19.4.6 Nile River Bridge Design

(1) Basic Study Flow for the Nile River Bridge Design

The basic study flow for the Nile River bridge design is illustrated in Figure 19.4.6-1. One of the control points for the Circumferential Street C3 at the south-eastern section is the Nile river bridge location. The possible alternative site locations are identified using the satellite image, as discussed in Chapter 18, and existing conditions verified by site reconnaissance. Once the bridge site location is established, the alternatives for bridge type and scheme are proposed based on the river condition, engineering requirements, costs and available technology. The proposed alternative bridge types are then evaluated and the most applicable scheme is selected based on established policy and criteria.

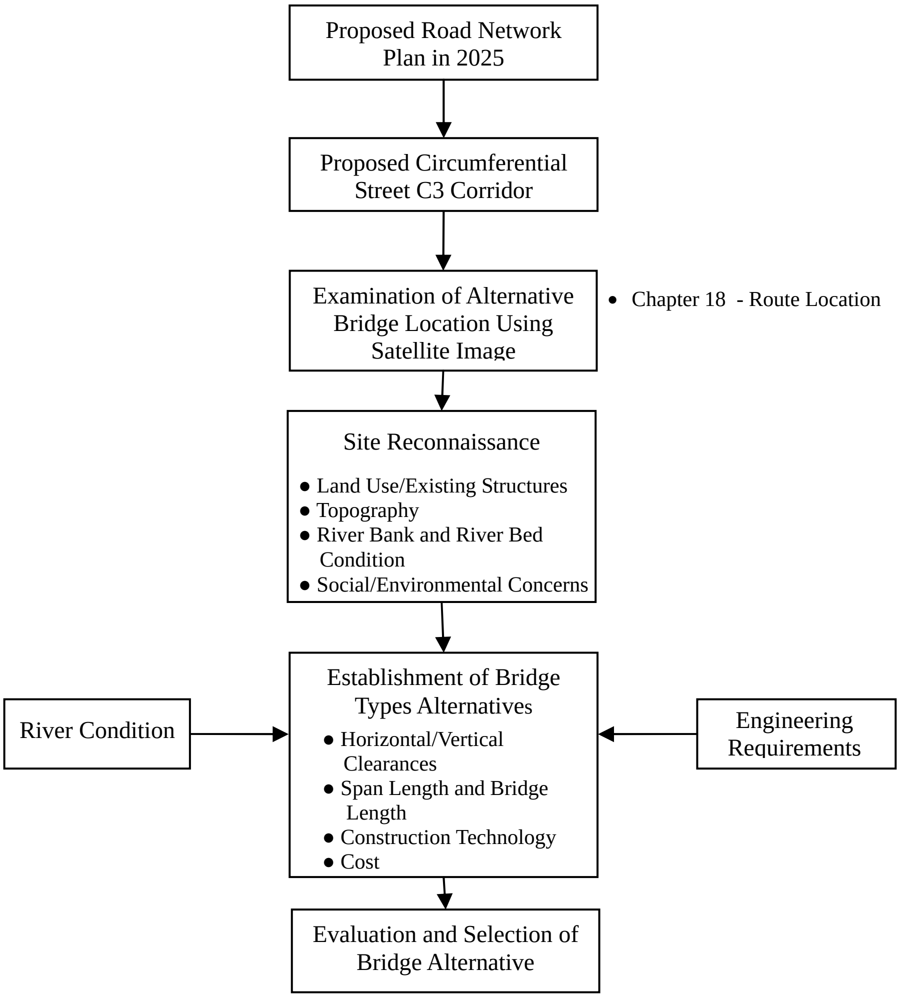


Figure 19.4.6-1 Study Flow for the Nile River Bridge Design

(2) Existing Conditions

The alternative route locations for White Nile River Bridge No.1 (south section) are discussed in Chapter 18.3.4 with the proposed bridge location shown in Figure 19.4.6-3. Based on the selected option, the existing conditions of the proposed bridge site are noted using the satellite images and site observations as follows:

1) Nile River

- The Nile River, running over about 6,800 km in length (Figure 19.4.6-2), is the longest river flowing from its southern origin to the north at over 35 degrees of latitude. It is fed by two major tributaries or main river systems: (1) the White Nile which rises from the Great Lakes region of central Africa, with the farthest source in southern Rwanda, and flowing north from there through Tanzania, Lake Victoria, Uganda and southern Sudan, and (2) the Blue Nile starting from Lake Tana in Ethiopia and flowing into Sudan from the southeast. The confluence of the two rivers is in the Sudanese capital Khartoum.

Source: http://en.wikipedia.org/wiki/File:River_Nile_route.jpg

Figure 19.4.6-2 The Nile River

- The average flow of the White Nile at Malakal is 924 m³/s, with a peak flow at approximately 1,218 m³/s in early March and a minimum flow is about 609 m³/s in late August. The fluctuation can be attributed to the substantial variation in the flow of the Sobat River which has a minimum flow of about 99 m³/s in August and a peak flow of over 680 m³/s in early March. (http://en.wikipedia.org/wiki/Nile)

2) Topography and General Condition of the Area

The conditions of the proposed site mentioned in this section are based on the satellite image and visual site inspection conducted.

- The selected C3 alignment (see Figure 19.4.6-3) is about 1.8km south of the existing Juba Bridge (Nile river crossing) on the upstream side.
- On the southwestern side of the river, the proposed alignment will merge with the newly constructed earth road from the Juba-Yei Road (R1) towards the Nile River. However, the proposed road on the eastern side of the river is an entirely new alignment which will intersect with the existing Radial street R6.
- The bridge site is in the straight alignment about 550m north (downstream side) of the island or the confluence of the two waterway channels of the river.
- The site, in general, is relatively flat terrain with dense residential areas on the west side and open grassland on the east side.
- Two banks are observed to be formed on either side of the river with the areas in between the banks being cultivated and used for agriculture (Figure 19.4.6-4).
- There are no observed remarkable structures or natural features on either side of the proposed centerline which may control the bridge location except that it is better to avoid the confluence point of the two channels. The bridge location is then controlled by the geometric requirements of the road alignment.

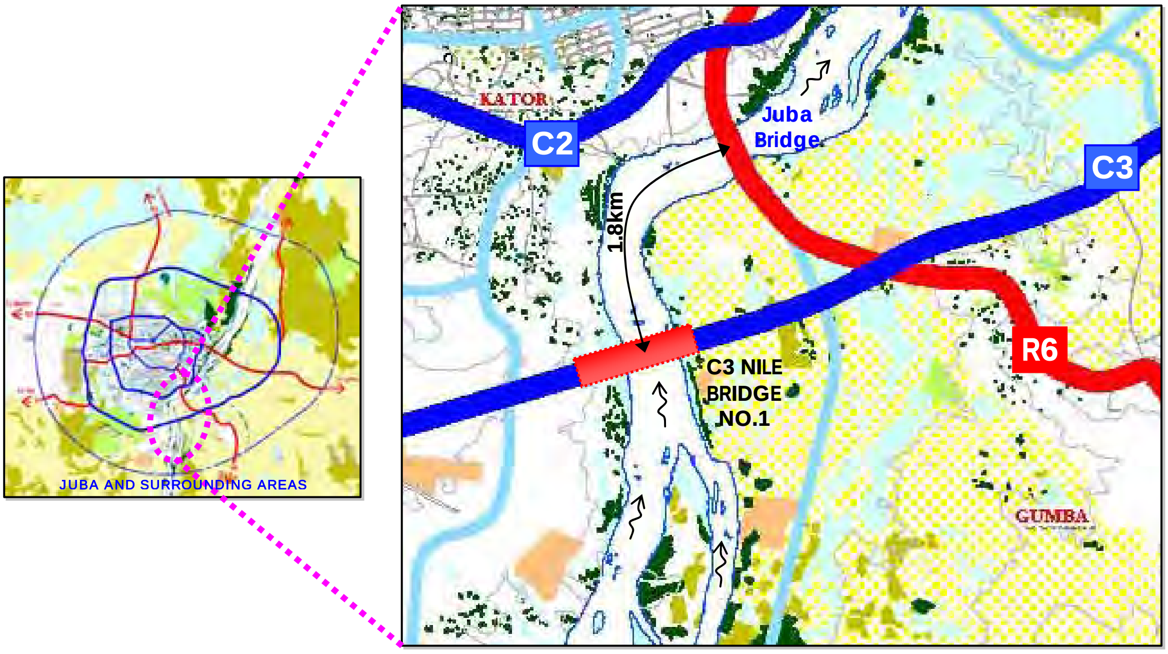


Figure 19.4.6-3 Location of C3 Nile River Crossing Bridge No.1

3) <u>River Condition at Proposed Bridge Site</u>

- There is no known record of the river flow at the proposed bridge site, although it is observed that water flows continuously throughout the year with average velocity of about 1.0 to 1.5 m/s. Moreover, it was observed during the reconstruction of the Juba Bridge that water flows at a rate of 1.5 to 2.0 m/s during peak flows.
- The river meanders from the upstream to the downstream side with single and dual waterway channels alternating from south to north direction of the river, as seen in

Figure 19.4.6-3.

- To avoid the confluence area of the two channels, the bridge is located 550m north of the formed island.
- There are two formed banks observed during site reconnaissance at the proposed bridge location, as shown in Figure 19.4.6-4 and Figure 19.4.6-5. The first banks are seen at the level of ordinary (normal time) waterway flow with a width of about 340m. The second banks are observed to be about 525m apart, which are 3m to 5m higher than the first bank. Interview with the local residents indicates that the river does not overflow on the second bank. The areas between the first and the second banks are being used for agricultural purposes by the nearby residents. Evidence of river swelling reaching 1m-2m above the first bank is observed.

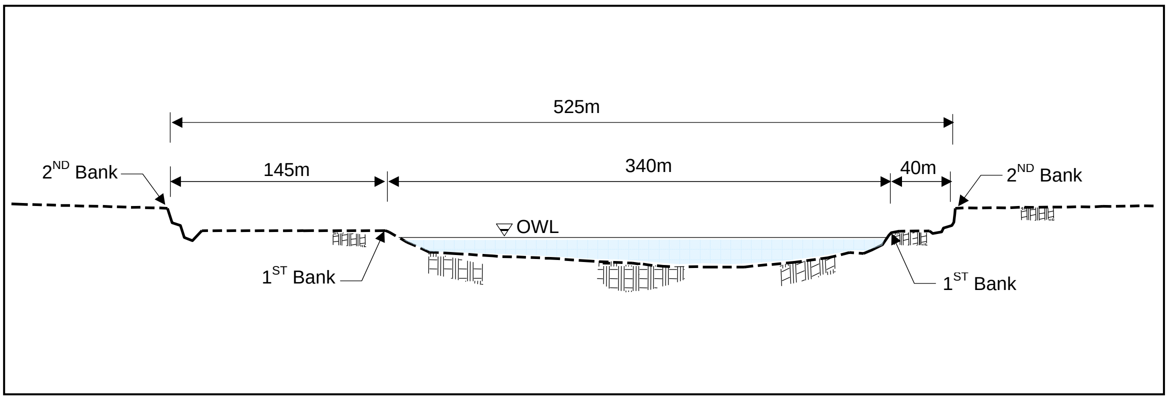


Figure 19.4.6-4 River Section at Proposed Site

- Bank scouring is not observed at the proposed site, although bank scouring are seen on the upstream side.
- Soil types at the banks are noted to be silty clays at the upper 2-3m and sandy gravel below this layer. Large boulders are observed on the river bed.
- Debris and fallen tress are observed on the river.
- Photos of the existing conditions of Nile River upstream and downstream of the proposed site are shown in Figure 19.4.6-5.

