Chapter 6 Bridges

Many bridges have been built to allow roads and rails to cross the Mejerda River and its tributaries in Zone D2, but it is clear that they need to be improved (replaced, raised) because there are places where the design river channel of this Study will not have sufficient downflow capacity.

Thus, as in the Master Plan, this Study includes improvements to existing bridges and the building of new bridges to accompany river improvements. The 11 bridges investigated in the Master Plan will be improved to accommodate changes to the design high-water level and channels. This section covers investigations of the bridge improvement plans required to improve the river, conducted according to the following procedures:

1. Fully understanding the current state of existing bridges and the capabilities they lack with respect to river improvements
2. Investigation of policy for improving existing bridges, selection of places in which to build new bridges
3. Improvement plans for existing bridges
4. Plans to build new bridges

Since the bridges in question are used differently for roads, highways and railways, this section also includes information on various design standards.

6.1 Fully Understanding the Current State of Existing Bridges and the Capabilities They Lack with Respect to River Improvements

6.1.1 Current State of Existing Bridges

Basic information about existing bridges was gathered prior to investigating bridge improvement policy. In addition to gathering the basic bridge specifications that serve as basic information, the team also surveyed existing structures and organizations that manage structures and verified the extent of damage at each site.

(1) Bridges Built in Zone D2

1) Bridges built in Zone D2

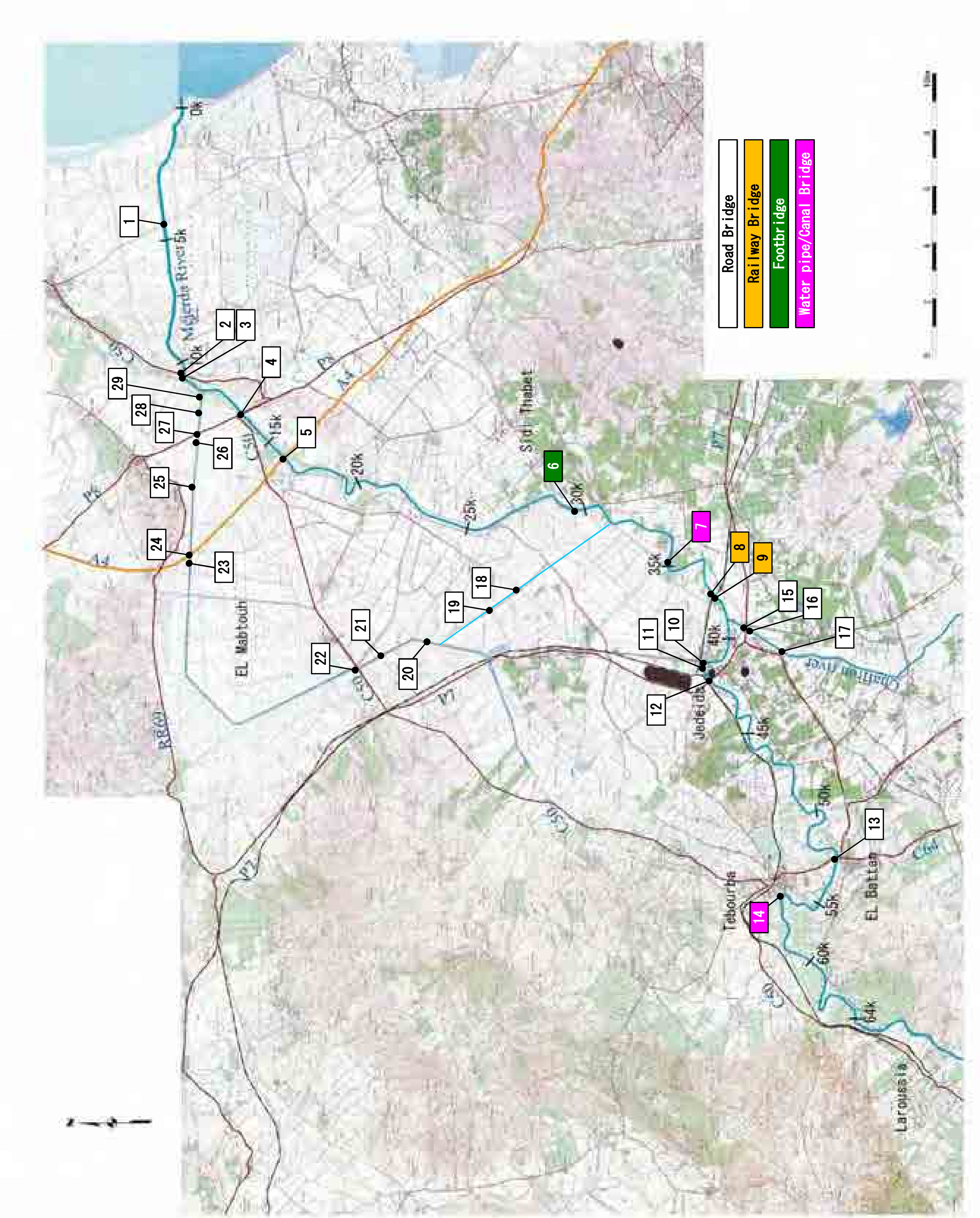
The list on the next page shows the 29 locations in which bridges have been built in Zone D2. Documentation Package 4.1 includes images and specifications for typical bridges confirmed through site surveys.

Table 6.3-1 Existing Bridges

Source: JICA Survey Team

No.	Bridge Name	Channel		Route	Bridge Length	Bridge Width	Remarks
		Name	Distance				
1	K.LANDAOUS BRIDGE	Medjerda	4.664	Rue Sadok Belhadi	19.600	8.750	
2	TOBIAS BRIDGE	Medjerda	10.828	MC50	87.400	10.500	
3	TOBIAS OLD BRIDGE	Medjerda	10.836	MC50	81.400	5.100	New bridge and location of piers do not match up
4	GP8 BRIDGE OVER OUED MEJERDA	Medjerda	13.728	GP8	145.200	9.040	
5	A4 MOTORWAY BRIDGE	Medjerda	16.017	MOTORWAY A4	126.500	14.500	
6	FOOTBRIDGE	Medjerda		Sidewalk	60.000	1.200	Wooden suspension bridge
7	WATER PIPE BRIDGE	Medjerda	34.440	Water supply	-	5.540	
8	JEDEIDA RAILWAY OLD BRIDGE	Medjerda	37.848	RAILWAY	60.500	4.160	New bridge and location of piers do not match up
9	JEDEIDA RAILWAY BRIDGE	Medjerda	37.834	RAILWAY	63.000	10.000	Girders show evidence of afflux from flooding
10	JEDEIDA BRIDGE	Medjerda	41.071	RVE507	87.200	12.000	
11	JEDEIDA OLD BRIDGE	Medjerda	41.091	RVE507	64.500	5.600	Historical bridge over narrow channel
12	JEDEIDA BRIDGE ON GP7	Medjerda	41.926	GP7	73.600	11.300	
13	EL BATTAN BRIDGE	Medjerda	53.111	MC64	94.070	8.500	Historical bridge
14	TEBOURBA IRRIGATION CANALS BRIDGE	Medjerda	56.899	IRRIGATION CANALS	125.000	5.540	
15	GP7 BRIDGE ON CHAFUROU	Chafurou		GP7	38.200	11.000	Bridge abutments located in flood channel
16	GP7 OLD BRIDGE ON CHAFUROU	Chafurou		GP7	-	-	New bridge and location of piers do not match up
17	EL H'BIBIA BRIDGE	Chafurou		Local Road	16.900	8.140	
18	Bridge on the local road	Mabtouh		Local Road	20.700	5.700	
19	FARM BRIDGE ON Driving CHANNEL	Mabtouh		Farm Road	-	-	Bridge for small farm road
20	FARM BRIDGE ON Driving CHANNEL	Mabtouh		Farm Road	-	-	Bridge for small farm road
21	FARM BRIDGE	Mabtouh		Farm Road	-	-	Bridge for small farm road
22	MC50 EL MABTOUH BRIDGE	Mabtouh		MC50	20.460	14.610	
23	FARM BRIDGE ON Oued Mabtouh	Mabtouh		Farm Road	-	-	Bridge for small farm road
24	A4 BRIDGE OVER Mabtouh	Mabtouh		MOTORWAY A4	52.600	14.000	
25	FARM BRIDGE ON Oued Mabtouh	Mabtouh		Farm Road	-	-	Bridge for small farm road
26	FARM BRIDGE ON Oued Mabtouh	Mabtouh		Farm Road	-	-	Bridge for small farm road
27	GP8 BRIDGE AND ROAD OVER Mabtouh	Mabtouh		GP8	36.500	9.900	
28	FARM BRIDGE ON Oued Mabtouh	Mabtouh		Farm Road	-	-	Bridge for small farm road
29	FARM BRIDGE ON Oued Mabtouh	Mabtouh		Farm Road	-	-	Bridge for small farm road

Source: JICA Survey Team



Source: JICA Survey Team

Figure 6.1-1 Current Bridge Locations

2) Organizations that manage bridges

The table below shows organizations that manage bridges in Zone D2 and organizations that manage various bridges:

Table 6.1 2 Organizations that Manage Bridges and Structures

Source: Preparatory Study

Structures	Organization
Bridges built for roads (national, governorate and regional roads)	MEHAT*, Civil Engineering Department
Tunis-Bizerte Highway	Tunisia Highways
Railway bridges	SNCFT**, Equipment Survey Department
Bridges built for farm roads (short, do not require technology)	MA***
Historical bridges	Ministry of Culture

*MEHAT: Ministry of Equipment, Housing and Land Development

*SNCFT: Tunisian Railways

***MA: Ministry of Agriculture

Table 6.1 3 Bridges and Responsible Organizations

	No.	Name	Organization
Roads Highways	1	K.LANDAOUS BRIDGE	MEHAT
	2	TOBIAS BRIDGE	MEHAT
	3	TOBIAS OLD BRIDGE	MEHAT
	4	GP8 BRIDGE OVER OUED MEJERDA	MEHAT
	5	A4 MOTORWAY BRIDGE	Tunisia Highways
	10	JEDEIDA BRIDGE	MEHAT
	11	JEDEIDA OLD BRIDGE	MEHAT
	12	JEDEIDA BRIDGE ON GP7	MEHAT
	13	EL BATTAN BRIDGE	MEHAT
	15	GP7 BRIDGE ON CHAFUROU	MEHAT
	17	EL H'BIBIA BRIDGE	MEHAT
	22	MC50 EL MABTOUH BRIDGE	MEHAT
	24	A4 BRIDGE OVER Mabtouh	Tunisia Highways
	27	GP8 BRIDGE AND ROAD OVER Mabtouh	MEHAT
Railways	8	JEDEIDA RAILWAY OLD BRIDGE	SNCFT
	9	JEDEIDA RAILWAY BRIDGE	SNCFT
Small Roads Farm Roads	16,18,19, 20,21,28, 29	FARM BRIDGE	MA
Irrigation Pipes	7	WATER PIPE BRIDGE	MA
	14	TEBOURBA IRRIGATION CANALS BRIDGE	MA

	No.	Name	Organization
Footbridges	6	FOOTBRIDGE	Unofficial

Source: Preparatory Study

(2) Studies of Existing Bridges

1) Documentation of existing bridges

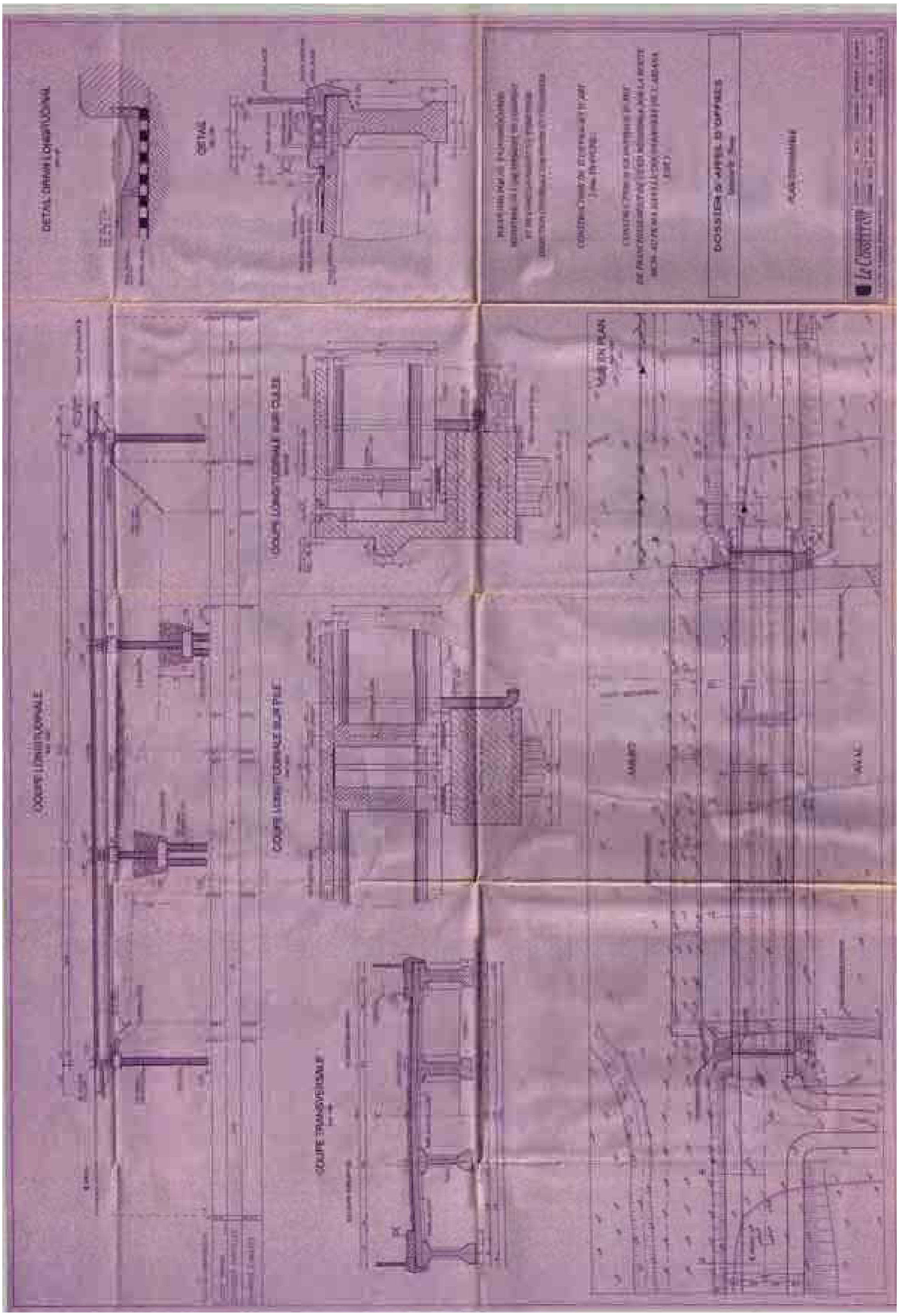
During site surveys, a study was done to determine whether design drawings serving as documentation for existing bridges existed. Design drawings could only be confirmed for the three bridges on the table below.

Typical drawings are shown on the next several pages, and the Material Package 4.2 includes all drawings.

Table 6.1-4 Bridges Confirmed on Design Drawings

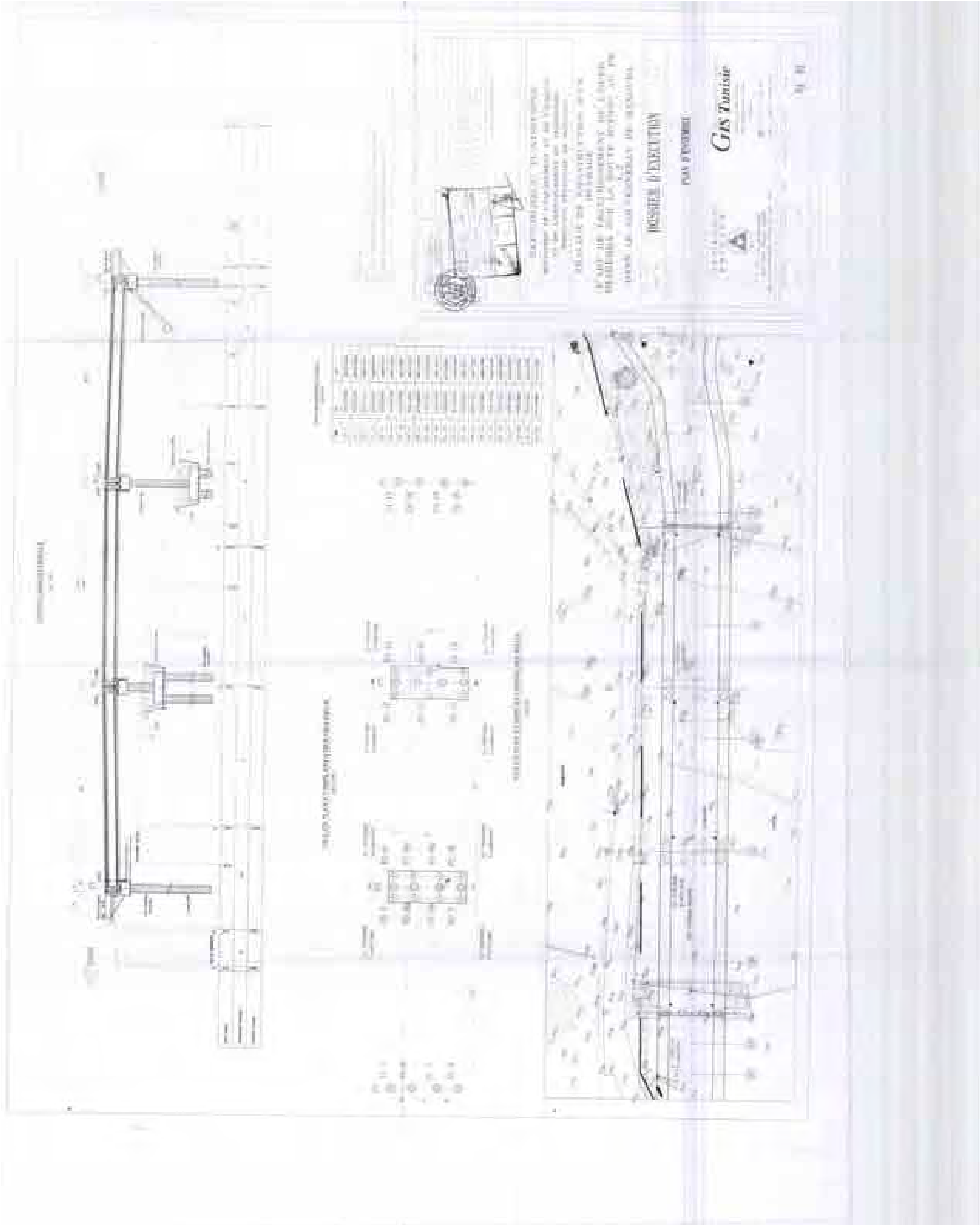
Source: JICA Survey Team

No.	Name	Drawings
2	TOBIAS BRIDGE	13 structural and other drawings
10	JEDEIDA BRIDGE	Overall drawings
9	JEDEIDA RAILWAY BRIDGE	Seven overall and other drawings



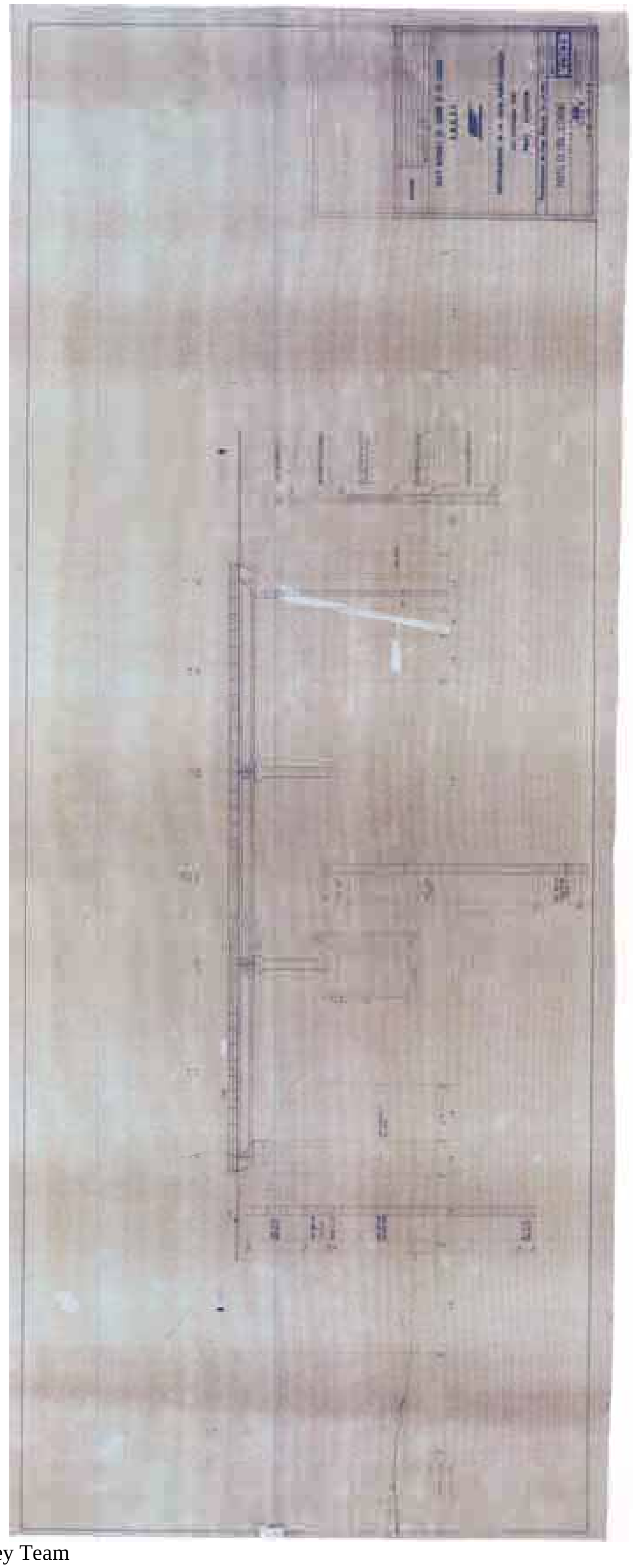
Source: JICA Survey Team

Figure 6.1 2 Existing Drawing for Tobias Bridge



Source: JICA Survey Team

Figure 6.1 3 Existing Drawing for Jedeida Bridge



Source: JICA Survey Team

Figure 6.1 4 Existing Drawing for Jedeida Railway Bridge

2) Historical bridges

Bridges of historical value in Tunisia can be designated as important cultural properties. Of the 29 bridges listed in the table above, the Jedeida Old Bridge and El Battan Bridge have received that designation.

The purpose of this designation is to regulate construction on these structures and in the areas surrounding them, preserve their historical and cultural value and make the public aware of their existence and value. Types of these structures are set forth in the Tunisian Cultural Heritage Law (Law No. 34-94, 24 February 1944). Chapter 2 (On Preservation) of this law includes details about construction on these structures and in the areas surrounding them:

- Article 9: A permit from the ministry in charge of cultural heritage is required to do construction within the borders of a cultural site
- Article 10: . . . no more than two (2) months shall pass before a permit application is answered . . .
- Article 12: All construction is subject to scientific and technical studies conducted by entities given authority by the ministry in charge of cultural heritage

Table 6.1 5 Bridges/Structures Designated as Important Cultural Properties

Source: JICA Survey Team

No.	Name	Registered on	Photo
11	JEDEIDA OLD BRIDGE	15 January 2001	
13	EL BATTAN BRIDGE	15 January 2001	

Source: Preparatory Study

Figure 6.1-5 Display Showing Structure's Registry as Important Cultural Property

3) Site survey

Current conditions were confirmed and measurements done during site surveys to fully understand the extent of damage and structural dimensions of existing bridges. Relevant authorities were also interviewed to see whether or not they had developed improvement plans for the future.

Table 6.1-6 Current State of Each Bridge

Source: JICA Survey Team

No.	Bridge Name	Channel		Condition
		Name	Distance	
1	K.LANDAOUS BRIDGE	Medjerda	4.664	
2	TOBIAS BRIDGE	Medjerda	10.828	Newly built in 2011
3	TOBIAS OLD BRIDGE	Medjerda	10.836	
4	GP8 BRIDGE OVER OUED MEJERDA	Medjerda	13.728	Not Good concrete deterioration, rebar corrosion apparent rebar, segregation concrete
5	A4 MOTORWAY BRIDGE	Medjerda	16.017	Good
6	FOOTBRIDGE	Medjerda		
7	WATER PIPE BRIDGE	Medjerda	34.440	
8	JEDEIDA RAILWAY OLD BRIDGE	Medjerda	37.848	General light corrosion of steel plates Massive stone pier, surrounded by sediment deposit and vegetation
9	JEDEIDA RAILWAY BRIDGE	Medjerda	37.834	Massive concrete pier, with some impact marks showing uncover rebars
10	JEDEIDA BRIDGE	Medjerda	41.071	Newly built in 2011
11	JEDEIDA OLD BRIDGE	Medjerda	41.091	Main span,Seriouusly damaged at several places Massive stone piers,Partially filled with debris jam and sediment deposit
12	JEDEIDA BRIDGE ON GP7	Medjerda	41.926	
13	EL BATTAN BRIDGE	Medjerda	53.111	Narrowness of gates call for jamming of debris Massive stone abutment,Fill with debris jam and sediment deposit
14	TEBOURBA IRRIGATION CANALS BRIDGE	Medjerda	56.899	Not Good
15	GP7 BRIDGE ON CHAFUROU	Chafurou		Good
16	GP7 OLD BRIDGE ON CHAFUROU	Chafurou		Not Good
17	EL H'BIBIA BRIDGE	Chafurou		Not Good
18	Bridge on the local road	Mabtouh		Good
19	FARM BRIDGE ON Driving CHANNEL	Mabtouh		
20	FARM BRIDGE ON Driving CHANNEL	Mabtouh		
21	FARM BRIDGE	Mabtouh		
22	MC50 EL MABTOUH BRIDGE	Mabtouh		Good
23	FARM BRIDGE ON Oued Mabtouh	Mabtouh		
24	A4 BRIDGE OVER Mabtouh	Mabtouh		Good
25	FARM BRIDGE ON Oued Mabtouh	Mabtouh		
26	FARM BRIDGE ON Oued Mabtouh	Mabtouh		
27	GP8 BRIDGE AND ROAD OVER Mabtouh	Mabtouh		Not Good
28	FARM BRIDGE ON Oued Mabtouh	Mabtouh		
29	FARM BRIDGE ON Oued Mabtouh	Mabtouh		

6.1-2 Current State of Downflow Capacity at Bridges

A study was done to confirm whether the vertical clearances and lengths of bridges in their current state were satisfactory in terms of design river cross section specifications and design high-water levels. The table below shows the results of the study.

The two assessment items are:

- Is vertical clearance satisfactory in terms of HWL?
- Is bridge length satisfactory in terms of HWL/river width?

Comments that explain reasons why some places were considered problematic in terms of downflow capacity are included in the Assessment column in the table below:

Table 6.1-7 Review of Current State of Downflow Capacity at Bridges

No.	Bridge Name	Channel		Water level calculation (W=1/10)	HWL (m)	Elevation (girder bottom) (m)	Bridge Length (m)	Riverwidth (HWL) (m)	Evaluation
		Name	Distance						
1	K.LANDAOUS BRIDGE	Medjerda	4.664	3.312	3.670	1.330	19.600	100	NG (girder elevation)
2	TOBIAS BRIDGE	Medjerda	10.828	6.951	7.092	9.680	87.400	82	OK
3	TOBIAS OLD BRIDGE	Medjerda	10.836	6.951	7.096		81.400	82	NG *1
4	GP8 BRIDGE OVER OUED MEJERDA	Medjerda	13.728	8.466	8.542	10.110	145.200	82	OK
5	A4 MOTORWAY BRIDGE	Medjerda	16.017	9.556	9.686	11.980	126.500	82	OK
6	FOOTBRIDGE	Medjerda		17.242	17.508			82	OK *2
7	WATER PIPE BRIDGE	Medjerda	34.440	17.562	17.793			100	OK *2
8	JEDEIDA RAILWAY OLD BRIDGE	Medjerda	37.848	19.178	19.275		60.500	100	NG *1
9	JEDEIDA RAILWAY BRIDGE	Medjerda	37.834	19.184	19.269	19.200	63.000	100	NG (girder elevation)
10	JEDEIDA BRIDGE	Medjerda	41.071	20.719	20.849	21.400	87.200	Existing Width	OK *3
11	JEDEIDA OLD BRIDGE	Medjerda	41.091	20.728	20.859		64.500	Existing Width	OK *3
12	JEDEIDA BRIDGE ON GP7	Medjerda	41.926	21.144	21.276	25.130	73.600	100	NG (bridge length)
13	EL BATTAN BRIDGE	Medjerda	53.111	26.436		28.050	94.070	Existing Width	OK *3
14	TEBOURBA IRRIGATION CANALS BRIDGE	Medjerda	56.899	30.773			125.000	Existing Width	OK *2
15	GP7 BRIDGE ON CHAFUROU	Chafurou					38.200	61	NG (bridge length)
16	GP7 OLD BRIDGE ON CHAFUROU	Chafurou					38.200	56	NG (bridge length)
17	EL H'BIBIA BRIDGE	Chafurou					16.900	62	NG (bridge length)
18	Bridge on the local road	Mabtouh					20.700		NG *4
19	FARM BRIDGE ON Driving CHANNEL	Mabtouh					20.700		NG *4
20	FARM BRIDGE ON Driving CHANNEL	Mabtouh					20.700		NG *4
21	FARM BRIDGE	Mabtouh					20.700		NG *4
22	MC50 EL MABTOUH BRIDGE	Mabtouh					20.460		NG *4
23	FARM BRIDGE ON Oued Mabtouh	Mabtouh					20.700		OK
24	A4 BRIDGE OVER Mabtouh	Mabtouh					52.600		OK
25	FARM BRIDGE ON Oued Mabtouh	Mabtouh					20.700		OK
26	FARM BRIDGE ON Oued Mabtouh	Mabtouh					20.700		OK
27	GP8 BRIDGE AND ROAD OVER Mabtouh	Mabtouh					36.500		OK
28	FARM BRIDGE ON Oued Mabtouh	Mabtouh					20.700		OK
29	FARM BRIDGE ON Oued Mabtouh	Mabtouh					20.700		OK

*1 : The pier locations are not aligned with the streamline
*2 : No problems with flooding in the past
*3 : Impossible to repair, because histrical bridge
*4 : Enormous change of the cross section

Source: JICA Survey Team

6.1.3 Problems with Current Conditions

The table above shows problems with bridges in their current state; the table below lists those problems and aligns them with the need for bridge improvement. Fifteen of the 29 bridges need to be replaced, and three need to be built anew. It is worth noting that the Kalaat Landaous Bridge, the bridge farthest downstream, needs to be replaced as part of river channel improvement, but it is outside the scope of this project because it will probably be treated as a road project.

