road (dropped article, fallen stone, collapsed soil), leaked oil, dirt	Hindrance to traffic, obstacles to traffic		
2.	Pothole, pitting, scaling	Hindrance to traffic	Over 20mm in depth and over 20cm in diameter	10mm to 20mm in depth
3.	Faulting	Hindrance to traffic	Over 20mm	10mm to 20mm
4.	Rutting		Ordinary section: over 25mm Climbing lane: over 40mm	Ordinary 15mm to 25mm Climbing lane; 20mm to 40mm
5.	Cracking		Longitudinal cracking or transverse cracking 5mm or more in width Alligator cracking losing the bearing capacity in case of rain	Longitudinal cracking or transverse cracking less than 5mm in width Alligator cracking
6.	Longitudinal surface roughness, corrugation		Uncomfortable driving Corrugation; over 30mm	Vertical displacement Corrugation 10mm to 30mm
7.	Stripping of carpet-coat (thin surfacing)		Stripping	
8.	Stagnant water		Partial stagnant water observed whenever raining	

* The numerical values are rough standards

Rating Classifications:

Rating	General Conditions
AA	Emergency repair is required because the damage is serious so that traffic safety or a third party is, or likely to be, jeopardised.
A	Discussion for repair is required because of heavy damage.
B	Discussion for repair is required although damage is not heavy.

Source: JICA Study Team

The specific items of inspection and their ratings for slopes are classified as shown in Table 8.4.

Table 8.4 Inspection Items and Ratings for Slopes

Item	Rating	AA	A	B
1.	Fall (rock & Debris)	Hindrance to traffic or a third party	Less possibility of growing	Very minor falls
2.	Crack, swelling, depression	Hindrance to traffic or a third party	Cracks, swelling or depression perceived from a long distance Less possibility of growing	Small cracks, swelling or depression Less possibility of growing
3.	Scaling gully erosion		Wide range Scaling or gully erosion Possibility of growing	Partial Scaling or gully erosion, less possibility of growing
4.	Seepage water	Seepage water with mud or drastic change of seepage water volume Hindrance to traffic of third party	Drastic change of seepage water volume Less possibility of collapse	Seepage water No possibility of collapse
5.	Fallen tree, unusual growth of weeds	Hindrance to traffic or a third party	Fallen or inclined trees, or unusual growth of weeds	
6.	Withering damage		Covering rate of vegetation; less than 30%	Covering rate of vegetation: 30% - 70%
7.	Accumulation of dirt		A lot of waste on the slope	
8.	Flaking stone boulder	Hindrance to traffic or a third party	Unstable flaking stones or boulders on slope	

* The numerical values are rough standards Scaling

Rating Classifications:

Rating	General Conditions
AA	Emergency repair is required because the damage is serious so that traffic safety or a third party is, or likely to be, jeopardised.
A	Discussion for repair is required because of heavy damage.
B	Discussion for repair is required although damage is not heavy.

Source: JICA Study Team

The specific items of inspection and their ratings for concrete superstructures are classified as shown in Table 8.5.

Table 8.5 Inspection Items and Ratings for Concrete Superstructures

Item	Rating	AA	A	B
1.	Crack, corner failure	Substantial cracks resulting in falls Hindrance to traffic or a third party	Scaling: 50cm or more in diameter	Scaling: less than 50cm in diameter
2.	Scaling	Possibility of growing Hindrance to traffic or a third party	Scaling: 50cm or more in diameter	Scaling: less than 50cm in diameter
3	Exposure and rust of reinforcing bar		Main steel bars: exposed 50cm or more in length rusted PC steel or sheath: remarkably exposed, more than 50cm in length	Main steel bars: partially exposed or rusted PC steel or sheath: partially exposed
4.	Air void, honeycomb		Substantial air voids or honeycombs observed	Air voids or honeycombs: smaller scale damage observed
5.	Deflection, unusual vibration		Unusual water stagnation on bridge deck, recurring Excessive deflection observed Unusual vibrations on bridge deck	
6.	Water leakage, free lime	Hindrance to a third party	Two directional free lime leaks observed. Space less than 50cm apart.	One directional free lime leak observed.
7.	Inadequate clearance under deck		Clearance under bridge deck: insufficient	