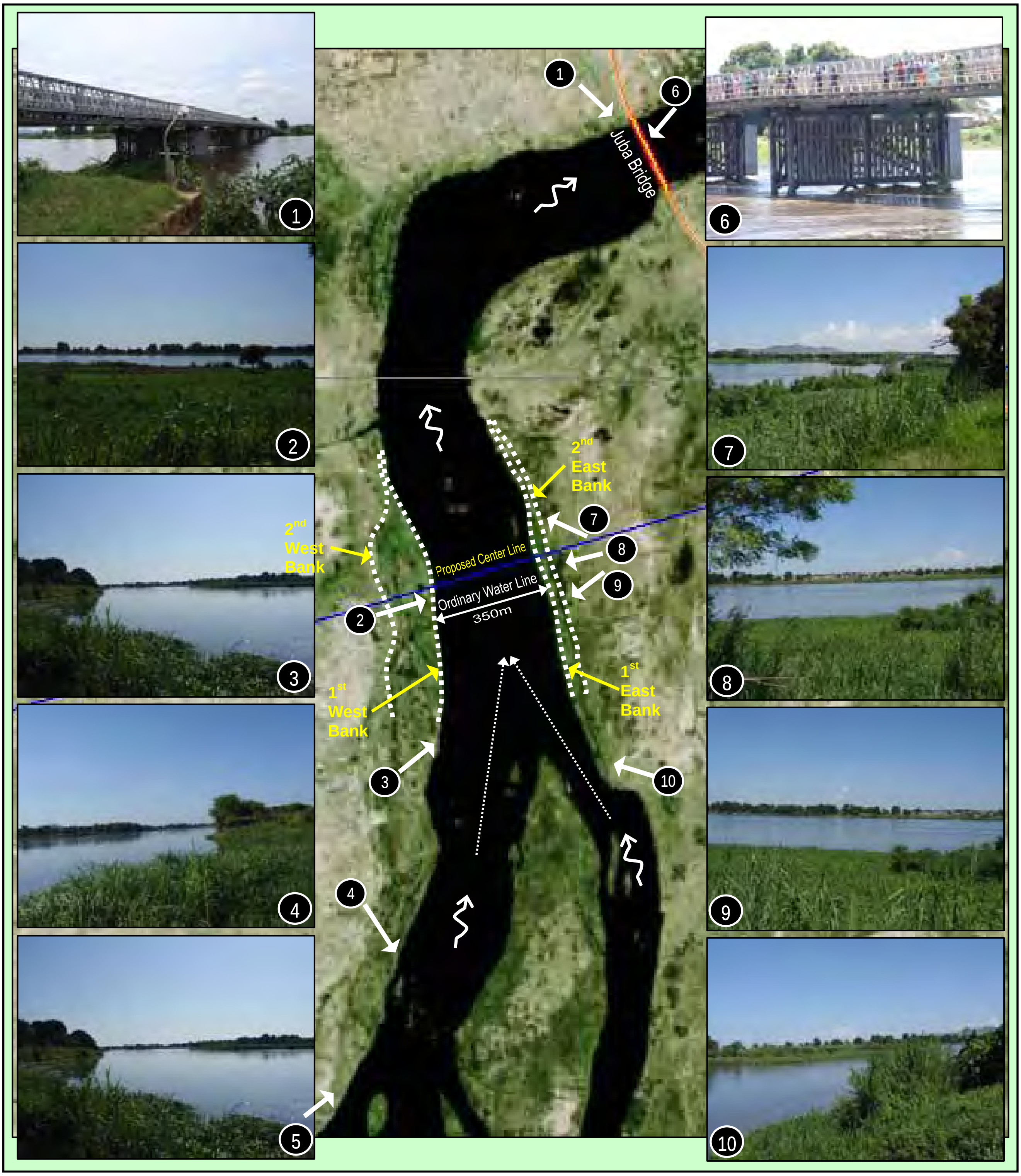
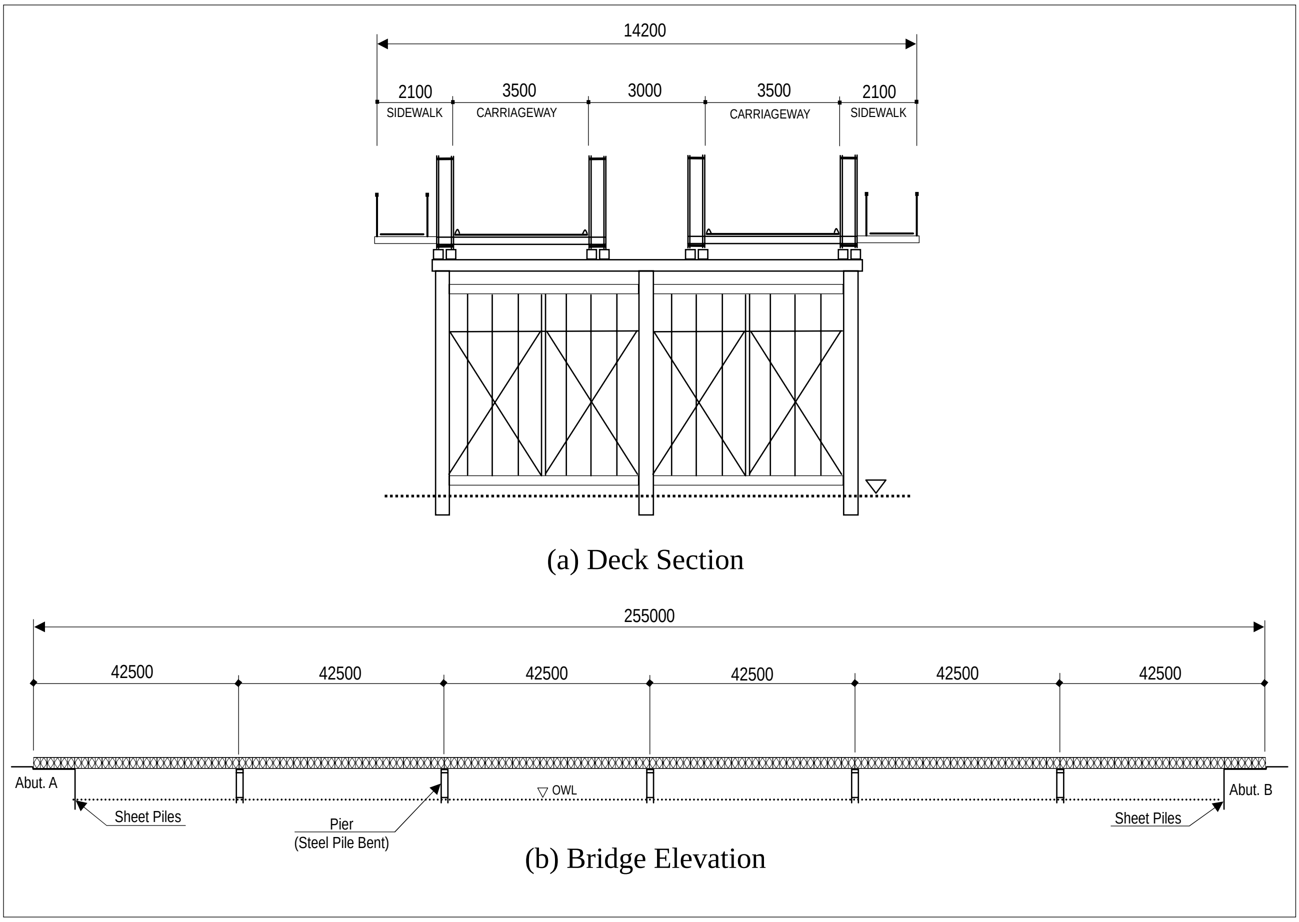


Figure 19.4.6-5 River Condition at the Proposed Site

4) Existing Juba Bridge Crossing the White Nile River

- The existing Juba Bridge, see Figure 19.4.6-6 and 19.4.6-7, crossing over the White Nile River is a twin-deck, six-span Mabey and Johnson Bridge (double panel truss type) with a total length of 255m. Five piers on steel bents support the superstructure in the river with spans of 42.5m.

Figure 19.4.6-6 Existing Juba Bridge



(a) Deck Section

(b) Bridge Elevation

Figure 19.4.6-7 General View of Existing Juba Bridge

- The superstructure of the bridge, originally built in 1974, collapsed in 2006 due to overloading of passing trucks. After evaluation by the contractor that the original substructures (founded on firm rock layers) are in good condition, the superstructure was replaced with the same type in October 2008. The newly reconstructed bridge is posted at 45 tons load limit and 20 km/hr speed limit.
- The river banks in the vicinity of the bridge are in stable conditions and show minimal signs of scouring. Moreover, there is no observed scouring around the bridge piers.
- It was observed by MTR during bridge reconstruction that the water depth at the bridge site is about 4m in average.
- Moreover, as seen from the high water marks at the piers, the freeboard (vertical clearance) of the deck soffit is about 3m.
- Although the load limit is posted at 45 tons, there is no means of controlling the truck weights crossing the bridge.
- Sagging of the superstructure is observed.

(3) Policy on Selection of Bridge Configuration

The choice of structural system for the proposed bridge shall be governed by the following:

1) <u>Bridge Span and Length</u>
   - The span arrangement and the bridge length shall not constrict the river waterway and maintain the river function.
   - The span arrangement shall provide sufficient horizontal and vertical clearances as required by the river function with sufficient freeboard from maximum flood water level. The existing Juba River Port is built at about 1.2km downstream of the existing Juba Bridge, and considering the river water depth and the presence of large boulders at the river bed upstream of the existing river port, barges and large boats are not expected to navigate the area beyond the existing bridge. As such, navigation clearances can be provided only for small fishing boats.
   - The spans shall be greater than or similar to the existing bridge spans.

2) <u>Bridge Structure Type</u>
   - The structure type selected shall be cost-effective, easy to maintain and faster to construct.
   - The structural system and construction method proposed shall be easy to implement considering available technology and materials at site.
   - The structural system selected shall be resistant and reliable to expected loads (including earthquake).
   - The structure type selected shall be aesthetically pleasing with minimal environmental impact.

(4) Alternative Bridge Types

Following the existing site conditions and the policy on bridge configuration, the basic requirements for the C3 Bridge crossing the Nile River are as follows:

- The total bridge length shall cover the second bank which is about 525m wide.
- Pier spans shall be no less than the existing bridge spans of about 42.5m. Considering the river discharge and the type of foundation at the river bed, it is desirable to use pier spans greater than 60m.
- Since the normal waterway channel extends only to the first bank, the main bridge shall cover only the normal width of the channel and approach bridges with shorter spans can be built until the second bank.
- The freeboard or vertical clearance from the maximum floodwater level shall be similar to or greater than the freeboard of the existing Juba Bridge.
- The proposed bridge shall require minimal maintenance.

1) Applicable Structure Types

The choices of applicable bridge superstructure types that can be used to the proposed Nile River bridge are illustrated in Figure 19.4.6-8 with various concrete and steel bridge types and span range presented in the figure.

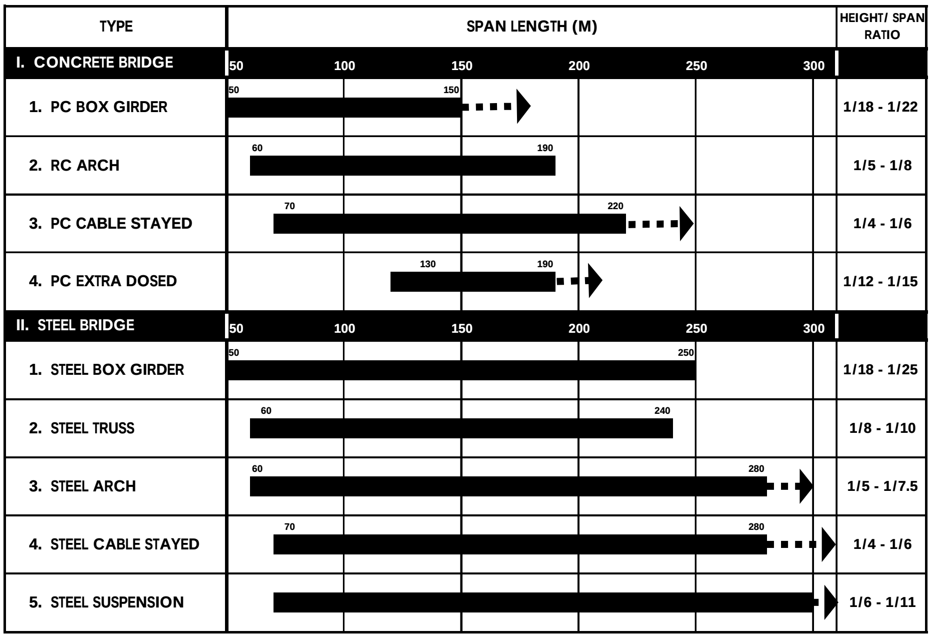
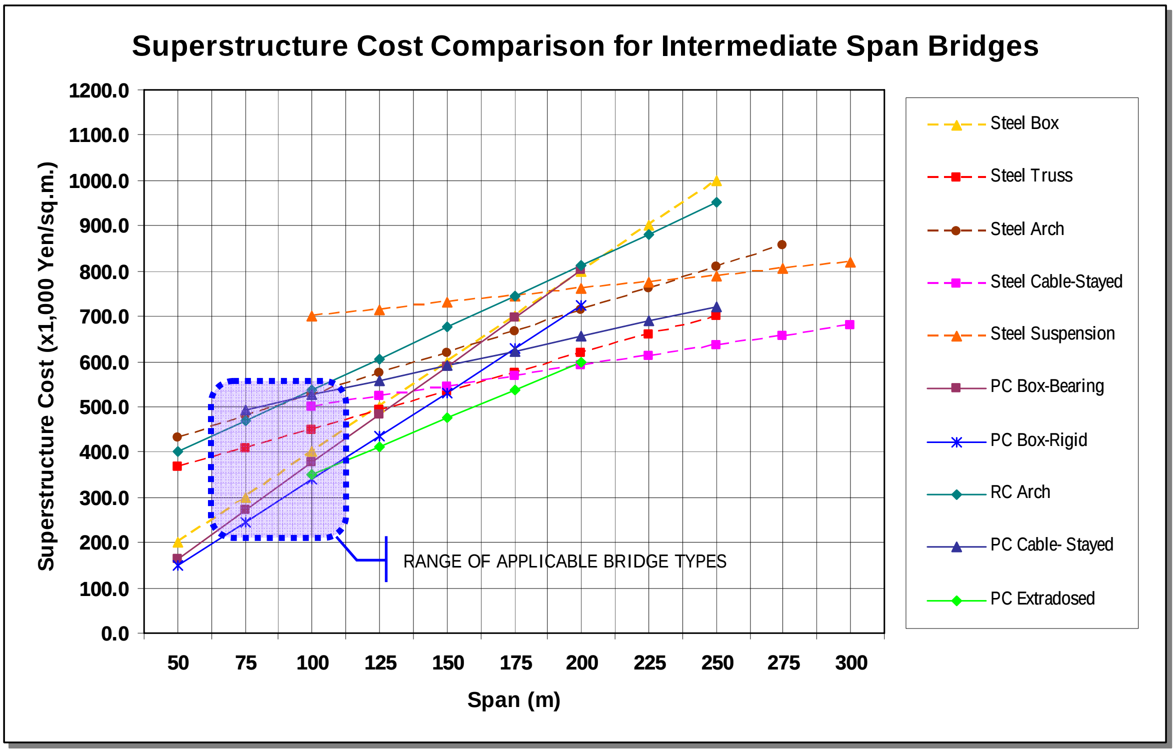


Figure 19.4.6-8 Applicable Bridge Types for Intermediate Span Bridges

Box girders (concrete and steel) are competitive and economical in the range considered for the Nile River crossing, from 60m to 100m. Truss and arch bridges are likewise competitive at this span range but prestressed concrete extradosed bridges are more competitive at longer spans until 200m. Moreover, cable stayed bridges and suspension bridges are recommended for longer spans greater than 200m.