Table 6.1-8 Problems with Bridges in Their Current State

Source: JICA Survey Team5.3-9

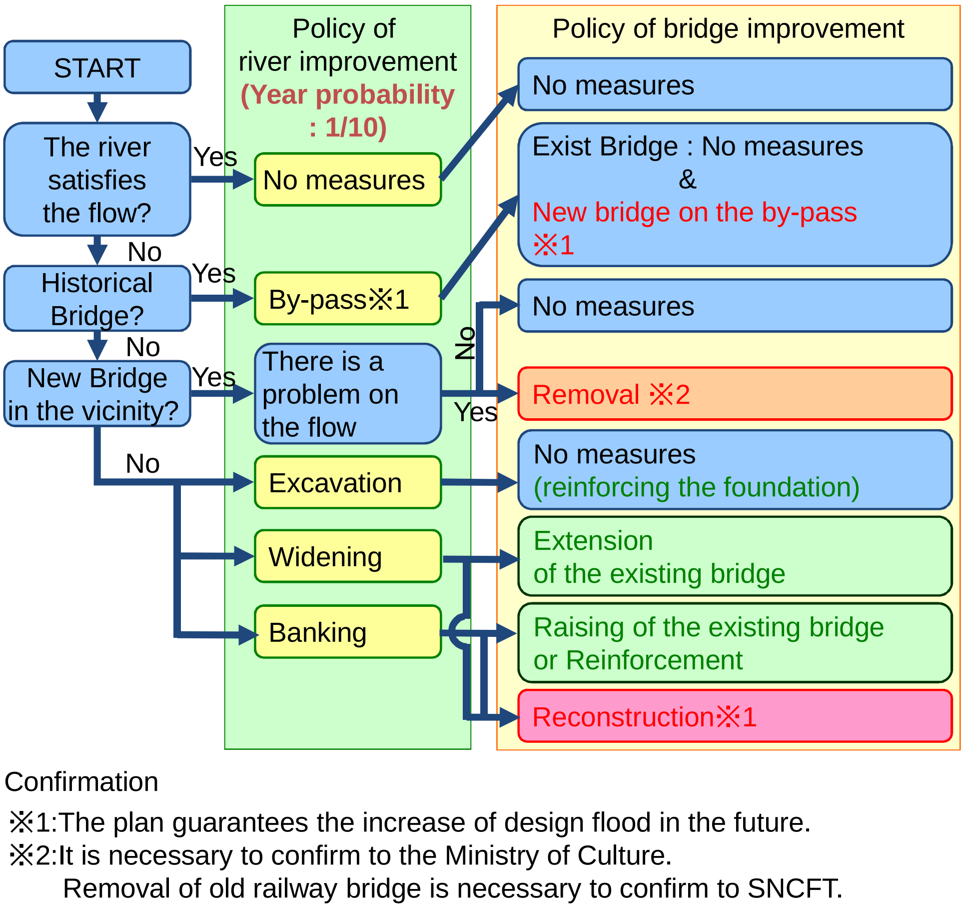
No.	Bridge Name	Channel		Downflow Capacity	Condition	Historical Bridge
		Name	Distance			
1	K.LANDAOUS BRIDGE	Medjerda	4.664	NG		
2	TOBIAS BRIDGE	Medjerda	10.828			
3	TOBIAS OLD BRIDGE	Medjerda	10.836	NG		
4	GP8 BRIDGE OVER OUED MEJERDA	Medjerda	13.728		Not Good	
5	A4 MOTORWAY BRIDGE	Medjerda	16.017			
6	FOOTBRIDGE	Medjerda				
7	WATER PIPE BRIDGE	Medjerda	34.440			
8	JEDEIDA RAILWAY OLD BRIDGE	Medjerda	37.848	NG	Not Good	○
9	JEDEIDA RAILWAY BRIDGE	Medjerda	37.834	NG		
10	JEDEIDA BRIDGE	Medjerda	41.071			
11	JEDEIDA OLD BRIDGE	Medjerda	41.091		Not Good	
12	JEDEIDA BRIDGE ON GP7	Medjerda	41.926	NG		
13	EL BATTAN BRIDGE	Medjerda	53.111			○
14	TEBOURBA IRRIGATION CANALS BRIDGE	Medjerda	56.899		Not Good	
15	GP7 BRIDGE ON CHAFUROU	Chafurou		NG		
16	GP7 OLD BRIDGE ON CHAFUROU	Chafurou		NG	Not Good	
17	EL H'BIBIA BRIDGE	Chafurou		NG	Not Good	
18	Bridge on the local road	Mabtouh		NG		
19	FARM BRIDGE ON Driving CHANNEL	Mabtouh		NG		
20	FARM BRIDGE ON Driving CHANNEL	Mabtouh		NG		
21	FARM BRIDGE	Mabtouh		NG		
22	MC50 EL MABTOUH BRIDGE	Mabtouh		NG		
23	FARM BRIDGE ON Oued Mabtouh	Mabtouh				
24	A4 BRIDGE OVER Mabtouh	Mabtouh				
25	FARM BRIDGE ON Oued Mabtouh	Mabtouh				
26	FARM BRIDGE ON Oued Mabtouh	Mabtouh				
27	GP8 BRIDGE AND ROAD OVER Mabtouh	Mabtouh		Shorter than existing dike	Not Good	
28	FARM BRIDGE ON Oued Mabtouh	Mabtouh				
29	FARM BRIDGE ON Oued Mabtouh	Mabtouh				
30	FARM BRIDGE(NEW)	Mabtouh				
31	FARM BRIDGE(NEW)	Mabtouh				
32	FARM BRIDGE(NEW)	Mabtouh				

* Outside the scope of the Project

6.2 Improvement Policy Selection Flowchart

6.2.1 Improvement Policy Selection Flowchart

Below is a selection flowchart used to develop bridge improvement policy in response to the problems with current conditions described in the previous sections:

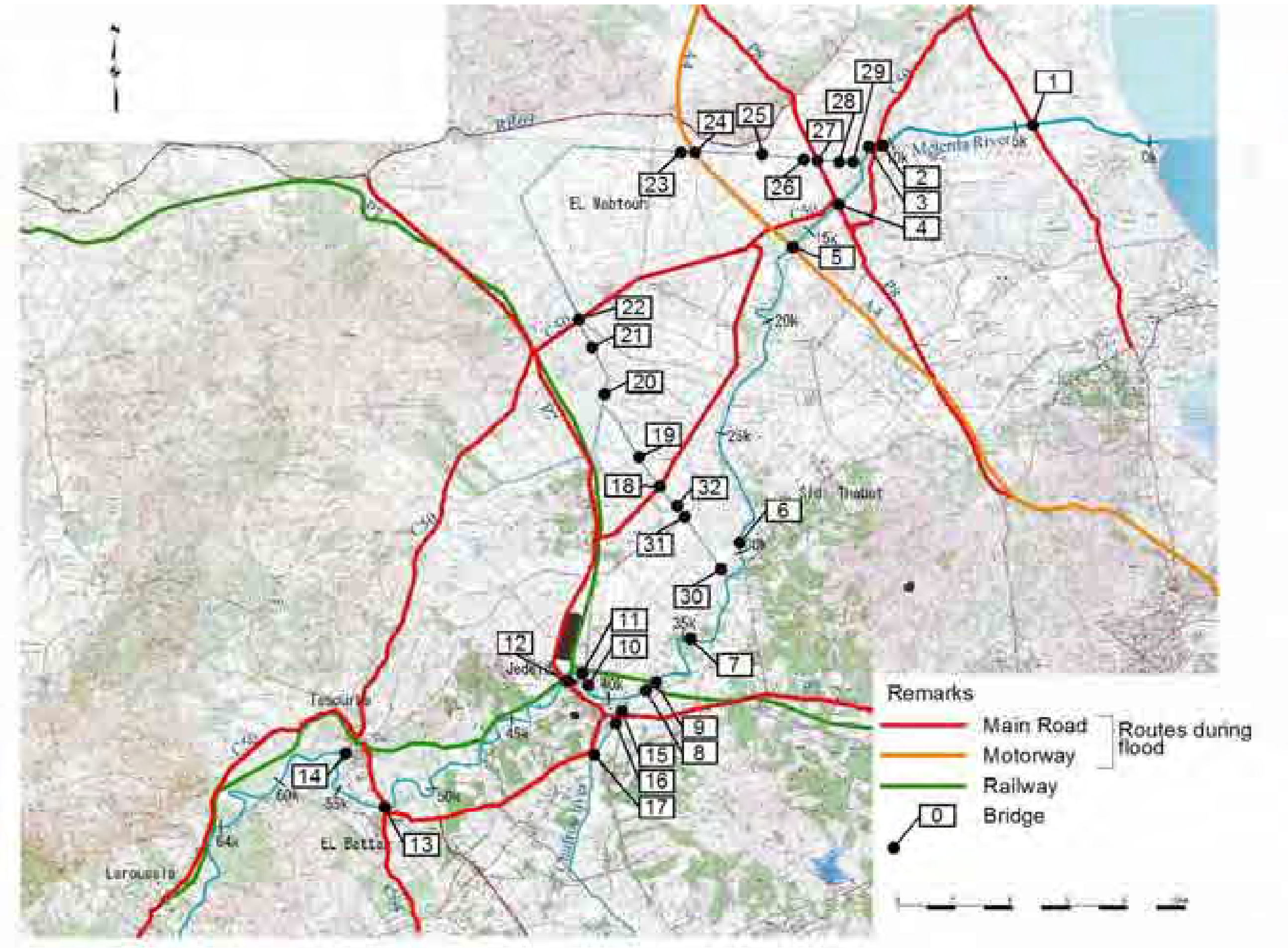


Source: JICA Survey Team

Figure 6.2-1 Bridge Improvement Policy Selection Flowchart

Required capabilities differ for each location in which bridges are to be replaced or built anew, so the size of each improved bridge must be configured appropriately. Deliberations with the Ministry of Agriculture and the Ministry of Equipment resulted in policy that required main roads to be passable during floods so that people and supplies could be moved and transported. Deliberations did not require bridges on farm roads to be passable on the condition that consideration was given such that the bridges' impassability would not cause areas to become isolated during floods. Deliberations with SNCFT resulted in a guarantee that railways would be passable during floods.

Based on the above policy, roadways were configured to ensure passability during floods (with ten-year flood design HWL). In addition to highways, national roads and other main roads and railways, the El Mabtouh Retarding Basin was selected in such a way that large areas would not become isolated. Below are the results of these roadway configurations:



Source: JICA Survey Team

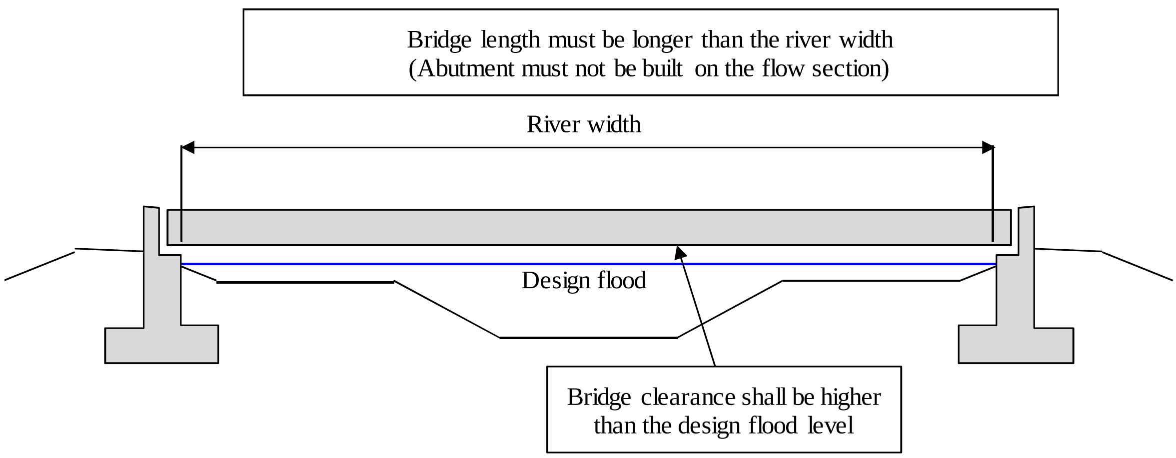
Figure 6.2-2 Roadways Guaranteed During Floods

Bridges to be replaced or built anew and those located on roadways guaranteed during floods will have Class A capabilities as described on the table below; bridges over all other roadways will have Class B capabilities.

Table 6.2-1 New Bridge Classifications

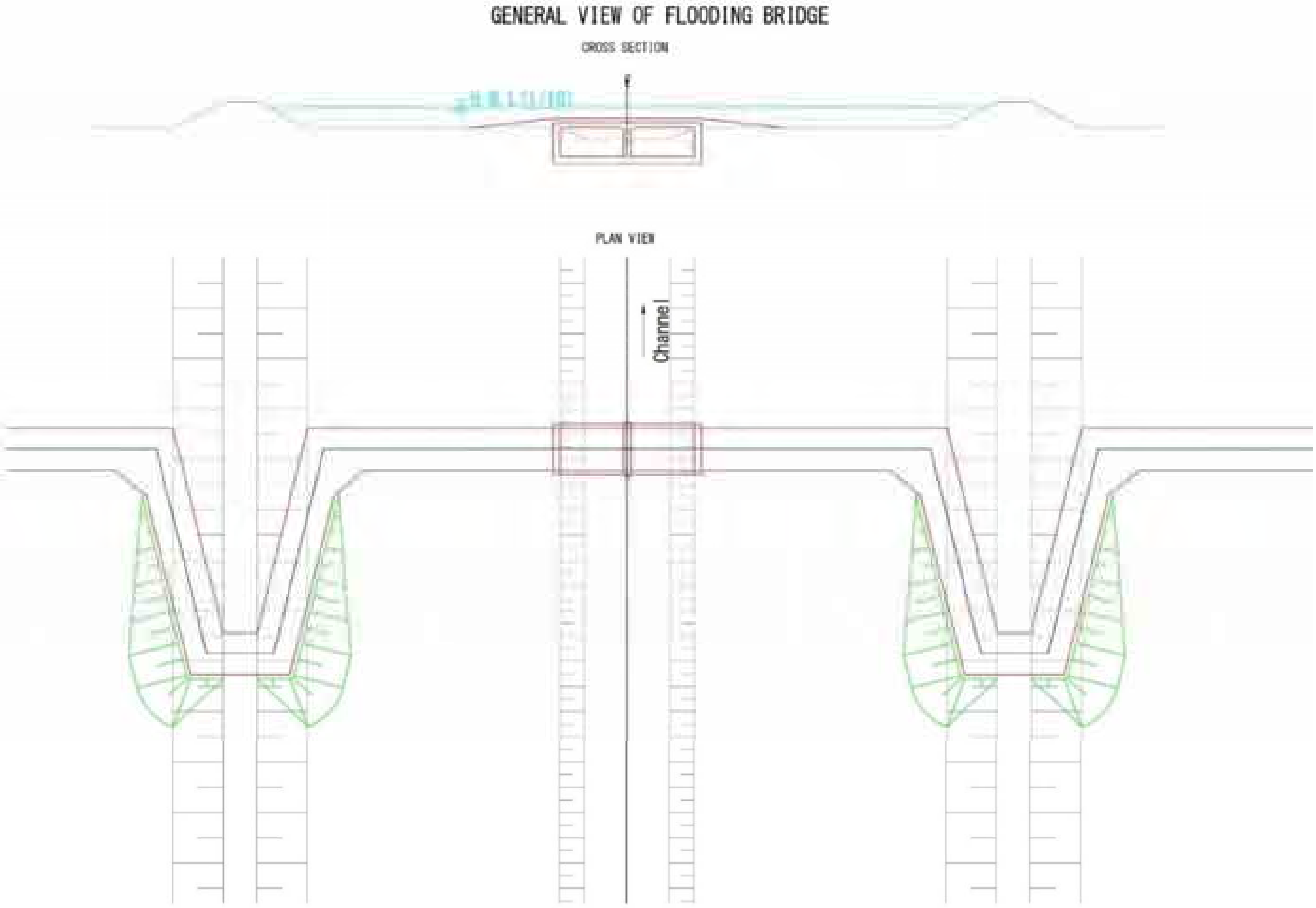
	Class A	Class B
Description	Passable during floods to move people and transport supplies	Bridges of minimum length to reduce costs since they are impassable during floods and necessitate detours to other bridges
Passability	Normal times: Passable	Normal times: Passable
	During floods: Passable	During floods: Impassable
Required Capabilities	Bridge functions guaranteed, even during floods	Bridge functions over low-channel rivers guaranteed during normal times
Bridge Plans	Vertical clearance higher than design high-water level, length longer than river width	These bridges only cross low channels; they are designed to become submerged during floods

Source: JICA Survey Team



Source: JICA Survey Team

Figure 6.2-3 Overview of Class A Bridges



Bridges over roadways not guaranteed during floods will be of the minimum possible scale and only cross low channels passable under normal flow conditions. They are designed to become submerged during floods.

However, such roads will run diagonally up and down the slopes of dikes to avoid causing discontinuity of the dikes.

Source: JICA Survey Team

Figure 6.2-4 Overview of Class B Bridges

6.2.2 Bridge Improvement Policy Selection Results

The table below shows the results of improvement policy selected based on the flowchart above:

Table 6.2-2 Improvement Policy Selection Results

No.	Bridge Name	Channel Name	Channel Distance	Histrical Bridge	flow	Condition	Policy of bridge improvement
1	K.LANDAOUS BRIDGE	Medjerda	4.664		NG		Reconstruction(Outside the scope of the project)
2	TOBIAS BRIDGE	Medjerda	10.828		OK		No measures
3	TOBIAS OLD BRIDGE	Medjerda	10.836		NG *1		Removal
4	GP8 BRIDGE OVER OUED MEJERDA	Medjerda	13.728		OK	Not Good	Reconstruction
5	A4 MOTORWAY BRIDGE	Medjerda	16.017		OK		No measures
6	FOOTBRIDGE	Medjerda			OK		No measures
7	WATER PIPE BRIDGE	Medjerda	34.440		OK		No measures
8	JEDEIDA RAILWAY OLD BRIDGE	Medjerda	37.848		NG *1	Not Good	Removal
9	JEDEIDA RAILWAY BRIDGE	Medjerda	37.834		NG		Extension of the existing bridge
10	JEDEIDA BRIDGE	Medjerda	41.071		-- *2		No measures
11	JEDEIDA OLD BRIDGE	Medjerda	41.091	○	-- *2	Not Good	No measures
12	JEDEIDA BRIDGE ON GP7	Medjerda	41.926		NG		Extension of the existing bridge
13	EL BATTAN BRIDGE	Medjerda	53.111	○	-- *2		No measures
14	TEBOURBA IRRIGATION CANALS BRIDGE	Medjerda	56.899		-- *2	Not Good	No measures
15	GP7 BRIDGE ON CHAFUROU	Chafurou			NG		Reconstruction
16	GP7 OLD BRIDGE ON CHAFUROU	Chafurou			NG *1	Not Good	Removal
17	EL H'BIBIA BRIDGE	Chafurou			NG	Not Good	Reconstruction as "Flooding Bridge"
18	Bridge on the local road	Mabtouh			NG		Reconstruction
19	FARM BRIDGE ON Driving CHANNEL	Mabtouh			NG		Reconstruction as "Flooding Bridge"
20	FARM BRIDGE ON Driving CHANNEL	Mabtouh			NG		Reconstruction as "Flooding Bridge"
21	FARM BRIDGE	Mabtouh			NG		Reconstruction as "Flooding Bridge"
22	MC50 EL MABTOUH BRIDGE	Mabtouh			NG		Reconstruction
23	FARM BRIDGE ON Oued Mabtouh	Mabtouh			-- *2		No measures
24	A4 BRIDGE OVER Mabtouh	Mabtouh			-- *2		No measures
25	FARM BRIDGE ON Oued Mabtouh	Mabtouh			-- *2		No measures
26	FARM BRIDGE ON Oued Mabtouh	Mabtouh			-- *2		No measures
27	GP8 BRIDGE AND ROAD OVER Mabtouh	Mabtouh			NG *3	Not Good	Reconstruction
28	FARM BRIDGE ON Oued Mabtouh	Mabtouh			-- *2		No measures
29	FARM BRIDGE ON Oued Mabtouh	Mabtouh			-- *2		No measures

*1 : The pier locations are not aligned with the streamline
*2 : No river channel improvement
*3 : Lower than the existing levee

Source: JICA Survey Team5.3-13

6.2.3 New Bridge Design

The river improvement of this Project includes improvements to the Mejerda and Chafrou Rivers as well as to the El Mabtouh Retarding Basin. Irrigation channels run through the section from the Mejerda River to the El Mabtouh Retarding Basin and feature bridges where they intersect roads, but the figure on the next page shows places in which there are no existing waterways and, thus, no existing bridges.

However, this Project calls for a channel to the retarding basin to be built, and new bridges will be built in places in this section where the new channel intersects existing roads.

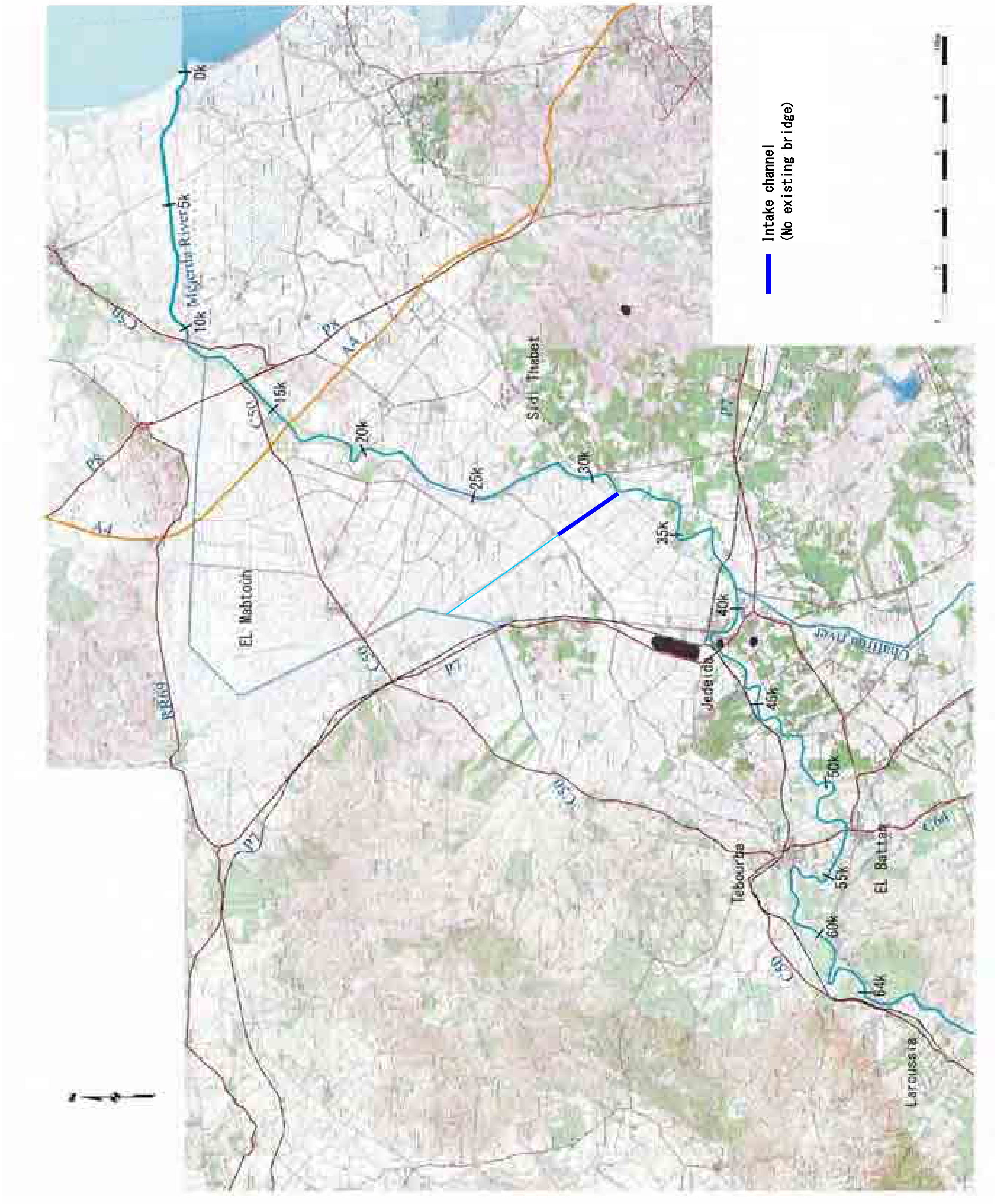


Figure 6.2-5 Location where New Bridge is Required

6.2.4 List of Bridges Requiring Improvement (Bridge Reconstruction/New Bridge Construction)

As mentioned above, 15 of the 29 existing bridges need to be replaced, and three need to be built anew. It is worth noting that the Kalaat Landaous Bridge, the bridge farthest downstream, needs to be replaced as part of river channel improvement, but it is outside the scope of this project because it will probably be treated as a road project.

Table 6.2-3 List of Bridges Requiring Improvement

No.	Bridge Name	Channel		Route	Policy of bridge improvement	Classification
		Name	Distance			
1	K.LANDAOUS BRIDGE	Medjerda	4.664	Rue Sadok Belhadi	Reconstruction *	
2	TOBIAS BRIDGE	Medjerda	10.828	MC50	No measures	
3	TOBIAS OLD BRIDGE	Medjerda	10.836	MC50	Removal	
4	GP8 BRIDGE OVER OUED MEJERDA	Medjerda	13.728	GP8	Reconstruction	A
5	A4 MOTORWAY BRIDGE	Medjerda	16.017	MOTORWAY A4	No measures	
6	FOOTBRIDGE	Medjerda		Sidewalk	No measures	
7	WATER PIPE BRIDGE	Medjerda	34.440	Water supply	No measures	
8	JEDEIDA RAILWAY OLD BRIDGE	Medjerda	37.848	RAILWAY	Removal	
9	JEDEIDA RAILWAY BRIDGE	Medjerda	37.834	RAILWAY	Extension of the existing bridge	
10	JEDEIDA BRIDGE	Medjerda	41.071	RVE507	No measures	
11	JEDEIDA OLD BRIDGE	Medjerda	41.091	RVE507	No measures	
12	JEDEIDA BRIDGE ON GP7	Medjerda	41.926	GP7	Extension of the existing bridge	
13	EL BATTAN BRIDGE	Medjerda	53.111	MC64	No measures	
14	TEBOURBA IRRIGATION CANALS BRIDGE	Medjerda	56.899	IRRIGATION CANALS	No measures	
15	GP7 BRIDGE ON CHAFUROU	Chafurou		GP7	Reconstruction	A
16	GP7 OLD BRIDGE ON CHAFUROU	Chafurou		GP7	Removal	
17	EL H'BIBIA BRIDGE	Chafurou		Local Road	Reconstruction	B
18	Bridge on the local road	Mabtouh		Local Road	Reconstruction	A
19	FARM BRIDGE ON Driving CHANNEL	Mabtouh		Farm Road	Reconstruction	B
20	FARM BRIDGE ON Driving CHANNEL	Mabtouh		Farm Road	Reconstruction	B
21	FARM BRIDGE	Mabtouh		Farm Road	Reconstruction	B
22	MC50 EL MABTOUH BRIDGE	Mabtouh		MC50	Reconstruction	A
23	FARM BRIDGE ON Oued Mabtouh	Mabtouh		Farm Road	No measures	
24	A4 BRIDGE OVER Mabtouh	Mabtouh		MOTORWAY A4	No measures	
25	FARM BRIDGE ON Oued Mabtouh	Mabtouh		Farm Road	No measures	
26	FARM BRIDGE ON Oued Mabtouh	Mabtouh		Farm Road	No measures	
27	GP8 BRIDGE AND ROAD OVER Mabtouh	Mabtouh		GP8	Reconstruction	A
28	FARM BRIDGE ON Oued Mabtouh	Mabtouh		Farm Road	No measures	
29	FARM BRIDGE ON Oued Mabtouh	Mabtouh		Farm Road	No measures	
30	FARM BRIDGE(NEW)	Mabtouh		Farm Road	New construction	B
31	FARM BRIDGE(NEW)	Mabtouh		Farm Road	New construction	B
32	FARM BRIDGE(NEW)	Mabtouh		Farm Road	New construction	B

* Outside the scope of the project

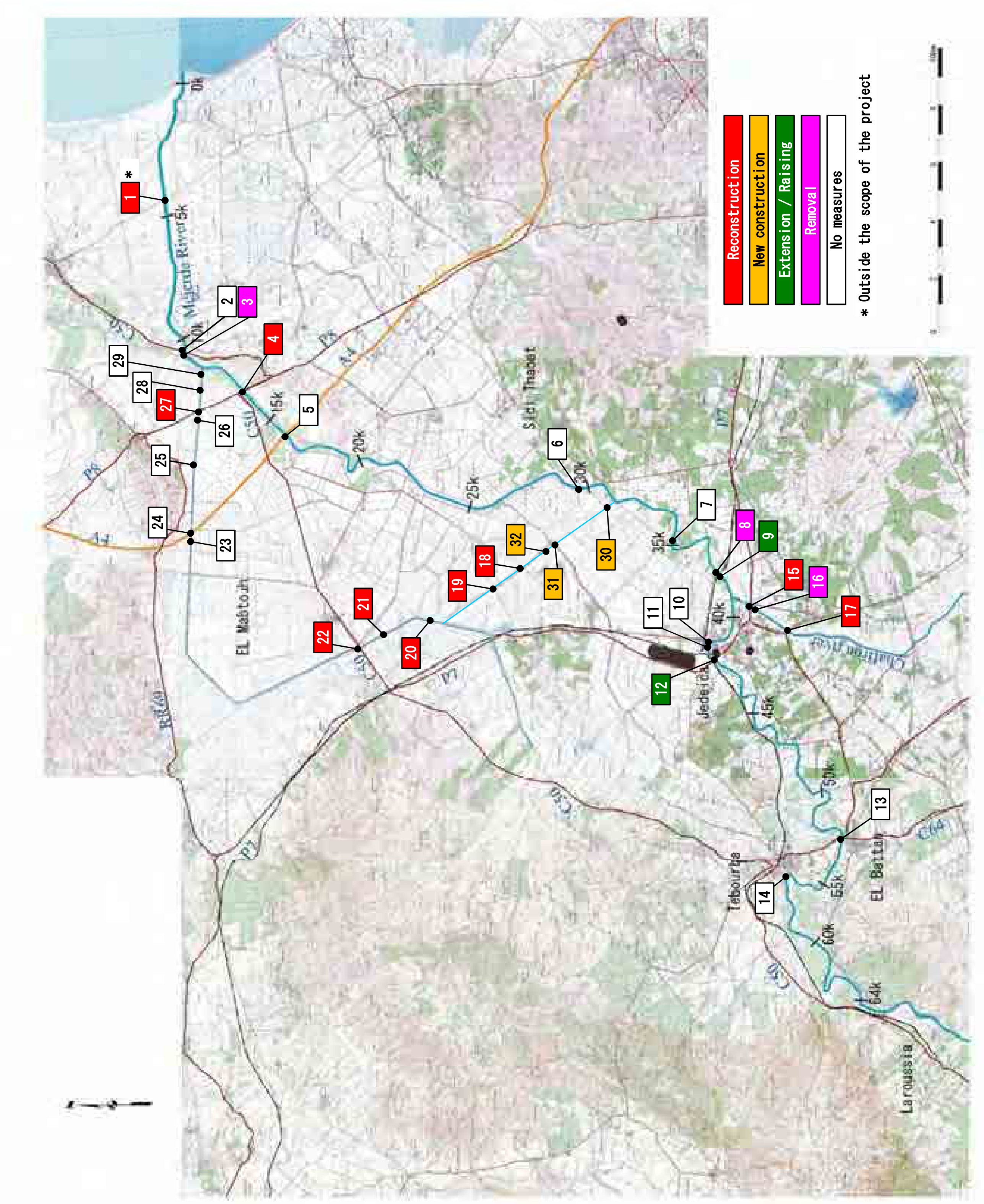
Source: JICA Survey Team

Table 6.2-4 Numbers of Bridges

Policy of bridge improvement	Medjerda	Chafurou	Mabtouh	TOTAL
Reconstruction	1	1	3	5
Reconstruction as "Flooding Bridge"		1	3	4
Extension of the existing bridge	2			2
Removal	2	1		3
No measures	8		6	14
Reconstruction *1	1			1
Existing bridge	14	3	12	29
New construction as "Flooding Bridge"			3	3
TOTAL	14	3	15	32

Source: JICA Survey Team

*1 Outside the scope of the project(K.LANDAOUS BRIDGE)



Source: JICA Survey Team

Figure 6.2-6 Locations of Bridges to be Reconstructed/Newly Built

6.3 Existing Bridge Improvement Plans

6.3.1 No. 1 K.LANDAOUS BRIDGE

(1) Overview

・This submersible bridge is on the primary route connecting Ariana to Kalaat Landaous, a two-lane road with mid-level traffic or lower.

・RC consecutive box culvert construction

・See picture:

Figure 6.3-1 K. Andalous Bridge in August 2012

(2) Hydrological Assessment

The vertical clearance on this bridge is lower than the design high-water level, inhibiting the downflow cross section and causing the structure to become submerged during floods and cutting off traffic for several weeks.