* The numerical values are rough standards

Rating Classifications:

Rating	General Conditions
AA	Emergency repair is required because the damage is serious so that traffic safety or a third party is, or likely to be, jeopardised.
A	Discussion for repair is required because of heavy damage.
B	Discussion for repair is required although damage is not heavy.

Source: JICA Study Team

The specific items of inspection and their ratings for bridges are classified as shown in Table 8.6.

Table 8.6 Inspection Items and Ratings for Bridges

Item	Rating	AA	A	B
1.	Crack, corner failure	Remarkable cracks resulting in falls Hindrance to a third party	Cracks: more than 0.3mm in width Corner failures, minimum crack space: 50cm or more	Cracks: more than 0.3mm in width Minimum crack space: 50cm to 1m
2.	Scaling	Hindrance to a third party	50cm or more in diameter	Less than 50cm in diameter
3	Exposure and main steel bar		50cm or more in length	Partially exposed or rusted
4.	Air void, honeycomb		Large air voids or honeycombs observed in main structure	Large air void or honeycombs observed
5.	Water leakage, free lime	Hindrance to a third party	Steel components: rusted	Leakage of water or free lime: partially observed steel components: rusted
6.	Settlement, movement, tilting		Settlement: more than 25mm in depth The superstructure shoes or the surrounding structures affected Possibility of adding larger stress to the girder due to changes of temperature	15mm to 25mm Possibility of affecting the superstructure shoes or the surrounding structures
7.	Scour, lowering of stream bed		Exposed up to under the designated line Surroundings of abutment wing: remarkably scoured	Upper part of footing or caisson: exposed due to scour or lowering of stream bed Surroundings of abutment wing: scoured

* The numerical values are rough standards

Rating Classifications:

Rating	General Conditions
AA	Emergency repair is required because the damage is serious so that traffic safety or a third party is, or likely to be, jeopardised.
A	Discussion for repair is required because of heavy damage.
B	Discussion for repair is required although damage is not heavy.

Source: JICA Study Team

(2) Road Cleaning Works

The types of cleaning activities related to the Dead Sea Parkway consist of cleaning the road surface, parking and stone paved areas in the Parkway Facility and the interchanges and incidental facilities.

Dust and trash will stay on the road surface, particularly on the right shoulder and on the inner shoulder based on the traffic volume. Service level (frequency of sweeping) is classified into four categories by traffic volume (vehicle per day), using sweeping machine.

The cleaning works for Parkway Facility are required daily or every other day since many passengers, tourists and drivers require a rest and feel refreshed when stopping at the areas.

Road incidental facilities such as guard-rails, traffic signs, drainage, etc. shall be cleaned at least once a year to increase traffic safety and extend the useful life of the facilities. These cleaning activities are indicated in Table 8.7 considering the type of work by machine or manually.

Table 8.7 Road Cleaning Work

		Type of Work	Frequency	Remarks
1.	Road Surface			
	a. Shoulder of through traffic	Machine	see notes	
	b. Inner shoulder (Interchange)	Machine	see notes	
2.	Parkway Facility (PF) and Interchange			
	c. Paved area and parking lots of PF	Manual	1.0/2 weeks	
	d. Green area of PF	Manual	1/2 weeks	Daily watering in the initial stage
	e. Green area of Interchange	Manual	1/2 weeks	Daily watering in the initial stage
3.	Road incidental facilities			
	f. Guard rail, Guard pipe	Machine	1.0/year	
	g. Traffic/Guide sign	Manual	1.0/year	
	h. Drainage pipe	Machine	1.0/year	
	i. Drainage ditch on shoulder & slope	Manual	1.0/year	
	j. Inlet & outlet on slope & toe		1.0/year	
	k. Bridge joint	Manual/Machine	1.0/year	
	l. Inlet on bridge	Manual	1.0/year	
	m. Lighting post & lamp	Manual	1.0/year	