A comparison of superstructure costs for intermediate to long span bridges is illustrated in Figure 19.4.6-9 where the costs per spans are normalized to give a comparative cost for each bridge type. Although the waterway for the Nile River bridge location is 340m wide and the bank distance is about 550m, it is not necessary to apply the one type of bridge to span the river but rather several shorter span bridges can be adopted to cross the river.



<u>Note</u>: Costs are based on construction costs of bridges in Japan
<u>Source</u>: Study Team

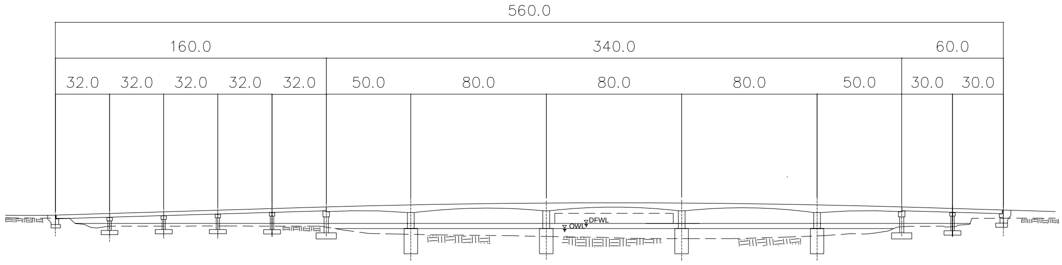
Figure 19.4.6-9 Costs of Different Bridge Superstructure Types

2) <u>Alternative Bridge Schemes</u>

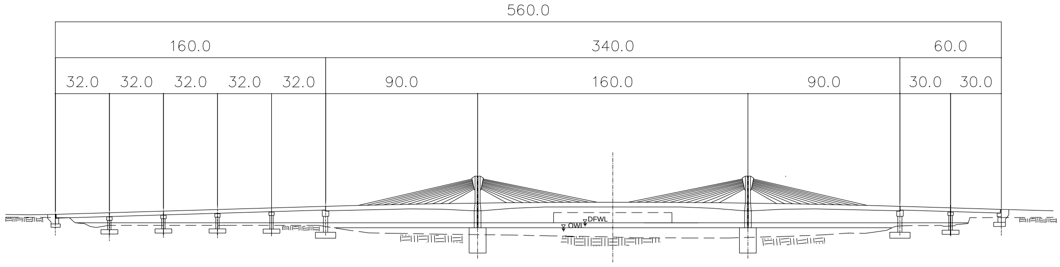
The following schemes are candidate bridge types for waterway crossing, considering the range of applicable spans for the proposed bridge site (see Figure 19.4.6-10):

- Scheme 1 – Five Span Continuous Prestressed Concrete Box Girder Bridge
- Scheme 2 – Three Span Prestressed Concrete Extradosed Bridge
- Scheme 3 – Four Span Steel Tied Arch Bridge
- Scheme 4 – Four Span Steel Truss Bridge
- Scheme 5 – Three Span Steel Cable Stayed Bridge

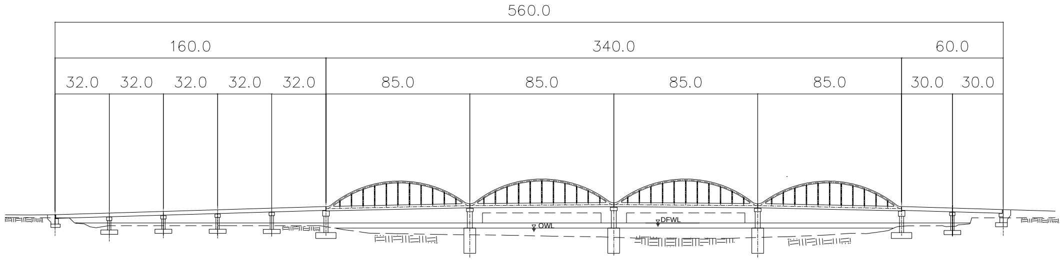
The above schemes are compared in terms of structural system characteristics, construction method, time and costs, and aesthetic and environmental aspects. The comparison of the five schemes is presented in Table 19.4.6-1 where Scheme 1 (Prestressed Concrete Box Girder) is the recommended bridge scheme due to its simplicity being still symbolic with aesthetic treatment, cheaper construction cost and least maintenance requirements.



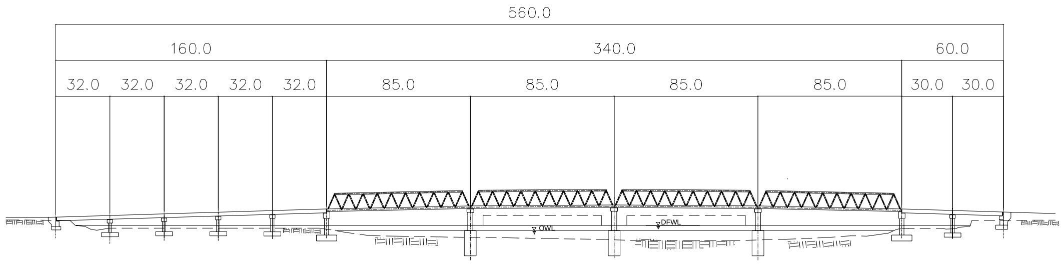
(a) Scheme 1 – Five Span Continuous Prestressed Concrete Box Girder Bridge



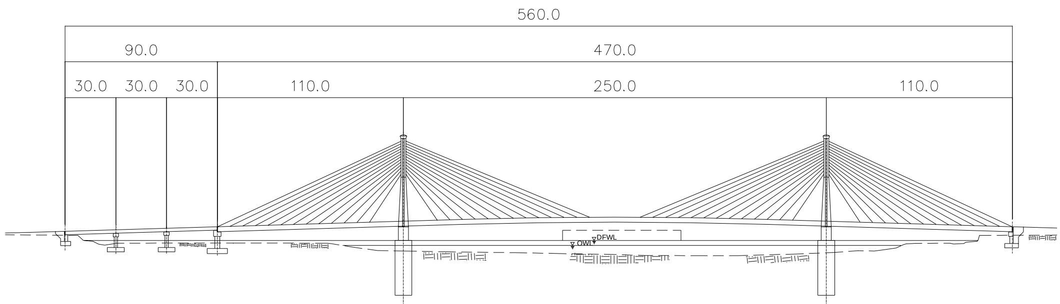
(b) Scheme 2 – Three Span Prestressed Concrete Extradosed Bridge



(c) Scheme 3 – Four Span Steel Tied Arch Bridge



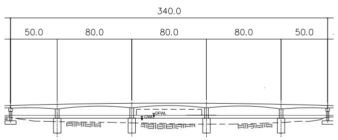
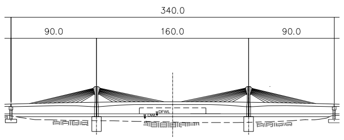
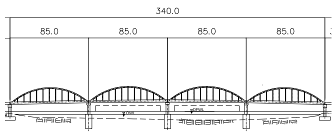
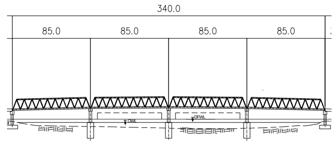
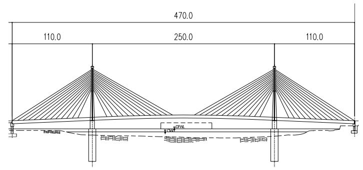
(d) Scheme 4 – Four Span Steel Truss Bridge



(e) Scheme 5 – Three Span Steel Cable Stayed Bridge

Figure 19.4.6-10 Candidate Bridges for Nile River Crossing

Table 19.4.6-1 Comparison of Bridge Alternatives for Nile River Crossing

	SCHEME 1 PRESTRESSED CONCRETE BOX GIRDER BRIDGE	SCHEME 2 PRESTRESSED CONCRETE EXTRADOSED BRIDGE	SCHEME 3 STEEL TIED ARCH BRIDGE	SCHEME 4 STEEL TRUSS BRIDGE	SCHEME 5 STEEL CABLE STAYED BRIDGE
SCHEME & LAYOUT (Main bridge basically covers the ordinary waterway of 340m in width)					
STRUCTURAL SYSTEM	• Five-span continuous prestressed box girder bridge superstructure (50+3@80+50 = 340m). • Superstructure is basically continuous over five spans supporting self weight and live load. Structural dimensions takes advantage of continuity over piers. • Expansion joints only at end locations (2 positions).	• Three-span extradosed (prestressed concrete) superstructure (90+160+90 = 340m). • Superstructure is basically prestressed box girder with stay cables acting as external prestressing. Structural dimensions takes advantage of continuity over piers and additional eccentricity of stay cables. • Expansion joints only at end locations (2 positions).	• Four-span steel tied arch bridge superstructure (4@85 = 340m). • Superstructure is basically four simply supported tied arches. Structural dimensions decided by simply supported structure. • Expansion joints at each pier locations (5 positions) – needs more maintenance.	• Four-span steel tied arch bridge superstructure (4@85 = 340m). • Superstructure is basically four simply supported trusses. Structural dimensions decided by simply supported structure. • Expansion joints at each pier locations (5 positions) – needs more maintenance.	• Three-span self-anchored steel cable-stayed bridge superstructure (110+250+110 = 470m). Longer bridge span is better for this scheme. • Superstructure is basically continuous over piers and is mainly supported by stay cables anchored at pylons/towers. • Expansion joints only at end locations (2 positions).
CONSTRUC-TION	• Basically constructed by balanced cantilever method – 2 sets on each side of bank (four piers). • Four piers to be constructed on river waterway using cofferdam. • Construction duration longer by 12% than Scheme 3. • Construction cost is cheapest among all schemes.	• Constructed by balanced cantilever method on each pier (2 piers at same time). • Only two piers will be constructed on river waterway but with larger scale than Scheme 1. • Construction duration longer by 8% than Scheme 3. • Construction cost is 36% higher than Scheme 1.	• Steel sections prefabricated and erected on site by cranes. • Three piers will be constructed on river waterway. • Construction duration similar to Scheme 4. • Construction cost is 50% higher than Scheme 1.	• Steel sections prefabricated and erected on site by cranes (similar to Scheme 3). • Three piers will be constructed on river waterway. • Construction duration similar to Scheme 3. • Construction cost is 26% higher than Scheme 1.	• Steel sections prefabricated and erected on site with cable stays by balanced cantilever method. • Only two piers will be constructed on river but with largest scale among other schemes. • Construction duration longer by 20% than Scheme 3. • Construction cost is 70% higher than Scheme 1 (most expensive).
AESTHETIC & ENVIRON-MENT	• Simple and elegant structure. • Fits the river environment but with more pier encroachment on river. • Minimal maintenance required for concrete structure.	• Aesthetically pleasing with external cables complementing girder slenderness. Can become a landmark for Juba. • Towers are rather short compared to Scheme 5. • Structural form adopts well with the environment. Less encroachment on river. • Minimal maintenance required for concrete structure but stay cables need constant inspection.	• Series of arch form suits well with the wide river. • Vertical hangers present series of lines obstructing river view. • One pier less than Scheme 1, less river encroachment. • Steel needs maintenance (painting) that may affect river water quality during application.	• Too many truss members present series of lines obstructing river view. • One pier less than Scheme 1, less river encroachment. • Steel needs maintenance (painting) that may affect river water quality during application.	• Presents an aesthetically elegant bridge for the River Nile. • Stay cables blend well with the river and can serve as a landmark for Juba. • Less river encroachment as only two piers constructed near first bank. • Steel deck and stay cables need maintenance similar to Schemes 3 and 4.
EVALUATION	• **RECOMMENDED** (Cheapest structure with minimal maintenance; simplest structure but can be made symbolic by aesthetic treatment of girder and pier shapes)	• **ALTERNATE OPTION** (Elegant structure that can be made as symbolic bridge for Juba; less river encroachment and adopts well with environment; maintenance requirement less than steel option)	• **NOT RECOMMENDED** (More expensive option with more maintenance requirements)	• **NOT RECOMMENDED** (More expensive option with more maintenance requirements)	• **NOT RECOMMENDED** (Most expensive with more maintenance requirements)

The general layout of the proposed bridge scheme for the Nile River crossing is illustrated in Figure 19.4.6-11. The proposed bridge consists of a main bridge over the normal waterway and east and west approach bridges over the flood bank. A summary of the proposed bridge structure is presented in Table 19.4.6-2.