The design high-water level is 3.670 meters; a 1.0-meter freeboard must be added to that to ensure a 4.670-meter vertical clearance.

(3) Existing Bridge Improvement Plan

Traffic is heavy on the primary road connecting Ariana and Kalaat Andalous, and many shoreline development projects have been planned in the area.

The Ministry of Equipment planned the replacement of this bridge, so that part has been eliminated from this Project. In addition to vertical clearance of 4.670 meters, the bridge needs to be around 580 meters long to ensure that it spans the river as shown in the figure below:

Source: JICA Survey Team

Figure 6.3-2 K. Landaous Bridge Reconstruction Specifications

6.3.2 No. 3 TOBIAS OLD BRIDGE

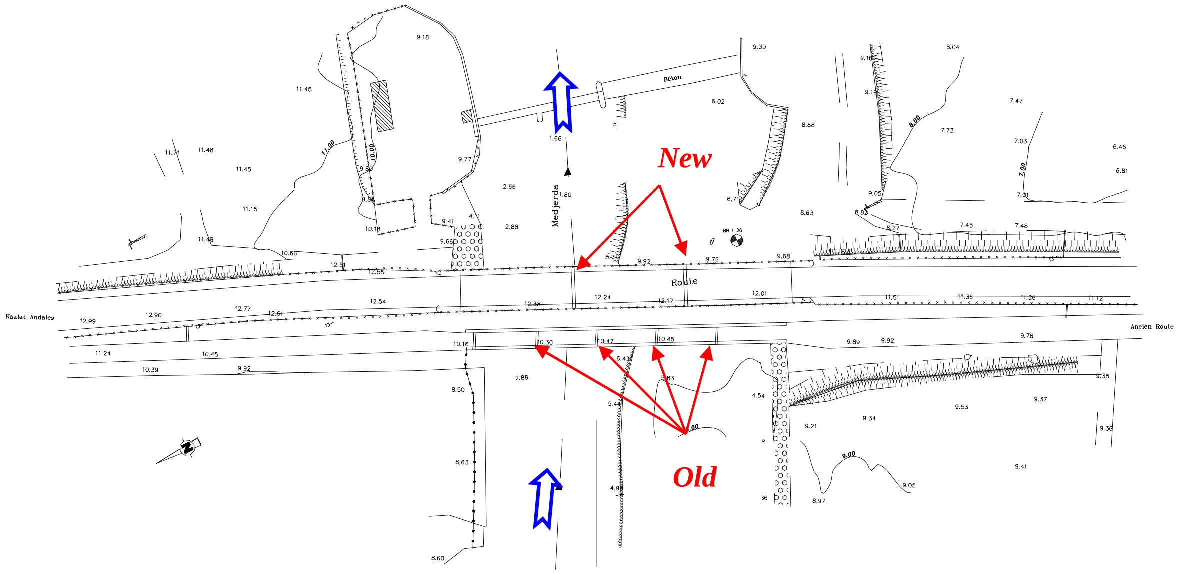
(1) Overview

- Bridge by which MC50 crosses the Mejerda River; a new bridge is being built downstream of it
- A dilapidated structure built before 1948
- Five-span Gerber RC bridge
- See picture:

Figure 6.3-3 Tobias Old Bridge in August 2012

(2) Hydrological Assessment

This bridge is parallel to the new bridge, but, as the figure below shows, the pier locations are not aligned with the streamline, and the streamline has become disturbed. This inhibits the downflow of floodwaters and causes local scouring and otherwise negatively impacts the bridge structure.



Source: JICA Survey Team

Figure 6.3-4 Location of Bridge Piers

(3) Existing Bridge Improvement Plan

This bridge is slated to be demolished. It is problematic in terms of downflow, and the new bridge features a pedestrian walkway on the downstream side, so the demolition of the old bridge would not present a problem to pedestrian or automobile passage.

6.3.3. No. 4 GP8 BRIDGE OVER OUED MEJERDA

(1) Overview

・Bridge by which GP8 crosses the Mejerda River
・Built in 1973 at the latest
・Nine-span simple RC bridge
・See picture:

Figure 6.3-5　Current Status of GP8 Bridge Over Oued MejerdaBridge（Aug., 2012）

・The cross sections of the two 60 cm x 60 cm piers on this bridge are small compared to those of other bridges.

・Much damage has been confirmed; this bridge has health problems. Typical damage includes abrasion and rebar exposure on piers and main girders as shown in the figure below, damage to expansion apparatus and main girder cracking.

1) Abrasion/exposed rebar on piers, main girders　　2) Main girder cracking (curved cracks appearing midspan)

Source: JICA Survey Team

Figure 6.3-6 Extent of Damage

(2) Hydrological Assessment

The vertical clearance and length of this bridge in its current state can ensure the required cross section specifications through the excavation of sand piled up at the bridge's location.

(3) Existing Bridge Improvement Plan

Verification of the current state of the existing bridge revealed much damage, and its health and load bearing capacity are probably insufficient. Major reinforcement of the substructure is required if the current structure is to be used, but the superstructure will probably need to be updated soon as well, so there is little merit to using the current structure.

Thus, this bridge is slated to be replaced.

6.3-4 No. 8 JEDEIDA RAILWAY OLD BRIDGE

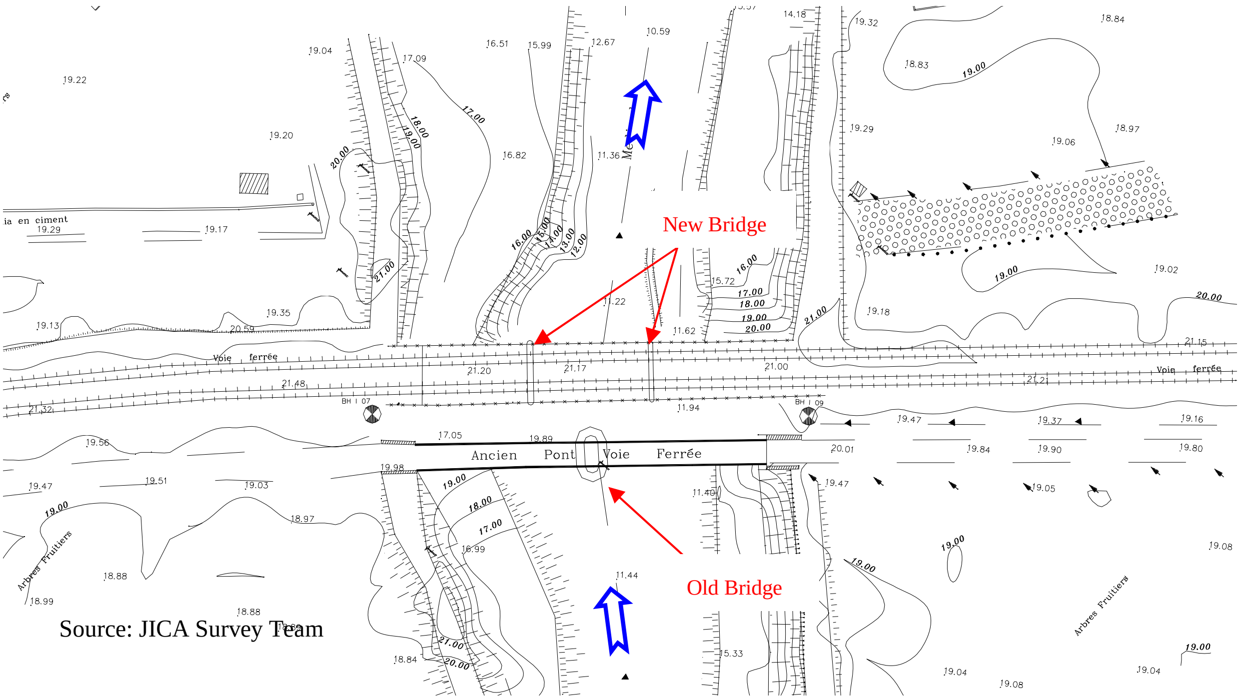
(1) Overview

・Bridge by which the Tunis-Bizerte Line crosses the Mejerda River; the new bridge was built downstream.
・The tracks have been abandoned; they are not being used.
・Demolition possible (result of deliberations with SNCFT)
・Two-span simple steel through truss bridge
・See picture:

Figure 6.3-7 Current Status of Jedeida Railway Old Bridge (Aug., 2012)

(2) Hydrological Assessment

This bridge is parallel to the new bridge, but, as the figure below shows, the pier locations are not aligned with the streamline, and the streamline has become disturbed. This inhibits the downflow of floodwaters and causes local scouring and otherwise negatively impacts the bridge structure.



Source: JICA Survey Team

Figure 6.3-8 Location of Bridge Piers

(3) Existing Bridge Improvement Plan

This bridge is slated to be demolished. It is problematic in terms of downflow, and the Tunis-Bizerte Line runs on the new bridge downstream, so the demolition of the old bridge would not present a problem to railway passage.

That said, water pipes have been added to the bridge, so they need to be moved to the new bridge after the demolition of the old bridge (SNCFT has confirmed and approved this relocation).

6.3.5 No. 9 JEDEIDA RAILWAY BRIDGE

(1) Overview

- Bridge by which the Tunis-Bizerte Line crosses the Mejerda River; the old bridge is located upstream.
- Three-span two PCT girder bridge
- Built in 1981-1982
- Two sets of one-way tracks, isolated superstructure and integrated substructure
- Evidence of afflux from flooding on girder surfaces, concrete damage and rebar exposure likely caused by impact from floating objects during floods
- See picture:

Figure 6.3-9 Current Status of Jedeida Railway Bridge (Aug., 2012)

(2) Hydrological Assessment

The current vertical clearance is 19.200 meters, but the design high-water level is 19.269 meters, so a 1.0-meter freeboard must be added to that to ensure a 20.369-meter vertical clearance. Length of 100 meters must also be ensured to fulfill downflow cross section specifications.

(3) Existing Bridge Improvement Plan

Thirty years have passed since this bridge was built, but there are no signs of major damage, and it can be used in its current state. However, it will be jacked up and spans added to ensure vertical clearance and length. Deliberations with SNCFT resulted in instructions to satisfy the following requirements so that the roadway can function during construction, so they must be considered when devising detailed plans.

・Conduct a thorough structural safety investigation after jacking up the bridge.
・The longitudinal grade of the temporary roadway will be less than 9%.
・One road will be guaranteed during construction.

＊ The setting contents at the review of this time are shown on Reference Package 4.3.

6.3.6 No. 12 JEDEIDA BRIDGE ON GP7

(1) Overview

・Bridge by which GP7 crosses the Mejerda River
・Built in 1945, replaced in 2009.
・Five-span PC girder bridge
・Two sets of one-way tracks, isolated superstructure and integrated substructure
・Evidence of afflux from flooding on girder surfaces, concrete damage and rebar exposure likely caused by impact from floating objects during floods
・See picture:

Figure 6.3-10 Current Status of Jedeida Bridge on GP7 (Aug., 2012)

(2) Hydrological Assessment

The current vertical clearance is 25.130 meters, which is satisfactory with respect to the design high-water level of 21.276 meters, but the current length does not fulfill downflow cross section specifications (100 meters).

(3) Existing Bridge Improvement Plan

Seventy years have passed since this bridge was built, but it was replaced in 2009 and there are no signs of major damage. However, spans will be added in order to provide the required length.

6.3.7 No. 15 GP7 BRIDGE ON CHAFROU

(1) Overview

・Bridge by which GP7 crosses the Chafrou River; the old bridge is located upstream.
・Three-span PC hollow slab bridge
・See picture:

Figure 6.3-11 Current Status of GP7 Bridge on Chafurou (Aug., 2012)

(2) Hydrological Assessment

The current vertical clearance is 18.9 meters, but the design high-water level is 19.800 meters, so including a 1.0-meter freeboard, the bridge must be given a 20.800-meter vertical clearance. Length of 61 meters must also be ensured to fulfill downflow cross section specifications.

(3) Existing Bridge Improvement Plan

This bridge shows no signs of major damage. However, improving the current structure would be difficult because its vertical clearance and length are significantly lacking, so it is slated to be replaced.

6.3.8 No. 16 GP7 OLD BRIDGE ON CHAFROU

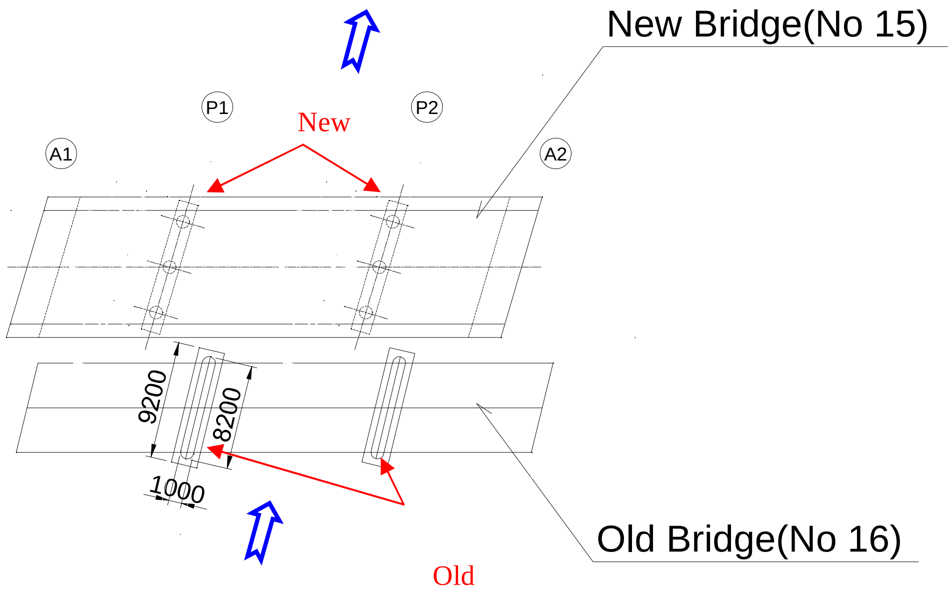
(1) Overview

・Bridge by which GP7 crosses the Chafrou River; the new bridge was built downstream.
・Three-span concrete bridge
・See picture:

Figure 6.3-12 Current Status of GP7 Old Bridge on Chafurou(Aug., 2012)

(2) Hydrological Assessment

This bridge is parallel to the new bridge, but, as the figure below shows, the pier locations are not aligned with the streamline, and the streamline has become disturbed. This inhibits the downflow of floodwaters and causes local scouring and otherwise negatively impacts the bridge structure.



Source: JICA Survey Team

Figure 6.3-13 Location of Bridge Piers

(3) Existing Bridge Improvement Plan

This bridge is slated to be demolished. It is problematic in terms of downflow, and the new bridge features a pedestrian walkway on the downstream side, so the demolition of the old bridge would not present a problem to pedestrian or automobile passage.

6.3.9 No. 17　EL H'BIBIA BRIDGE

(1) Overview

- A low-traffic bridge that crosses the Chafrou River.
- Four-span concrete bridge
- See picture:

Figure 6.3-14　Current Status of El H'Bibia Bridge (Aug., 2012)

(2) Hydrological Assessment

The current vertical clearance is about 19.5 meters, but the design high-water level is 19.800 meters, so a 1.0-meter freeboard must be added to that to ensure a 20.800-meter vertical clearance. Length of 62 meters must also be ensured to fulfill downflow cross section specifications.

In addition, the picture below shows how the water level rose at the bridge's location during the flood of January 2003.

Source: Preparatory Study

Figure 6.3-15: Picture from El H'Bibia Bridge on January 13, 2003

(3) Existing Bridge Improvement Plan

Improving the current structure would be difficult because its length is significantly lacking, so it is slated to be replaced.

6.3.10 No. 18 Bridge on the local road, No. 22 MC50 EL MABTOUH BRIDGE

(1) Overview

・Bridges located on the channel from Mejerda River to El Mabtouh Retarding Basin
・No. 18: concrete bridge; No. 22: box culvert construction
・See picture:

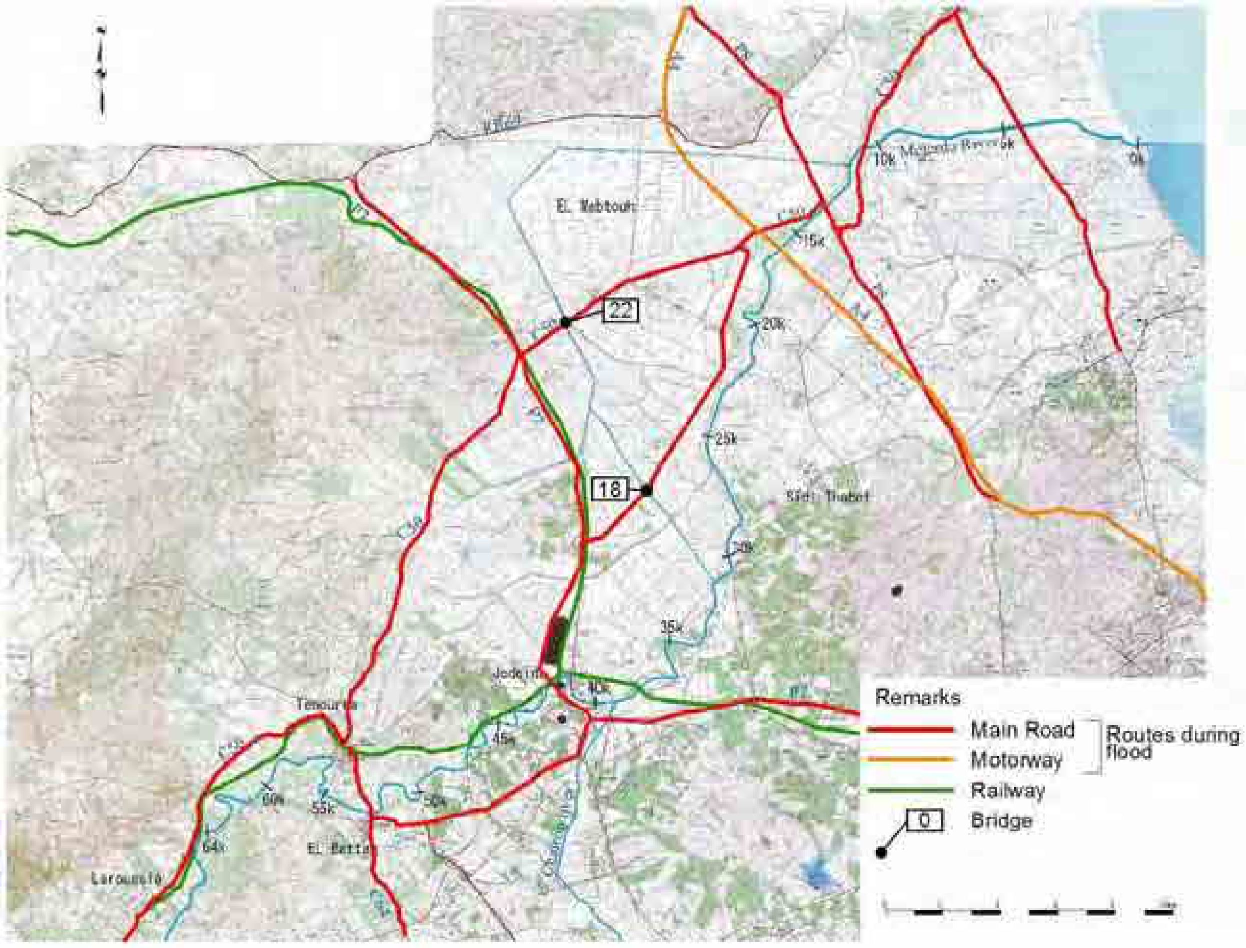


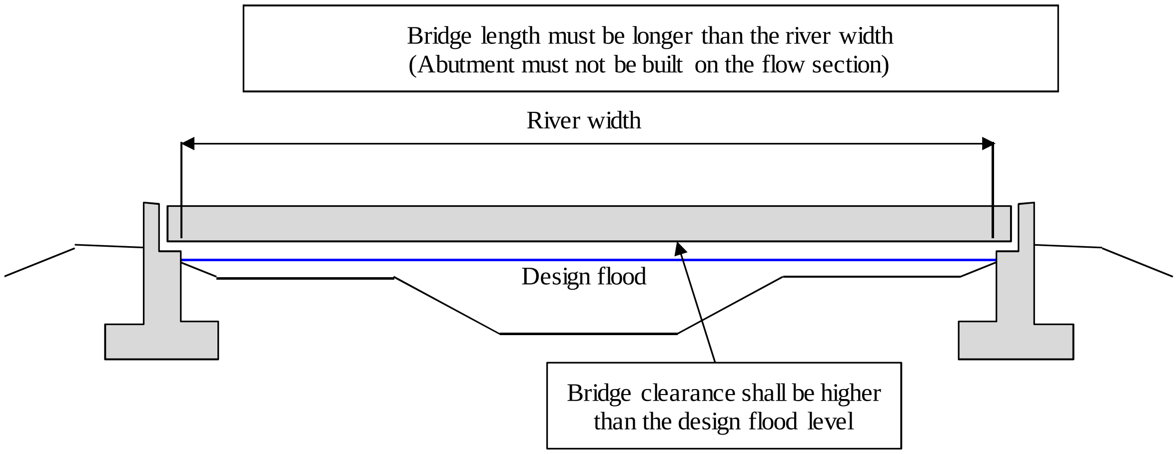
Figure 6.3-16 Location of Bridge Nos. 18 and 22

(2) Hydrological Assessment

The channel in the section from the Mejerda River to the El Mabtouh Retarding Basin is too narrow to fulfill downflow cross section specifications required for the design flow rate of this Project. Thus, the channel is slated to be widened.

(3) Existing Bridge Improvement Plan

These bridges will be replaced because downflow cross section specifications are significantly lacking. Bridge Nos. 18 and 22 are to become Class A bridges to remain passable during floods.



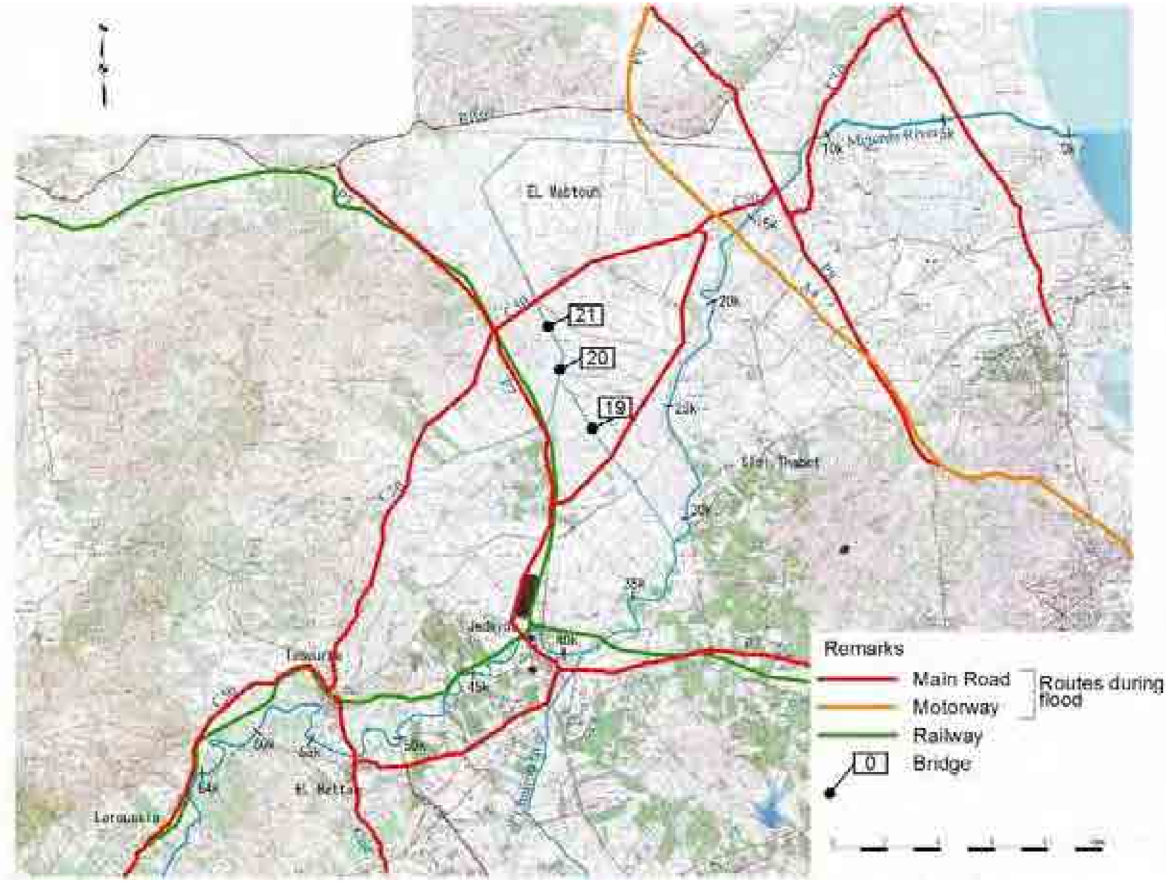
Source: JICA Survey Team

Figure 6.3-17 Overview of Class A Bridges

6.3.11 No. 19-21 FARM BRIDGE

(1) Overview

- Bridges located on the channel from Mejerda River to El Mabtouh Retarding Basin
- Concrete bridges
- See picture:



Source: JICA Survey Team

Figure 6.3-18 Location of Bridges No. 19-21

(2) Hydrological Assessment

The channel in the section from the Mejerda River to the El Mabtouh Retarding Basin is too narrow to fulfill downflow cross section specifications required for the design flow rate of this Project.

(3) Existing Bridge Improvement Plan

These bridges will be replaced because downflow cross section specifications are significantly lacking. However, since these routes are used mostly for agriculture and are not primary routes, the bridges over them are to be Class B bridges, built to the minimum scale such that they cross low channels under normal flow conditions and become submerged during floods. They will run diagonally up and down the slopes of dikes to avoid causing discontinuity of the dikes.

Figure 6.3-19   Overview of Class B Bridges

6.3.12 No. 27 GP8 BRIDGE AND ROAD OVER Mabtouh

(1) Overview

・Bridge by which GP8 crosses over the diversion channel

・Four-span RC girder bridge

・See picture:

Figure 6.3-20 Current Status of GP8 Bridge and Road Over MabtouhBridge (Aug., 2012)

・Damage was confirmed, and there are health problems. Typical damage includes abrasion/exposed rebar on the slabs and cracks on the bearings.

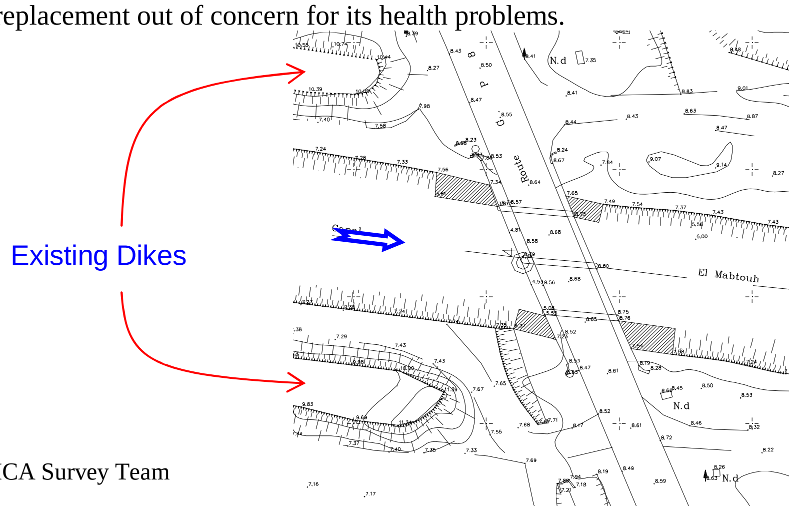
(2) Hydrological Assessment

The existing cross section of the diversion channel generally allows a flow rate that enables downflow, but the three piers located where the river narrows are inhibiting 10% of the river cross section.

In addition, a dike that cuts off that area has caused flooding in the past.

(3) Existing Bridge Improvement Plan

The downflow capacity of the river cross section in its current state is satisfactory, but the current structure significantly inhibits that cross section and the existing dike cuts it off. Thus, this bridge is slated for replacement out of concern for its health problems.



Source: JICA Survey Team

Figure 6.3-21 Existing Dikes

6.4 Plans for New Bridges

This section presents the results of investigations of structure types and specifications of bridges to be replaced and bridges to be built anew, including the new sections of bridges to be improved.

Structure types and specifications were determined according to construction experience in Japan and construction experience studied in Tunisia.

6.4.1 Bridge Construction Experience Study

(1) Bridges on the Mejerda River

A study of bridge construction experience in Tunisia revealed that RC T-girder, PC I-girder, steel girder and many other superstructure types were adopted according to the sizes of the bridges. However, PC I-girder was the main superstructure type adopted for bridges that cross the Mejerda River. The table below shows specifications and girder heights-to-span ratios for bridges on general roads studied:

Table 6.4-1 Superstructure construction results (PCI girder)

Source: JICA Survey Team

No	Channel	Max span (m)	Girder Heights (m)	Girder Heights /Span
1	Mejerda	28.0	1.8	1/15.6
2	Mejerda	28.0	1.8	1/15.6
3	Mejerda	37.0	2.0	1/18.5

For the substructures, steel or concrete three-column piers and wall type piers were adopted, and reverse piles were often used to build foundations. It is worth noting that steel piles have also been used.

(2) Box Culverts

Box culvert structures have been adopted often in Tunisia, especially on small structures in the area surrounding the El Mabtouh Retarding Basin in Zone D2.

6.4.2 Superstructures

(1) Class-A Bridges

1) Structure Type

Class A bridges will be around 150 meters long with substructure clearance of around 10 meters to ensure that their lengths are longer than the width of the river and that their design heights include enough freeboard to clear the design high-water level.

It is best to drastically reduce the number of piles that inhibit the river cross section, but there is little merit to adopting PC box girder, steel girder or other structure types that increase span lengths because there is no need to build large temporary structures for substructure construction since flow rates are low during normal times.

Thus, PC I-girder superstructures, the type often used on bridges that cross the Mejerda River, will be adopted.

2) Structure Specifications

The figures below are cross sections of new bridges approved by the Ministry of Agriculture that qualify as Class A bridges. The rationale:

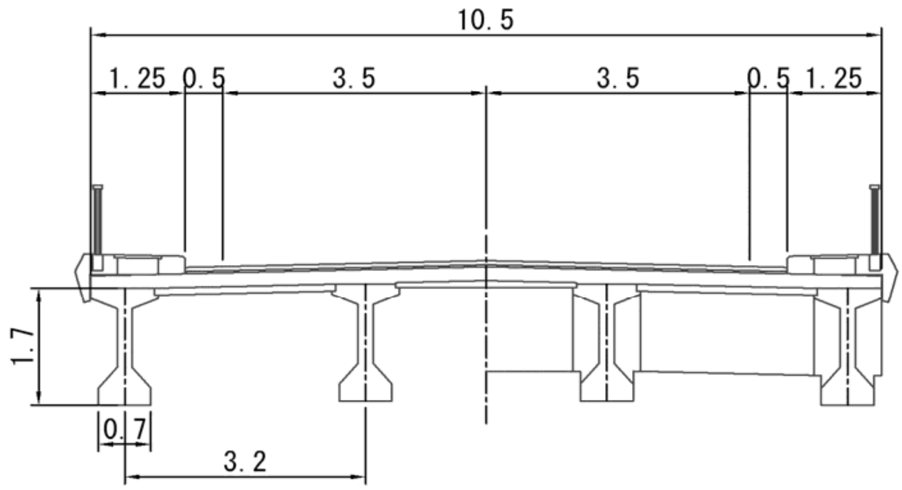
- Roads in their current state have two lanes and thus fall into Category 1 with road width 2 @ 3.5 meters.