Criteria for Road cleaning frequency

Sectional Traffic Volume (cars/day)	Road Shoulder	
	Right Shoulder	Inner Shoulder
Less than 5,000	1.0/month	0.5/month
5,000 – 20,000	1.5/month	0.75/month
20,000 – 50,000	3.0/month	1.5/month
More than 50,000	1.0/week	2.0/month

Source: JICA Study Team

(3) Maintenance and Repair Works of Roadway Pavement

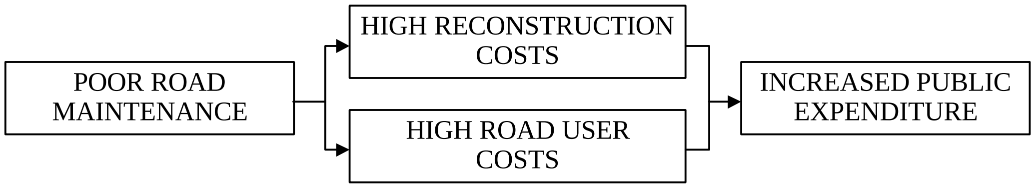
1) Maintenance Policies and Service Level

An optimum and preventive maintenance policy is recommended. This entails setting standards/levels of intervention at the lowest acceptable level of service so that expenditure is the minimum required to arrest deterioration. This is the economic basis of the road maintenance and operations.

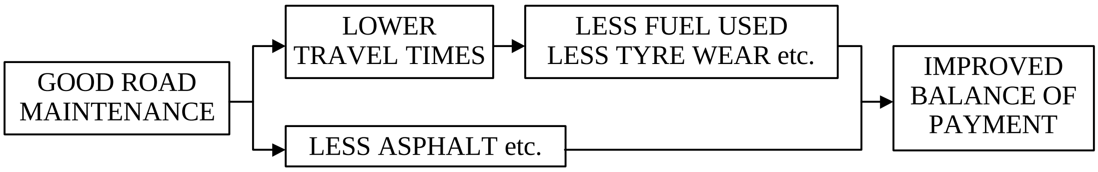
If standards are too high maintenance costs will be greater than necessity. If standards are too low, maintenance funds may be saved but minor discrepancy may lead to much-complicated works such as rehabilitation and/or reconstruction, which will be very expensive, especially if the road is allowed to collapse.

Optimum standards preserve the road in an acceptable condition and minimize rehabilitation and reconstruction costs.

- If these standards are not adhered to, after 10 years or so further rehabilitation will be required and it has been estimated that this will cost at least ten times (10 x) any savings on maintenance.
- Also, if maintenance is neglected vehicle operating costs will progressively increase at considerable expense to road users.



- Regular routine maintenance costs are low, so public money spent on maintenance shows a higher rate of return than other road works.



- Also, most routine road maintenance expenditure is in local currency, especially if labour-based methods are used, whereas a large proportion of rehabilitation/ reconstruction and vehicle operating expenditure may require inputs in foreign currency.

Box culvert cleaning is one good example of regular routine road maintenance that can provide great savings. By maintaining the smooth flow of the storm water, expensive reconstruction can often be postponed or even avoided. This is particularly relevant to the Dead Sea Parkway where serious structural and slope damage may be alleviated by better drainage maintenance.

In this regard, an important part of the maintenance policy is the concept of preventive maintenance.

Accordingly, the early repair of minor potholes before causing major deteriorations is an importance part of routine maintenance. Also, the sealing of cracks to prevent water seeping into the road structure and weakening the road foundation is another very important routine activity.

In order to prevent pothole formation, open areas should be sealed by using bitumen/hot liquid asphalt to arrest deterioration.