Table 19.4.6-2 Proposed Nile Bridge River Crossing

Bridge Section	Bridge Type	Configuration		Section Length (m)
		No. of Spans	Span Lengths (m)	
West Bank Approach	Precast Prestressed I-Girder (AASHTO Type)	5	5 @ 32	160
Main Bridge	Prestressed Box Girder	5	50 + 3@80 + 50	340
East Bank Approach	Precast Prestressed I-Girder (AASHTO Type)	2	2 @ 30	60
Total Bridge Length				560

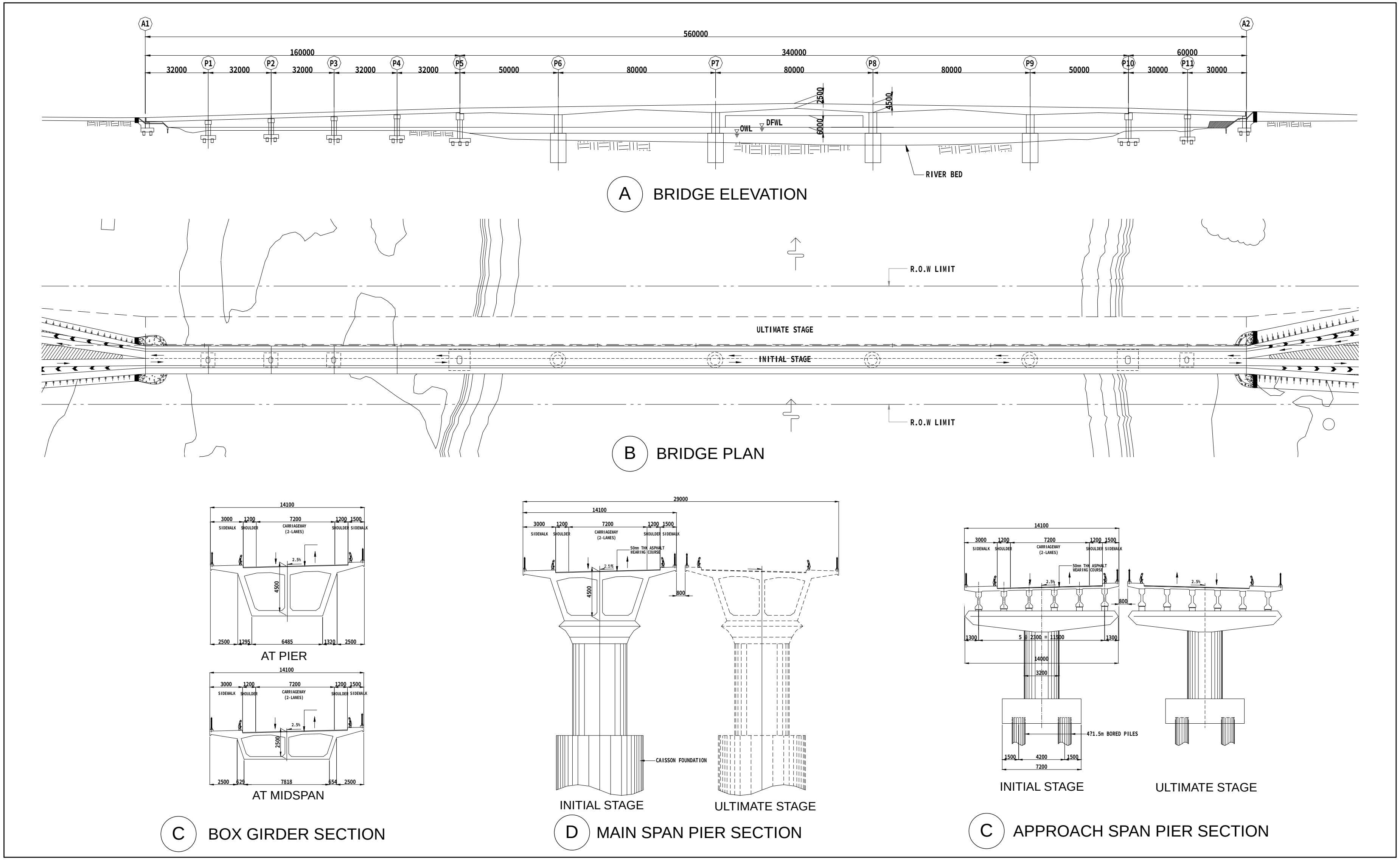


Figure 19.4.6-11 Proposed Nile River Crossing

19.4.7 Ancillary Facilities Design

(1) Utility Space for Public Services

Public service utilities are installed either underground or overhead. Fundamentally, the right-of -way for ultimate stage should be acquired from the initial stage of construction. The standard cross-section provides an open space (refer to typical cross section for ultimate stage in Figure 19.3.4-1) in between the street and the boundary of the ROW. This space shall be utilized as utility space for public services. The following are common public utilities.

- Water pipes (main and distribution)
- Electric power ducts
- Telecommunication lines
- Sanitary sewers

(2) Parking Space

In the absence of adequate off-street parking facilities within the urban areas and its neighborhood, the vehicles are forced to park along the road sides, usually in an improper manner, impeding traffic flow of thru traffic and increasing accident potential. Such kind of parking is prominent in the streets inside the Central Commercial District and its vicinity.

In order to improve such situation, a 3.5m wide multi-purpose lane is provided to be used for parking space on both sides of the street for all streets considered. However, there are certain places where parking should be restricted. Road marking and parking prohibited signs should be provided at such places to prohibit parking. The major parking restricted zones are as follows:

- More than 50m before and after the intersection or roundabout
- More than 20m on either sides of a bus bay
- Loading/unloading zones
- Hospitals, schools and other institutional facilities
- Other restricted areas

(3) Green Belt and Side Walk

A green belt space for trees or vegetation is recommended to be provided in between the travelled way and the sidewalk. The green belt helps to segregate the pedestrians and vehicles and secure safety of the pedestrians. It also enhances the aesthetic value of the road environment.

For the Study Roads, following widths are proposed for the green belt.

- 3.0 meters for C2 and C3 Streets
- 2.0 meters for Lologo and Nyakuron Radial Streets

Sidewalks with a width of 4.5m for C2and C3 and 2.5m for Lologo and Nyakuron Radial Streets are provided. The pavement structure of the sidewalk is composed of 30mm asphalt concrete and 100mm base course. Figure 19.4.7-1 shows the general plan of green belt and sidewalk.

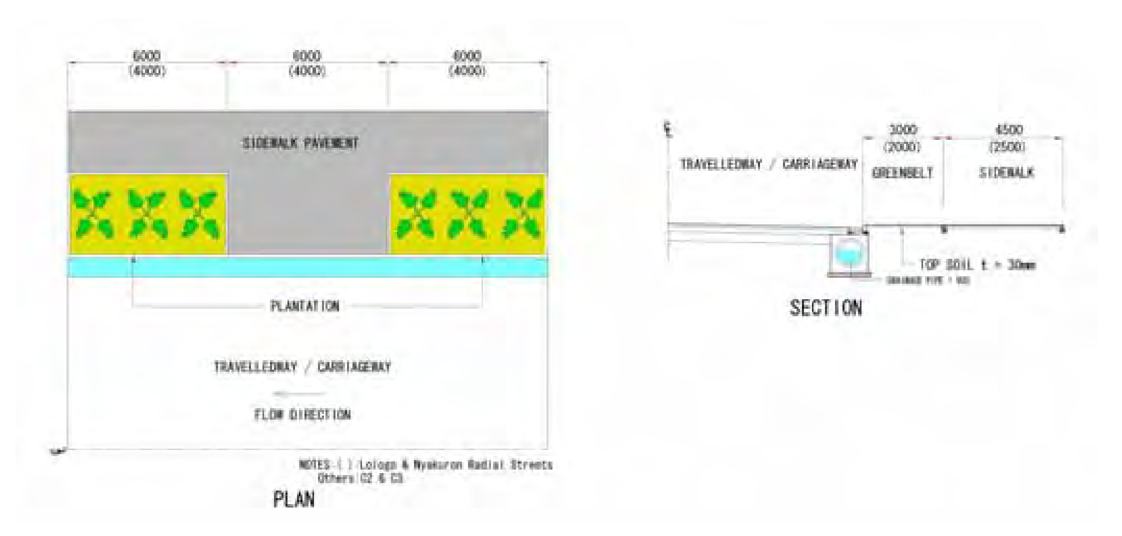


Figure 19.4.7-1 General Plan of Green Belt and Sidewalk

(4) Pedestrian Crossing

Provision of pedestrian crossings helps to reduce traffic accidents during pedestrians crossing streets and to streamline the traffic flow. Therefore, pedestrian crossings, as illustrated in Figure 19.4.7-2 are recommended to be provided at intersections, roundabouts, bus stops, bus bays, markets, hospitals, schools, religious facilities and other public areas.

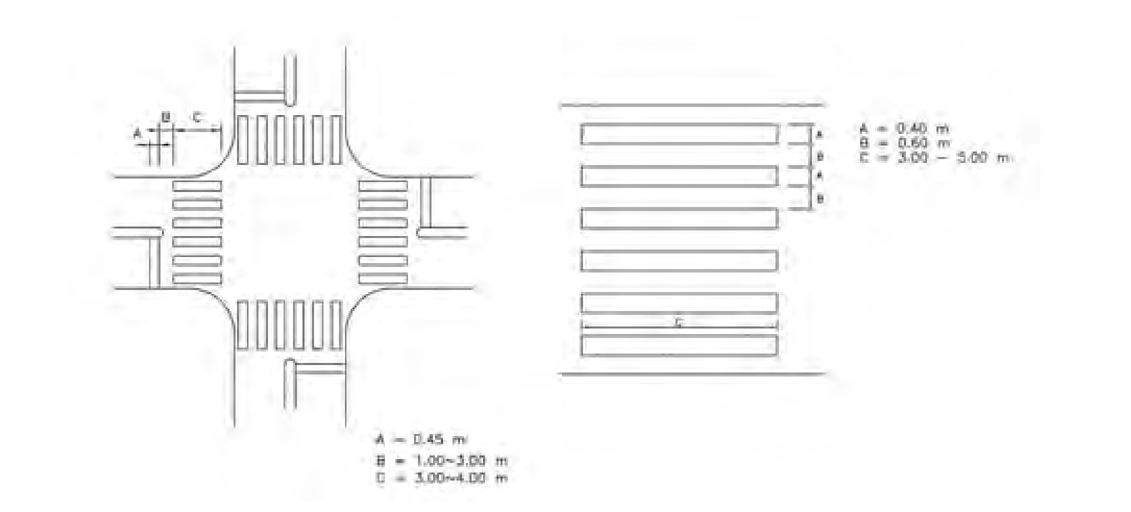


Figure 19.4.7-2 Typical Pedestrian Crossing

(5) Bus Bay

Microbus is one of the most commonly operated public transportation in Juba. Currently, there are microbuses operating in the existing stretches of C2, C3 and Lologo Radial Street. However there are no designated bus stops or provision of bus bays along these streets. Generally, these buses stop wherever passengers sign them to stop and often cause hindrance to the flow of following vehicles.

Since the Study Roads are expected to be utilized by buses, provision of bus bays as exclusive space for bus stops is deemed necessary for the safety of the public and to avoid obstruction to traffic flow. For this purpose, the multi-purpose lanes are used with the necessary road markings and road signs. Figure 19.4.7-3 illustrates the standard bus bay and road markings to be applied.

The provision of bus stops/bays is proposed at the following locations:

- Vicinities of intersections/roundabouts (generally on the entry side)
- Hospitals, schools, universities or other public facilities
- Along the route at an interval of every 500 m to 1,000m

The exact locations of bus stops should be determined after consulting with the relevant authorities.

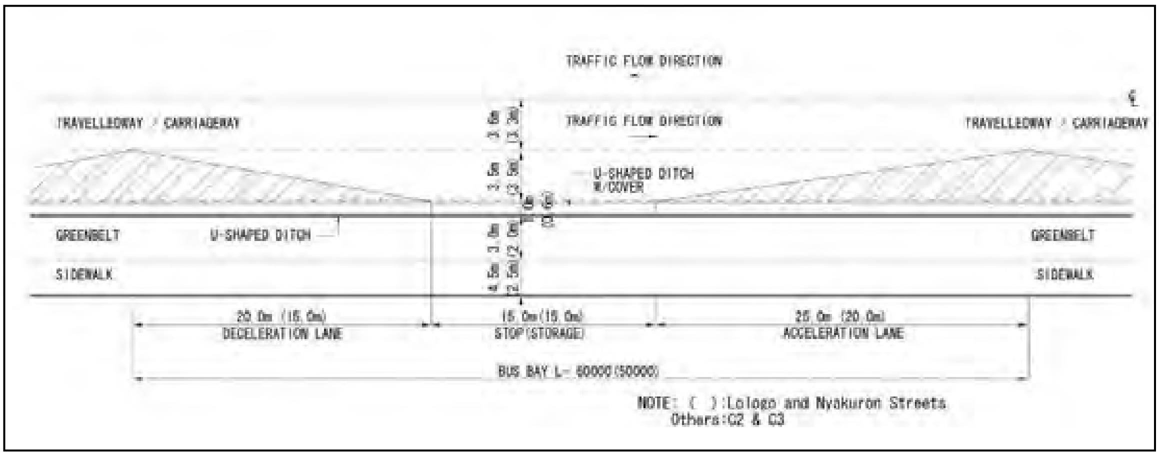


Figure 19.4.7-3 Plan of Typical Bus Bay

(6) Road Markings

In order to encourage safe operation of traffic and to reduce traffic accident, road markings as mentioned below are recommended to be provided on all the Study Roads. The details of road markings are shown in the Preliminary Design Drawings (Section 19.4.8).

- Edge line (lane boundaries)
- Pedestrian crossing (at bus stops, hospitals, schools, universities, religious facilities, markets and other public facilities)
- Arrows and zebras (at intersections, roundabouts and no parking zones)

(7) Traffic Signs

Traffic signs are the instruments for controlling, warning and informing drivers to secure the safety and efficiency of roads. Warning signs, regulatory signs and informatory signs are recommended to be installed at proper locations.

Figure 19.4.7-4 shows the example of traffic sign.