Roads in Tunisia are divided into the following three categories:
Category 1: Road Width 2 @ 3.5 meters (two lanes)
Category 2: Road Width 1 @ 5.0 meters (one lane)
Category 3: Road Width 1 @ 3.0 meters (one lane)

- The maximum span length is between 28 and 37 meters historically, so the basic span length is set at 30 meters, with span lengths of 25.0 meters, 30.0 meters and 35.0 meters applicable in individual cases.
- PC I-girders have historically had a girder height-to-span ratio between 1/15 and 1/18 in Tunisia, so the ratio was set at 1/15 for this Study and girder heights were configured according to that ratio:

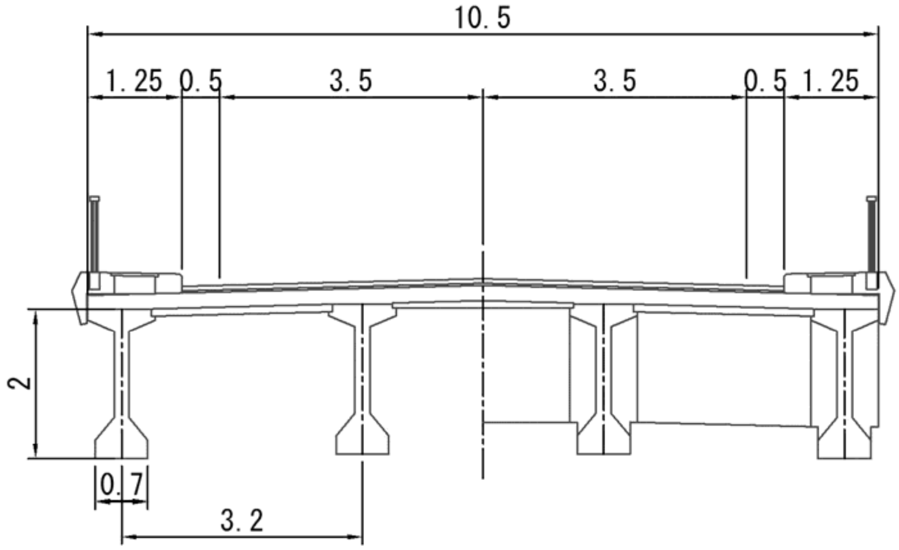
Span Length 25.0 meters = Girder Height 1.7 meters
Span Length 30.0 meters = Girder Height 2.0 meters
Span Length 35.0 meters = Girder Height 2.4 meters

- The number of main girders was set according to main girder spacing on existing bridges; there will be four main girders spaced 3.2 meters apart on two-lane roads (total width 10.5 meters).



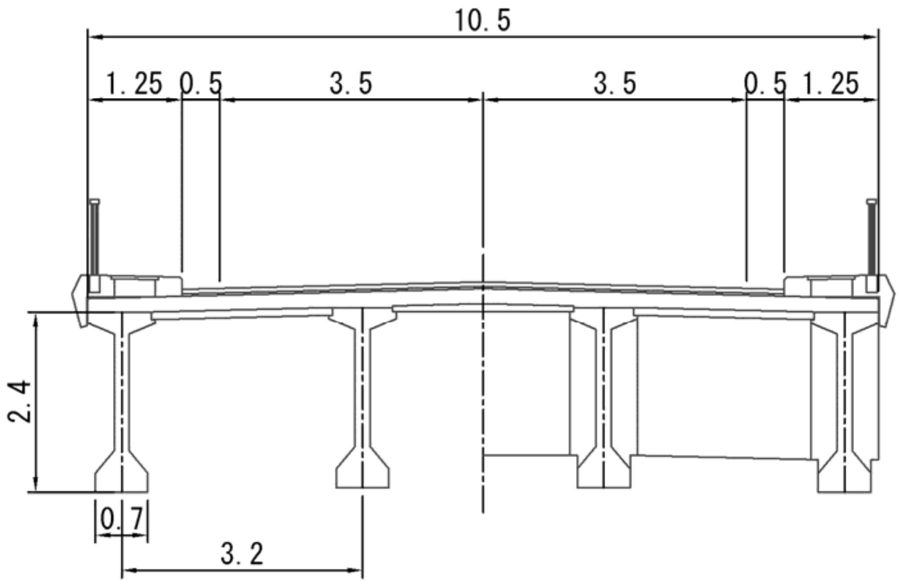
Source: JICA Survey Team

Figure 6.4-1: The cross section of a bridge (Span length=25.0m)



Source: JICA Survey Team

Figure 6.4-2 The cross section of a bridge(Span length=30.0m)



Source: JICA Survey Team

Figure 6.4-3 The cross section of a bridge (Span length=35.0m)

(2) Class B Bridges

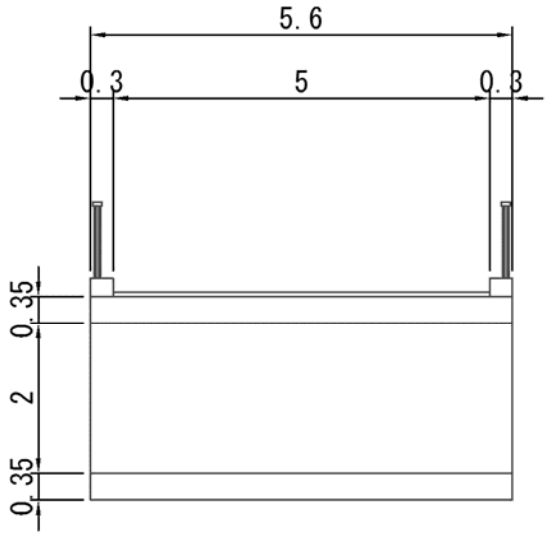
1) Structure Type

Class B bridges cross over low channels, are about 30 meters long and have substructure clearance of around two meters; this is not an economically efficient bridge type. Therefore, they will be box culvert bridges.

2) Structure Specifications

The figure below is a cross section of a Class B bridge. The rationale:

- Farm roads were measured and found to be 5.6 meters wide with effective widths of 4.4 meters. They will be treated as Category 2 roads, and an effective width of 5.0 meters will be ensured.



Source: JICA Survey Team

Figure 6.4-4: The cross section of a bridge

6.4.3 Substructures

(1) Abutment Types

Various types of abutments have been adopted according to structure height, supporting soil conditions, and economic efficiency. In general, however, the appropriate abutment type from those shown on the table below is determined according to the structure height.

Design height for abutments in this Study is between 5.0 and 12.0 meters and supporting soil conditions are not good, so inverted T-type abutments will be used.

Table 6.4-2 Abutment Types and Standard Height

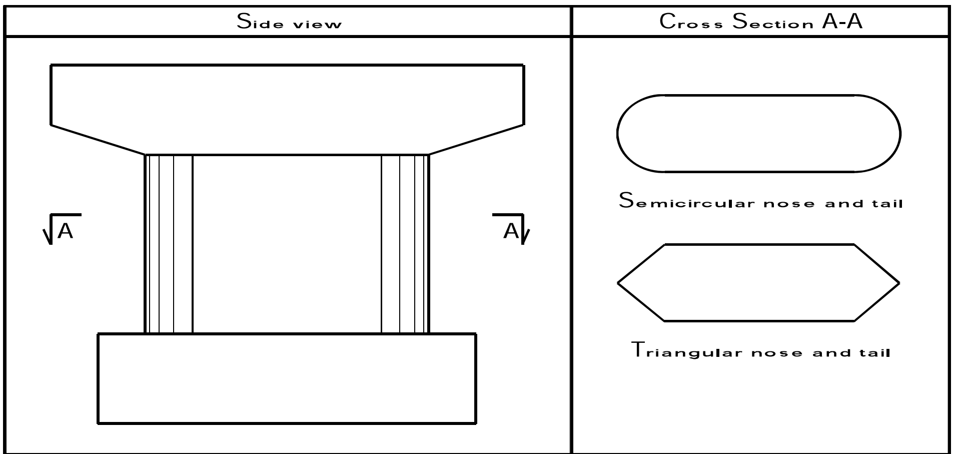
Source: JICA Survey Team

Abutment Type	Height(m)			Remarks
	10	20	30	
Grabity Type				
Semi-grabity Type				
Cantilever Type				
Counterfort Type				
Rigid Frame Type				

(2) Pier Types

Interviews about earthquake resistant designs in Tunisia revealed that seismic forces were either not considered at all or were small enough to be negligible. Therefore, it is possible to make pier structures for this Study small.

It is obviously important to make sure that piers fulfill required capabilities for structures in the course of investigating pier types, but it is also best to use as few materials as possible and to build economically efficient structures. Therefore, in terms of economic efficiency, column piers, which Tunisians have worked with before, should be used. However, the piers used in this design were wall type piers (shown below) that do not inhibit the flow of the river.



Source: JICA Survey Team

Figure 6.4-5: The wall type pier

6.4.4 Foundations

(1) Geological Properties

The soil is principally comprised of clay that is sometimes consolidated (clay that includes sand and/or silt) to a depth greater than 45 meters (not confirmed to rock layers). The various geologies studied in the target region of this Study are comprised of generally uniform, thin soils; there is little chance of encountering rock layers locally. The table below shows supporting layers at the locations of main bridges:

Table 6.4-3 Supporting Layers

Location	Boring	Layer Name	N Value	Supporting Layer Location (m)		
				Top Surface Depth	Bottom Surface Depth	Thickness
Jedeida Bridge	BHI25	Sand Bedrock	50+ 60+	13	30 (hole bottom)	17+
Railway Bridge	BHI07 (left bank)	Sand/clay	30+	28	33 (hole bottom)	5+
	BHI09 (right bank)	Silty clay/sandy clay	20+	25	30 (hole bottom)	5+
Highway Bridge	BHI22 (left bank)	Sandy clay	20+	29	45 (hole bottom)	16+
			(50+	38	45 (hole bottom)	7+)
	BHI23 (left bank)	Silty clay	20+	31	45 (hole bottom)	14+
			(50+	41	45 (hole bottom)	4+)
	BHI24 (right bank)	Sandy clay	20+	34	45 (hole bottom)	11+
			(50+	41	45 (hole bottom)	4+)
GP8 Bridge	BHI14 (left bank)	Silty clay	20+	29	45 (hole bottom)	16+
	BHI15 (left bank)	Sandy clay	(50+	38	45 (hole bottom)	7+)
	BHI16 (right bank)	Sandy clay	20+	35	45 (hole bottom)	10+
			(50+	41	45 (hole bottom)	4+)
			20+	28	45 (hole bottom)	17+
			(50+	38	45 (hole bottom)	7+)
Tobias Bridge	BHI26 (right bank)	Silty clay/sand	30+	42	50 (hole bottom)	18+
Kalaat Anadalous Bridge	BHI21 (right bank)	Sandy clay	10+ (40-45 m)	No supporting layer at 45-meter hole bottom		
El Mabtouh Retarding Basin	BHII06	Silty clay	20+ (26-27 m) 30+ (29-30 m)	Unable to confirm supporting layer to 30-meter hole bottom		

(Source: Prepared during this Study based on Preparatory Study Soil Survey Report data)

(2) Foundation Types

Pile foundations will be used since layers considered to be supporting layers are very deep. Pile foundations support loads via end bearing capacity and skin friction, but supporting layers are deep in

Zone D2 and interviews with local construction workers revealed that friction piles had been used, so friction piles will be used for foundations in this Study.

(3) Structure Specifications

The Mejerda River region does not contain supporting soil or solid layers, so friction piles with relatively small diameters are effective as foundation piles (in order to increase the proportion of pile area to load). Therefore, pile diameters will be uniform without regard to superstructure span length, and one-meter piles, which have been used to build bridges that cross the Mejerda River, will be used.

6.4.5 Plans for New Bridges

Design drawings for new bridges planned under the above conditions are shown on the Design Drawing Package.

6.5 Design Standards

6.5.1 Road Bridges

The use of the following standards on facility and road drawings and facility designs was proposed during discussions held at the October 20, 2010 meeting between MEHAT (Civil Engineering Department) and the JICA Survey Team.

(1) Drawings (Longitudinal Cross Sections, Design Drawings)

- Technical Recommendations Related to Overall and Geometrical Concepts

Primary road facilities (excluding expressways and two-lane highways)
Technical Guide SETRA August 1994 Code: B9413

- ICTAAL: Regulations on Technical Conditions of Interurban Expressway Facilities

Notice dated December 12, 2000, SETRA (transportation/road facility study organization)
Issued December 2000 Code: B0103

(2) Structural Design (Road Structures)

- Building Embankments and Clearing Roadbeds (abbreviated GTR) –Technical Guide-

SETRA (transportation/road facility study organization), LCPC (civil engineering research institute)
Issued September 1992 Code: D9233

- Designing and Building Embankments -Technical Guide-

SETRA (transportation/road facility study organization), Issued March 2007 Code: 0702

(3) Structural Design (Concrete Structures)

Table 6.5-1 Regulations on Concrete Facility Designs

Item	Standard/Regulation	Version
Live load	CCTG (General Technical Specifications) Vol. 61, Issue 2 "Structural Designs, Live Loads on Road Bridges" Special live loads are different for each bridge.	June 1977
Foundation construction	CCTG (General Technical Specifications) Vol. 62, Issue 5 "Technical Regulations for Civil Structure Foundation Construction Plans and Designs"	December 1993
Superstructure-rebar concrete	CCTG (General Technical Specifications) Volume 62, Issue 1, Chapter 1 "Technical Regulations for Reinforced Concrete Structure and Building Plans and Designs Under the Limit State Design Method – 1999 Revision of BAEL91" • Allowable cracking conditions depend on the surrounding environment (three classes of environment: Good, Normal, Bad) • In general, the environment is Normal.	April 1999
Prestressed concrete	CCTG (General Technical Specifications) Volume 62, Issue 1, Chapter 1 "Technical Regulations for Reinforced Concrete Structure and Building Plans and Designs Under the Limit State Design Method – 1999 Revision of BAEL91" • Prestressed classes are different for each bridge (three classes: 1, 2, 3) • In general, Class 2.	April 1999
Regulations related to earthquake resistance concepts	"Guide on General Bridge-Design in Earthquake-Prone Areas"	January 2000

Source: Preparatory Study

(4) Structural Design (Steel Components, Other Components)

Refer to Eurocodes when the regulations above are insufficient.

Eurocode 0: Basis of structural design (EN1990)
Eurocode 1: Actions on structures (EN1991)
Eurocode 2: Design of concrete structures (EN1992)
Eurocode 3: Design of steel structures (EN1993)
Eurocode 4: Design of composite steel and concrete structures (EN1994)

Eurocode 5: Design of timber structures (EN1995)

Eurocode 6: Design of masonry structures (EN1996)

Eurocode 7: Geotechnical design (EN1997)

Eurocode 8: Design of structures for earthquake resistance (EN1998)

Eurocode 9: Design of aluminum structures (EN1999)

(5) Structural Conditions for Rivers

Conditions for structural designs with respect to rivers are defined based on recommendations in Technical Guide "River and Bridges, SETRA, Issued 2007, Code: DT4263." The table below shows the main measures:

Table 6.5-2 Regulations on Hydrological Designs for Bridges (based on SETRA Guide)

Source: "Rivers and Bridges" SETRA 2007 Code: DT4263

Flooding	Probability	Water Use Purpose	Facility Purpose	Design Measures
Full capacity	Two years (99.9% chance of happening within 10 years)	No noticeable impact on riverbed.	—	Types and locations that minimize impact to riverbed
Intense flooding	50 years (18% chance of happening within 10 years)	—	Structures must not suffer damage.	Endurable flow (verify serviceability limits) - anti-erosion measures
Exceptional flooding	100 years (10% chance of happening within 10 years)	No noticeable impact on surrounding area.	—	Build inner rings of arches higher than maximum water level* -emergency drainage facilities- road dike protection
Unparalleled flooding	200-500 years	—	No major damage to structures	Ultimate flow (verify ultimate limit state)

*Design freeboard such that floating objects can pass through. Theory on this is below.

This guide will serve as a reference when assessing erosion risk and investigating the scales of protective facilities and foundation construction.

Source: "Rivers and Bridges" SETRA 2007, Eurocode: DT4263

1) Minimum Span of Structures (danger from floating objects)

The SETRA Guide does not refer directly to span lengths with which structures over rivers should comply, but Page 303 of the Japanese standard ("Revised Explanation/Ordinance for Structural Standards for River Administration Facilities" Japan River Association, November 1999) offers the following:

$L = 20 + 0.005Q$

L: span length (m), Q: flow rate (m^3/s)

The design high-water flow rate with respect to this project is 800 m^3 per second from Laroussia Dam to the El Mabtouh Retarding Basin diversion channel and 600 m^3 per second from the diversion channel to Kalaat Landaous Bridge. Therefore, the distance between spans must be at least 24.0 meters (20 + 0.005(800)).

2) Clearance Beneath Structures (allowing floating objects to pass underneath structures)

The aforementioned SETRA Guide says the following:

"The fixed height of the inner ring must be determined based on reference floods (in general, hundred-year floods) and consideration must be made for riverbed buildup due to solid deposits, riverbank expansion due to the way the river moves (flow velocity, curvature at curved reaches), and to ensure a minimum amount of space to allow floating objects to pass underneath. In its discussion of the Sejournet Process, SETRA Model Document Ohvm63 requires clearance of 0.60 to 1.50 meters in line with aperture size 2 to 8 meters."

Page 115 of the Japanese standard (River Structure Facility Standards" Japan River Association, November 1999) uses the following relationships in terms of the flow rates considered:

Table 6.5-3 Defining Freeboard (Japanese Standard)

Source: "River Structure Facility Standards" Japan River Association, November 1999

Flow Rate (m^3/s)	**< 200**	**200<… <500**	**500<… <2000**	**2000<… <5000**	**5000<… <10000**	**>10000**
Freeboard (clearance) (m)	0.6	0.8	1.0	1.2	1.5	2

Source: "River Structure Facility Standards" Japan River Association, November 1999

Overall, the natures of the Japanese and French standards are the same.

Freeboard depends on the size of dangerous floating objects that could be swept downriver during floods. The sizes of floating objects differ; while France and Japan have thick forests and tall trees, the forests of the Mediterranean coastal nation of Tunisia are not very dense and contain small trees. It follows that freeboard in Tunisia would be smaller, but interviews with local construction workers revealed that a roughly 1.0-meter freeboard had been ensured along the Mejerda River, so the plan calls for 1.0 meters of freeboard.

6.5.2 Railway Bridges

Based on discussions held at the October 22, 2010 meeting between Tunisian Railways and the JICA Study Team, the French standard enacted in 1960 (25-ton axle load) will be applied. This standard is stricter than the UIC (International Union of Railways) standard (22.5-ton axle load).

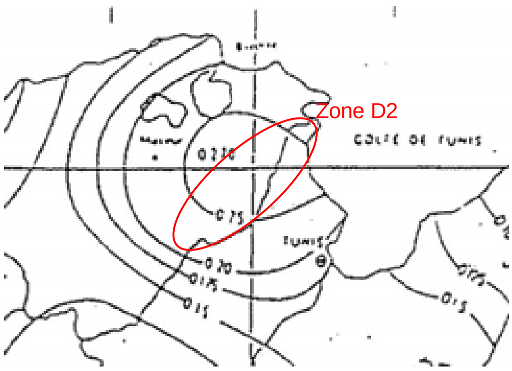
6.5.3 Earthquake Resistance Standards

According to the May 1997 proposal on Tunisian earthquake resistance standards, seismic acceleration on foundations involving bridges in Section D2 is 0.25 g = 2.45 m/s^{-2}.

However, verifying acting seismic forces with standards and updated bridge designs in mind through on-site interviews showed that road bridges crossing the Mejerda River have dead loads of 0.3-0.5% and that no clear standards exist for railway bridges because the acting seismic forces on them are not considered.

Thus, dead loads in terms of seismic force taking designs into consideration were set at 0-0.5% for each bridge, and detailed designs with the following guidelines need to be determined through discussion:

1) Class A Road Bridges   Dead Load 0.5%
2) Class B Road Bridges   Dead Load 0% (not considered)
3) Railway Bridges   Dead Load 0% (not considered)



Source: Preparatory Study

Figure 6.5-1 Proposal on Tunisian Earthquake Resistance Standards

Chapter 7 Construction Plan and Project Cost Estimation

7.1 Overview of Construction and Compensation

7.1.1 Construction

The table below contains details of the main construction to be implemented during this Project:

Table 7-1 Mejerda River Improvement Project Construction Details

River Improvement Construction	Main Construction Details
1. Preparation work	・Material and equipment yard ・Setting up worker lodging, management office
2. Temporary works	・Construction roads, river-crossing roads, temporary docks ・Cofferdams, cut-and-cover work, large sandbags
3. River earthwork	・Remove trees/roots, demolish existing structures, scrape topsoil ・Excavation and banking
4. River structures 4.1 Protective dikes 4.2 Groundsill work 4.3 Overflow dike/diversion facilities 4.4 Sluiceways/sluice gates	・Stone pitching, riprap work, gabions ・Main groundsill work, front aprons, bed protection work ・Sidewall protection, crest concrete ・Main overflow dike work, front aprons, bed protection work ・Sidewall protection, crest concrete ・Main sluiceway work, flap gate work
5. Bridge work	・Bridge improvement ・Bridge building ・Bridge demolition

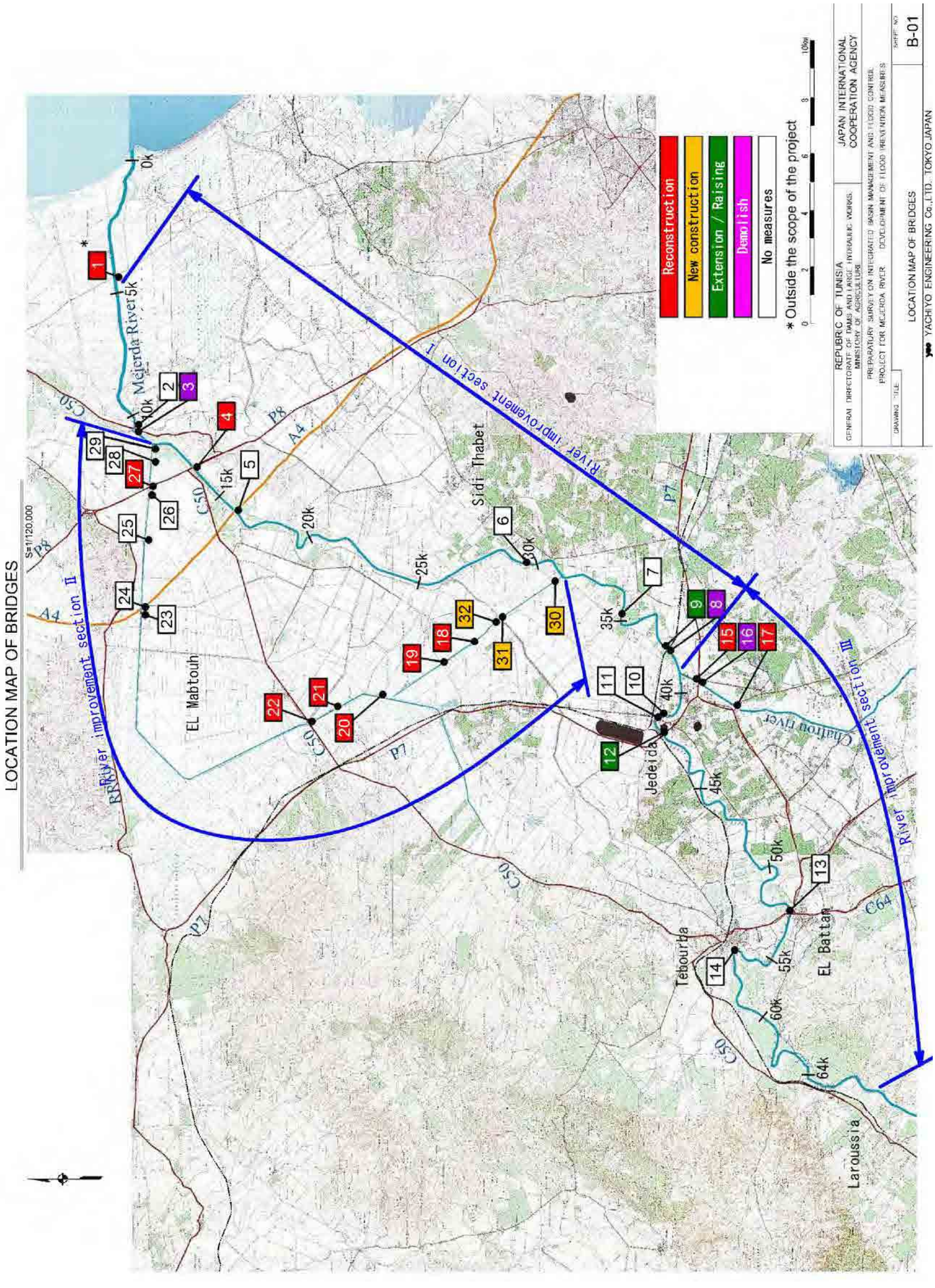
1) Tree/Root Removal
   Before excavation, tamarisk and other trees that grow in flood channels will be removed along with their roots. The reeds that proliferate in the El Mabtouh Channel will also be removed.
2) Topsoil Scraping
   Topsoil will be scraped to a depth of 30-50 centimeters, separated along with general soil and hauled away either to dumping areas or to storage areas. Topsoil contains organic matter and thus will be diverted to use outside of construction.
3) Excavation Work
   The dirt left behind after topsoil scraping will be excavated as general soil and used for embankments (dikes) and in other areas of construction. Leftover soil will be transported to dumping areas.
4) Banking Work
   The resulting soil will be used to build up dikes or fill in areas around structures.
5) Concrete Work
   For volume, management, quality and cost purposes, concrete for the overflow dike and other construction projects will be purchased from local batching plants.
6) Protective Dike and Bed Protection Work (concrete slope cribwork, gabion work)
   Concrete slope cribwork and gabions will be constructed to protect riverbanks and riverbed areas expected to suffer erosion.
7) Soil Transportation Work
   The dirt from topsoil scraping and general soil will be separated, transported and stored. General soil will be used as-is for embankments. It will be transported an average distance of three kilometers or less. Four-meter-wide construction roads will be built along the riverside.
8) Transporting and Disposing of Construction Materials and Soil (dumping areas, temporary dumping areas)
   Topsoil scraped during flood channel excavation will be transported to dumping areas, general soil will be used for banking, and leftover soil will be transported to dumping areas. Discussions with implementing agencies resulted in the plan to have a dumping area within four kilometers of each construction zone. The soil will be transported an average distance of about three kilometers. (Dumping areas are to be 200 m x 300 m x 1 m)
9) Bridge Improvement
   Existing bridges that require improvement due to insufficient river down flow capacity with the current structure in place will be replaced, raised or expanded, whichever method is most appropriate at each location.
10) Bridge Building
   The plan calls for new channels, and new bridges will be built in places where bridges do not yet exist.
11) Bridge Demolition
   Existing bridges that present channel flow problems will be demolished when possible.

7.1.2 Construction Zones

Construction work under this Project has been divided into three major construction zones, each of which is divided into smaller construction zones.

Table 7-2 Construction Zone Chart

JOB DIVISION No.		STATION No. (Point No.)	NOTE	DISTANCE SUPPLEMENTARY (km)	DISTANCE SECTION (km)	FLOW DISCHARAGE (m^3/sec)	TYPICAL CROSS SECTION
I	I-1	MD447-α	RIVER-MOUTH	0.00		600	MD428
					4.66		
		MD434	K.LANDAOUS BRIDGE	4.66			
					6.12		
		MD416	TOBIAS DAM	10.78			
					1.03		
		MD411	OUTLET WORKS	11.81		600	MD380
					20.54		
	I-2	MD353	DIVERTING WEIR	32.35		800	MD344
					5.50		
	I-3	MD338	JEDEIDA OLD(NEW) RAILAWAY BRIDGE	37.85			
					0.94		
		MD336	CHAFFROU RIVER CONFLUENCE	38.79			
II (EL MABTOUH BASIN)	II-1	-- (POINT⑩)	OUTLET WORKS	0			
					6.16		
		85(POINT⑧)	EXPRESSWAY CROSS POINT	6.16			
					1.61		
		78(POINT⑦)	CONTOROL GATE WORKS	7.77			
					5.86		
		54(POINT⑥)	OVERFLOW WEIR	13.63			
					4.75		
		36(POINT⑤)	ROAD CROSS POINT (C50)	18.38			
					3.72		
		22(POINT④)	CONFLUENCE PIONT	22.10			
					5.17		
		1(POINT②)		27.27			
					3.73		
		-- (POINT①)	DIVERTING WEIR	31.00		200	
III	III-1	MD336	CHAFFROU RIVER CONFLUENCE	38.79		800	MD296
					2.28		
		MD328	JEDEIDA ROAD BRIDGE	41.07			
					12.04		
	III-2	MD285	EL BATTANE WEIR BRIDGE	53.11			
					11.86		
		MD252	LARROUSIA DAM	64.97			



Source: JICA Survey Team

Figure 7-1 Construction Zone Map

7.1.3 Construction Figures

(1) Main Types of Construction

The table below shows the main types of construction in each construction zone:

Table 7-3 Main Types of Construction in Each Construction Zone

(1) Construction Zone I: Mejerda River Improvement (Lower)	
(1) Channel excavation work (widening)	
(2) Banking (protective dike) work	
(3) Bridge work	・Demolition/rebuilding ・Expanding/raising ・Demolition
(4) Sluiceway work	・Demolition/rebuilding ・Demolition
(2) Construction Zone II: Retarding Basin Improvement	
(1) Inflow channel work	・Excavation ・Banking
(2) Channel bridge work	・Demolition/rebuilding ・Building
(3) Overflow dike work	
(4) Flow control (gate) work	
(5) Diversion channel improvement (dike leveling)	
(6) Diversion gate work	
(7) Raising area roads	
(8) Bridge work	・Demolition/rebuilding ・Building
(3) Construction Zone III: Mejerda River Improvement (Upper)	
(1) Channel excavation work (widening)	
(2) Banking (protective dike) work	
(3) Bridge work	・Expanding/raising

(2) Construction Figures

The table below shows figures related to river construction and bridge construction:

Table 7-4 Quantities and Types of River Construction

Classification	Job Division	Works	Unit	River Improvement I	River Improvement II	River Improvement III	Total
Structural Measures	Length		Km	34.1	31.2	26.1	91.4
	River Improvement						
		Excavation	1000m3	5,659	2,361	2,048	10,068
		Embankment	1000m3	508	525	73	1,106
		Removal	1000m3	5,151	1,815	1,975	8,941
	River Facilities						
	El Mabtouh						
		Inflow Weir	Unit	-	1	-	1
		Discharge Control	Unit	-	1	-	1
		Outflow Gate	Unit	-	1	-	1
		Overflow Weir	Unit	-	1	-	1
	Mejerda River						
		Sluiceway	Unit	5	0	4	9
	Bridges			9	15	8	32
		Reconstruction	Bridge	2	6	2	10
		Construction	Bridge	0	3	0	3
		Raising	Bridge	1	0	1	2
		Demolish	Bridge	2	0	1	3
		No Measures	Bridge	4	6	4	14

Source: JICA Survey Team

7.1.4 Compensation Figures

(1) Acquiring Work Sites

At Construction Zone I and II, land acquisition cost is required for the expansion of river channel in the course of improving the Mejerda River. At the El Mabtouh retarding basin (Zone II), land acquisition is required to the new construction and expansion of discharge channel. Work site acquisition costs have been calculated based on the results of the plans devised during this Study.

Construction Zone II is divided into two (2) areas, state-owned land and private land (described in detail later in (2) 4) (c), Chapter 8: 8.2.2 Social Environment Survey Results, refer to Figure 8-8.), and state-owned land, so no acquisition is necessary. The area requiring land acquisition cost is shown on the Table below. Land for expansion of access road width is also required for bridge height increase. However, the latter is extremely smaller than land needed for the expansion of river channel and the Tunisia side is responsible for work site acquisition costs.

Table 7-5 Breakdown of Work Sites Acquisition Areas

Construction Zone	River Channel Width (m^2)	Expansion of Bridge Access Road Width (m^2)
Zone I	619,000	3,630
Zone II	1,254,800	1,910
Zone III	443,800	1,110
Subtotal	2,318,200	6,650
Total	2,324,850 m^2	

Source: JICA Survey Team

(2) House Compensation

Two houses will have to be moved to widen the river channel in the course of improving the Mejerda River. Loan money cannot be applied toward the money used for house compensation; the Tunisia side is responsible for the resulting cost.