Spot sealing should be done on an ad hoc basis as part of the routine maintenance and more widespread sealing on a periodic basis will generally form the main operation of the preventive maintenance plan. This will not only insure against potholes but also reduce other structural damage.

Generally, on average bituminous roads should be re-laid every 5-7 years according to quality of materials and workmanship, climate and traffic.

Table 8.8 shows the typical defects on flexible roads, which can be avoided by preventive maintenance:

Table 8.8 Preventive Maintenance on Road Defects

Defect	Maintenance on Demand	Preventive Maintenance
Alligator Cracking	Full-Depth Repair	Crack Sealing (may slow down alligator cracking)
Bleeding	Apply Hot Sand	Seal with large aggregates
Block Cracking	Seal Cracks	Improve sub-drainage
Depression	Level-Up Overlay	Improve sub-drainage
Polished Aggregated	Skid Resistant Surface Treatment	Seal with hard aggregates
Potholes	Full-Depth Repair	Crack Sealing and Seal Coats
Pumping	Full-Depth Repair	Crack Sealing and Seal Coats
Ravelling and Weathering	Seal Coats	Rejuvenating Seal
Rutting	Level-Up Overlay and/or Cold Milling	Strengthen shoulders
Swell	Removal and Replacement	Paved Shoulder encapsulation

Source: JICA Study Team

(4) Maintenance and Repair of Slopes

Slope protection works are performed to protect the slopes from erosion and weathering by covering them with vegetation or structures. Slopes will be stabilised by means of drainage works or retaining structures.

Applicable repair methods are shown in Table 8.9, which will serve to reduce the deterioration of slope failure and/or others.

Table 8.9 Repair Methods for Slopes

Deterioration	Applicable Repair Methods
Slope Failure	Concrete block grid retaining
	Replacement
	Reconstruction with cutting
	Mat gabion
	Cast in place concrete block crib with anchors
	Concrete block crib
	Stone pitching
	Cast in place concrete block crib with suppressing pile
	Drain basket with steel crib
	Net hurdling
Cracks, Convexity of Slope Soil	Concrete spraying
	Grid crib
Scaling, Gully Erosion	Concrete block crib
	Replacement
Plant Withering	Soil improvement with sodding mats
Loose Rocks, Boulders	Rock fall prevention net, wire ropes with net
Scouring	Gabions, mat gabions

Source: JICA Study Team

Vegetation should be planted on slopes to prevent erosion from rainwater by growing plants on the slope faces and by firmly binding the faces with plant roots, thus easing temperature changes on the ground surface, and providing beautiful views created by greening. Vegetation should be frequently used in places where it is possible, since the installation and maintenance costs for vegetation are relatively low in most cases, if native plants are used.

Slope protection works with structures should be adopted for areas where slopes are not suited to vegetation or stability of slopes cannot be assured with vegetation alone. In order to resist earth pressures and stabilize slopes, retaining walls, pile works, slope anchor works and setting gabions should be applied.

Where there is spring water on the face of a slope, the surface drainage such as berm ditch and vertical ditch works should be installed in addition to the slope protection works in order to prevent erosion and scouring.

Detailed countermeasures should be established depending upon the types of slope damage to cut slopes, embankment slopes, debris flows or landslides.

These damage and failures shall be identified by routine inspection, periodic inspection and special inspection. Appropriate emergency repairs will then be determined based on the rating criteria as shown in Table 8.10. Other repair works for slope protection countermeasures should be discussed and determined through site inspections and by further analysis.