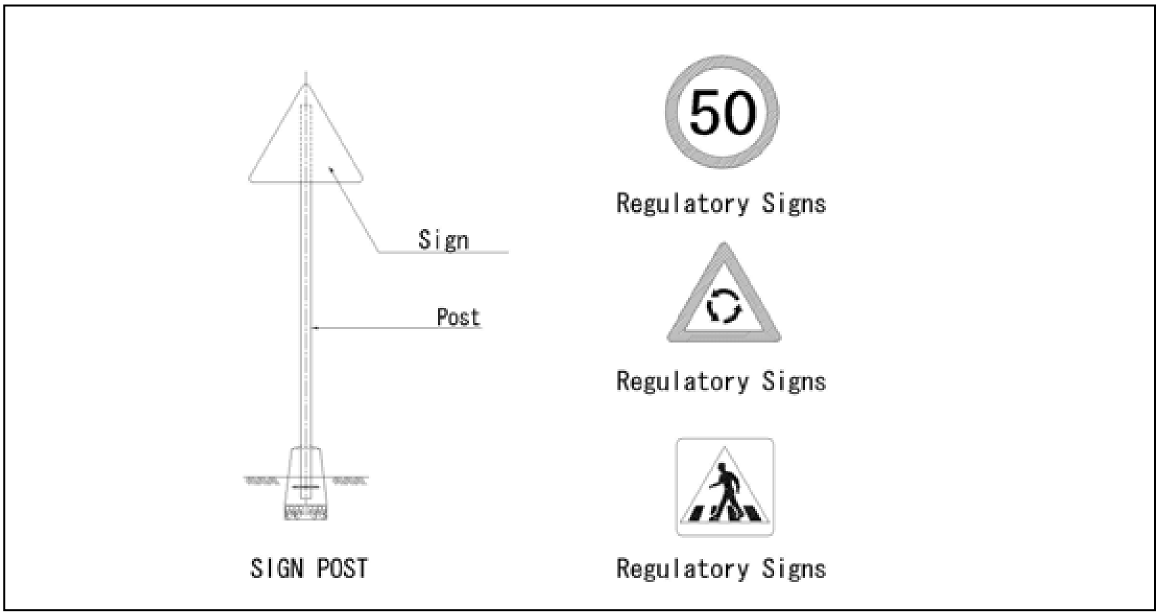


Figure 19.4.7-4 Example of Traffic Signs and Sign Post

(8) Street Lighting

The objectives of street lighting are to maintain good driving conditions for drivers, to reduce night time traffic accidents and to decorate roads and bridges and attract potential road users. Street lighting shall be thus provided for all the Study Roads. The details of street lighting are shown in the Preliminary Design Drawings in Section 19.4.8

(9) Traffic Signals

Traffic signals shall be installed at at-grade signalized intersections for traffic control, safety of drivers and pedestrians and smooth handling of traffic flow. Figure 19.4.7-5 shows the typical drawing of a traffic signal.

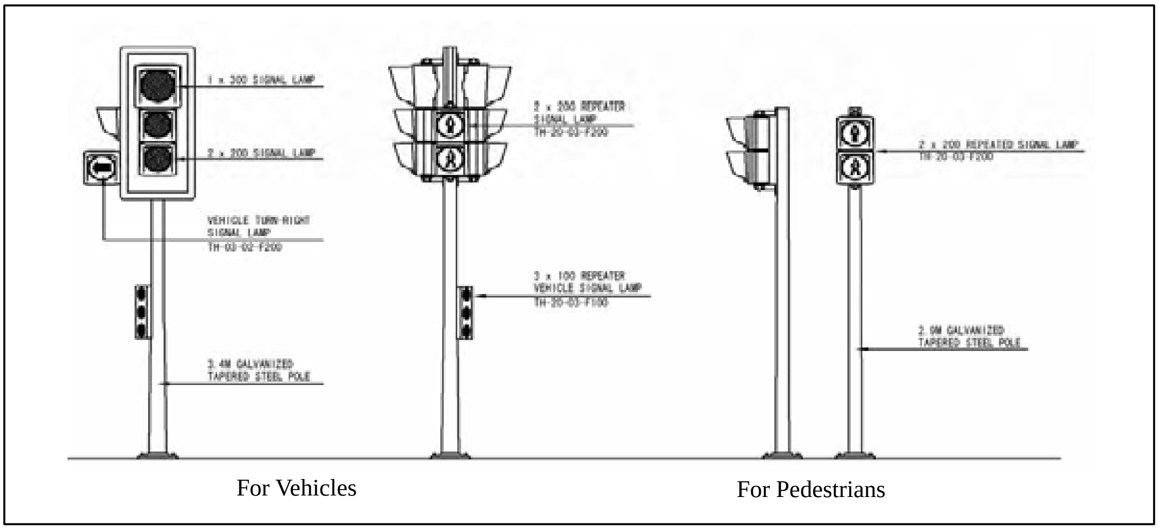


Figure 19.4.7-5 Typical Traffic Signal

19.4.8 Preliminary Design Drawings

The preliminary design drawings of each of the Study Roads and structures are presented in the "Preliminary Design Drawings" attached to this Report in the separate volume. Table 19.4.8-1 shows the lists of the drawings contained.

Table 19.4.8-1 List of Preliminary Design Drawings

No.	Title	Drawing No.	Scale
1.	Location Map	Lo-1	Not to Scale
2.	Typical Cross Section	CS1 – 3	1:150
3.	Plan and Profile		
	Circumferential Street		
	C2	PL2-1 – 10	H=1:2500 V=1:500
	C3	PL3-1 – 14	Ditto
	Collector Street		
	CS-A (Lologo Radial Street)	PLA-1 – 5	H=1:2500 V=1:500
	CS-B (Nyakuron Radial Street)	PLB-1 – 3	Ditto
4.	Typical Plan of Intersection	PI-1 – 2	1:2000, 1:250
5.	Typical Plan of Drainage System		
	C2	PD2-1 – 6	1:500
	C3	PD3-1 – 9	Ditto
	CS-A	PDA-1 – 3	Ditto
	CS-B	PDB-1 – 2	Ditto
6.	Bridges		
	Single Span RC Bridge on Piles, L=20m	BR-1	1:200
	Multi-Span RC Bridge on Piles, L = 30-35m	BR-2	Ditto
	Multi-Span RC Bridge on Piles, L = 50m	BR-3	Ditto
	Nile River Main Span Bridge – PC Box Girder, Span = 80m	BR-4	Ditto
	Nile River Approach Bridge – PC I-Girder, Span = 30-32m	BR-5	Ditto
7.	Culverts		
	Single Cell – 3m x 3m Opening	CL-1	1:200
	Single Cell – 4m x 3m Opening	CL-2	Ditto
	Double Cell – 3m x 3m Opening	CL-3	Ditto
	Double Cell – 4m x 3m Opening	CL-4	Ditto
8.	Standard Details		
	Details of Green Belt, Sidewalk & Verge Block	SD-1	1:150, 1:25
	Lateral Drainage (L-shaped Gutter, Catch Basin)	SD-2	1:10, 1:20
	Median Drainage (Catch Basin and Earth Ditch)	SD-3	1:30
	Bus Bay	SD-4	1:400
	Cross Roads and House Access	SD-5	1:300
	Standard Pavement Marking	SD-6	Not to Scale
	Traffic Signal	SD-7	1:100

19.5 CONSTRUCTION PLAN AND COST ESTIMATE

19.5.1 Construction Method

(1) General

Table 19.5.1-1 shows the major components of the project for the construction of the Study Roads.

Table 19.5.1-1 Major Components of the Project

Road Section	Road Length (km)	No. of Signalized Intersections	No. of Bridges	No. of Culverts
Circumferential Street C2	8.0	5	2 (L=20m & 35m)	7 (1-cell: 3x3 & 4x3; 2-Cells: 4x3)
Circumferential Street C3	12.6	4	6 (L=20m – 35m; 1- Nile Bridge, L=560m)	6 (1-cell: 4x3; 2-Cells: 3x3 & 4x3)
Collector Street CSA (Lologo Radial Street)	3.6	-	2 (L=20m & 50m)	3 (1-cell: 3x3 & 4x3; 2-Cells: 4x3)
Collector Street CSB (Nyakuron Radial Street)	2.2	-	1 (L=30m)	4 (1-cell: 3x3; 2-Cells: 3x3 & 4x3)

The project is divided into the following packages.

- Construction of Circumferential Street C2 including structures
- Construction of Circumferential Street C3 including structures but excluding Nile River Bridge
- Construction of Nile River Bridge
- Construction of Collector Streets CSA (Lologo Radial Street) including structures
- Construction of Collector Streets CSB (Nyakuron Radial Street) including structures

(2) Stage Construction

As discussed in Section 19.3.5, a stage construction scheme is proposed to be introduced as followe:

Initial Stage: 2 lanes of travelled way with multi-purpose lanes along with green belt and sidewalk will be constructed.

Ultimate Stage: To accommodate the increasing traffic demand, the roads will be widened to 4 lanes. The expected time for widening is before year 2025.

The initial stage construction shall be implemented in the following manner:

- Right-of-way : Right-of way for the ultimate stage shall be fully acquired at the initial stage.
- Road section : Outer travelled lanes shall be constructed, leaving the inner lanes unpaved.
- Bridges : The bridges close to the major intersections shall be constructed in full width for the ultimate stage. Other bridges are constructed for the initial number of lanes on one side of the road (in general, downstream side of the river), connected with the abutting road sections by shifting the traveled lanes.
- Box culverts : The box culverts shall be constructed for ultimate number of lanes to avoid frequent shifting of the travelled lanes.
- Intersections : Intersections shall be constructed in the whole area for the ultimate stage, but the only lanes for initial stage are provided and the remaining space is utilized for exclusive left turn lanes and channelization for right turn lane.

(3) Construction Method

The construction works of the road projects will include excavation of earth, hauling, placement and compaction of large quantity of embankment materials, pavement, bridges, culverts and other structural works and installation of street facilities and electrical facilities for street lightning and traffic signals.

The horizontal alignment is determined by making utmost use of the existing roads while the vertical alignment is planned such that the heights are slightly higher (by average 1m) than the existing ground. Accordingly, a huge volume of earth will be required for embankment. To minimize the hauling of borrow materials, excavated soil within the project and from other on-going projects shall be utilized as much as possible and the remaining volume will be hauled from borrow pits close to the embankment site.

The proposed bridges and culverts are mostly reinforced concrete type of structures. They will be constructed basically by cast-in-place with all staging method using falseworks and formworks. Aggregates for reinforced concrete are locally available around the proposed sites. However, cement and steel reinforcements have to be procured from outside; Uganda or Kenya.

19.5.2 Construction Schedule

Construction schedule of the project is estimated as shown in Table 19.5.2-1.

Table 19.5.2-1 Estimated Construction Schedule

Package	1st Year	2nd Year	3rd Year	4th Year	5th Year
C2 (East and South Section)					
C3 (East and South Section)					
Nile River Bridge					
CSA (Juba～Kajo Keji)					
CSB (C2～C3)					

19.5.3 Procurement Plan

(1) Procurement of Local Construction Materials

Embankment materials and aggregate for concrete and pavement are locally available from the following sources:

<u>Materials</u>	<u>Material Sources (Borrow Pits and Quarry Sites)</u>
Soil	: North of Airport and Tompin area, east side of Nile River
Course Aggregates	:Juba and its surroundings
Sand	: Juba and its surroundings
Crushed Stone	:Jebel Kujur (an east and west sides of Jubel Kujur Mountain)

Note: *There is an on-going project for the construction of an asphalt plant including a crusher plant and concrete plant in Luri Payam, which is expected to be completed within year 2009. The asphalt and concrete required for the construction of the Project could be made available from this plant, given that the plant will be under operation during the time of construction. However, procurement from the above plant is not considered for estimation of construction cost under this Study.*

(2) Procurement of Locally Available Equipment

Most of the construction equipment required for the project is available within Juba under the ownership of local contractors. Most of them are second hand equipment imported from other countries. Major equipment available in Juba is as follows:

- Dump Truck (2-10 ton)
- Backhoe (0.6m3, 0.8m3)
- Bulldozers (15-32 ton)
- Macadam Roller (10 ton)
- Tire Roller (8 ton)
- Motor Grader (W=3.1m)

Although these equipment are presently in good condition, the number is limited. Spare parts of the equipment are not available in Juba and have to be procured from neighboring countries such as Kenya and Uganda.

(3) Materials to be Procured from Other Countries

Construction materials to be procured from other countries are as follows:

1) From Japan
   - Traffic signals
   - Street lights
   - Hot paint for road (pavement) marking
   - Batching (mixing) plant

2) From Kenya or Uganda
   - Cement (40 kg bag and bulk)
   - Reinforcement bars (D6 – D32)
   - Concrete additives
   - Pipe culverts
   - Asphalt (straight)
   - Plywood for framework
   - Scaffoldings
   - Welding rod
   - Oxygen, acetylene

(4) Procurement of Labor

Approximately 4 million people were estimated to be displaced from (or within) Southern Sudan by the 20 year fighting between the northern and southern regions of Sudan. This fighting not only caused the population to flee from their homes but also deprived them from getting proper education. As a consequence, the region faces severe shortage of technical personnel. Most of the civil engineers engaged in the on-going road rehabilitation projects are hired from the neighboring countries: Kenya and Uganda. There are some vocational training projects being implemented in order to train the returnees of the internally displaced persons. However, as training related to road construction is quite few, there are only few graduates who could work at the construction sites.

Considering the aforementioned situation, following policy shall be adopted for the procurement of labor for road construction.

- Technical personal from neighboring countries; Kenya or Uganda, shall be locally-hired.
- Skilled/semi-skilled labors shall be locally-hired from Kenya or Uganda, and
- Common Labors shall be hired from Southern Sudan.

19.5.4 Project Cost Estimate

(1) Basic Concept for Project Cost Estimate

The estimate of the project cost is based on the results of the preliminary engineering design and quantity of each work item, and construction plan described in the preceding section. The basic premises in estimating the project cost are as follows:

- All the construction works will be executed under the initiative of international contractors.
- The unit price of each cost component was determined based on the economic conditions or market prices prevailing in June, 2009.
- Components of the project cost are as follows:
  - Construction cost,
  - Land and properties acquisition cost (omitted as the prices are extra-ordinarily high),
  - Engineering cost including detailed design and construction supervision,
  - Contractor’s profit and overhead,
  - Government administrative expenses, and
  - Physical contingency.
- Components of the construction cost are as follows:
  - Direct construction cost,
  - Transportation cost and packaging cost,
  - Site operation and administration cost, and
  - Contractor’s general expenses.
- Engineering cost, consisting of detailed engineering design and construction supervision, is assumed to be 8% of the construction cost..
- Contractor’s profit and overhead are assumed to be 15% of the construction cost.
- Administrative cost is assumed to be 5% of the construction cost.
- Physical contingency is assumed to be 10% of the total project cost.