Table 7-6 Resident Relocation Compensation Figures

Construction Zone, Distance Marker	House Compensation Area (m^2)
Zone I, 24.7 km (right bank)	150
Zone III, 46.5Km (left bank)	500

Source: JICA Survey Team

7.2 Construction Plan

7.2.1 Methods for Main Types of Construction

(1) Removing Trees/Roots (flood channel)

Tamarisk and reeds will be removed by hand and by machine. Removed tamarisk and reeds will be loaded into dump trucks by hand or by backhoes (with thumbs attached) and transported to a temporary dumping area (distance of one kilometer or less). Temporary dumping areas for tamarisk and reeds will be set up at one-kilometer intervals throughout construction zones. At temporary dumping areas, tamarisk and reeds will be fed through wood chippers, and the chips will be strewn about the slopes by machine to reuse them as vegetation base material. Roots will be dug out by bulldozers with rippers and piled up. Roots will be loaded into dump trucks by backhoes (with thumbs attached) and transported to temporary dumping areas. Roots will also be fed through wood chippers, finely chopped and strewn about the slopes by machine to reuse them as vegetation base material.

(2) Topsoil Scraping/Excavation (flood channels and slopes)

Bulldozers will scrape the topsoil from the tops of slopes toward the bottoms efficiently (30-50 centimeters thick). Then, the bulldozers will scrape 30-50 centimeters of topsoil from the flood channel and pile it up every 100 meters or so along the flood channel. That dirt will be transported to dumping areas within a distance three kilometers by wheel loaders or dump trucks. After topsoil scraping, bulldozers will excavate again in the same order and pile up that dirt along the flood channel in the same way as in the topsoil scraping. That dirt will be piled up every 100 meters or so along the flood channel and then transported to embankments by wheel loaders or dump trucks. After excavation, the bulldozers will shape the slopes by compacting them and shape the flood channel (keeping drainage in mind and making slopes drain in the direction of the channel).

(3) Banking

Areas to be banked will be split into 50-meter zones. First, bulldozers will scrape topsoil and transport that soil to dumping areas. After the topsoil has been scraped, bulldozers will transport dirt excavated from the flood channel, compact the dirt to a thickness of 35 centimeters with rollers, and finish the banks to a thickness of 30 centimeters. Then, after it has been compacted by bulldozers, the soil will be re-compacted with tire rollers.

After piling up embankments to the requisite height, backhoes will compact and shape their slopes and crowns.

(4) Concrete Slope Cribwork and Bed Protection Work as Part of Protective Dike Work

Slopes will be excavated to the requisite locations by bulldozers (backhoes) and then concrete slope cribwork will be done, followed by the laying of siphon prevention material and foundational broken stone. Next, slope cribwork will be filled by backhoes with natural stones (30-50 centimeters) transported to the sites.

At work yards, gabions will be stuffed with riprap by backhoes and lowered by cranes into the river channel, excavated to the requisite cross section by backhoes.

(5) Expanding El Mabtouh Retarding Basin, Excavating Low Channels

Construction in channels will start after water is pumped out of them by submersible pump and their insides dried to the extent possible.

Reeds inside channels will be removed along with their roots, piled up temporarily and transported to disposal areas.

Channels will be excavated by backhoes to expand them, and the dirt will be loaded into dump trucks and transported to places in the retarding basin or along the main river where banking will occur. Soil that contains moisture and is unfit for use in banking will be piled up temporarily so that it can dry.

(6) Banking in El Mabtouh Retarding Basin

Before building embankments, topsoil at banking locations will be scraped and banking soil prepared. Soil excavated from the vicinity will be used for banking. Bulldozers will be used to roll banks to a thickness of 35 centimeters, and then finished by compaction to a thickness of 30 centimeters. Then, banks will be compacted with tire rollers.

Areas to be banked will be split into 50-meter zones, and slopes will be shaped into straight banks by backhoes to finish them.

(7) El Mabtouh Retarding Basin, Flow Control Facilities, Overflow Dike, etc.

In principle, structural work will be done during the dry season. Work will be done on excavation surfaces with lower water levels, and sumping and cofferdam work with sandbags and such will be done at the same time.

Most excavation will be done by backhoes, and foundation excavation and leveling will be done by hand. Open excavation will be done on slope surfaces and the bottoms of foundations will be leveled and compacted. Then, they will be filled with riprap and chippings, compacted, and covered with blinding concrete.

Concrete will be poured by chute, crane or pump truck. Ready-mix concrete will be purchased from a manufacturer in the area.

(8) Bridge Construction, Replacement

Class A bridges all currently exist and are located along primary roads, so they will be demolished after traffic is detoured to temporary bridges. After the existing bridges are demolished, foundation piles will be driven in requisite positions, abutments and bridge frames will be built, and then girders will be installed. Girders will be manufactured at nearby yards, transported to bridge sites by truck and installed by crane.

Box culverts will be cast in place to create Class B bridges. In places where a bridge already exists, traffic will be detoured and the existing bridge demolished before box culverts are cast.

(9) Bridge Jacking, Expansion

Traffic will be detoured to temporary bridges. Main girders will be lifted temporarily off spans over which the bridge is to be jacked up or expanded, and jacks will be used to raise bridges to the requisite height. For expansion, girders for additional spans will be manufactured at nearby yards while the additional substructure is being built, transported to bridge sites by truck and installed by crane.

7.2.2 Construction Plan

(1) Construction Plan (Main Construction)

1) Preparation Work

Preparation work involves making arrangements for the main construction. Whether it is done properly or not has a huge effect on the efficiency, quality, economic efficiency and schedule of the construction. It is an extremely important part of proper construction management.

2) Preparatory Surveying (Groundbreaking Survey)

Before construction starts, preparatory surveying is done to verify compliance with design drawings. If preparatory surveying reveals inconsistencies with design drawings, the causes of those inconsistencies will be surveyed and proper actions taken promptly.

a. Setting Water Level Markers

Temporary water level markers will be set up using distance markers or the foundations of structures and other immovable objects. When such objects are not usable, temporary water level markers will be installed. They will be set up outside of construction areas on solid ground where there is no chance that they will be compromised by general traffic, and they require proper protection.

Positions of temporary water level markers will be determined by measuring the water level at existing water level markers and confirming positions by referencing at least one other existing water marker; temporary water markers cannot be placed unless this confirmation is done.

b. Setting Temporary Coordinates

Coordinate markers will be set up in addition to distance markers where necessary. As with the temporary water level markers, they will be set up outside of construction areas. These temporary markers will be placed upon confirming the positions of river structures and such with reference to design drawings.

Boundary markers and water survey markers will be verified before any measuring work is done. Boundary markers may be broken, removed or become lost if there is a time lapse between work site acquisition and start of construction, resulting in discrepancies. Thus, markers need to be verified to make sure that they are in the correct positions. In addition, implementing agencies must be consulted and proper measures taken before repositioning existing distance markers or water level markers when construction requires them to be repositioned.

3) Grade Stakes

Grade stakes serve as references in the course of working on structures and must remain in place during construction. They must be inspected regularly and verified and corrected when doubts exist.

As a rule, grade stakes will be placed at 10-meter intervals on straight reaches of the channel and at five-meter intervals on curved and other complicated reaches, but it is best to place them at closer intervals when necessary.

4) Drainage Earthwork

Drainage for earthwork includes draining spring water, standing water, groundwater and rainwater at excavation sites and expansion sites in construction areas and on transportation routes. Problems with drainage in civil engineering work carried out by machines are very closely related to the efficiency and quality of the work, so the most up-to-date considerations must be given to draining construction areas.

Unlined drainage ditches will be dug to drain standing water and other surface water to areas outside banks. Most situations do not call for large-scale drainage facilities; construction methods, sequences and the progression of the schedule should account for drainage, and a flexible approach is needed to account for the weather.

5) Procedures for Related Laws, Regulations and Agencies

When work permits are needed prior to beginning construction, procedures for related agencies must be carried out promptly with the number of days required for prior deliberations taken into account.

(2) Construction Plan (Temporary Works)

1) Construction Roads

General, primary roads will be used as construction roads, and new construction roads will also be built. Construction roads will be 4.0 meters wide within the banks of the river. Broken stone will be laid to a thickness of 20-30 centimeters to create roadbeds fully capable of supporting dump trucks.

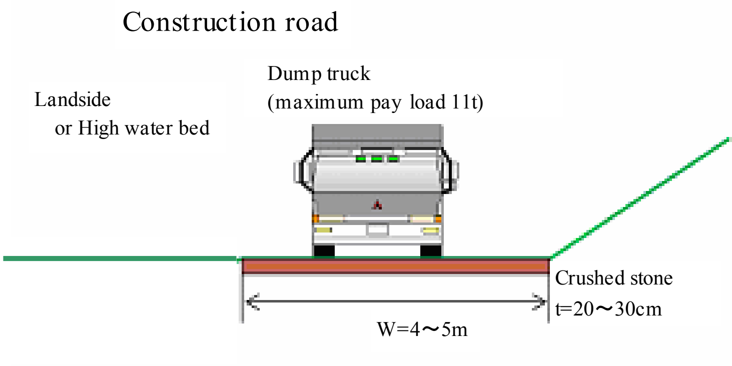
When building sloped construction roads from the crowns of dikes toward the river, dirt will be piled up above and outside the cross sections of the straight slopes of the dikes, and such roads will face downstream. One-lane roads will feature turnouts if traffic volume during the construction period requires them.

New, temporary dirt roads meant to cross flood channels will be built to extremely low heights so that they do not inhibit the flow of floodwaters. When there is no choice but to build them tall, they will be demolished or otherwise taken care of during flood season.

When construction roads require temporary bridges to cross channels or the river, the height, direction and structure of the bridges will be determined upon investigation of river conditions, construction scale and construction periods.

Steel plates will be placed as necessary to ensure traffic ability of construction roads and within construction areas.

When building detour roads outside of construction areas, consideration must be given such that the construction itself is not inhibited and also that road capacity does not suffer. Implementing agencies must be consulted to set up safety facilities and signage as the situation demands.



Source: JICA Survey Team

Figure 7-2: Construction Road

2) Temporary Facilities

There are two types of temporary facilities; those directly related to construction and those indirectly related.

a. Directly Related Temporary Facilities

1) Rebar/Formwork

Rebar and formwork fabrication yards are temporary facilities related to concrete. Permanent roofs must be installed over the yards to prevent exposure to rain and sunlight.

2) Machinery, Heavy Machinery

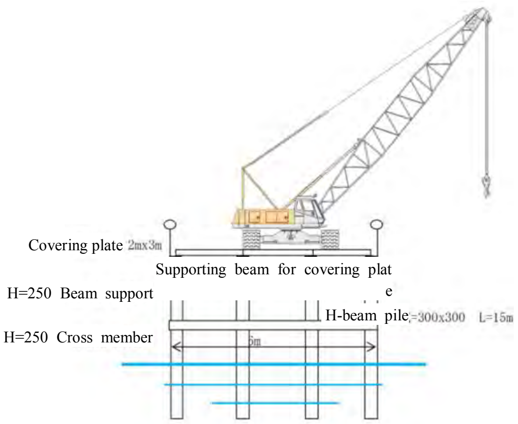
Repair shops for maintaining, inspecting and repairing machinery and heavy machinery are required. As with the yards above, these shops must have permanent roofs to prevent exposure to rain and sunlight. Particular care must be taken to set aside places to store fuels and oils used.

3) Temporary Bridges

Temporary bridges will be built to detour traffic around bridge construction.

4) Temporary Docks

Temporary docks will be built to build and install pier foundations and PC girders.



Source: JICA Survey Team

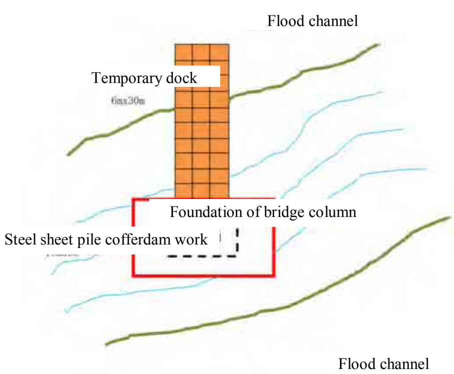
Figure 7-3: Temporary Docks

5) Jacking Work

Steel cradles that have steel H-piles or other temporary piles will be placed beneath each girder, and jacks placed atop the cradles will be used to jack up the existing superstructure. The same method will be used for temporary lifting employed during bridge expansion.

6) Steel Sheet Pile Cofferdams

Steel sheet pile cofferdams will be installed when cast-in-place pile work and substructure framework are done in the part of the river that flows.

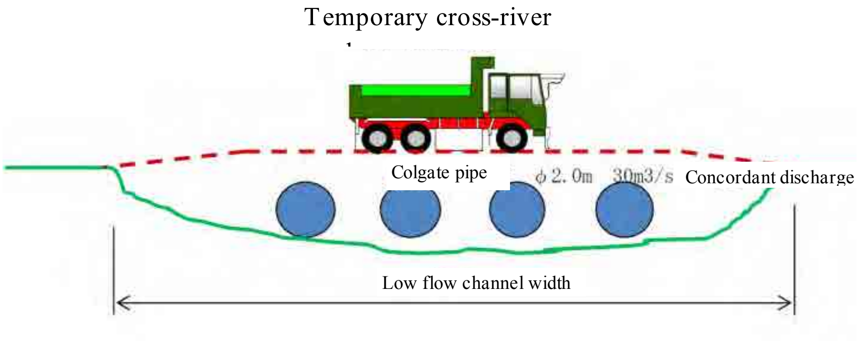


Source: JICA Survey Team

Figure 7-4 Bankup by Steel Sheet Pile

7) River-Crossing Roads

Corrugated pipes, large sandbags and excavation soil will be used to build construction roads that cross the river to ensure that the river can be crossed during construction.



Source: JICA Survey Team

Figure 7-5 Construction Road for River-Crossing

8) Cofferdam Work for Overflow Dike, Diversion Facilities

Large sandbags will be used to build cofferdams for foundation work during the dry season.

9) Drainage Work

Pumps will be used to drain spring water and other water that appears after cofferdams are built.

10) Dumping Areas

Dumping areas will be set up every four kilometers along embankments and will be 200 m x 300 m x 1 m.

b. Indirectly Related Temporary Facilities

1) Offices, Laboratories, Storehouses, Garages

Offices, laboratories, storehouses, garages, oil and fuel storage and transformer stations will be built within construction areas and as part of the construction schedule. Related laws and regulations will be observed as these facilities are built. Particular care must be taken to prevent theft when handling hazardous materials. These facilities will not be built outside the banks.

2) Lodging

Lodging will be built to accommodate the number of workers. Care must be taken to observe related laws and regulations and prevent pollution to the environment as these facilities are built. These facilities will not be built outside the banks.

3) Electricity

Power supply facilities on work sites are required to provide electricity for machinery facilities, construction lighting, water supply and drainage, cut-and-cover and office lighting.

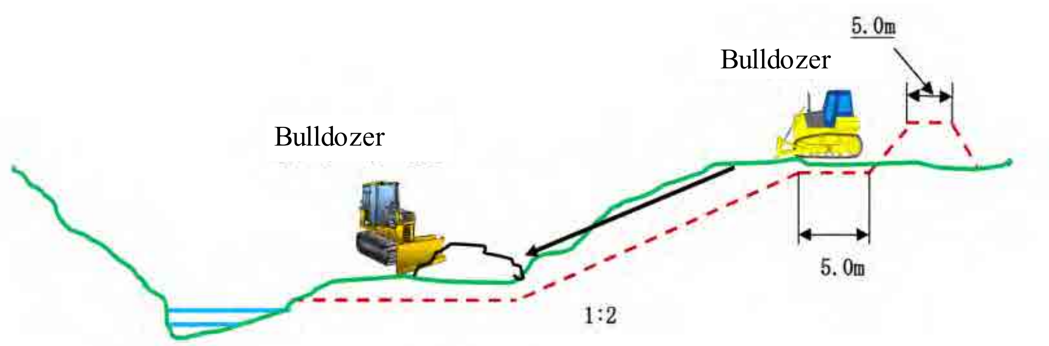
(3) Excavation and Transportation

1) Excavation

a. Bank excavation will be done by bulldozers from crown to foot.

b. The flood channel will be excavated after slope excavation is complete.

c. Dirt will be piled up in the flood channel.

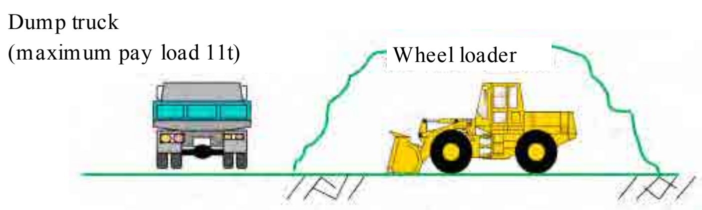


Source: JICA Survey Team

Figure 7-6 Excavation

2) Loading and Transportation

Excavated dirt piled up in the flood channel will be loaded into dump trucks by wheel loaders. The dirt will be transported to embankments or to dumping areas based on dirt transportation plans.

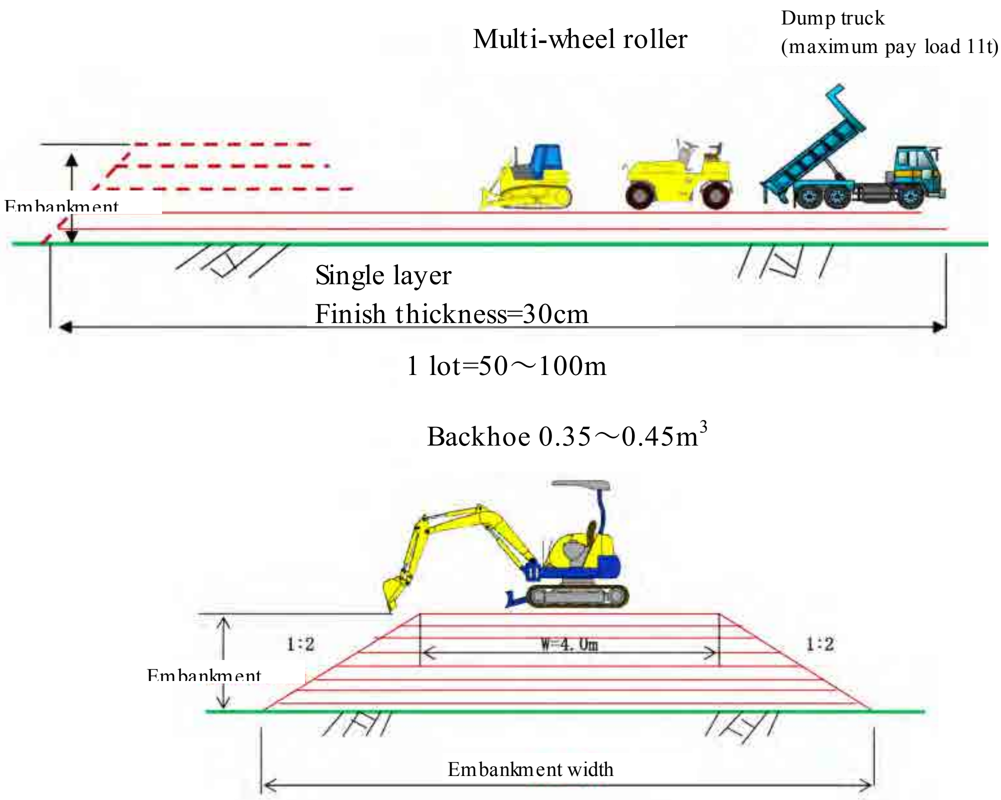


Source: JICA Survey Team

Figure 7-7 Loading and Transportation

(4) Banking

Dirt transported from the flood channel by dump trucks will be dumped in places where embankments are planned and compacted by bulldozers. Then, it will be re-compacted with tire rollers. It will be rolled to a thickness of 35 centimeters and finished to a thickness of 30 centimeters. Banking work will be done in 50- to 100-meter segments. After dirt is piled up, slopes will be shaped and compacted by backhoes. (See figure below)



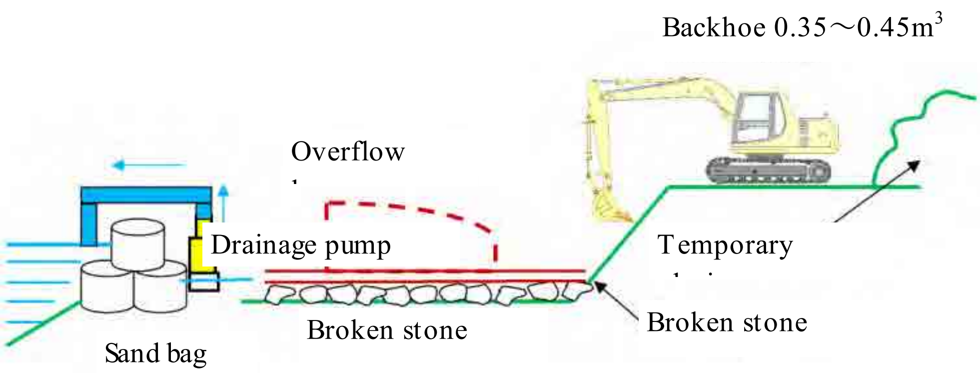
Source: JICA Survey Team

Figure 7-8 Banking

(5) Structure Construction (Diversion Facilities, Overflow Dike, etc.)

a. Structure Foundation Excavation

Cofferdams made of large sandbags will be built around areas to be excavated below the level of the river. If spring water appears, pumps will be used to drain it. After excavation is complete, dirt will be spread to the requisite dimensions and compacted. Then, riprap and chippings will be spread in that order and compacted to the requisite thickness.

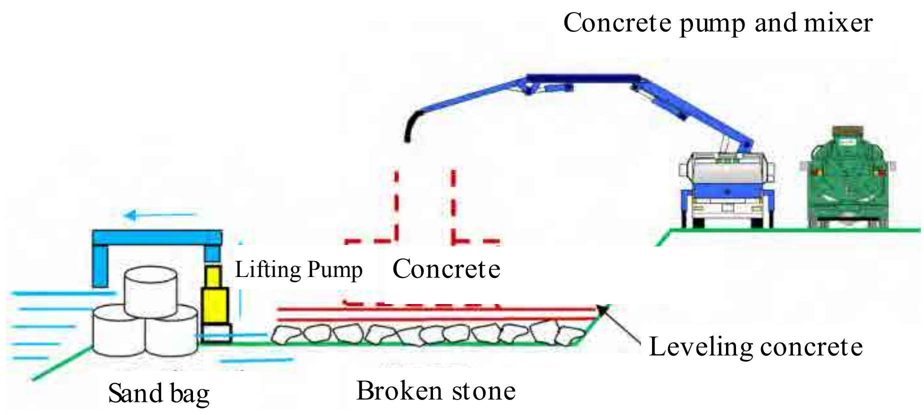


Source: JICA Survey Team

Figure 7-9 Structure Foundation Excavation

b. Pouring Concrete for Structures

Chutes will be used to pour concrete when the distance is short, cranes will be used when there is distance or height to be reckoned with, and pumps will be used when large amounts of concrete are to be poured at an isolated location.



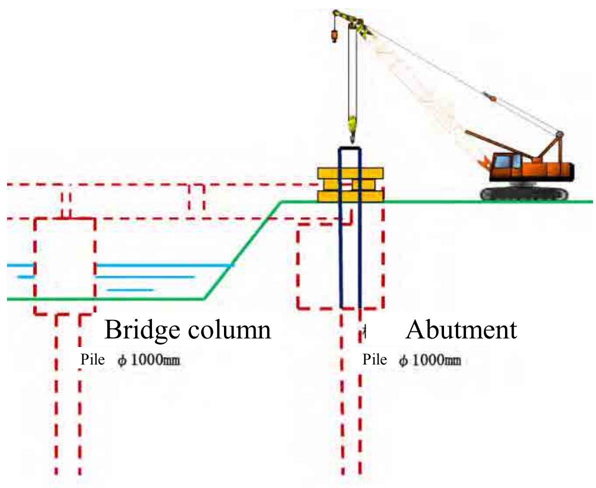
Source: JICA Survey Team

Figure 7-10 Pouring Concrete for Structures

(6) Bridge Work

a. Cast-in-Place Piles

An auger will be used to excavate to the requisite depth while the borehole walls are protected with a bentonite slurry. A crane will be used to raise a reinforced frame, and concrete will be poured from the pile tips up through a tremie pipe. The bentonite will be circulated and reused repeatedly.

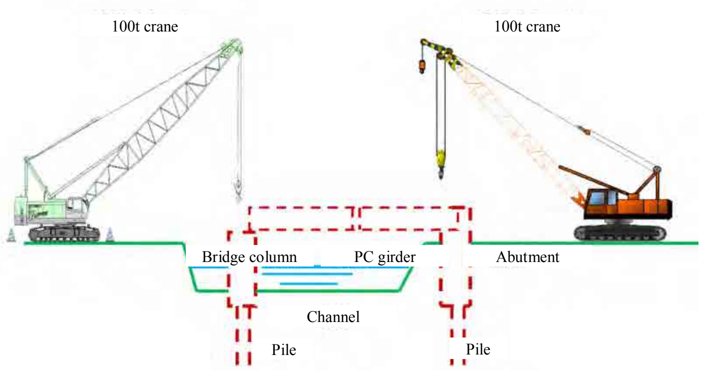


Source: JICA Survey Team

Figure 7-11 Cast-in-Place Pile Work

b. PC Girder Installation (Using Cranes)

Crossbeams will be cast in place and joined to main girders after cranes have lowered them to the requisite positions.



Source: JICA Survey Team

Figure 7-12 PC Girder Installation

c. Bridge Jacking

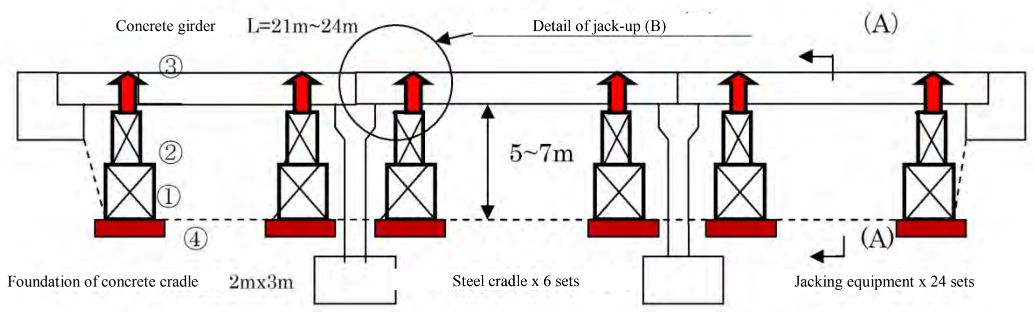
Reinforcement work on existing bridges will be completed and, depending on the condition of the ground, temporary piles or steel cradles on top of foundation concrete will be set up before jacking up bridges.

After setting up steel cradles, jacks will be placed atop the cradles to support each main girder and devices required to operate the jacks will be arranged. The figure below is an example of this setup on a three-span bridge.

Jacking Equipment Arrangement and Number of Cradles

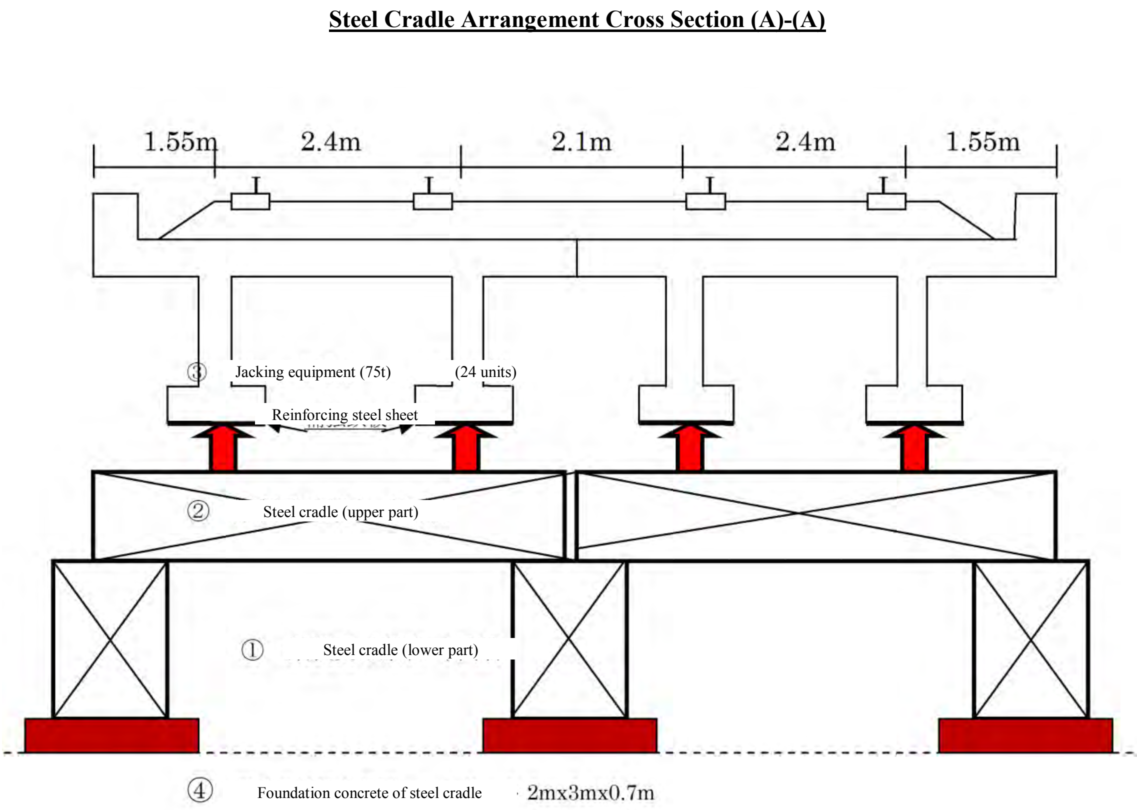
A set of six steel cradles is required to jack up a three-span bridge. There are 12 girders, so 24 jacks are required. A set of three pump units to connect to the jacks is required.

① Steel Cradle (Lower) 1.0t each	Total 18 cradles	18t
② Steel Cradle (Upper) 2.5t each	Total 18 cradles	30t
③ Jack 75t	Total 24 jacks	
④ Steel Cradle Foundation Concrete	Total 18 foundations	76 m^3



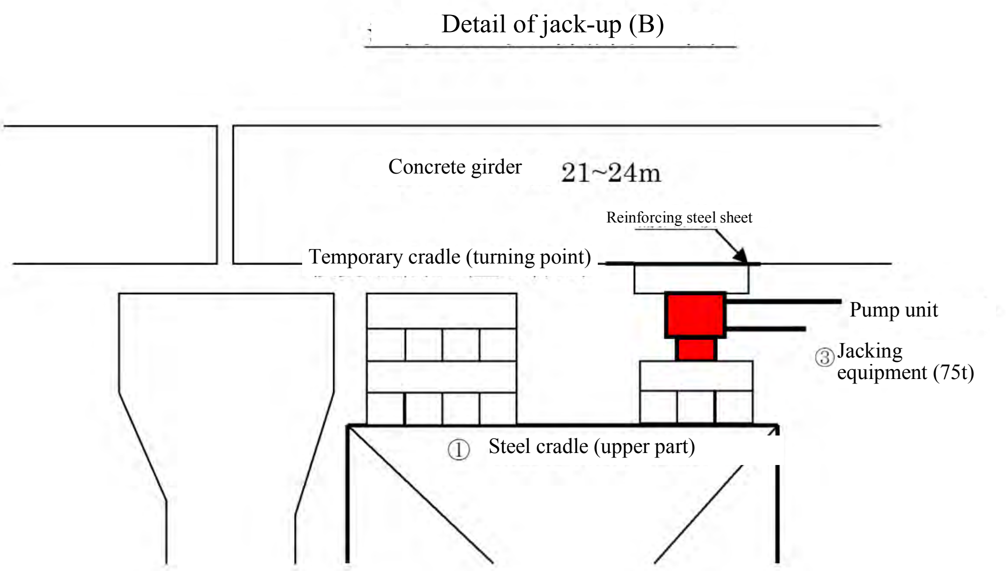
Source: JICA Survey Team

Figure 7-13 Example of Jacking Equipment, Cradle Arrangement for Bridge Jacking



Source: JICA Survey Team

Figure 7-14 Example of Jack Arrangement for Bridge Jacking (Cross Section)



Source: JICA Survey Team

Figure 7-15 Example of Jack Arrangement for Bridge Jacking (Detailed Drawing)

(7) Borrow Areas/Dumping Areas/Vegetation Dumping Areas

a. Borrow Areas

This construction requires protective dike materials (diameter 30-50 cm), broken stone for concrete (5-25 mm) and construction road crusher materials (0-30 mm), but there is no need to develop them anew; they will be procured from existing quarries. Quarries are located in Tebla and Sebala on the outskirts of Tunis. Materials will be transported from Tebla in the upper basin (about 5-10 kilometers) and from Sebala in the lower basin (12-14 kilometers).