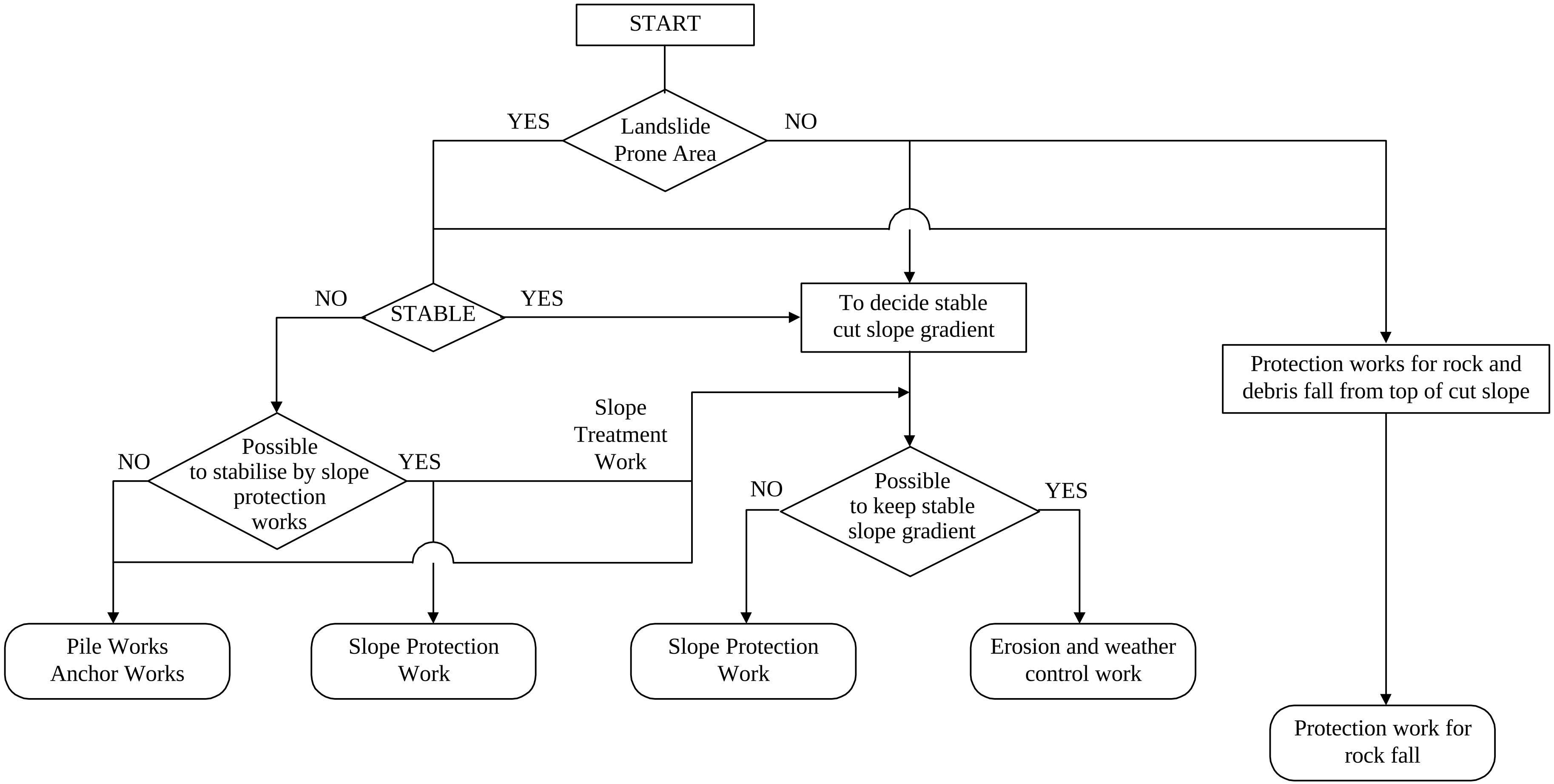
Flow diagram of selecting countermeasures of slope protection works in cut-sections is shown in Figure 8.4 for quick reference.

Table 8.10 Rating Criteria for Inspection Works

Rating	General Conditions
AA	Emergency repair is required because the damage is serious so that traffic safety or a third party is, or likely to be, jeopardised.
A	Discussion for repair is required because of heavy damage.
B	Discussion for repair is required although damage is not heavy.
OK	No need to repair because of no damage or minor damage.