(2) Unit Costs

The list of unit costs of construction work items is shown in Table 19.5.4-1.

Table 19.5.4-1 Unit Costs

Work Item		Description	Specification	Unit	Unit Rate US$
1.	**Road Construction**				
	(1) Site Clearance				
	Site Clearance			m2	6.50
	(2) Earth Works				
	1) Excavation			m3	18.00
	2) Embankment			m3	7.00
	3) Filling			m3	7.00
	4) Sodding			m2	2.50
	(3) Pavement Works				
	1) Subgrade Preparation			m2	6.90
	2) Sub Base Course		CBR>40	m3	24.00
	3) Prime Coat			m2	4.50
	4) Base Course		CBR>80	m3	81.20
	5) Tack Coat			m2	3.00
	6) AC Surface Course	t=10cm		m3	505.00
	(4) Pavement Works (Sidewalk)				
	1) Top Soil			m2	7.00
	2) Subbase	t=10cm		m3	24.00
	3) Asphalt Concrete	t=3cm		m3	505.00
	(5) Drainage Works				
	1) Crushed Stone			m3	24.00
	2) Pipe Culvert (D900mm)	Lateral drainage & Median drainage	dia. 900mm	m	400.00
	3) Pipe Culvert (D1200mm)	Cross drainage	dia. 1200	m	450.00
	(6) Concrete Works				
	1) Concrete 20/20			m3	325.00
	2) Reinforcing Bar			ton	1,980.00
	3) Formwork			m2	40.00
	(7) Ancillary Works				
	(1) Road Marking	Hot paint		m2	5,000.00
	(2) Street Lighting			km	110,000.00
	(3) Traffic Sign			km	75,200.00
2.	**Traffic Signal**				
	(1) Signal			Set	50,000.0
3.	**Bridge**				
	(1) Single Span RC on Piles, L=20m			m2	7,150.0
	(2) Multi-Span RC on Piles, L=30-35m			m2	6,250.0
	(3) Multi-Span RC on Piles, L=50m			m2	6,700.0
	(4) Nile River Bridge- PC Box Girder, Span =80m			m2	8,125.0
	(5) Nile River Approach Bridge -PC Box Girder, Span =30-32m			m2	7,300.0
4.	**Culverts**				
	(1) Single Cell - 3m x 3m Opening			m2	19,500.0
	(2) Single Cell - 4m x 3m Opening			m2	24,200.0
	(3) Double Cell - 3m x 3m Opening			m2	31,670.0
	(4) Double Cell - 4m x 3m Opening			m2	39,640.0
TOTAL					

<u>Note</u>: Unit costs are based on the estimated costs of Bridge and Culverts Reconstruction Project (JICA Study Team)

(3) Work Quantities

Estimation of work quantities are based on the preliminary design. A list of major work quantities is shown in Table. 19.5.4-2.

Table 19.5.4-2 Major Work Quantities

Work Item		Unit	C2	C3	CSA	CSB
1.	**Road Construction (per km)**					
	(1) Site Clearance					
	Site Clearance	m2	50,000	60,000	40,000	40,000
	(2) Earth Works					
	1) Excavation	m3	14,700	17,600	8,200	9,000
	2) Embankment	m3	22,800	21,700	28,600	16,400
	3) Filling	m3	2,700	2,400	1,700	2,700
	4) Sodding	m2	14,600	14,200	13,100	11,900
	(3) Pavement Works					
	1) Subgrade Preparation	m2	16,600	16,600	16,000	16,000
	2) Sub Base Course	m3	5,810	4,980	4,800	5,600
	3) Prime Coat	m2	16,600	16,600	16,000	16,000
	4) Base Course	m3	3,320	3,320	2,400	3,200
	5) Tack Coat	m2	16,600	16,600	16,000	16,000
	6) AC Surface Course	m3	1,560	1,560	1,500	1,500
	(4) Pavement Works (Sidewalk)					
	1) Top Soil	m2	3,000	3,000	2,000	2,000
	2) Subbase	m2	1,200	1,200	800	800
	3) Asphalt Concrete	m2	360	360	240	240
	(5) Drainage Works					
	1) Crushed Stone	m3	716	716	706	706
	2) Pipe Culvert D900mm	m	2,132	2,132	2,118	2,118
	3) Pipe Culvert D1200mm	m	180	180	142	142
	(6) Concrete Works					
	1) Concrete 20/20	m3	819	819	755	755
	2) Reinforcing Bar	ton	19	19	16	16
	3) Formwork	m2	6,011	6,011	5,876	5,876
	(7) Ancillary Works					
	1) Road Marking	m2	13	13	12	12
	2) Street Lighting	km	1	1	1	1
	3) Traffic Sign	km	1	1	1	1
2.	**Traffic Signal**					
	1) Signal	Set	5	4	0	0
3.	**Bridge**					
	1) One-span, L=20m W=15.6m	loc	1			
	2) One-span, L=20m W=28.5m	loc		1		
	3) 3-Span, L=30m W=15.6m	loc		3		
	4) 3-Span, L=35m W=15.6m	loc		1		
	5) 3-Span, L=35m W=28.5m		1			
	6) 3-Span, L=30m W=11.8m	loc			1	1
	7) 3-Span, L=50m W=11.8m	loc			1	
	8) Nile River Bridge, W=14.1m L(Approach)=220m L(Main) =340m	loc		1		
4.	**Culvert**					
	(1) Single Cell - 3m x 3m Opening	loc	3		1	2
	(2) Single Cell - 4m x 3m Opening	loc	1	4	1	
	(3) Double Cell - 3m x 3m Opening	loc		1		1
	(4) Double Cell - 4m x 3m Opening	loc	3	1	1	1

(4) Estimated Construction Cost

The estimated construction cost is summarized in Table 19.5.4-3(a) to (d).

Table 19.5.4-3(a) Cost of Circumferential Street C2

	Major Work Item	Unit	Quantity	Unit Cost (US$)	Cost (US$ Million)
1.	Road Construction	km	7.99	4,489,663	35.87
2.	Signalized Intersection	Set	5.00	250,200	1.25
3.	Bridge				
	One-span, L=20m W=15.6m	loc	1	2,231,000	2.23
	3-Span, L=35m W=28.5m		1	6,234,000	6.23
	Sub-Total				8.47
4.	Culverts	All			
	Single Cell - 3m x 3m Opening x 32m	loc	3	624,000	1.87
	Single Cell - 4m x 3m Opening x 32m	loc	1	1,013,000	1.01
	Double Cell - 4m x 3m Opening x 32m	loc	3	1,268,000	3.80
	Sub-Total				6.69
TOTAL (1+2+3+4)					52.28

Table 19.5.4-3(b) Cost of Circumferential Street C3

	Major Work Item	Unit	Quantity	Unit Cost (US$)	Cost (US$ Million)
1.	Road Construction	km	12.60	4,508,747	56.81
2.	Signalized Intersection	Set	4.00	200,000	0.80
3.	Bridge				
	One-span, L=20m W=28.5m	loc	1	4,076,000	4.08
	3-Span, L=30m W=15.6m	loc	3	2,925,000	8.78
	3-Span, L=35m W=15.6m	loc	1	3,413,000	3.41
	Nile River Bridge, W=14.1m L(Approach)=220m L(Main) =340m	loc	1	61,596,000	61.60
	Sub-Total				77.86
4.	Culverts				
	Single Cell - 4m x 3m Opening x 32m	loc	4	1,013,000	4.05
	Double Cell - 3m x 3m Opening x 32m	loc	1	774,000	0.77
	Double Cell - 4m x 3m Opening x 32m	loc	1	1,268,000	1.27
	Sub-Total				6.09
TOTAL (1+2+3+4)					141.56

Table 19.5.4-3(c) Cost of Radial Street CSA (in Lologo)

	Major Work Item	Unit	Quantity	Unit Cost (US$)	Cost (US$ Million)
1.	Road Construction	km	3.57	4,044,239	14.44
2.	Bridge				
	3-Span, L=30m W=11.8m	loc	1	2,213,000	2.21
	3-Span, L=50m W=11.8m	loc	1	3,953,000	3.95
	Sub-Total				6.17
3.	Culverts				
	Single Cell - 3m x 3m Opening	loc	1	624,000	0.62
	Single Cell - 4m x 3m Opening	loc	1	1,013,000	1.01
	Double Cell - 4m x 3m Opening	loc	1	1,268,000	1.27
	Sub-Total				2.91
TOTAL					23.51

Table 19.5.4-3(d) Cost of Radial Street CSB (in Nyakuron)

Major Work Item		Unit	Quantity	Unit Cost (US$)	Cost (US$ Million)
1.	Road Construction	km	2.18	4,061,399	8.85
2.	Bridge				
	3-Span, L=30m W=11.8m	loc	1	2,213,000	2.21
3.	Culverts				
	Single Cell - 3m x 3m Opening	loc	2.00	624,000	1.25
	Double Cell - 3m x 3m Opening	loc	1.00	774,000	0.77
	Double Cell - 4m x 3m Opening	loc	1.00	1,268,000	1.27
	Sub-Total				3.29
TOTAL					14.36

(5) Land Acquisition and Compensation Cost

The land acquisition and the compensation cost is a component of the project cost. It is therefore necessary to calculate the area of land take as well as the number of households entitled for relocation. However, according to the results of the environmental and social survey, the unit cost of land and property compensation is extra-ordinarily high, not considered reasonable. At the moment, such costs shall be excluded from the project cost because of unreasonable acquisition cost.

It is therefore recommended that proper estimation of these costs be conducted after re-confirming the unit costs during further studies.

(6) Estimated Project Cost

The project cost is estimated as shown in Table 19.5.4-4.

Table 19.5.4-4 Project Costs

(unit : million US$)

	C2	C3 including Nile River Bridge	CSA (Lologo Radial St.)	CSB (Nyakuron Radial St.)	Total
① Construction Cost	52.28	141.56	23.51	14.36	231.71
② Engineering Cost for DD and SV (8% of ①)	4.18	11.32	1.88	1.15	18.54
③ Contractor Overhead (15% of ①)	7.84	21.23	3.53	2.15	34.76
④ Administration Cost (5% of ①)	2.61	7.08	1.18	0.72	11.59
⑤ Contigency (10% of (①+②+③+④))	6.69	18.12	3.01	1.84	29.66
Total Project Cost	**73.61**	**199.32**	**33.10**	**20.22**	**326.25**

19.6 INITIAL ENVIRONMENTAL EXAMINATION

19.6.1 Natural Environment

Figure 19.6.1-1 shows the location of the Study Roads.

C2 section inside the Central Commercial District (CCD) is discussed in Section 17.7. C2 section outside the CCD traverses the boundary of housing area and other area of cemetery and grassland/ bush. Moreover, this route crosses several tributaries of the Nile River.

C3 section between CSA and R6 crosses the White Nile River and passes through the temporary residential area on the western side of the river and the community boundary on the eastern side. The other sections of C3 are located in grassland or bush area. On both banks of the White Nile River, abundant woods and trees thrive including Mango and Neem trees.

CSA, on north side of C3, is located in Lologo where IDPs and refugees live, while on the south of C3, CSA passes through grassland and crosses several branches of the White Nile River.

CSB is located in the bush area.

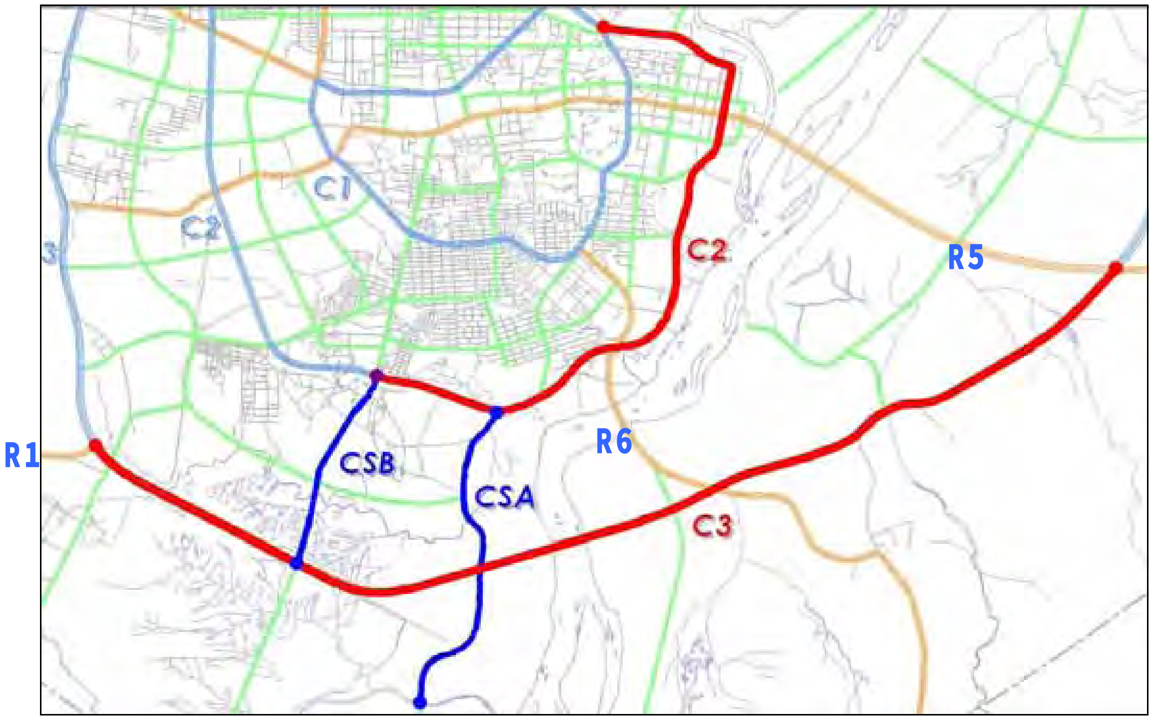


Figure 19.6.1.-1 Route Locations of C2, C3, CSA and CSB

19.6.2 Social Environment

The social facilities situated on the roadside of the Study Roads are summarized in Table 19.6.2-1 and shown in Photos 19.6.2-1 to 19.6.2-6.