There is no need to develop new borrowed areas because the excavated soil from the river and from the retarding basin is enough for the embankments.

b. Dumping Area

According to the site survey, confirmed candidates of dumping area are the following three locations. Since the surplus earth acceptable amount at the three sites becomes 13,825Km^3, processing of 7,931Km^3 surplus earth generated by the use is capable.

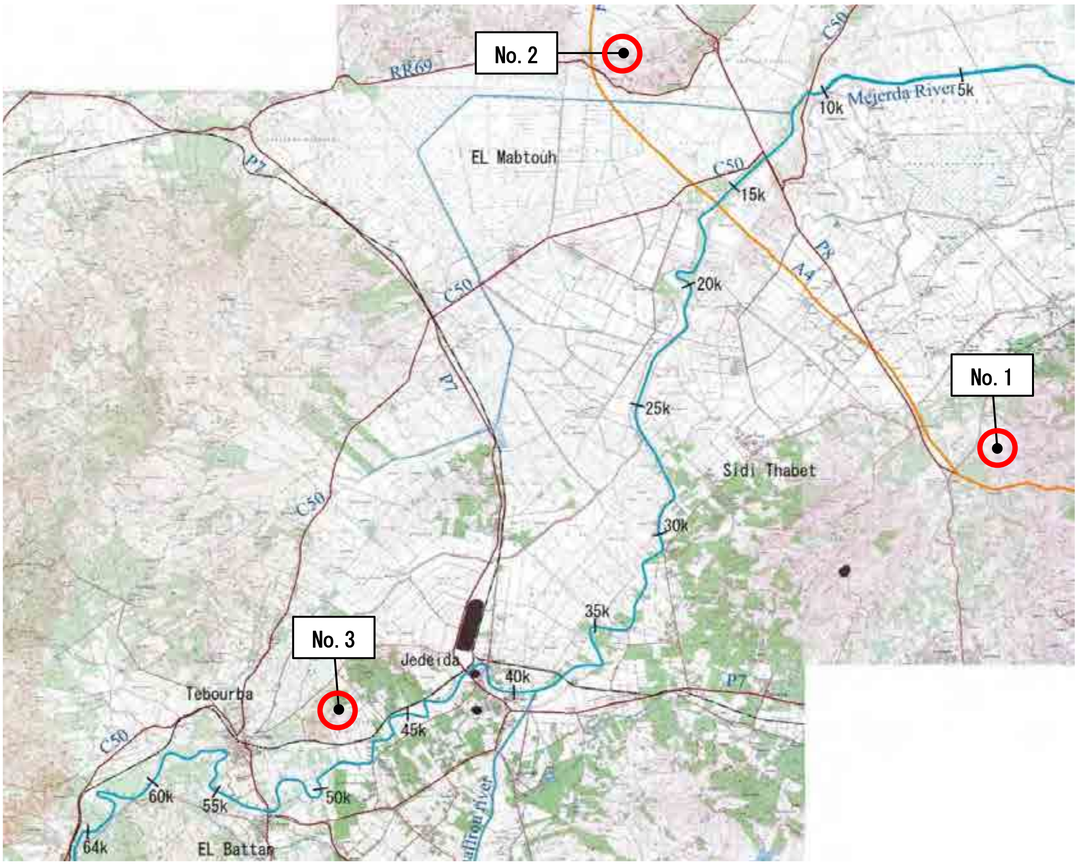


Figure 7-16: Candidates for Dumping Area

Table 7-7 Candidates for Dumping Area-1

Location	Nali, Ariana Governorate	Current Application	Empty Lot of Quarry/Soil Sampling
Capacity	6,950Km^3	● Calculated by Measured Area x Banking Height, 20m (value at hearing) from Map	
Full View Photo			
Current Photo			

Table 7-8 Candidates for Dumping Area-2

Location	Express Way Side in Bizerte Governorate	Current Application	Empty Lot of Soil Sampling for Express Way
Capacity	675Km^3	● Calculated by Measured Area x Banking Height, 5m (value at hearing) from Map	
Full View Photo			

Current Photo		

Table 7-9 Candidates for Dumping Area-3

Location	Charofi, Aiyari in Manouba Governorate	Current Application	Quarry/Soil Sampling Site
Capacity	6,200Km^3	● Calculated by Measured Area x Banking Height, 20m (value at hearing) from Map	
Full View Photo			
Current Photo			

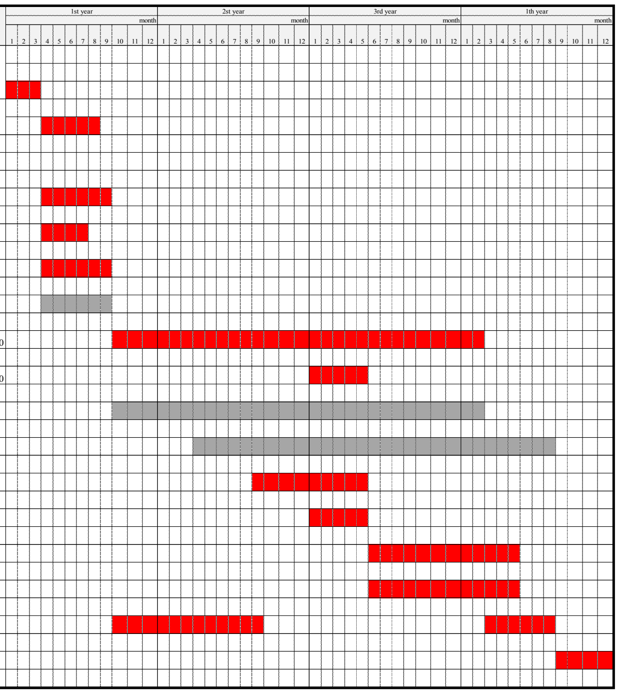
c. Vegetation Dumping Areas

Branches and roots will be shredded at vegetation dumping areas and reused as vegetation base material on slopes. They will be strewn about the slopes by spraying machines.

The table below shows the work schedule based on the construction plans above. The construction is expected to take four years.

Table 7-10 River Construction Zone I Work Schedule

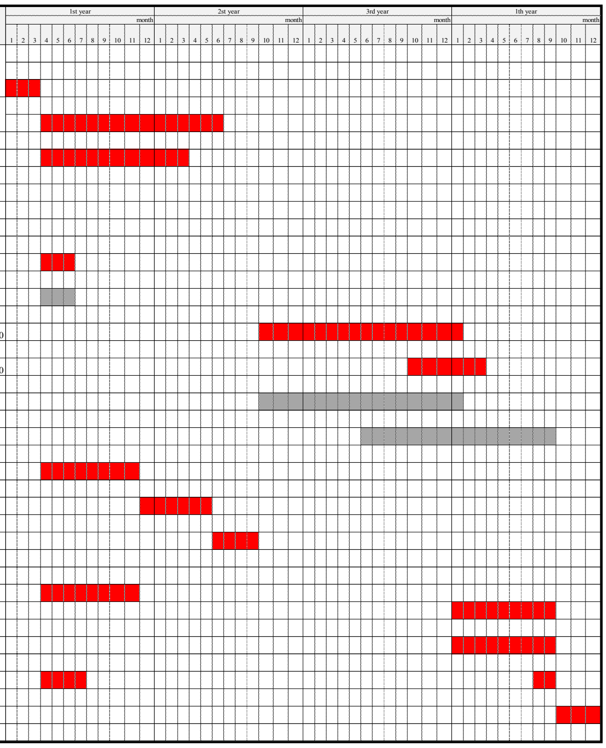
Job division	Type of works	Classification	BQ		Daily workload		Party formation	Number of days	Number of available day
River improvement I									
-1	Prelimanary work	Prelimanary work	1	LS					
-2	Bridge works	Reconstruction	1	Bridge	-		5M/B		
		New construction	0	Bridge	-		4M/B		
		Extension/Raising	2	Bridge	-		3M/B		
		Removal	2	Bridge	-		2M/B		
-3	Earth works	Clearing and grubbing(tama	2,470,614	m^2	-	m^2/day			
		Stripping	2,470,614	m^2	-	m^2/day			
		Excavation	6,987,235	m^3	300	m^3/day	41	568	860
		Embankment	391,495	m^3	690	m^3/day	7	81	130
		Trimming of slope	1,141,129	m^2	-	m^2/day			
		Surplus soil disporsal	6,595,740	m^3	-	m^3/day			
-4	Sluice way works	Main body	6	Num	-		3M/N		
		Gate works	6	Num	-		3M/N		
-5	Service road works	Asphalt pavement	10,239	m^3	-	m^3/day			
		Course base	40,956	m^3	-	m^3/day			
-6	Temporary construction roa	Crushed rock	54,608	m^3	-	m^3/day			
-7	Clearance work	Clearance work	1	LS					



Source: JICA Survey Team

Table 7-11 River Construction Zone II Work Schedule

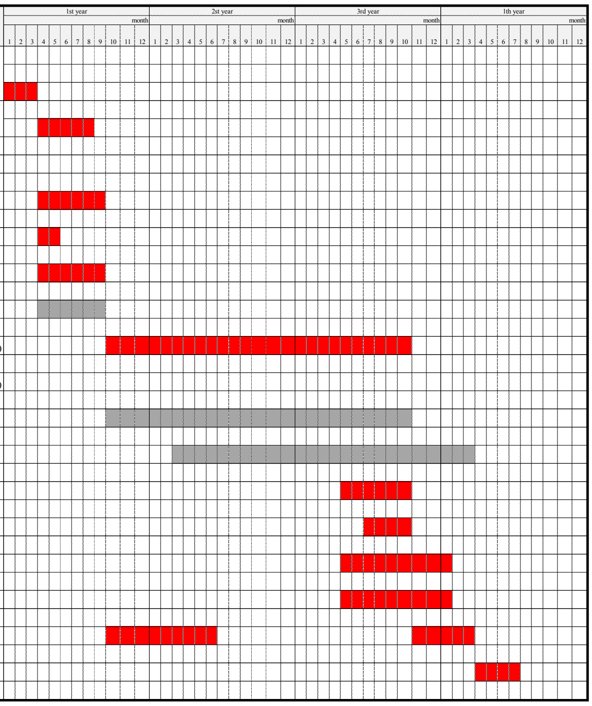
Job division	Type of works	Classification	BQ		Daily workload		Party formation	Number of days	Number of available day
River improvement II									
-1	Prelimanary work	Prelimanary work	1	Lump sum					
-2	Bridge works	Reconstruction	6	Bridge	-		5M/B		
		New construction	3	Bridge	-		4M/B		
		Extension/Raising	0	Bridge	-		3M/B		
		Removal	0	Bridge	-		2M/B		
-3	Earth works	Clearing and grubbing(tama	10,000	m^2	-	m^2/day			
		Stripping	10,000	m^2	-	m^2/day			
		Excavation	2,330,935	m^3	300	m^3/day	25	310	470
		Embankment	524,666	m^3	690	m^3/day	7	108	170
		Trimming of slope	501,893	m^2	-	m^2/day			
		Surplus soil disporsal	1,806,269	m^3	-	m^3/day			
-4	Facility works	Sluicing outlet works	1	Num					
		Contorol gate works	1	Num					
		Overflow weir	1	Num					
		Inlet overflow dike	1	Num					
-5	Service road works	Asphalt pavement	7,452	m^3	-	m^3/day			
		Course base	29,808	m^3	-	m^3/day			
-6	Temporary construction roa	Crushed rock	19,872	m^3	-	m^3/day			
-7	Clearance work	Clearance work	1	LS					



Source: JICA Survey Team

Table 7-12 River Construction Zone III Work Schedule

Job division	Type of works	Classification	BQ		Daily workload		Party formation	Number of days	Number of available day
River improvement III									
-1	Prelimanary work	Prelimanary work	1	LS					
-2	Bridge works	Reconstruction	1	Bridge	-		5M/B		
		New construction	0	Bridge	-		4M/B		
		Extension/Raising	2	Bridge	-		3M/B		
		Removal	1	Bridge	-		2M/B		
-3	Earth works	Clearing and grubbing(tama	2,371,908	m^2	-	m^2/day			
		Stripping	2,371,908	m^2	-	m^2/day			
		Excavation	6,039,726	m^3	300	m^3/day	41	491	740
		Embankment	0	m^3	690	m^3/day	7	0	0
		Trimming of slope	952,952	m^2	-	m^2/day			
		Surplus soil disporsal	6,039,726	m^3	-	m^3/day			
-4	Sluice way works	Main body	4	Num	-		3M/N		
		Gate works	4	Num	-		3M/N		
-5	Service road works	Asphalt pavement	7,854	m^3	-	m^3/day			
		Course base	31,416	m^3	-	m^3/day			
-6	Temporary construction roa	Crushed rock	41,888	m^3	-	m^3/day			
-7	Clearance work	Clearance work	1	LS					



Source: JICA Survey Team

7.3 Project Cost Estimation

7.3.1 Project Cost Estimation System

The system below was used to estimate the cost of the Mejerda River Improvement Project:

(A) Direct construction cost

(B) Consulting service (CS) cost (cumulative)

(C) Work site compensation cost (cumulative)

(D) Administrative cost (5% of total project cost)

(E) Price increase (foreign currency: 2.1%, domestic currency: 0.2%)

(F) Reserves (5%)

(G) Taxes (VAT: 18%)

(A) Direct Construction Cost (Direct Cost, Base Cost for Construction)

National standards for estimating costs do not exist in Tunisia, so direct construction costs were calculated based on work items in 6.1.3 Construction Figures and on the unit prices in 6.1.4. The unit price for each type of construction was set based on bidding prices on past projects implemented by the Ministry of Agriculture (MA) and on recent market price construction within Tunisia.

Also, according to interviews with the Ministry of Agriculture and local construction workers, most of the required materials, equipment and workforce can be procured from within Tunisia.

(B) Consulting Service Cost

The consulting service consists of the following and is calculated by multiplying the cost per engineer by the required man-month (MM).

1) Detailed design of river improvement and non-structure measures and bidding preparation for it

Costs for measurements required for detail design and other supplemental surveys, river improvement and bridges associated with improvement based on measurements, detail designs for river structures and auxiliary structures, drawing preparation, quantity estimation and the project are calculated. Also, tender documents will be prepared and assistance provided for bidding based on the results of detail design.

As for non-structures, dam flood management system, evaluation and flood disaster prevention, as well as organization strengthening and capability development are planned and their detailed design is produced.

Bidding document is prepared and bidding is supported based on detailed design results.

2) Construction Management in Construction Zones I, II and III

The following construction management in the three construction zones is performed: schedule control, quality control, performance management, environmental management, health and safety management, and handling of complaints from construction companies.

3) Handling of non-structures

Consulting service on dam flood control system, evacuation and flood prevention plan, as well as organization strengthening and capability development is performed based on the detailed design.

(C) Compensation Cost

1) Site Acquisition Cost

Work sites need to be acquired in the course of improving the Mejerda River. Site acquisition cost was calculated based on the plans developed from this Study. Construction Zone II is state-owned land, so no acquisition is necessary.

2) House Compensation Cost

Houses to be relocated will be recorded in the course of improving the Mejerda River.

(D) Administrative Cost

Administrative cost to the owners of this project of 5% of total project cost will be recorded.

(E) Inflation Costs (annual rate)

Inflation of 2.1% for foreign currency and 0.2% for domestic currency indicated by JICA will be recorded.

(F) Contingency

Contingency was reported as a uniform 5% of price increases for foreign and domestic currency.

(G) Tariffs/Taxes

Customs duties/ Value Added Tax (VAT) were set as 18%. The customs duties are exempted and the tax will be returned within 45 days after submission of receipt for the procured material to MA.

a. Exchange rates: 1 USD = 1.61 TND = 79.0 JPY
   1 TND = 49.0 JPY (November 6, 2012)
b. Currency composition: Local Currency Portion (__)
   Foreign Currency Portion (__)
c. Interesrt: construction: 1.7%, consultants: 0.01%
d. Commitment charge: 0.1%

(H) Project Taking-over and Defect Liability

The Project shall be taken over at the completion of construction.

As for the bond, the term of the performance security (bond) shall be until the construction completion and defect correction, and thus it applies also during the defect period. (Standard Bidding Documents Under Japanese ODA Loans, Procurement of Works, JICA, October 2012)

7.3.2 Project Cost Unit Price Estimation

The following unit price charts were used to calculate the cost of the Mejerda River Improvement Project. The construction unit price for each construction sort is set referring to the bit price for past project conducted by MA (Ministry of Agriculture) or market construction cost in Tunisia, and the division of foreign and local currencies of the unit price (FC, LC) is determined by the unit price of work type in reference to the following ratio used in the SAPROF (Special Assistance for Project Formation) survey of JBIC and JICA provided by the Ministry of Agriculture (MA).

Table 7-13 Ratio of Foreign and Local Currencies by Work Type (JBIC, SAPROF)
(JBIC,SAPROF)

Description	Foreign currency (%)	Local Currency (%)
1.Transmission Pipeline		
1)Transportation of PC and fitting	70	30
2)Earthworks	70	30
3)Pipe installation and test	60	40
4)Civil works including building works	60	40
5)Installation of hydro-mechanical equipment & fitting	70	30
6)Other minor works	50	50
7)Supply of hydro-technical and fitting	90	10
8)Supply of PC pipes & fitting	55	45
9)Supply of Vehicle	95	5
2.Pump Station		
1)Transportation of PC and fitting	70	30
2)Earthworks	70	30
3)PC Pipe installation	60	40
4)Civil works including building works	60	40
5)Other minor works	50	50
6)Supply and Installation of pumping equipment	85	15
7)Supply of PC pipes & fitting	55	45

Source: Foreign and local currency portions applied in 1995 and in 2003 for the SAPROF studies of projects financed by JBIC and JICA (Ministry of Agriculture)

Table 7-14 Unit Prices for Construction Cost Estimation (1)

No	item	unit	Unit Price			Ratio		Remarks
			Foreign	Local	Total	Foreign	Local	
			yen	TND	TND	%	%	
Earth work excavation								
100	clearing and grubbing (tamarix φ20cm>)	unit	2998	21.7	82.9	70	30	
101	clearing and grubbing (tamarix φ10-20cm)	unit	1766	12.7	48.7	70	30	
102	clearing and grubbing (tamarix φ10cm<)	m2	85.5	0.63	2.37	70	30	
103	Stripping t=0.5m	m2	53.2	0.38	1.47	70	30	
104	branch cutting	day	67382	486	1861	70	30	
105	plant spraying	day	39376	285	1089	70	30	
106	filling materials transport	m3km	23.4	0.17	0.65	70	30	
107	trimming of slope	m2	204	1.47	5.63	70	30	
108	temporary drainage(pump,generator)	day	40573	294	1122	70	30	
109	Surplus soil disporsal	m3	70.2	0.51	1.94	70	30	
Excavation								
201	Excavation for river common soil (with average hauling distance of 1km)	m3	152	1.1	4.2	70	30	
202	excavation (common soil)	m3	238	1.73	6.59	70	30	
203	Excavation for river loose sand (with average hauling distance of 1km)	m3	720	5.21	19.9	70	30	
204	Excavation for river hard soil (with average hauling distance of 1km)	m3	720	5.21	19.9	70	30	
205	Excavation for river rock (with average hauling distance of 1km)	m3	825	5.96	22.8	70	30	
Earth work filling(dike)								
301	Stripping	m3	84.9	0.62	2.35	70	30	
302	fill granding t=0.35m	m3	93.4	0.68	2.59	70	30	
303	Backfill surrounding structures due to excavation	m3	284	2.06	7.86	70	30	
304	gabion	m3	4315	31.2	119	70	30	
305	drainage(t=0.15m)	m3	1431	10.4	39.6	70	30	
306	geotextile	m2	499	3.6	13.8	70	30	
307	riprap(l=5.5m,t=1.0m)	m2	1219	8.81	33.7	70	30	
308	foot protection(w=1.5m,h=1.0m)	m2	1219	8.81	33.7	70	30	
Road construction								
401	approach road subgrade	m2	117	0.84	3.23	70	30	
402	approach road lower subbase	m3	1324	9.6	36.6	70	30	
403	approach road upper subbase	m3	1484	10.7	41	70	30	
404	approach road asphalt pavement	m3	14242	103	394	70	30	
405	temporary construction road	m3	1329	9.6	36.7	70	30	

Table 7-15 Unit Prices for Construction Cost Estimation (2)

No	item	unit	Unit Price			Ratio		Remarks
			Foreign	Local	Total	Foreign	Local	
			yen	TND	TND	%	%	
Main body works								
501	Scaffolding	m2	147	19	22	70	30	
502	Support	m3	147	20	23	70	30	
503	φ500 Concrete pile L=10m	pile	76660	554	2118	70	30	
504	φ500 Concrete pile L=25m	pile	191650	1385	5296	70	30	
Gate works								
601	Service bridge	m2	34300	300	1000	70	30	
602	Electric works	set	686000	6000	20000	70	30	
Contorol house works								
701	RC House	m2	51450	450	1500	70	30	
Appurtenant works								
801	Foundation work	m	3209.16	23.171	88.7	70	30	
802	Step works	m2	4096.8	29.58	113	70	30	
Concrete								
901	floor slab concrete c=400kg	m3	7498	54.2	207	70	30	
902	abutment/pier base concrete c=350kg	m3	6828	49.3	189	70	30	
903	blinding concrete c=200kg	m3	5361	38.7	148	70	30	
904	break concrete	m3	6661	48.1	184	70	30	
905	train bridge demolish work	t	2843	20.5	78.5	70	30	
Form								
1001	form C1	m2	1223	8.84	33.8	70	30	
1002	form C2	m2	1550	11.2	42.8	70	30	
1003	form C3	m2	2058	14.9	56.9	70	30	
1004	curb form adding fee	m2	465	3.36	12.8	70	30	
Rebar								
209	reinforcement	kg	104	0.76	2.88	70	30	

Table 7-16 Unit Prices for Construction Cost Estimation (3)

No	item	unit	Unit Price			Ratio		Remarks
			Foreign	Local	Total	Foreign	Local	
			yen	TND	TND	%	%	
Concrete constructure								
1101	Centrifugal reinforced concrete pipe 0.4m<φ<0.8m	ml	7917	57.2	219	70	30	
1102	PC Ibeam(L=35m)	unit	4051211	29274	111952	70	30	
1103	PC Ibeam(L=29.8m)	unit	3424242	24745	94627	70	30	
1104	PC Ibeam(L=30m)	unit	3448419	24918	95294	70	30	
1105	PC Ibeam(L=28.85m)	unit	3309763	23916	91462	70	30	
1106	PC Ibeam(L=25.85m)	unit	2948076	21303	81468	70	30	
1107	PC Ibeam(L=25m)	unit	2845566	20562	78635	70	30	
1108	PC Ibeam(L=23.05m)	unit	2610505	18863	72139	70	30	
1109	PC Ibeam(L=22.50m)	unit	2544140	18385	70306	70	30	
1110	PC Ibeam(L=22.45m)	unit	2538156	18341	70140	70	30	
1111	PC Ibeam(L=22.10m)	unit	2495967	18036	68974	70	30	
1112	PC Ibeam(L=22.05m)	unit	2489922	17992	68807	70	30	
1113	prestressed concrete floor slab	m2	16696	121	462	70	30	
1114	Cast in place place concrete pile	m	29921	216	827	70	30	
Electrical equipment and hydraulic equipment								
1201	manual(W<1.5m,H<1.5m)	kg	344	2.49	9.5	70	30	
1202	side gate larger than 2.0m×2.0m	kg	247	1.79	6.83	70	30	
1203	other metal works	kg	247	1.79	6.83	70	30	
Each work								
1301	train bridge upgradingH=1.1m	unit	2221470	16052	61388	70	30	
1302	installation of anchor	unit	27827	202	770	70	30	
1303	Chipping	m2	7372	53.3	204	70	30	
1304	Cast in micro pile φ20cm L=25m	m	23159	167	640	70	30	
1305	rubber dam 50m×2.9m	unit	41071754	296790	1134989	70	30	
Temporary								
1401	temporary coffering	unit	2561	18.5	70.8	70	30	
1402	sheet pile working	ml	112743	815	3116	70	30	
1403	temporary bridge with H beam	m2	11604	83.8	321	70	30	
1404	river section road working	m2	4860	35.1	134	70	30	
1405	temporary rail way	m	16451	119.5	455.4	70	30	

The consultant service (M/M) shall be as follows:

3) Professional A : 2,562,000 yen (52,286 TND)
4) Professional B: 735,000 (15,000 TND)
5) Supporting Staff : 220,500 (4,500 TND)

7.3.3 Construction Figure Tables

Below are tables showing construction figures for each construction zone:

Table 7-17 Construction Figures for Construction Cost Estimation (Construction Zone I-1)

River improvement section Ⅰ						借款対象率		100	
No	item	unit	Quantity	Unit Price		Cost		Total	Remarks
				Foreign	Local	Foreign	Local		
				yen	TND	yen	TND	yen	
A	**Earth works**					**1,876,925,434**	**13,606,738**	**2,543,655,583**	
	clearing and grubbing (tamarix φ10cm<)	m2	2,871,070	85.5	0.63	245,476,485	1,808,774	334,106,416	
	Stripping t=0.5m	m2	2,871,070	53.2	0.38	152,740,924	1,091,007	206,200,247	
	Excavation for river common soil (with average hauling distance of 1km)	m3	5,661,217	152	1.1	860,504,984	6,227,339	1,165,644,580	
	fill granding t=0.35m	m3	508,332	93.4	0.68	47,478,209	345,666	64,415,831	
	trimming of slope	m2	1,023,663	204	1.47	208,827,252	1,504,785	282,561,698	
	Surplus soil disporsal	m3	5,152,113	70.2	0.51	361,678,333	2,627,578	490,429,636	
	Backfill surrounding structures due to excavation	m3	772	284	2.06	219,248	1,590	297,174	
B	**Main body works**					**48,685,734**	**404,123**	**68,487,771**	
	floor slab concrete c=400kg	m3	1,461	7498	54.2	10,956,078	79,197	14,836,733	
	form C3	m2	2,425	2058	14.9	4,990,650	36,133	6,761,143	
	reinforcement	kg	102,200	104	0.76	10,628,800	77,672	14,434,728	
	blinding concrete c=200kg	m3	215	5361	38.7	1,152,079	8,317	1,559,594	
	form C1	m2	103	1223	8.84	125,358	906	169,756	
	Support	m3	980	147	20	144,089	19,604	1,104,685	
	Scaffolding	m2	1,823	147	19	267,981	34,637	1,965,194	
	Water bar width of 350mm	ml	129	2741	19.8	352,219	2,544	476,889	
	Waterproof joints	ml	62	2154	15.5	133,117	958	180,054	
	Centrifugal reinforced concrete pipe 0.4m<φ<0.8m	ml	48	7917	57.2	380,016	2,746	514,550	
	sheet pile working	ml	128	112743	815	14,431,104	104,320	19,542,784	
	φ500 Concrete pile L=10m	pile	30	76660	554	2,299,800	16,620	3,114,180	
	Excavation for river common soil (with average hauling distance of 1km)	m3	7,144	152	1.1	1,085,888	7,858	1,470,950	
	Backfill surrounding structures due to excavation	m3	5,786	284	2.06	1,643,224	11,919	2,227,263	
	Surplus soil disporsal	m3	1,358	70.2	0.51	95,332	693	129,268	
C	**Contorol house works**					**3,097,290**	**27,090**	**4,424,700**	
	RC House	m2	60	51450	450	3,097,290	27,090	4,424,700	
D	**Appurtenant works**					**32,175,234**	**232,492**	**43,567,322**	
	gabion	m3	3,669	4315	31.2	15,831,735	114,473	21,440,902	
	geotextile	m2	6,106	499	3.6	3,046,894	21,982	4,123,992	
	abutment/pier base concrete c=350kg	m3	987	6828	49.3	6,737,870	48,649	9,121,683	
	form C1	m2	2,043	1223	8.84	2,498,222	18,057	3,383,038	
	cobble foundation of structure excavation	m2	2,214	440	3.18	974,160	7,041	1,319,145	
	Step works	m2	266	4096.8	29.58	1,089,339	7,865	1,474,740	
	abutment/pier base concrete c=350kg	m3	182	6828	49.3	1,244,744	8,987	1,685,127	
	form C1	m2	571	1223	8.84	698,578	5,049	945,999	
	temporary construction road	m3	40	1329	9.6	53,692	388	72,696	

Table 7-18 Construction Figures for Construction Cost Estimation (Construction Zone I-2)

River improvement section Ⅰ									借款対象率 100
No	item	unit	Quantity	Unit Price		Cost		Total	Remarks
				Foreign	Local	Foreign	Local		
				yen	TND	yen	TND	yen	
E	**Service road works**					**247,718,804**	**1,790,199**	**335,438,535**	
	approach road asphalt pavement	m3	11,636	14242	103	165,719,912	1,198,508	224,446,804	
	approach road upper subbase	m3	46,544	1484	10.7	69,071,296	498,021	93,474,315	
	Excavation for river common soil (with average hauling distance of 1km)	m3	58,180	152	1.1	8,843,360	63,998	11,979,262	
	Surplus soil disporsal	m3	58,180	70.2	0.51	4,084,236	29,672	5,538,154	
F	**Temporary construction road works**					**82,476,411**	**595,766**	**111,668,965**	
	temporary construction road	m3	62,059	1329	9.6	82,476,411	595,766	111,668,965	
3	**No 3 old bridge demolish**					**5,063,840**	**36,569**	**6,855,705**	
	break concrete	m3	323	6661	48.1	2,151,503	15,536	2,912,782	
	filling materials transport	m3km	485	23.4	0.17	11,337	82	15,373	
	temporary bridge with H beam	m2	250	11604	83.8	2,901,000	20,950	3,927,550	
4	**No 4 new bridge construction**					**182,015,718**	**1,317,572**	**246,576,738**	
	Cast in place place concrete pile	m	1,162	29921	216	34,768,202	250,992	47,066,810	
	blinding concrete c=200kg	m3	38	5361	38.7	202,646	1,463	274,326	
	abutment/pier base concrete c=350kg	m3	1,740	6828	49.3	11,879,354	85,772	16,082,189	
	form C1	m2	344	1223	8.84	420,834	3,042	569,885	
	form C2	m2	1,076	1550	11.2	1,667,955	12,052	2,258,519	
	curb form adding fee	m2	296	465	3.36	137,780	996	186,562	
	reinforcement	kg	257,800	104	0.76	26,811,200	195,928	36,411,672	
	PC Ibeam(L=29.8m)	unit	12	3424242	24745	41,090,904	296,940	55,640,964	
	PC Ibeam(L=25.85m)	unit	8	2948076	21303	23,584,608	170,424	31,935,384	
	prestressed concrete floor slab	m2	1,021	16696	121	17,046,616	123,541	23,100,125	
	floor slab concrete c=400kg	m3	415	7498	54.2	3,111,670	22,493	4,213,827	
	Excavation for river common soil (with average hauling distance of 1km)	m3	3,288	152	1.1	499,776	3,617	676,999	
	filling materials transport	m3km	4,110	23.4	0.17	96,174	699	130,410	
	fill granding t=0.35m	m3	1,918	93.4	0.68	179,141	1,304	243,049	
	trimming of slope	m2	308	204	1.47	62,832	453	85,017	
	approach road upper subbase	m3	920	1484	10.7	1,365,280	9,844	1,847,636	
	approach road asphalt pavement	m3	147	14242	103	2,093,574	15,141	2,835,483	
	temporary construction road	m3	600	1329	9.6	797,400	5,760	1,079,640	
	temporary bridge with H beam	m2	852	11604	83.8	9,886,608	71,398	13,385,090	
	temporary coffering	unit	564	2561	18.5	1,444,404	10,434	1,955,670	
	temporary drainage(pump,generator)	day	120	40573	294	4,868,760	35,280	6,597,480	