Source: JICA Study Team

Figure 8.4 A Flow Diagram for Selecting Countermeasures for Slope Protection in Cut Sections



Source: JICA Study Team

(5) Maintenance and Repair of Bridges

For the purposes of discussion in this section, there are six categories of work related to the maintenance and repair of bridges. These categories are related to the concrete superstructure, concrete substructure, steel structure, painting, shoe, railing, and curb. In this section, discussions are focused on repair and maintenance work related to concrete substructures and concrete superstructures.

Damage and failure of bridges should be identified by routine inspection, periodic inspection and special inspection. Emergency repair work should be determined based on the rating criteria as shown in Table 8.5 and 8.6.

1) Pre-stressed Concrete Superstructure

The following is an example of repair work to concrete superstructure.

Category	Type	Deterioration	Repair method
Concrete Superstructure	Pre-stressed Concrete Girder	Exposure and rust of reinforcing bar, scaling, cracks	Lining

Deterioration conditions are mainly divided into 3 types, as follows:

A Type ------- Conical scaling with diameters of about 20cm, which occur at thin cover points like the stirrup reinforcing bar.

B Type ------- Linear cracks which occur in the direction of the main reinforcement at the corner.

C Type ------- Scaling with constant face width, which occurs with the progress of the rust of the reinforcing bar at thin cover depth points.

The causes of deterioration were determined as follows:

- Severe natural conditions near the Dead Sea.
- Inadequate concrete cover to the reinforcing bars.

The typical Work Flow Chart for the deteriorated concrete is shown in Figure 8.5.

Figure 8.5 Work Flow Chart

Removal of deteriorating concrete surface treatment of rusting reinforcing bar	The deteriorated concrete where scaling and crack occurred were completely removed. Reinforcing bars were exposed by desk-sander or sand blast, etc.
↓	
Coating of corrosion - inhibiting material	Coating of Polymer cement.
↓	
Grouting of section	Grouting of section
↓	
Lining	

Source: JICA Study Team

The concrete lining method has been adopted not only for repair of chloride damaged girders but also for the repair of slabs, piers, handrails and curbs.

Lining methods have various specifications as to the required thickness, the number of coats, etc., varying according to the rate of deterioration of the structure, the level of deterioration and the materials used. Because of this reason, it is very important to use the method of protection appropriate to the intended application.

(6) Maintenance of Guardrails, Markings, Reflectors

To provide the safest possible environment for motorists, it is important that traffic safety devices that provide guidance and help prohibit head-on accidents be maintained in optimum condition. Guardrail that is damaged has very little safety value to motorists. Likewise, traffic markings or reflectors that cannot be seen offer very little guidance to drivers. It is important to provide a driving environment that offers motorists every possible advantage to minimise the probability of traffic accidents on the Dead Sea Parkway.

8.2.6. Data Collection and Analysis for Improving OMM System

The OMM system of the Dead Sea Parkway should basically adopt the preventive method, however in order to up-date and further strengthen the OMM system study and analysis of collected data and statistical information is necessary.

(1) Accident Data Collection and Analysis

In order to adequately access the safety issues of the Dead Sea Parkway, it is helpful to have an accurate and up to date database describing all of the accidents on the Dead Sea Parkway. In the database, information can be obtained regarding the time and place of the accident, type of accident, severity of the accident, weather conditions, etc.

(2) Effect of Adverse Weather/Traffic Conditions

Another of the important aspects of traffic safety to be investigated is the effect of adverse weather on traffic accidents. Abnormal amounts of rainfall, icing, snow, high winds, or other unusual conditions may require special treatment to reduce accident potential.

(3) Frequent Breakdowns of Vehicles

Frequent breakdowns of vehicles on the Dead Sea Parkway were observed in the Istanbul area. It is helpful to detect and remove these vehicles as soon as possible, as vehicles stopped along the Dead Sea Parkway restrict travel, reduce capacity, and increase potential for accidents with other drivers.