Table19.6.2-1 Roadside Land Use

Items	C2	C3			CSA		CSB
		R1～CSA	CSA～R6	R6～R5	North of C3	South of C3	
Sidewalk							
Roadside Tree	○				○		
Electric Wire	○				○		
Community with Traditional Houses	○		○		○	○	
Shop	○				○		
Market							
Government Facility							○ (MOD)
Commercial Facility							
Business Facility							
Education Facility							
Medical Facility							
Sports Facility	○						
Church							
Mosque							
Cemetery	○						
Water Supply Facility							
Well							
Monument							
Cultivated Field, Grassland, Bush, Forest/Grove/Woodland	○	○	○	○		○	○
Nile River and its Tributaries	○	○	○	○	○	○	○

(a) Near Yei Road

(b) Near Nile River

Photo19.6.2-1 C3, R1～CSA Section (under construction)

(a) White River Nile

(b) Mango tree on bank of White Nile River

Photo19.6.2-2 C3, CSA～R6 Section

Photo19.6.3 C3, R6～R5 Section

(a) North Side

(b) North Side

(c) North Side

(d) South Side

Photo19.6.2-4 CSA (Lologo Radial Road)

Photo19.6.2-5 Access Road to CSB (Junction of Yei Road – Juba Univ.)

Photo19.6.2-6 New building of Ministry of Defense (in southern Nyakuron)

19.6.3 Environmental Evaluation

The evaluation results for environmental elements are summarized in Table 19.6.3-1.

The project is evaluated as B(some impacts) in terms of "involuntary resettlement" and "traffic accidents".

<u>Involuntary resettlement</u>
C3 in the section of west bank of the Nile River and CSA (Lologo Radial Street) in the section on the north of C3 will involve the resettlement of inhabitants. Adequate talks with stakeholders and sufficient compensation are essential to solve the resettlement problem.

<u>Traffic accidents</u>
The improvement of the running condition will increase vehicle speed and consequently more traffic accidents are likely to occur. It is therefore necessary to take software- and hardware-related measures against traffic accidents. The traffic safety measures are incorporated in the design.

Table19.6.3-1 Evaluation Results for Environmental Elements

Environmental Elements	Evaluation Results
Social Environment	
1. Involuntary resettlement	B
2. Local economy, employment and livelihood	E
3. Land use and local resources utilization	E
4. Existing social infrastructure and services	E
5. Local communities	E
6. Benefit and damage misdistribution	D
7. Gender	E
8. Children's rights	E
9.Cultural heritage	D
10.Local conflicts of interests	D
11.Public sanitation	E
12. Infectious diseases such as HIV/AIDS	D
13. Water usage and right	E
14. Traffic accidents	B
Natural Environment	
15. Biota and ecosystem (Fauna and flora)	D
16. Geographical features	D
17. Soil erosion	D
18. Underground water	D
19. Hydrology situation	D
20. Coastal zone (mangroves etc.)	D
21. Landscape	D
22. Climate exchange	D
23.Global warming	D
Pollution	
24. Air pollution	E
25. Water pollution	D
26. Soil contamination	D
27. Bottom sediment in sea and rivers	D
28. Waste	D
29. Noise and vibration	D
30. Ground subsidence	D
31. Offensive odors	D

Note) A: serious impacts, B: some impacts, C: degree of impacts is unknown, D: Few impacts
E: Desirable impact

19.7 SIMPLIFIED ECONOMIC EVALUATION

19.7.1 Economic Cost

The project cost calculated in the previous section is a financial cost. It is converted to economic cost for the economic evaluation purpose. The economic cost is the one deducting the government taxes and shadow prices of unskilled labor from the financial cost In this Study, the conversion factor is set at 0.907, referring to the Feasibility Study for Improvement Works of the Juba to Nimule Road, USAID/Sudan Infrastructure Service Project, May 2007.

Table 19.7.1-1 shows the economic Costs.

.

Table 19.7.1-1 Economic Cost Estimate

Unit: Million US$

Description	Financial Cost	Economin Cost
C2 Project		
1 Construction Cost	52.28	47.42
2 Engineering Cost	4.18	3.79
3 Contractor Overhead	7.84	7.11
4 Administrative Cost	2.61	2.37
5 Contingency	6.69	6.07
Total	**73.61**	**66.76**
C3 Project including Nile River Bridge		
1 Construction Cost	141.56	128.39
2 Engineering Cost	11.32	10.27
3 Contractor Overhead	21.23	19.26
4 Administrative Cost	7.08	6.42
5 Contingency	18.12	16.43
Total	**199.32**	**180.78**
CSA (Lologo Radial Street) Project		
1 Construction Cost	23.51	21.32
2 Engineering Cost	1.88	1.71
3 Contractor Overhead	3.53	3.20
4 Administrative Cost	1.18	1.07
5 Contingency	3.01	2.73
Total	**33.10**	**30.02**
CSB (Nyakuron Radial Street) Project		
1 Construction Cost	14.36	13.02
2 Engineering Cost	1.15	1.04
3 Contractor Overhead	2.15	1.95
4 Administrative Cost	0.72	0.65
5 Contingency	1.84	1.67
Total	**20.22**	**18.34**

Maintenance Cost

Maintenance cost per year is assumed 1% of the construction cost. Rehabilitation cost is assumed 10% of the construction cost, being spent every 10 years.

19.7.2 Economic Benefit

(1) Traffic Demand Forecast

Future traffic demand forecasted in the form of OD Matrix (year 2015 and 2025) is assigned on the road network to estimate traffic volume for each project road. The estimated traffic volume in case of "with project" is already shown in Chapter 19.3.3 (See Table 19.3.3-1).

The estimated vehicle-kilometers and vehicle-hours in both "without project" and "with project" cases are shown in Table 19.7.2-1 and Table 19.7.2-2 respectively. These tables are used as the basis for the benefit calculation.

Table 19.7.2-1 Total Vehicle-Kilometers

Unit: 1,000 PCU・km

Road	Year	W/O Case	W Case	W/O - W
C2	2015	1,313	1,301	12
	2025	3,435	3,400	35
C3	2015	1,313	1,297	16
	2025	3,732	3,431	301
CSA (Lologo Radial Street)	2015	1,297	1,284	13
	2025	3,468	3,427	42
CSB (Nyakuron Radial Street)	2015	1,297	1,287	10
	2025	3,438	3,431	7

Table 19.7.2-2 Total Vehicle-Hours

Unit: PCU・hours

Road	Year	W/O Case	W Case	W/O - W
C-2	2015	44,117	41,534	2,583
	2025	115,730	112,032	3,698
C-3	2015	45,626	42,221	3,405
	2025	129,737	113,634	16,103
CSA (Lologo Radial Street)	2015	42,221	40,729	1,492
	2025	116,558	113,440	3,118
CSB (Nyakuron Radial Street)	2015	42,221	41,587	634
	2025	114,256	113,634	622

(2) Basic Vehicle Operation Cost

The basic vehicle operating cost (BVOC) is estimated by the Study Team as shown in Table 19.7.2-3.

Table 19.7.2-3 Basic Vehicle Operating Cost

Vehicle Type	Running Cost [US$/km]	Fixed Cost [US$/hr.]	Time Cost [US$/hr.]
Motor Cycle	0.042	0.052	1.20
Car	0.180	0.621	3.23
Bus	0.143	0.088	11.25
Truck	0.304	0.485	0

Source: JICA Study Team

Vehicle operating costs by surface type and travel speed are set up.

(3) Estimation of Benefits

The saving in vehicle operating costs and travel time cost are estimated as shown in Table 19.7.2-4.

Table 19.7.2-4 Estimation of Benefit

Unit: US$/day

Road	Year	VOC Saving	TTC Saving	Total Saving
C-2	2015	9,059	10,331	19,390
	2025	17,671	19,848	37,519
C-3	2015	4,697	15,526	20,223
	2025	71,386	82,561	153,947
CSA (Lologo Radial St.)	2015	5,632	7,023	12,655
	2025	11,708	11,268	22,976
CSB (Nyakuron Radial St.)	2015	2,425	2,697	5,122
	2025	10,278	5,630	15,908

VOC: Vehicle Operating Cost TTC: Travel Time Cost

19.7.3 Economic Evaluation

(1) Evaluation Period

The analysis periods is set at 20 years after opening to traffic.

(2) Implementation Schedule

The implementation schedule is assumed as shown in Table 19.7.3-1.

Table 19.7.3-1 Assumed Implementation Schedule

	C-2	C-3	CSA (Lologo Radial Street)	CSB (Nyakuron Radial St.)
Detailed Design	Y2010	Y2010	Y2010	Y2010
Right of Way Acquisition	Y2010	Y2010	Y2010	Y2010
Construction	Y2011-13	Y2011-14	Y2011-12	Y2011-12
Opening to Traffic	Y2014~	Y2015~	Y2013~	Y2013~

(3) Economic Indicators

The economic evaluation is made by comparing costs with benefits accruing from the road improvement project. The evaluation results are indicated as the following evaluation indicators:

- Net present value (NPV)
- Benefit/cost ratio (B/C)
- Economic internal rate of return (EIRR)

(4) Benefit Cost Analysis

Based on the above mentioned benefit and cost estimations, the economic analysis of each project was made. Table 19.7.3-2 shows the results of the benefit–cost analysis of each project during the analysis period of 20 years. Table 19.7.3-3 shows the benefit cost stream.

Table 19.7.3-2 Economic Indications of Benefit Cost Analysis

Economic Indicators	C2	C3	CSA (Lologo Radial Street)	CSB (Nyakuron radial Street)
Net Present Value (NPV) in Million US$	19.6	70.2	21.4	11.6
Benefit Cost Ratio (B/C)	1.315	1.438	1.728	1.648
Economic Internal Rate of Return (EIRR)	11.3%	11.4%	15.0%	13.8%

Note: 1. Project life is assumed to be 20 years
2. Discount rate is 8%

(5) Sensitivity Analysis

The sensitivity analysis is conducted by increasing or decreasing the estimated costs and benefit to see the better or worse case scenario. Table 19.7.3-4 shows the results of the sensitivity analysis.

(6) Summary of Economic Analysis

The implementation of the C2, C3, Lologo Radial Street and Nyakuron Radial Street projects is justified from the national economic point of view since economic indicators of all cases are more than the cut-off level which is considered as 8%* of EIRR in the Southern Sudan, except for the following two extreme cases:

- C2 project, in case of cost increasing 20% and benefit decreasing 20% (EIRR: 6.5%)
- C3 project, in case of cost increasing 20% and benefit decreasing 20% (EIRR: 7.6%)

Even in the above extreme cases, the EIRRs are close to the cut-off level (8%).

* Referring to the “Feasibility Study for Improvement Works of the Juba to Nimule Road, USAID/Sudan Infrastructure Service Project, 2007 May”.

Table 19.7.3-3 (1/4) Benefit-Cost Stream (C2 Project)

Undiscounted Benefit Cost Stream Revenue unit : 1,000US $

Year	Construction Cost	Maintenance Cost	Cost Total	Benefit	Benefit - Cost
2010	1,896.7		1,896.7		-1,896.7
2011	6,486.8		6,486.8		-6,486.8
2012	29,190.5		29,190.5		-29,190.5
2013	29,190.5		29,190.5		-29,190.5
2014		474.2	474.2	6,159.8	5,685.6
2015		474.2	474.2	7,077.5	6,603.4
2016		474.2	474.2	7,560.4	7,086.3
2017		474.2	474.2	8,076.3	7,602.1
2018		474.2	474.2	8,627.4	8,153.2
2019		474.2	474.2	9,216.0	8,741.8
2020		474.2	474.2	9,844.9	9,370.7
2021		474.2	474.2	10,516.6	10,042.4
2022		474.2	474.2	11,234.2	10,760.0
2023		4,741.8	4,741.8	12,000.7	7,259.0
2024		474.2	474.2	12,819.6	12,345.4
2025		474.2	474.2	13,694.4	13,220.2
2026		474.2	474.2	13,968.3	13,494.1
2027		474.2	474.2	14,247.6	13,773.5
2028		474.2	474.2	14,532.6	14,058.4
2029		474.2	474.2	14,823.2	14,349.1
2030		474.2	474.2	15,119.7	14,645.5
2031		474.2	474.2	15,422.1	14,947.9
2032		474.2	474.2	15,730.5	15,256.4
2033		4,741.8	4,741.8	16,045.1	11,303.3

Discounted Benefit Cost Stream Revenue unit : 1,000US $

Year	Discount Factor	Construction Cost	Maintenance Cost	Cost Total	Benefit	Benefit - Cost
2010	1.00	1,896.7		1,896.7		-1,896.7
2011	1.08	6,006.3		6,006.3		-6,006.3
2012	1.17	25,026.1		25,026.1		-25,026.1
2013	1.26	23,172.4		23,172.4		-23,172.4
2014	1.36		348.5	348.5	4,527.6	4,179.1
2015	1.47		322.7	322.7	4,816.9	4,494.1
2016	1.59		298.8	298.8	4,764.4	4,465.5
2017	1.71		276.7	276.7	4,712.4	4,435.8
2018	1.85		256.2	256.2	4,661.1	4,404.9
2019	2.00		237.2	237.2	4,610.3	4,373.1
2020	2.16		219.6	219.6	4,560.1	4,340.4
2021	2.33		203.4	203.4	4,510.4	4,307.0
2022	2.52		188.3	188.3	4,461.3	4,272.9
2023	2.72		1,743.5	1,743.5	4,412.7	2,669.1
2024	2.94		161.4	161.4	4,364.6	4,203.1
2025	3.17		149.5	149.5	4,317.0	4,167.6
2026	3.43		138.4	138.4	4,077.2	3,938.8
2027	3.70		128.2	128.2	3,850.7	3,722.5
2028	4.00		118.7	118.7	3,636.8	3,518.1
2029	4.32		109.9	109.9	3,434.7	3,324.8
2030	4.66		101.7	101.7	3,243.9	3,142.2
2031	5.03		94.2	94.2	3,063.7	2,969.5
2032	5.44		87.2	87.2	2,893.5	2,806.3
2033	5.87		807.6	807.6	2,732.7	1,925.1
			Total	62,093.3	81,651.9	19,558.6