Table 7-19 Construction Figures for Construction Cost Estimation (Construction Zone I-3)

River improvement section Ⅰ						借款対象率		100	
No	item	unit	Quantity	Unit Price		Cost		Total	Remarks
				Foreign	Local	Foreign	Local		
				yen	TND	yen	TND	yen	
4'	**No 4 old bridge demolish**					**4,914,937**	**35,493**	**6,654,073**	
	break concrete	m3	734	6661	48.1	4,889,174	35,305	6,619,139	
	filling materials transport	m3km	1,101	23.4	0.17	25,763	187	34,935	
8	**No 8 old railway bridge demolish**					**3,600,686**	**25,997**	**4,874,563**	
	train bridge demolish work	t	170	2843	20.5	483,310	3,485	654,075	
	break concrete	m3	32	6661	48.1	216,376	1,562	292,938	
	temporary bridge with H beam	m2	250	11604	83.8	2,901,000	20,950	3,927,550	
9	**No 9 railwaybridge extension**					**103,989,535**	**752,459**	**140,860,044**	
	Cast in place place concrete pile	m	468	29921	216	14,003,028	101,088	18,956,340	
	blinding concrete c=200kg	m3	14	5361	38.7	76,126	550	103,054	
	abutment/pier base concrete c=350kg	m3	542	6828	49.3	3,703,507	26,740	5,013,783	
	form C1	m2	119	1223	8.84	145,048	1,048	196,421	
	form C2	m2	248	1550	11.2	384,710	2,780	520,922	
	curb form adding fee	m2	95	465	3.36	44,036	318	59,627	
	reinforcement	kg	81,300	104	0.76	8,455,200	61,788	11,482,812	
	PC Ibeam(L=25m)	unit	8	2845566	20562	22,764,528	164,496	30,824,832	
	train bridge upgradingH=1.1m	unit	12	2221470	16052	26,657,640	192,624	36,096,216	
	Stripping	m3	1,105	84.9	0.62	93,815	685	127,384	
	filling materials transport	m3km	1,389	23.4	0.17	32,503	236	44,073	
	fill granding t=0.35m	m3	642	93.4	0.68	59,963	437	81,354	
	trimming of slope	m2	308	204	1.47	62,832	453	85,017	
	approach road lower subbase	m3	920	1324	9.6	1,218,080	8,832	1,650,848	
	approach road upper subbase	m3	147	1484	10.7	218,148	1,573	295,220	
	temporary rail way	m	600	16451	119.5	9,870,600	71,700	13,383,900	
	temporary bridge with H beam	m2	852	11604	83.8	9,886,608	71,398	13,385,090	
	temporary coffering	unit	564	2561	18.5	1,444,404	10,434	1,955,670	
	temporary drainage(pump,generator)	day	120	40573	294	4,868,760	35,280	6,597,480	

Table 7-20 Construction Figures for Construction Cost Estimation (Construction Zone II-1)

River improvement section Ⅱ						借款対象率		100	
No	item	unit	Quantity	Unit Price		Cost		Total	Remarks
				Foreign	Local	Foreign	Local		
				yen	TND	yen	TND	yen	
A	**Earth works**					**914,263,579**	**6,633,879**	**1,239,323,641**	
	clearing and grubbing (tamarix φ10cm<)	m2	2,603,265	85.5	0.63	222,579,158	1,640,057	302,941,948	
	Stripping t=0.5m	m2	2,603,265	53.2	0.38	138,493,698	989,241	186,966,492	
	Excavation for river common soil (with average hauling distance of 1km)	m3	1,719,030	152	1.1	261,292,560	1,890,933	353,948,277	
	fill granding t=0.35m	m3	973,782	93.4	0.68	90,951,239	662,172	123,397,655	
	trimming of slope	m2	693,726	204	1.47	141,520,088	1,019,777	191,489,166	
	Surplus soil disporsal	m3	804,013	70.2	0.51	56,441,713	410,047	76,533,997	
	Backfill surrounding structures due to excavation	m3	10,511	284	2.06	2,985,124	21,653	4,046,104	
B	**Main body works**					**307,250,394**	**2,415,468**	**425,608,339**	
	floor slab concrete c=400kg	m3	9,639	7498	54.2	72,273,597	522,437	97,872,986	
	form C3	m2	11,929	2058	14.9	24,549,573	177,740	33,258,827	
	reinforcement	kg	674,052	104	0.76	70,101,408	512,280	95,203,104	
	blinding concrete c=200kg	m3	2,299	5361	38.7	12,326,547	88,983	16,686,710	
	form C1	m2	745	1223	8.84	911,380	6,588	1,234,170	
	Support	m3	2,353	147	20	345,847	47,054	2,651,493	
	Scaffolding	m2	8,044	147	19	1,182,453	152,834	8,671,324	
	Water bar width of 350mm	ml	1,666	2741	19.8	4,566,780	32,989	6,183,230	
	Waterproof joints	ml	811	2154	15.5	1,747,756	12,577	2,364,014	
	reinforcement	kg	3,729	104	0.76	387,770	2,834	526,622	
	Centrifugal reinforced concrete pipe 0.4m<φ<0.8m	ml	368	7917	57.2	2,913,456	21,050	3,944,886	
	sheet pile working	ml	889	112743	815	100,228,527	724,535	135,730,742	
	φ500 Concrete pile L=10m	pile	130	76660	554	9,965,800	72,020	13,494,780	
	φ500 Concrete pile L=25m	pile	30	191650	1385	5,749,500	41,550	7,785,450	
C	**Contorol house works**					**2,901,780**	**25,380**	**4,145,400**	
	RC House	m2	56	51450	450	2,901,780	25,380	4,145,400	
D	**Appurtenant works**					**62,347,372**	**450,482**	**84,421,007**	
	gabion	m3	5,015	4315	31.2	21,641,020	156,477	29,308,410	
	geotextile	m2	17,144	499	3.6	8,554,607	61,717	11,578,720	
	abutment/pier base concrete c=350kg	m3	1,212	6828	49.3	8,275,877	59,754	11,203,827	
	form C1	m2	3,812	1223	8.84	4,661,465	33,694	6,312,454	
	cobble foundation of structure excavation	m2	3,864	440	3.18	1,700,028	12,287	2,302,070	
	Step works	m2	285	4096.8	29.58	1,167,998	8,433	1,581,227	
	abutment/pier base concrete c=350kg	m3	397	6828	49.3	2,707,302	19,547	3,665,127	
	form C1	m2	913	1223	8.84	1,116,905	8,073	1,512,488	
	temporary construction road	m3	88	1329	9.6	117,018	845	158,437	
	riprap(l=5.5m,t=1.0m)	m2	10,177	1219	8.81	12,405,154	89,655	16,798,247	
E	**Service road works**					**194,941,667**	**1,408,792**	**263,972,482**	
	approach road asphalt pavement	m3	9,157	14242	103	130,413,994	943,171	176,629,373	
	approach road upper subbase	m3	36,627	1484	10.7	54,354,468	391,909	73,558,004	
	Excavation for river common soil (with average hauling distance of 1km)	m3	45,784	152	1.1	6,959,168	50,362	9,426,926	
	Surplus soil disporsal	m3	45,784	70.2	0.51	3,214,037	23,350	4,358,179	

Table 7-21 Construction Figures for Construction Cost Estimation (Construction Zone II-2)

River improvement section Ⅱ						借款対象率		100	
No	item	unit	Quantity	Unit Price Foreign yen	Unit Price Local TND	Cost Foreign yen	Cost Local TND	Total yen	Remarks
F	**Temporary construction road works**					**26,409,888**	**190,771**	**35,757,677**	
	temporary construction road	m3	19,872	1329	9.6	26,409,888	190,771	35,757,677	
18	**No 18 new bridge construction**					**122,266,973**	**884,660**	**165,615,294**	
	Cast in place place concrete pile	m	800	29921	216	23,936,800	172,800	32,404,000	
	blinding concrete c=200kg	m3	32	5361	38.7	172,624	1,246	233,685	
	abutment/pier base concrete c=350kg	m3	916	6828	49.3	6,254,448	45,159	8,467,229	
	form C1	m2	332	1223	8.84	406,281	2,937	550,176	
	form C2	m2	531	1550	11.2	823,670	5,952	1,115,302	
	curb form adding fee	m2	111	465	3.36	51,429	372	69,638	
	reinforcement	kg	134,200	104	0.76	13,956,800	101,992	18,954,408	
	PC Ibeam(L=22.50m)	unit	12	2544140	18385	30,529,680	220,620	41,340,060	
	PC Ibeam(L=22.45m)	unit	8	2538156	18341	20,305,248	146,728	27,494,920	
	prestressed concrete floor slab	m2	643	16696	121	10,735,528	77,803	14,547,875	
	floor slab concrete c=400kg	m3	296	7498	54.2	2,219,408	16,043	3,005,525	
	Excavation for river common soil (with average hauling distance of 1km)	m3	1,544	152	1.1	234,688	1,698	317,910	
	filling materials transport	m3km	2,106	23.4	0.17	49,280	358	66,823	
	fill granding t=0.35m	m3	842	93.4	0.68	78,643	573	106,698	
	trimming of slope	m2	382	204	1.47	77,928	562	105,443	
	approach road upper subbase	m3	3,814	1484	10.7	5,659,976	40,810	7,659,656	
	approach road asphalt pavement	m3	152	14242	103	2,164,784	15,656	2,931,928	
	temporary construction road	m3	360	1329	9.6	478,440	3,456	647,784	
	temporary bridge with H beam	m2	84	11604	83.8	974,736	7,039	1,319,657	
	temporary coffering	unit	282	2561	18.5	722,202	5,217	977,835	
	temporary drainage(pump,generator)	day	60	40573	294	2,434,380	17,640	3,298,740	
18'	**No 18 old bridge demolish**					**421,854**	**3,046**	**571,126**	
	break concrete	m3	63	6661	48.1	419,643	3,030	568,128	
	filling materials transport	m3km	95	23.4	0.17	2,211	16	2,998	
19	**No 19 new bridge construction**					**5,953,718**	**43,233**	**8,072,136**	
	blinding concrete c=200kg	m3	20	5361	38.7	109,364	789	148,049	
	abutment/pier base concrete c=350kg	m3	257	6828	49.3	1,755,479	12,675	2,376,555	
	form C2	m2	304	1550	11.2	470,425	3,399	636,986	
	form C3	m2	165	2058	14.9	339,364	2,457	459,758	
	reinforcement	kg	24,900	104	0.76	2,589,600	18,924	3,516,876	
	Excavation for river common soil (with average hauling distance of 1km)	m3	1,176	152	1.1	178,752	1,294	242,138	
	filling materials transport	m3km	1,890	23.4	0.17	44,226	321	59,970	
	fill granding t=0.35m	m3	546	93.4	0.68	50,996	371	69,189	
	trimming of slope	m2	30	204	1.47	6,120	44	8,281	
	approach road subgrade	m2	93	117	0.84	10,881	78	14,709	
	approach road upper subbase	m3	67	1484	10.7	99,428	717	134,556	
	approach road asphalt pavement	m3	21	14242	103	299,082	2,163	405,069	

Table 7-22 Construction Figures for Construction Cost Estimation (Construction Zone II-3)

River improvement section Ⅱ						借款対象率		100	
No	item	unit	Quantity	Unit Price		Cost		Total	Remarks
				Foreign	Local	Foreign	Local		
				yen	TND	yen	TND	yen	
19'	**No 19 old bridge demolish**					**421,854**	**3,046**	**571,126**	
	break concrete	m3	63	6661	48.1	419,643	3,030	568,128	
	filling materials transport	m3km	95	23.4	0.17	2,211	16	2,998	
20	**No 20 new bridge construction**					**5,911,036**	**42,925**	**8,014,369**	
	blinding concrete c=200kg	m3	20	5361	38.7	109,364	789	148,049	
	abutment/pier base concrete c=350kg	m3	256	6828	49.3	1,748,651	12,626	2,367,312	
	form C2	m2	299	1550	11.2	464,070	3,353	628,381	
	form C3	m2	165	2058	14.9	339,364	2,457	459,758	
	reinforcement	kg	24,900	104	0.76	2,589,600	18,924	3,516,876	
	Excavation for river common soil (with average hauling distance of 1km)	m3	1,209	152	1.1	183,768	1,330	248,933	
	filling materials transport	m3km	1,929	23.4	0.17	45,139	328	61,207	
	fill granding t=0.35m	m3	566	93.4	0.68	52,864	385	71,724	
	trimming of slope	m2	24	204	1.47	4,896	35	6,625	
	approach road subgrade	m2	84	117	0.84	9,828	71	13,285	
	approach road upper subbase	m3	53	1484	10.7	78,652	567	106,440	
	approach road asphalt pavement	m3	20	14242	103	284,840	2,060	385,780	
20'	**No 20 old bridge demolish**					**421,854**	**3,046**	**571,126**	
	break concrete	m3	63	6661	48.1	419,643	3,030	568,128	
	filling materials transport	m3km	95	23.4	0.17	2,211	16	2,998	
21	**No 21 new bridge construction**					**6,065,920**	**44,048**	**8,224,257**	
	blinding concrete c=200kg	m3	20	5361	38.7	109,364	789	148,049	
	abutment/pier base concrete c=350kg	m3	257	6828	49.3	1,755,479	12,675	2,376,555	
	form C2	m2	303	1550	11.2	470,270	3,398	636,776	
	form C3	m2	165	2058	14.9	339,364	2,457	459,758	
	reinforcement	kg	24,900	104	0.76	2,589,600	18,924	3,516,876	
	Excavation for river common soil (with average hauling distance of 1km)	m3	1,176	152	1.1	178,752	1,294	242,138	
	filling materials transport	m3km	6,370	23.4	0.17	149,058	1,083	202,120	
	fill granding t=0.35m	m3	539	93.4	0.68	50,343	367	68,302	
	trimming of slope	m2	32	204	1.47	6,528	47	8,833	
	approach road subgrade	m2	96	117	0.84	11,232	81	15,183	
	approach road upper subbase	m3	72	1484	10.7	106,848	770	144,598	
	approach road asphalt pavement	m3	21	14242	103	299,082	2,163	405,069	
21'	**No 21 old bridge demolish**					**528,992**	**3,820**	**716,174**	
	break concrete	m3	79	6661	48.1	526,219	3,800	712,414	
	filling materials transport	m3km	119	23.4	0.17	2,773	20	3,760	

Table 7-23 Construction Figures for Construction Cost Estimation (Construction Zone II-4)

River improvement section Ⅱ								借款対象率	100
No	item	unit	Quantity	Unit Price		Cost		Total	Remarks
				Foreign	Local	Foreign	Local		
				yen	TND	yen	TND	yen	
22	**No 22 new bridge construction**					**125,669,922**	**909,363**	**170,228,701**	
	Cast in place place concrete pile	m	904	29921	216	27,048,584	195,264	36,616,520	
	blinding concrete c=200kg	m3	33	5361	38.7	176,913	1,277	239,491	
	abutment/pier base concrete c=350kg	m3	957	6828	49.3	6,533,030	47,170	8,844,372	
	form C1	m2	343	1223	8.84	419,244	3,030	567,732	
	form C2	m2	562	1550	11.2	870,480	6,290	1,178,686	
	curb form adding fee	m2	114	465	3.36	53,196	384	72,031	
	reinforcement	kg	140,000	104	0.76	14,560,000	106,400	19,773,600	
	PC Ibeam(L=22.10m)	unit	12	2495967	18036	29,951,604	216,432	40,556,772	
	PC Ibeam(L=22.05m)	unit	8	2489922	17992	19,919,376	143,936	26,972,240	
	prestressed concrete floor slab	m2	798	16696	121	13,323,408	96,558	18,054,750	
	floor slab concrete c=400kg	m3	330	7498	54.2	2,474,340	17,886	3,350,754	
	Excavation for river common soil (with average hauling distance of 1km)	m3	1,802	152	1.1	273,904	1,982	371,032	
	filling materials transport	m3km	2,442	23.4	0.17	57,143	415	77,485	
	fill granding t=0.35m	m3	988	93.4	0.68	92,279	672	125,199	
	trimming of slope	m2	178	204	1.47	36,312	262	49,133	
	approach road upper subbase	m3	1,640	1484	10.7	2,433,760	17,548	3,293,612	
	approach road asphalt pavement	m3	123	14242	103	1,751,766	12,669	2,372,547	
	temporary construction road	m3	600	1329	9.6	797,400	5,760	1,079,640	
	temporary bridge with H beam	m2	150	11604	83.8	1,740,600	12,570	2,356,530	
	temporary coffering	unit	282	2561	18.5	722,202	5,217	977,835	
	temporary drainage(pump,generator)	day	60	40573	294	2,434,380	17,640	3,298,740	
22'	**No 22 old bridge demolish**					**2,832,450**	**20,454**	**3,834,704**	
	break concrete	m3	423	6661	48.1	2,817,603	20,346	3,814,572	
	filling materials transport	m3km	635	23.4	0.17	14,847	108	20,133	

Table 7-24 List of Construction Figures for Cost Survey (Zone II-5)

River improvement section Ⅱ						借款対象率		100	
No	item	unit	Quantity	Unit Price		Cost		Total	Remarks
				Foreign	Local	Foreign	Local		
				yen	TND	yen	TND	yen	
27	**No 27 new bridge construction**					**58,515,632**	**423,338**	**79,259,175**	
	Cast in place place concrete pile	m	450	29921	216	13,464,450	97,200	18,227,250	
	blinding concrete c=200kg	m3	14	5361	38.7	72,910	526	98,699	
	abutment/pier base concrete c=350kg	m3	414	6828	49.3	2,824,744	20,395	3,824,119	
	form C1	m2	173	1223	8.84	211,701	1,530	286,681	
	form C2	m2	343	1550	11.2	532,270	3,846	720,728	
	curb form adding fee	m2	39	465	3.36	18,135	131	24,556	
	reinforcement	kg	58,700	104	0.76	6,104,800	44,612	8,290,788	
	PC Ibeam(L=23.05m)	unit	8	2610505	18863	20,884,040	150,904	28,278,336	
	prestressed concrete floor slab	m2	333	16696	121	5,559,768	40,293	7,534,125	
	floor slab concrete c=400kg	m3	137	7498	54.2	1,027,226	7,425	1,391,071	
	Excavation for river common soil (with average hauling distance of 1km)	m3	501	152	1.1	76,152	551	103,156	
	filling materials transport	m3km	819	23.4	0.17	19,165	139	25,987	
	fill granding t=0.35m	m3	228	93.4	0.68	21,295	155	28,892	
	trimming of slope	m2	84	204	1.47	17,136	123	23,187	
	approach road upper subbase	m3	714	1484	10.7	1,059,576	7,640	1,433,926	
	approach road asphalt pavement	m3	62	14242	103	883,004	6,386	1,195,918	
	temporary construction road	m3	600	1329	9.6	797,400	5,760	1,079,640	
	temporary bridge with H beam	m2	270	11604	83.8	3,133,080	22,626	4,241,754	
	temporary coffering	unit	231	2561	18.5	591,591	4,274	800,993	
	temporary drainage(pump,generator)	day	30	40573	294	1,217,190	8,820	1,649,370	
27'	**No 27 old bridge demolish**					**2,075,791**	**14,990**	**2,810,303**	
	break concrete	m3	310	6661	48.1	2,064,910	14,911	2,795,549	
	filling materials transport	m3km	465	23.4	0.17	10,881	79	14,754	
30	**No 30 new bridge construction**					**6,607,796**	**47,953**	**8,957,510**	
	blinding concrete c=200kg	m3	20	5361	38.7	109,364	789	148,049	
	abutment/pier base concrete c=350kg	m3	265	6828	49.3	1,806,689	13,045	2,445,883	
	form C2	m2	335	1550	11.2	519,250	3,752	703,098	
	form C3	m2	165	2058	14.9	339,364	2,457	459,758	
	reinforcement	kg	24,900	104	0.76	2,589,600	18,924	3,516,876	
	Excavation for river common soil (with average hauling distance of 1km)	m3	817	152	1.1	124,184	899	168,220	
	filling materials transport	m3km	5,380	23.4	0.17	125,892	915	170,707	
	fill granding t=0.35m	m3	279	93.4	0.68	26,059	190	35,355	
	trimming of slope	m2	130	204	1.47	26,520	191	35,884	
	approach road subgrade	m2	194	117	0.84	22,698	163	30,683	
	approach road upper subbase	m3	350	1484	10.7	519,400	3,745	702,905	
	approach road asphalt pavement	m3	28	14242	103	398,776	2,884	540,092	

Table 7-25 List of Construction Figures for Cost Survey (Zone II-6)

River improvement section Ⅱ					借款対象率			100	
No	item	unit	Quantity	Unit Price		Cost		Total	Remarks
				Foreign	Local	Foreign	Local		
				yen	TND	yen	TND	yen	
31	**No 31 new bridge construction**					**6,366,985**	**46,217**	**8,631,636**	
	blinding concrete c=200kg	m3	20	5361	38.7	109,364	789	148,049	
	abutment/pier base concrete c=350kg	m3	262	6828	49.3	1,789,619	12,922	2,422,774	
	form C2	m2	324	1550	11.2	502,665	3,632	680,641	
	form C3	m2	165	2058	14.9	339,364	2,457	459,758	
	reinforcement	kg	24,900	104	0.76	2,589,600	18,924	3,516,876	
	Excavation for river common soil (with average hauling distance of 1km)	m3	948	152	1.1	144,096	1,043	195,193	
	filling materials transport	m3km	5,590	23.4	0.17	130,806	950	177,371	
	fill granding t=0.35m	m3	389	93.4	0.68	36,333	265	49,294	
	trimming of slope	m2	88	204	1.47	17,952	129	24,291	
	approach road subgrade	m2	160	117	0.84	18,720	134	25,306	
	approach road upper subbase	m3	224	1484	10.7	332,416	2,397	449,859	
	approach road asphalt pavement	m3	25	14242	103	356,050	2,575	482,225	
32	**No 32 new bridge construction**					**6,374,737**	**46,285**	**8,642,694**	
	blinding concrete c=200kg	m3	20	5361	38.7	109,364	789	148,049	
	abutment/pier base concrete c=350kg	m3	267	6828	49.3	1,823,076	13,163	2,468,068	
	form C2	m2	347	1550	11.2	537,075	3,881	727,234	
	form C3	m2	165	2058	14.9	339,364	2,457	459,758	
	reinforcement	kg	25,700	104	0.76	2,672,800	19,532	3,629,868	
	Excavation for river common soil (with average hauling distance of 1km)	m3	1,242	152	1.1	188,784	1,366	255,728	
	filling materials transport	m3km	5,950	23.4	0.17	139,230	1,012	188,794	
	fill granding t=0.35m	m3	647	93.4	0.68	60,430	440	81,988	
	trimming of slope	m2	48	204	1.47	9,792	71	13,249	
	approach road subgrade	m2	118	117	0.84	13,806	99	18,663	
	approach road upper subbase	m3	113	1484	10.7	167,692	1,209	226,938	
	approach road asphalt pavement	m3	22	14242	103	313,324	2,266	424,358	

Table 7-26 List of Construction Figures for Cost Survey (Zone III-1)

River improvement section Ⅲ						Loan Taget Rate		100	
No	item	unit	Quantity	Unit Price		Cost		Total	Remarks
				Foreign	Local	Foreign	Local		
				yen	TND	yen	TND	yen	
A	**Earth works**					**674,319,927**	**4,888,845**	**913,873,332**	
	clearing and grubbing (tamarix φ10cm<)	m2	1,080,852	85.5	0.63	92,412,846	680,937	125,778,747	
	Stripping t=0.5m	m2	1,080,852	53.2	0.38	57,501,326	410,724	77,626,791	
	Excavation for river common soil (with average hauling distance of 1km)	m3	2,056,509	152	1.1	312,589,368	2,262,160	423,435,203	
	fill granding t=0.35m	m3	73,216	93.4	0.68	6,838,374	49,787	9,277,932	
	trimming of slope	m2	325,178	204	1.47	66,336,312	478,012	89,758,883	
	Surplus soil disporsal	m3	1,974,953	70.2	0.51	138,641,701	1,007,226	187,995,776	
B	**Main body works**					**14,512,396**	**112,543**	**20,027,026**	
	floor slab concrete c=400kg	m3	379	7498	54.2	2,843,242	20,553	3,850,321	
	form C3	m2	812	2058	14.9	1,671,919	12,105	2,265,052	
	reinforcement	kg	26,400	104	0.76	2,745,600	20,064	3,728,736	
	blinding concrete c=200kg	m3	80	5361	38.7	428,880	3,096	580,584	
	form C1	m2	40	1223	8.84	48,431	350	65,584	
	Scaffolding	m2	412	147	19	60,505	7,820	443,705	
	Water bar width of 350mm	ml	62	2741	19.8	171,038	1,236	231,579	
	Waterproof joints	ml	30	2154	15.5	63,758	459	86,240	
	Centrifugal reinforced concrete pipe 0.4m<φ<0.8m	ml	64	7917	57.2	506,688	3,661	686,067	
	sheet pile working	ml	40	112743	815	4,509,720	32,600	6,107,120	
	Excavation for river common soil (with average hauling distance of 1km)	m3	3,488	152	1.1	530,176	3,837	718,179	
	Backfill surrounding structures due to excavation	m3	3,216	284	2.06	913,344	6,625	1,237,967	
	Surplus soil disporsal	m3	272	70.2	0.51	19,094	139	25,892	
D	**Appurtenant works**					**19,446,416**	**140,515**	**26,331,668**	
	gabion	m3	2,172	4315	31.2	9,372,180	67,766	12,692,734	
	geotextile	m2	3,224	499	3.6	1,608,776	11,606	2,177,490	
	abutment/pier base concrete c=350kg	m3	626	6828	49.3	4,275,011	30,867	5,787,481	
	form C1	m2	1,225	1223	8.84	1,497,930	10,827	2,028,465	
	cobble foundation of structure excavation	m2	1,319	440	3.18	580,360	4,194	785,887	
	Step works	m2	187	4096.8	29.58	766,921	5,537	1,038,252	
	abutment/pier base concrete c=350kg	m3	123	6828	49.3	838,478	6,054	1,135,126	
	form C1	m2	385	1223	8.84	470,610	3,402	637,290	
	temporary construction road	m3	27	1329	9.6	36,149	261	48,944	
E	**Service road works**					**186,254,049**	**1,346,009**	**252,208,491**	
	approach road asphalt pavement	m3	8,749	14242	103	124,603,258	901,147	168,759,461	
	approach road upper subbase	m3	34,994	1484	10.7	51,931,096	374,436	70,278,450	
	Excavation for river common soil (with average hauling distance of 1km)	m3	43,743	152	1.1	6,648,936	48,117	9,006,684	
	Surplus soil disporsal	m3	43,743	70.2	0.51	3,070,759	22,309	4,163,896	
F	**Temporary construction road works**					**62,011,140**	**447,936**	**83,960,004**	
	temporary construction road	m3	46,660	1329	9.6	62,011,140	447,936	83,960,004	

Table 7-27 List of Construction Figures for Cost Survey (Zone III-2)

River improvement section Ⅲ						Loan Taget Rate		100	
No	item	unit	Quantity	Unit Price		Cost		Total	Remarks
				Foreign	Local	Foreign	Local		
				yen	TND	yen	TND	yen	
12	**No 12 Bridge Reinforcement of the existing pier**					**39,806,952**	**287,979**	**53,917,942**	
	Cast in place place concrete pile	m	300	29921	216	8,976,300	64,800	12,151,500	
	blinding concrete c=200kg	m3	8	5361	38.7	43,424	313	58,784	
	abutment/pier base concrete c=350kg	m3	290	6828	49.3	1,977,389	14,277	2,676,976	
	form C1	m2	143	1223	8.84	174,400	1,261	236,168	
	form C2	m2	293	1550	11.2	454,770	3,286	615,788	
	form C3	m2	47	2058	14.9	97,138	703	131,598	
	curb form adding fee	m2	25	465	3.36	11,672	84	15,804	
	reinforcement	kg	40,400	104	0.76	4,201,600	30,704	5,706,096	
	PC Ibeam(L=28.85m)	unit	4	3309763	23916	13,239,052	95,664	17,926,588	
	prestressed concrete floor slab	m2	207	16696	121	3,456,072	25,047	4,683,375	
	floor slab concrete c=400kg	m3	106	7498	54.2	794,788	5,745	1,076,303	
	Stripping	m3	1,195	84.9	0.62	101,456	741	137,760	
	filling materials transport	m3km	993	23.4	0.17	23,236	169	31,508	
	fill granding t=0.35m	m3	864	93.4	0.68	80,698	588	109,486	
	approach road asphalt pavement	m3	19	14242	103	270,598	1,957	366,491	
	temporary construction road	m3	240	1329	9.6	318,960	2,304	431,856	
	temporary bridge with H beam	m2	480	11604	83.8	5,569,920	40,224	7,540,896	
	Chipping	m2	2	7372	53.3	15,481	112	20,966	
15	**No 15 new bridge construction**					**106,603,458**	**771,319**	**144,398,067**	
	Cast in place place concrete pile	m	700	29921	216	20,944,700	151,200	28,353,500	
	blinding concrete c=200kg	m3	21	5361	38.7	114,725	828	155,306	
	abutment/pier base concrete c=350kg	m3	834	6828	49.3	5,693,186	41,106	7,707,397	
	form C1	m2	229	1223	8.84	280,556	2,028	379,923	
	form C2	m2	552	1550	11.2	855,290	6,180	1,158,118	
	curb form adding fee	m2	114	465	3.36	53,103	384	71,905	
	reinforcement	kg	122,000	104	0.76	12,688,000	92,720	17,231,280	
	PC Ibeam(L=29.8m)	unit	4	3424242	24745	13,696,968	98,980	18,546,988	
	PC Ibeam(L=25.85m)	unit	8	2948076	21303	23,584,608	170,424	31,935,384	
	prestressed concrete floor slab	m2	603	16696	121	10,067,688	72,963	13,642,875	
	floor slab concrete c=400kg	m3	245	7498	54.2	1,837,010	13,279	2,487,681	
	Excavation for river common soil (with average hauling distance of 1km)	m3	686	152	1.1	104,272	755	141,247	
	filling materials transport	m3km	1,128	23.4	0.17	26,395	192	35,791	
	fill granding t=0.35m	m3	310	93.4	0.68	28,954	211	39,283	
	trimming of slope	m2	490	204	1.47	99,960	720	135,255	
	approach road upper subbase	m3	5,394	1484	10.7	8,004,696	57,716	10,832,770	
	approach road asphalt pavement	m3	127	14242	103	1,808,734	13,081	2,449,703	
	temporary bridge with H beam	m2	300	11604	83.8	3,481,200	25,140	4,713,060	
	temporary coffering	unit	312	2561	18.5	799,032	5,772	1,081,860	
	temporary drainage(pump,generator)	day	60	40573	294	2,434,380	17,640	3,298,740	
15'	**No 15 old bridge demolish**					**2,477,557**	**17,891**	**3,354,233**	
	break concrete	m3	370	6661	48.1	2,464,570	17,797	3,336,623	
	filling materials transport	m3km	555	23.4	0.17	12,987	94	17,610	

Table 7-28 List of Construction Figures for Cost Survey (Zone III-3)

River improvement section Ⅲ						Loan Taget Rate		100	
No	item	unit	Quantity	Unit Price		Cost		Total	Remarks
				Foreign	Local	Foreign	Local		
				yen	TND	yen	TND	yen	
16	**No 16 old bridge demolish**					**4,407,623**	**31,830**	**5,967,286**	
	break concrete	m3	225	6661	48.1	1,498,725	10,823	2,029,028	
	filling materials transport	m3km	338	23.4	0.17	7,898	57	10,709	
	temporary bridge with H beam	m2	250	11604	83.8	2,901,000	20,950	3,927,550	
17	**No 17 new bridge construction**					**7,257,317**	**52,708**	**9,840,015**	
	blinding concrete c=200kg	m3	24	5361	38.7	128,128	925	173,449	
	abutment/pier base concrete c=350kg	m3	321	6828	49.3	2,194,519	15,845	2,970,925	
	form C2	m2	427	1550	11.2	661,695	4,781	895,978	
	form C3	m2	188	2058	14.9	387,110	2,803	524,442	
	reinforcement	kg	31,300	104	0.76	3,255,200	23,788	4,420,812	
	Excavation for river common soil (with average hauling distance of 1km)	m3	1,240	152	1.1	188,480	1,364	255,316	
	filling materials transport	m3km	585	23.4	0.17	13,689	99	18,562	
	fill granding t=0.35m	m3	1,045	93.4	0.68	97,603	711	132,422	
	trimming of slope	m2	8	204	1.47	1,632	12	2,208	
	approach road subgrade	m2	55	117	0.84	6,435	46	8,699	
	approach road upper subbase	m3	16	1484	10.7	23,744	171	32,133	
	approach road asphalt pavement	m3	21	14242	103	299,082	2,163	405,069	
17'	**No 17 old bridge demolish**					**1,359,308**	**9,816**	**1,840,295**	
	break concrete	m3	203	6661	48.1	1,352,183	9,764	1,830,634	
	filling materials transport	m3km	305	23.4	0.17	7,125	52	9,662	

Table 7-29 List of Construction Figures for Cost Survey (Zone IV)

Gate works						Loan Taget Rate		100	
No	item	unit	Quantity	Unit Price		Cost		Total	Remarks
				Foreign	Local	Foreign	Local		
				yen	TND	yen	TND	yen	
1	**Gate works**					**51,336,440**	**396,539**	**70,766,866**	
	side gate larger than 2.0m×2.0m	kg	141,670	247	1.79	34,992,490	253,589	47,418,366	
	Electric works	set	3	686000	6000	2,058,000	18,000	2,940,000	
	Service bridge	m2	417	34300	300	14,285,950	124,950	20,408,500	

7.3.4 Project Cost Estimation

The total project cost is shown in the table below. The total cost is 13.34 billion JPY (272 million TND). Details of project cost of main construction zones follow the total cost.