(4) Damage and Deterioration Data Collection and Analysis

Damage and deterioration of the Dead Sea Parkway should be identified and classified depending on location in order to establish counter and mitigation measures for avoiding frequent damage and deterioration.

8.3. Environmental Considerations

The sub-project site is located in the wild area, where unique natural environment can be seen. Therefore, adverse impact on the natural environmental will expected during operation stage, unless some mitigation measures are not to taken seriously.

Environmental consideration based upon on-site survey has been undertaken. Table 8.11 summarises the key adverse impacts and proposed mitigation measures at the operation stage.

Table 8.11 Potential Impacts and Proposed Mitigation Measures

Factors and Impact	Actions cause impact	Mitigation measures
Waste Pollution: - increase of tourist litter	- increasing number of tourists	- place litter boxes for collecting general waste - improve the existing waste collection system
Landscape - deterioration of landscape	- changes of socio-economic activities and land use change	-development strategy and regulations should be established - sustainable development measures should be taken
Ecology - impacts on the aquatic ecosystem in wadis - impacts on the animals especially endangered animals	- wastewater from plant and temporary facilities - illegal hunting and collection	- provide advanced warning signs that notify speed reduction and location of animal crossing, if any - take measure to raise public awareness on ecological sensitivities and importance of the area especially for tourists - activity and protection regulations should be established - raise awareness by environmental education
Archaeological remains - damage to existing archaeological remains and newly discovered sites	- illegal collection	- place signage and fences to protect important sites, if any - activity and protection regulations should be established - raise awareness by environmental education
Traffic & Safety: - increase conflict between vehicles and visitors	- increase of tourists	- secure safety for visitors - raise awareness by environmental education

Source: JICA Study Team

In relation to the maintenance of the road, especially for the Dead Sea Parkway, the following are required:

(1) The location of the Parkway is an environmentally sensitive area. Therefore, intensive maintenance is required until the impacts of this new construction have subsided.

(2) Before and after rains, particular attention should be taken for the slope protections, cleaning of culvert and ditches to avoid large scale erosions which will alter the eco-system of the area

The road will be significant in the tourism promotion of Jordan as well as the Amman Tourism Region. For the Parkway together with the Madab-Ma'in Spa Section high standard road maintenance is required to meet the expectation of international tourism which goes along with the environmental awareness of people who visiting Jordan encompassing the conservation of the world heritage, the Dead Sea.

Chapter 9 Issues to be resolved in further stage

There are still many issues to be solved by the Jordanian side to proceed further in the implementation stage.

9.1. Particular Issues

(1) Soil investigation in Part-A area

The contractor needs to conduct confirmation boreholes prior to the commencement of the actual road construction at the designated location in Part-A, which is included in the scope of works stipulated in the tender documents.

The borehole data should be submitted to MPWH and the design in the tender documents should be confirmed based on the result of the investigation.

(2) Coordination with Dead Sea Panoramic Complex sub-project

The site location is remote from the supply points of construction materials and labour force as well as construction machines and equipment. In this case, costs of the temporary works become higher in general. However, there is another sub-project, the Dead Sea Panoramic Complex, in the same area. The Ministry of Public Works and Housing is the employer and also manages the packages for both the Dead Sea Panoramic Complex and Dead Sea Parkway. In this situation it is strongly suggested to coordinate both sub-projects each other in order to save temporary works costs. These arrangement should be discussed prior to the contract agreement with the contractors.

(3) Road side communication

Because the parkway site is situated at away from the town and isolated area, various communication facilities (emergency telephones or wireless systems) and measures on roadside, in particular at Parkway Facility, should be considered for the future provisions in order to facilitate for the emergency cases such as road accident, car trouble, running out of fuel or buttery and natural disasters while driving on the Parkway.