Table 7-30 Total Project Cost

	FC	LC	Total	
	Yen	TND	Yen	TND
A. ELIGIBLE PORTION				
(1) Procurement / Construction	**6,959,082,828**	**43,748,261**	**9,102,747,622**	**185,770,360**
River Improvement Section I	2,590,668,000	18,830,000	3,513,338,000	71,700,776
River Improvmeent Section II	1,858,556,000	13,672,000	2,528,484,000	51,601,714
River Improvement Section III	1,118,462,000	8,111,000	1,515,901,000	30,936,755
Gate Work	51,337,000	397,000	70,790,000	1,444,694
Base cost for JICA financing	5,619,023,000	41,010,000	7,628,513,000	155,683,939
Price escalation	1,008,674,931	655,011	1,040,770,449	21,240,213
Physical contingency	331,384,897	2,083,251	433,464,172	8,846,208
(2) Consulting services	**455,249,037**	**13,797,808**	**1,131,341,623**	**23,088,605**
Base cost	381,432,000	12,970,480	1,016,985,519	20,754,807
Price escalation	52,138,512	170,289	60,482,694	1,234,341
Physical contingency	21,678,526	657,038	53,873,411	1,099,457
ELIGIBLE PORTION Grand Total	**7,414,331,865**	**57,546,069**	**10,234,089,245**	**208,858,964**
B. NON ELIGIBLE PORTION				
(1) Procurement / Construction	**0**	**0**	**0**	**0**
Base cost for JICA financing	0	0	0	0
Price escalation	0	0	0	0
Physical contingency	0	0	0	0
(2) Land Acquisition	**0**	**34,959,785**	**1,713,029,488**	34,959,785
Base cost	0	33,000,000	1,617,000,000	33,000,000
Price escalation	0	295,034	14,456,655	295,034
Physical contingency	0	1,664,752	81,572,833	1,664,752
(3) Administration cost	**0**	**12,190,937**	**597,355,937**	12,190,937
(4) VAT	**0**	**43,887,375**	**2,150,481,372**	43,887,375
(5) Import Tax	**0**	**0**	**0**	**0**
NON ELIGIBLE PORTION Grand Total	**0**	**91,038,098**	**4,460,866,796**	**91,038,098**
TOTAL (A+B)	**7,414,331,865**	**148,584,167**	**14,694,956,042**	**299,897,062**
C. Interest during Construction	**482,283,643**	**0**	**482,283,643**	**9,842,523**
Interest during Construction(Const.)	481,763,397	0	481,763,397	9,831,906
Interest during Construction (Consul.)	520,246	0	520,246	10,617
D. Commitment Charge	**107,163,729**	**0**	**107,163,729**	**2,187,015**
GRAND TOTAL (A+B+C+D)	**8,003,779,237**	**148,584,167**	**15,284,403,413**	**311,926,600**
E. JICA finance portion incl. IDC (A + C + D)	**8,003,779,237**	**57,546,069**	**10,823,536,617**	**220,888,502**

Source: JICA Survey Team (Based on the Cost Estimate Kit prepared by JICA)

Table 7-31 Project Cost by Construction Zone (River Improvement Section I)

item	unit	Quantity	Unit Price		Cost		Total
			Foreign	Local	Foreign	Local	
			yen	TND	yen	TND	yen
Earth works	set	1			1,876,926,000	13,607,000	2,543,669,000
Main body works	set	1			48,686,000	405,000	68,531,000
Contorol house works	set	1			3,098,000	28,000	4,470,000
Appurtenant works	set	1			32,176,000	233,000	43,593,000
Service road works	set	1			247,719,000	1,791,000	335,478,000
Temporary construction road works	set	1			82,477,000	596,000	111,681,000
No 3 old bridge Demolish	set	1			5,064,000	37,000	6,877,000
No 4 new bridge construction	set	1			182,016,000	1,318,000	246,598,000
No 4 old bridge Demolish	set	1			4,915,000	36,000	6,679,000
No 8 old railway bridge Demolish	set	1			3,601,000	26,000	4,875,000
No 9 railwaybridge extension	set	1			103,990,000	753,000	140,887,000
Total					2,590,668,000	18,830,000	3,513,338,000

Table 7-32 Project Cost by Construction Zone (River Improvement Section II)

item	unit	Quantity	Unit Price		Cost		Total
			Foreign	Local	Foreign	Local	
			yen	TND	yen	TND	yen
Earth works	set	1			914,264,000	6,634,000	1,239,330,000
Main body works	set	1			307,251,000	2,416,000	425,635,000
Contorol house works	set	1			2,902,000	26,000	4,176,000
Appurtenant works	set	1			62,348,000	451,000	84,447,000
Service road works	set	1			194,942,000	1,409,000	263,983,000
Temporary construction road works	set	1			26,410,000	191,000	35,769,000
No 18 new bridge construction	set	1			122,267,000	885,000	165,632,000
No 18 old bridge Demolish	set	1			422,000	4,000	618,000
No 19 new bridge construction	set	1			5,954,000	44,000	8,110,000
No 19 old bridge Demolish	set	1			422,000	4,000	618,000
No 20 new bridge construction	set	1			5,912,000	43,000	8,019,000
No 20 old bridge Demolish	set	1			422,000	4,000	618,000
No 21 new bridge construction	set	1			6,066,000	45,000	8,271,000
No 21 old bridge Demolish	set	1			529,000	4,000	725,000
No 22 new bridge construction	set	1			125,670,000	910,000	170,260,000
No 22 old bridge Demolish	set	1			2,833,000	21,000	3,862,000
No 27 new bridge construction	set	1			58,516,000	424,000	79,292,000
No 27 old bridge Demolish	set	1			2,076,000	15,000	2,811,000
No 30 new bridge construction	set	1			6,608,000	48,000	8,960,000
No 31 new bridge construction	set	1			6,367,000	47,000	8,670,000
No 32 new bridge construction	set	1			6,375,000	47,000	8,678,000
Total					1,858,556,000	13,672,000	2,528,484,000

Table 7-33 Project Cost by Construction Zone (River Improvement Section III)

item	unit	Quantity	Unit Price		Cost		Total
			Foreign	Local	Foreign	Local	
			yen	TND	yen	TND	yen
Earth works	set	1			674,320,000	4,889,000	913,881,000
Main body works	set	1			14,513,000	113,000	20,050,000
Appurtenant works	set	1			19,447,000	141,000	26,356,000
Service road works	set	1			186,255,000	1,347,000	252,258,000
Temporary construction road works	set	1			62,012,000	448,000	83,964,000
No 12 Bridge Reinforcement of the existing pier	set	1			39,807,000	288,000	53,919,000
No 15 new bridge construction	set	1			106,604,000	772,000	144,432,000
No 15 old bridge Demolish	set	1			2,478,000	18,000	3,360,000
No 16 old bridge Demolish	set	1			4,408,000	32,000	5,976,000
No 17 new bridge construction	set	1			7,258,000	53,000	9,855,000
No 17 old bridge Demolish	set	1			1,360,000	10,000	1,850,000
Total					1,118,462,000	8,111,000	1,515,901,000

Table 7-34 Project Cost by Construction Zone (Gate Works)

item	unit	Quantity	Unit Price		Cost		Total
			Foreign	Local	Foreign	Local	
			yen	TND	yen	TND	yen
Gate works	set	1			51,337,000	397,000	70,790,000
Total					51,337,000	397,000	70,790,000

Table 7-35 Land Acquisition Cost

item	Local	Total
	TND	yen
Land Acquisition Cost	28,000,000	1,372,000,000

Table 7-36 Consulting Service Fee

		Unit	Qty.	Foreign Portion (Yen)		Local Portion TND		Combined Total
				Rate	Amount ('000)	Rate	Amount ('000)	('000) Yen
A	Remuneration							
1	Professional (A)	M/M	136	2,562,000	348,432	0	0	348,432
2	Professional (B)	M/M	351	0	0	15,000	5,265	257,985
3	Supporting Staffs	M/M	759	0	0	4,500	3,416	167,360
	Subtotal of A				348,432		8,681	773,777
B	Direct Cost							
1	International Airfare		60	550,000	33,000		0	33,000
2	Domestic Airfare		0		0		0	0
3	Domestic Travel		0		0		0	0
4	Accommodation Allowance	M/M	136		0	7,500	1,020	49,980
5	Vehicle Rental (4WD)	Car/M	122		0	9,000	1,098	53,802
6	Office Rental	M/M	69		0	2,000	138	6,762
7	International Communications	M/M	69		0	500	35	1,691
8	Domestic Communications	M/M	69		0	599	41	2,025
9	Office Supply	M/M	69		0	100	7	338
10	Office Furniture and Equipment	M/M	69		0	1,000	69	3,381
11	Report Preparation	Month	69			200	14	676
12	Topographic Survey	Set	1				673	33,000
13	Geotechnical Survey	Set	1				449	22,000
14	Social Environment Monitoring Survey	Set	1				150	7,350
15	Environment Monitoring Survey	Set	1				596	29,204
	Subtotal of B				33,000		4,290	243,209
	Total				381,432		12,970	1,016,986

Note) The M/M bar chart for consulting service fee calculation is explained in Chapter 9.

7.4 Employing Japanese Techniques

7.4.1 Bridges

Below are two Japanese techniques that can be employed in the course of improving bridges:

1) Construction Beneath Roads/Railways in Use

2) Temporary Construction to Shorten Construction Schedules

(1) Technique for Construction Beneath Roads/Railways in Use

1) Construction Method Overview

This technique is for building structures beneath roads and railways in use without inhibiting their passability. Materials called elements are thrust into the ground such that they pass perpendicularly under the road and railways in use and support the natural ground in addition to becoming part of the main structure.

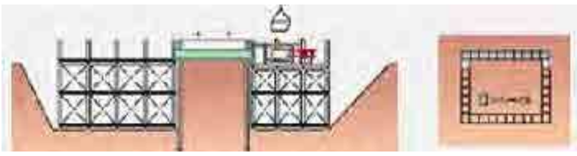
Applying this technique removes the need to add replacement roads or railways to secure passage when structures (abutments, piers, culverts) need to be built beneath the roads and railways in the course of jacking up or expanding bridges. Thus, this technique can shorten construction schedules, remove the need to acquire sites for the replacement roads or railways, and allow roadways to continue to be used in their current state to ensure smooth passage.

Below are schematic diagrams and construction steps:

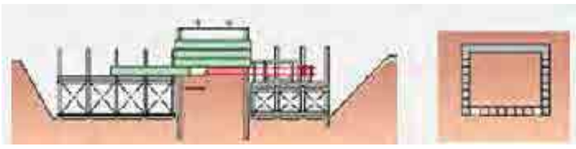
Figure 7-17 Technique Schematic Diagram

(1) Drill horizontal boreholes
・Horizontal boreholes are drilled for PC steel cables used to pull basic elements.

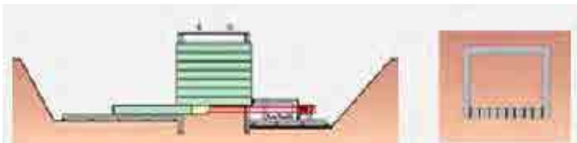
(2) Insert PC steel cable
・PC steel cables are inserted.



(3) Pull upper floor elements through the tunnel
・Elements are pulled through the tunnel. When this happens, the PC steel cables pulled along with the preceding element are used to pull the succeeding element.
(4) Fill joints with grout
・Once all upper floor elements have been pulled through the tunnel, they are joined by filling their joints with grout.
(5) Fill elements with concrete
・The insides of the upper floor elements are filled with concrete to form the upper floor slab.



(6) Pull side wall elements through the tunnel
・The left and right side wall elements are pulled through the tunnel following the same procedure as that for the upper floor elements.
(7) Fill joints with grout
(8) Fill elements with concrete



(9) Pull bottom floor elements through the tunnel
(10) Fill joints with grout
(11) Fill elements with concrete

(12) Excavate the inside of the box
(13) Finish the interior

Elements inserted from this side | Elements come out on this side

Figure 7-18 Upper Floor Element Pulling Procedure (3)

Figure 7-19 Excavation Complete

2) Results

Employing this technique delivers the following results:

- The construction schedule is shortened because replacements for the roads or railways in use are not necessary.
- There is no need to acquire sites for replacement roads or railways.
- Smooth passage can be ensured because roadways can continue to be used in their current state.
- High-precision work is possible with little impact on roads, railways and the rest of the surrounding environment since the elements are inserted using the pulling method.
- Elements are fitted together with joints and their insides filled with concrete, so they can double as the main structure, which shortens the construction schedule. The process does not have to result in a box shape; multi-span boxes, rings and many other shapes can be built.
- Since protection work from the pipe roof method and other methods is not necessary and earth covering can be minimized, structure construction foundations can be raised, which shortens approaches compared to other construction methods used beneath roads and railways.

3) Applicability to the Project

Employing this technique would raise the construction cost of jacking up railway bridges 50% over conventional construction methods, but it is effective when changing management conditions during construction stages or problems acquiring work sites preclude building replacement roadways.

Table 7-37 Comparison between Conventional and Proposed Construction Methods

Method	Conventional Method	Proposed Method
Items & Cost	Cost (TND)	Cost (TND)
	No.9	No.9
1)Substructure	788,000	2,862,000
2)Superstructure	1,366,000	1,366,000
3)Temporary	721,000	
Total	2,875,000 (1.00)	4,228,000 (1.47)
Evaluation	○	△

(2) Temporary Construction to Shorten Construction Schedules

1) Construction Method Overview

Under this technique, cable-stayed structures are used in the course of building temporary bridges and docks and superstructures are built in advance. Employing this technique removes the need for piles and other temporary facilities for building the substructures of temporary bridges and docks in the course of jacking up or expanding bridges. This can shorten construction schedules, improve the ability to perform work and restrict impact to the natural environment.

Below are schematic diagrams and construction steps:

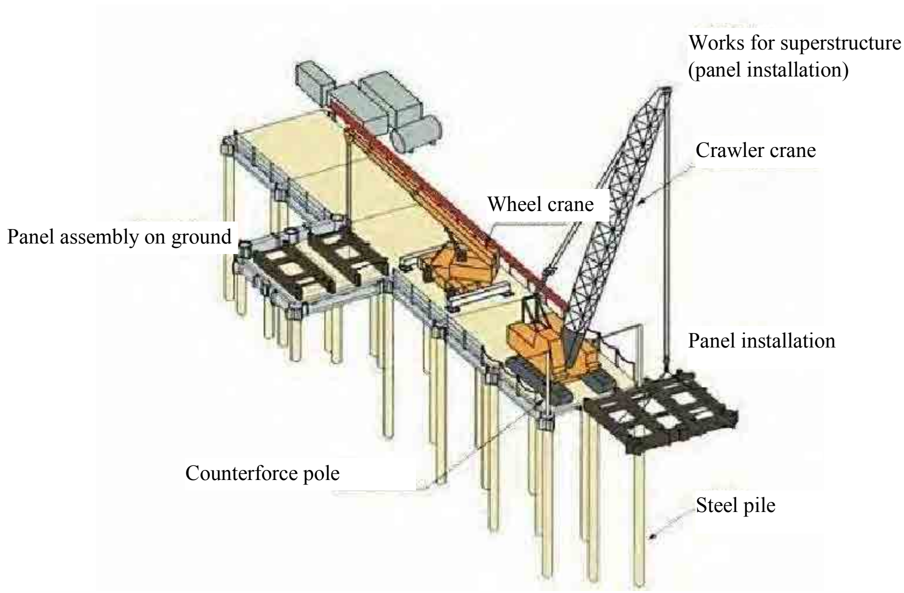
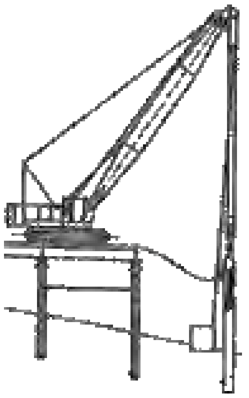


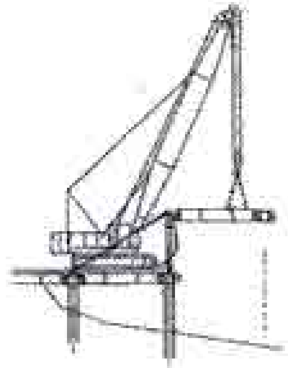
Figure 7-20 Technique Schematic Diagram

a. Each support (panel, the superstructure material installation unit) is assembled on-site.
b. Cranes use counterforce poles that maintain cantilevered panels and cable-suspension equipment to lower panels in sequence from atop temporary bridges and docks.
c. After lowering each panel, steel pipe piles are inserted and driven into guides at the front edge.
d. Steps a) through c) are repeated.

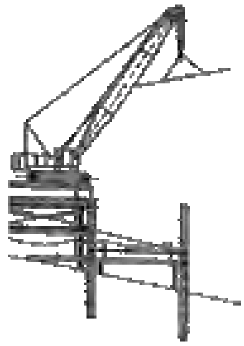
Below is a visual comparison of the conventional construction method and the proposed construction method:



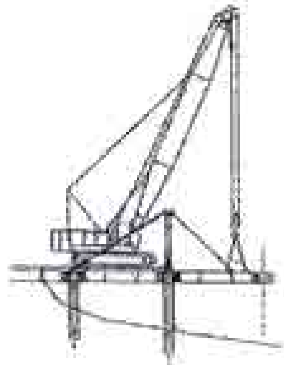
Driving support piles



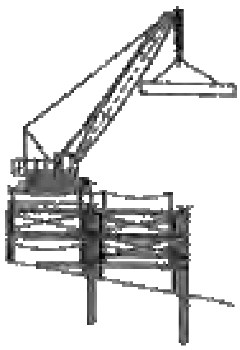
Lowering upper panel



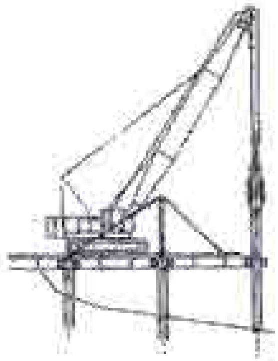
Installing anchor materials, building scaffolding



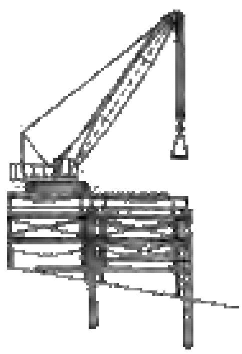
Connecting existing piers to cables



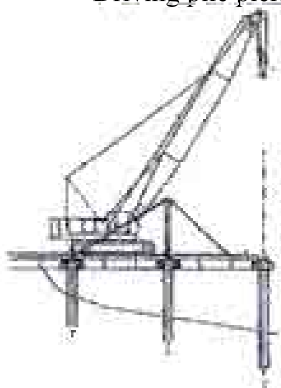
Main girder installation



Driving pile piers



Installing deck panels



Injecting filling/treating pile heads

Figure 7-21 Comparing Construction Methods (Left: Conventional; Right: Proposed)

2) Results

Employing this technique delivers the following results:

- Installing superstructures first eliminates the need to have work done in high places to build scaffolding at bridge sites, shortening the construction schedule and improving economic efficiency and safety.
- New panels can function as guides and separate the construction into panel units, and they are connected by pins, so work can be done on superstructures and substructures simultaneously, improving the ability to perform work.
- Installing superstructures assembled on flat ground and using them as guides for driving/casting piles minimizes ground excavation by removing the need to set up guides on the ground, which can restrict impact to the natural environment.
- Steel pipe piles perform well for their cross sections; substructures can be made smaller with steel pipe piles than with steel H-piles. They are extremely safe because they decrease flow resistance.
- This technique is very safe because it reduces the amount of manual labor performed atop unstable scaffolding in high places, on slopes or on the water.

3) Applicability to the Project

As shown below, employing this technique would raise the cost of building temporary bridges 10% over the conventional construction method, but it can shorten the construction schedule for the five temporary bridges required in the river improvement by about one-third.

Table 7-38 Comparison between Conventional and Proposed Construction Methods

(1) Quantity

Item	No.4	No.12	No.18	No.22	No.27
Material	852	480	84	150	270
Erection	852	480	84	150	270
Removal	852	480	84	150	270

(2) Cost and Construction Period

Method	Conventional Method							Proposed Method						
Items & Cost	Unit price	Cost (TND)						Unit price	Cost (TND)					
		No.4	No.12	No.18	No.22	No.27	Total		No.4	No.12	No.18	No.22	No.27	Total
Material	730	622,000	350,000	61,000	110,000	197,000	1,340,000	1480	1,261,000	710,000	124,000	222,000	400,000	2,717,000
Erection	1270	1,082,000	610,000	107,000	191,000	343,000	2,333,000	700	596,000	336,000	59,000	105,000	189,000	1,285,000
Removal	220	187,000	106,000	18,000	33,000	59,000	403,000	260	222,000	125,000	22,000	39,000	70,000	478,000
Total		1,891,000 (1.00)	1,066,000 (1.00)	186,000 (1.00)	334,000 (1.00)	599,000 (1.00)	4,076,000 (1.00)		2,079,000 (1.10)	1,171,000 (1.10)	205,000 (1.10)	366,000 (1.10)	659,000 (1.10)	4,480,000 (1.10)
	Amount par day	Construction days						Amount par day	Construction days					
		No.4	No.12	No.18	No.22	No.27	Total		No.4	No.12	No.18	No.22	No.27	Total
Preparation	5.00	5	5	5	5	5	25	5.00	5	5	5	5	5	25
Erection	6.99	122	69	13	22	39	265	30.77	28	16	3	5	9	61
Removal	20.83	41	24	5	8	13	91	54.55	16	9	2	3	5	35
Finishing	4.00	4	4	4	4	4	20	4.00	4	4	4	4	4	20
Total		172 (1.00)	102 (1.00)	27 (1.00)	39 (1.00)	61 (1.00)	401 (1.00)		53 (0.31)	34 (0.33)	14 (0.52)	17 (0.44)	23 (0.38)	141 (0.35)
Evaluation	○							△						

7.4.2 Dam Flood Management Operation

(1) Purpose of Employing Japanese Techniques

Dam management is one area where Japanese techniques can be employed. Dam management includes dam operation, dam facility management and reservoir management. Within dam operation are flood operation and water supply operation. There are many issues with diversion operation during floods on the Mejerda River, and Japanese techniques will be employed for flood operation.

As of 2010, there are a total of five dams on the Mejerda River with a flood control capacity of 518 million m^3: Sidi Salem Dam on the main river and Mellegue, Silliana, Bou Huertma and Sara Dams on tributaries. Sidi Salem Dam is located farthest downstream and has a flood control capacity of 285 million m^3, which is 55% of the capacity of all the dams, with a basin area of 18,150 km^2, which is 78% of the total. It is no exaggeration to say that Sidi Salem Dam controls flooding on the Mejerda River.

Sidi Salem Dam's optimal, effective control of the many floods in the 23,400-km^2 Mejerda River Basin serves to minimize flood damage downstream of the dam.

(2) Employing Flood Management Operation at Sidi Salem Dam

Currently, information is gathered by telephone and fax at Sidi Salem Dam during floods, and gate operation is determined and water discharged based on that information. Below is a conceptual diagram of gate operation:

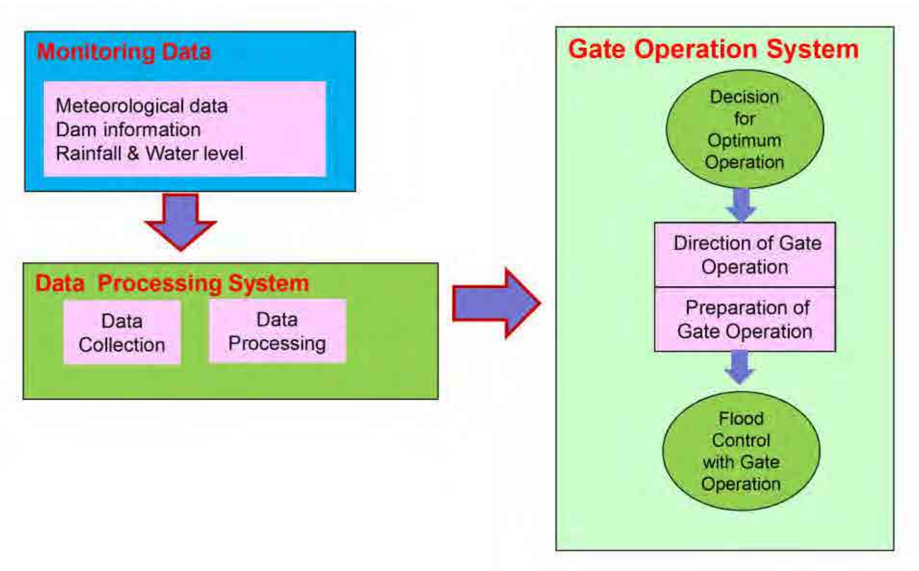


Figure 7-22 Current Sidi Salem Dam Flood Management (Gate Operation) Conceptual Diagram

There are issues with the amount of time it currently takes to gather and process hydrological information (rainfall, river levels, and dam data); these issues need to be resolved as soon as possible.

DGRE has a telemeter (SYCOHTRAC) improvement plan and a management plan to be integrated with the dam management system when the GPRS communication system is introduced. If the introduction of the telemeter and data processing systems resolves the issues, the faster processing speed should ensure enough time for operation related to dam operation and, initially, operate via the dam management system by processing and analyzing telemeter information. (See the blue arrows on the flowchart below)

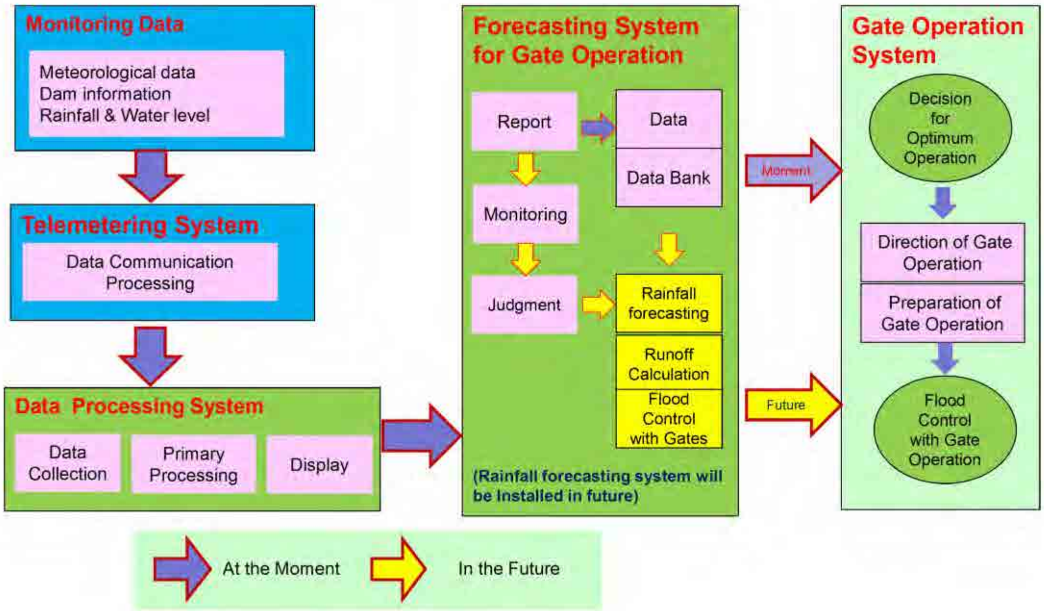


Figure 7-23 Sidi Salem Dam Flood Management System (Current Improvement Plan and Future System)

As indicated in the figure above, five flood control systems are required for effective dam flood management: monitoring data, telemetering, data processing, and forecasting and gate operation. The future system is expected to expand to include gate operation simulation that includes rainfall prediction (yellow arrows on the flowchart). Warnings to downstream areas are crucial when discharging water from dams, and sirens or audio warning facilities need to be introduced.

(3) Features of Dam Management Techniques in Japan

In Japan, dams are managed in response to long periods of sustained rainfall during the early summer rainy season and short periods of heavy rainfall during typhoon season, and dam operation methods that make full use of this experience have been established. The dam alarm system plan and design guideline for prevention of human damage are formulated partly because of the experience of dam water discharge having resulted in rapid increase of water level in lower steam and caused such damage in the past. The device and facility for the plan have been developed.

A system capable of estimating the entire process from rainfall, discharge, dam operation (inflow, outflow and water levels) to the water level in the lower stream has been developed for the gate operation in floods and it is used integrally with the dam discharge alarm system.

Working manuals and guidelines for dam flood management, gate operation and treatment facility include Dam Management Practice and Guidelines for Design of Dam Management Control and

Treatment Facility and procedures and methodologies of swift and accurate dam management (gate operation) have been established.

Employing the established techniques above can prevent flood damage from occurring downstream of dams. They can be also used when the current individual dam operation management is shifted to the integrated Mejerda River dam management in the future.

(4) Cost Estimation

The Japanese specifications are unable to be applied directly to the sites because management level of dam management system and familiarization level to system is different between Tunisia and Japan.

The software introduction cost for a dam management system (including distance observation other than dam management office) for a relatively small dam (height: 55m, catchment area: 10km^2 or less, one rain gauge, and one water gauge) in Japan is shown below. The software for distance observation is planned to be installed at a point five kilometers away from the dam.

Table 7-39 Dam Flood System Software Cost for Small Dam in Japan

Name of Software	Cost (1,000*JPN)	Cost (1,000*TND)
1) Reservoir Gate Control System	75,000	1,530
2)Remote Monitoring System	18,000	370
Total	93,000	1,900

Note: PC Personal Computer, UPS Uninterruptable Power Supply
Source: JICA Survey Team (Based on the cost for dam control system applied for the small scaled dam in Japan, Basin catchment area is below 10 km2)

Partly because the Sidi Salem Dam is bigger in the catchment area and reservoir than the dam described above, additional telemeter systems are needed. Language translation is also needed. However, it is fair to say that the cost for hydrological information gathering system, hydrological analysis, prediction calculation, gate operation calculation and other software is not necessarily proportionate to the scale of the dams. The approximate cost is assumed to be 2,300 ~ 2,500 TND by the additional 20 ~ 30% increasing calculation of the above amount.

Whether to develop and introduce a dam management system for floods should be examined in comparison with the improved system of SYCOHTRAC the Water Resources Bureau is planning to introduce.