Net Present Value(Million US$)	19.6
B/C Ratio	1.315
EIRR	11.3%

Table 19.7.3-3 (2/4) Benefit-Cost Stream (C3 Project)

Undiscounted Benefit Cost Stream Revenue — unit : 1,000US $

Year	Construction Cost	Maintenance Cost	Cost Total	Benefit	Benefit - Cost
2010	5,135.8		5,135.8		-5,135.8
2011	17,564.4		17,564.4		-17,564.4
2012	35,128.9		35,128.9		-35,128.9
2013	61,475.5		61,475.5		-61,475.5
2014	61,475.5		61,475.5		-61,475.5
2015		1,283.9	1,283.9	7,381.4	6,097.5
2016		1,283.9	1,283.9	8,923.5	7,639.6
2017		1,283.9	1,283.9	10,814.6	9,530.7
2018		1,283.9	1,283.9	13,141.4	11,857.5
2019		1,283.9	1,283.9	16,014.4	14,730.4
2020		1,283.9	1,283.9	19,574.5	18,290.5
2021		1,283.9	1,283.9	24,002.6	22,718.7
2022		1,283.9	1,283.9	29,531.3	28,247.3
2023		1,283.9	1,283.9	36,460.6	35,176.7
2024		12,839.5	12,839.5	45,179.1	32,339.6
2025		1,283.9	1,283.9	56,190.9	54,907.0
2026		1,283.9	1,283.9	57,314.8	56,030.8
2027		1,283.9	1,283.9	58,461.1	57,177.1
2028		1,283.9	1,283.9	59,630.3	58,346.3
2029		1,283.9	1,283.9	60,822.9	59,538.9
2030		1,283.9	1,283.9	62,039.3	60,755.4
2031		1,283.9	1,283.9	63,280.1	61,996.2
2032		1,283.9	1,283.9	64,545.7	63,261.8
2033		1,283.9	1,283.9	65,836.6	64,552.7
2034		12,839.5	12,839.5	67,153.4	54,313.9

Discounted Benefit Cost Stream Revenue — unit : 1,000US $

Year	Discount Factor	Construction Cost	Maintenance Cost	Cost Total	Benefit	Benefit - Cost
2010	1.00	5,135.8		5,135.8		-5,135.8
2011	1.08	16,263.4		16,263.4		-16,263.4
2012	1.17	30,117.3		30,117.3		-30,117.3
2013	1.26	48,801.2		48,801.2		-48,801.2
2014	1.36	45,186.3		45,186.3		-45,186.3
2015	1.47		873.8	873.8	5,023.7	4,149.8
2016	1.59		809.1	809.1	5,623.3	4,814.2
2017	1.71		749.2	749.2	6,310.2	5,561.1
2018	1.85		693.7	693.7	7,099.9	6,406.2
2019	2.00		642.3	642.3	8,011.2	7,368.9
2020	2.16		594.7	594.7	9,066.8	8,472.1
2021	2.33		550.7	550.7	10,294.3	9,743.6
2022	2.52		509.9	509.9	11,727.3	11,217.4
2023	2.72		472.1	472.1	13,406.5	12,934.4
2024	2.94		4,371.3	4,371.3	15,381.7	11,010.4
2025	3.17		404.8	404.8	17,713.7	17,309.0
2026	3.43		374.8	374.8	16,729.6	16,354.9
2027	3.70		347.0	347.0	15,800.2	15,453.2
2028	4.00		321.3	321.3	14,922.4	14,601.1
2029	4.32		297.5	297.5	14,093.4	13,795.9
2030	4.66		275.5	275.5	13,310.4	13,035.0
2031	5.03		255.1	255.1	12,571.0	12,315.9
2032	5.44		236.2	236.2	11,872.6	11,636.4
2033	5.87		218.7	218.7	11,213.0	10,994.3
2034	6.34		2,024.8	2,024.8	10,590.0	8,565.3
			Total	160,526.3	230,761.3	70,235.0

Net Present Value(Million US$)	70.2
B/C Ratio	1.438
EIRR	11.4%

Table 19.7.3-3 (3/4) Benefit-Cost Stream (Lologo Radial Street Project)

Undiscounted Benefit Cost Stream Revenue unit : 1,000US $

Year	Construction Cost	Maintenance Cost	Cost Total	Benefit	Benefit - Cost
2010	852.9		852.9		(852.9)
2011	8,751.2		8,751.2		(8,751.2)
2012	20,419.5		20,419.5		(20,419.5)
2013		213.2	213.2	2,294.9	2,081.7
2014		213.2	213.2	3,255	3,041.7
2015		213.2	213.2	4,619	4,405.5
2016		213.2	213.2	4,899	4,685.6
2017		213.2	213.2	5,197	4,983.5
2018		213.2	213.2	5,514	5,300.5
2019		213.2	213.2	5,851	5,637.8
2020		213.2	213.2	6,210	5,996.9
2021		213.2	213.2	6,592	6,379.1
2022		2,132.4	2,132.4	6,999	4,867.0
2023		213.2	213.2	7,433	7,219.5
2024		213.2	213.2	7,894	7,681.1
2025		213.2	213.2	8,386	8,172.9
2026		213.2	213.2	8,554	8,340.6
2027		213.2	213.2	8,725	8,511.7
2028		213.2	213.2	8,899	8,686.2
2029		213.2	213.2	9,077	8,864.2
2030		213.2	213.2	9,259	9,045.8
2031		213.2	213.2	9,444	9,230.9
2032		2,132.4	2,132.4	9,633	7,500.7

Discounted Benefit Cost Stream Revenue unit : 1,000US $

Year	Discount Factor	Construction Cost	Maintenance Cost	Cost Total	Benefit	Benefit - Cost
2010	1.00	852.9		852.9		(852.9)
2011	1.08	8,103.0		8,103.0		(8,103.0)
2012	1.17	17,506.4		17,506.4		(17,506.4)
2013	1.26		169.3	169.3	1,821.8	1,652.5
2014	1.36		156.7	156.7	2,392.5	2,235.7
2015	1.47		145.1	145.1	3,143.4	2,998.3
2016	1.59		134.4	134.4	3,087.1	2,952.7
2017	1.71		124.4	124.4	3,032.2	2,907.8
2018	1.85		115.2	115.2	2,978.9	2,863.7
2019	2.00		106.7	106.7	2,927.0	2,820.3
2020	2.16		98.8	98.8	2,876.5	2,777.7
2021	2.33		91.5	91.5	2,827.3	2,735.9
2022	2.52		846.8	846.8	2,779.5	1,932.7
2023	2.72		78.4	78.4	2,733.0	2,654.6
2024	2.94		72.6	72.6	2,687.7	2,615.1
2025	3.17		67.2	67.2	2,643.7	2,576.4
2026	3.43		62.2	62.2	2,496.8	2,434.6
2027	3.70		57.6	57.6	2,358.1	2,300.5
2028	4.00		53.4	53.4	2,227.1	2,173.7
2029	4.32		49.4	49.4	2,103.4	2,053.9
2030	4.66		45.7	45.7	1,986.5	1,940.7
2031	5.03		42.4	42.4	1,876.1	1,833.8
2032	5.44		392.2	392.2	1,771.9	1,379.7
			Total	29,372.3	50,750.4	21,378.1

Net Present Value(Million US$)	21.4
B/C Ratio	1.728
EIRR	15.0%

Table 19.7.3-3 (4/4) Benefit-Cost Stream (Nyakuron Radial Street Project)

Undiscounted Benefit Cost Stream Revenue unit : 1,000US $

Year	Construction Cost	Maintenance Cost	Cost Total	Benefit	Benefit - Cost
2010	521.0		521.0		-521.0
2011	5,345.3		5,345.3		-5,345.3
2012	12,472.3		12,472.3		-12,472.3
2013		130.2	130.2	1,627.2	1,496.9
2014		130.2	130.2	1,744.2	1,613.9
2015		130.2	130.2	1,869.6	1,739.4
2016		130.2	130.2	2,081.9	1,951.7
2017		130.2	130.2	2,321.3	2,191.1
2018		130.2	130.2	2,591.6	2,461.4
2019		130.2	130.2	2,897.1	2,766.9
2020		130.2	130.2	3,242.8	3,112.5
2021		130.2	130.2	3,634.3	3,504.1
2022		1,302.5	1,302.5	4,078.4	2,775.9
2023		130.2	130.2	4,582.4	4,452.1
2024		130.2	130.2	5,155.1	5,024.9
2025		130.2	130.2	5,806.5	5,676.3
2026		130.2	130.2	5,922.7	5,792.4
2027		130.2	130.2	6,041.1	5,910.9
2028		130.2	130.2	6,161.9	6,031.7
2029		130.2	130.2	6,285.2	6,154.9
2030		130.2	130.2	6,410.9	6,280.6
2031		130.2	130.2	6,539.1	6,408.8
2032		1,302.5	1,302.5	6,669.9	5,367.4

Discounted Benefit Cost Stream Revenue unit : 1,000US $

Year	Discount Factor	Construction Cost	Maintenance Cost	Cost Total	Benefit	Benefit - Cost
2010	1.00	521.0		521.0		-521.0
2011	1.08	4,949.3		4,949.3		-4,949.3
2012	1.17	10,693.0		10,693.0		-10,693.0
2013	1.26		103.4	103.4	1,291.7	1,188.3
2014	1.36		95.7	95.7	1,282.0	1,186.3
2015	1.47		88.6	88.6	1,272.4	1,183.8
2016	1.59		82.1	82.1	1,312.0	1,229.9
2017	1.71		76.0	76.0	1,354.5	1,278.5
2018	1.85		70.4	70.4	1,400.2	1,329.8
2019	2.00		65.2	65.2	1,449.3	1,384.1
2020	2.16		60.3	60.3	1,502.0	1,441.7
2021	2.33		55.9	55.9	1,558.7	1,502.8
2022	2.52		517.2	517.2	1,619.6	1,102.4
2023	2.72		47.9	47.9	1,684.9	1,637.0
2024	2.94		44.3	44.3	1,755.1	1,710.8
2025	3.17		41.1	41.1	1,830.5	1,789.4
2026	3.43		38.0	38.0	1,728.8	1,690.7
2027	3.70		35.2	35.2	1,632.7	1,597.5
2028	4.00		32.6	32.6	1,542.0	1,509.4
2029	4.32		30.2	30.2	1,456.3	1,426.2
2030	4.66		27.9	27.9	1,375.4	1,347.5
2031	5.03		25.9	25.9	1,299.0	1,273.2
2032	5.44		239.6	239.6	1,226.9	987.3
			Total	17,940.7	29,574.0	11,633.3

Net Present Value(Million US$)	11.6
B/C Ratio	1.648
EIRR	13.8%

Table 19.7.3-4 Sensitivity Analysis Results

C2

			Benefits		
			20% down	Base Case	20% up
Cost	20% down	NPV(m.$)	15.6	32.0	48.3
		B/C Ratio	1.315	1.644	1.972
		EIRR(%)	11.3%	14.3%	16.9%
	Base Case	NPV(m.$)	3.2	**19.6**	35.9
		B/C Ratio	1.052	**1.315**	1.578
		EIRR(%)	8.6%	**11.3%**	13.7%
	20% up	NPV(m.$)	-9.2	7.1	23.5
		B/C Ratio	0.877	1.096	1.315
		EIRR(%)	6.5%	9.1%	11.3%

C3

			Benefits		
			20% down	Base Case	20% up
Cost	20% down	NPV(m.$)	56.2	102.3	148,5
		B/C Ratio	1.438	1.797	2.156
		EIRR(%)	11.4%	13.7%	15.6%
	Base Case	NPV(m.$)	24.1	**70.2**	116.4
		B/C Ratio	1.150	**1.438**	1.725
		EIRR(%)	9.3%	**11.4%**	13.2%
	20% up	NPV(m.$)	-8.0	38.1	84.3
		B/C Ratio	0.958	1.198	1.438
		EIRR(%)	7.6%	9.7%	11.4%

CSA (Lologo Radial Street)

			Benefits		
			20% down	Base Case	20% up
Cost	20% down	NPV(m.$)	17.1	27.3	37.4
		B/C Ratio	1.728	2.160	2.592
		EIRR(%)	15.0%	18.4%	21.4%
	Base Case	NPV(m.$)	11.2	**21.4**	31.5
		B/C Ratio	1.382	**1.728**	2.073
		EIRR(%)	12.0%	**15.0%**	17.8%
	20% up	NPV(m.$)	5.4	15.5	25.7
		B/C Ratio	1.152	1.44	1.728
		EIRR(%)	9.7%	12.5%	15.0%

CSB (Nyakuron Radial Street)

			Benefits		
			20% down	Base Case	20% up
Cost	20% down	NPV(m.$)	9.3	15.2	21.1
		B/C Ratio	1.648	2.061	2.473
		EIRR(%)	13.8%	16.8%	19.5%
	Base Case	NPV(m.$)	5.7	**11.6**	17.5
		B/C Ratio	1.319	**1.648**	1.978
		EIRR(%)	11.1%	**13.8%**	16.2%
	20% up	NPV(m.$)	2.1	8.0	14.0
		B/C Ratio	1.099	1.374	1.648
		EIRR(%)	9.0%	11.6%	13.8%

19.8 IMPLEMENTATION PLAN

19.8.1 Implementation Organization

Implementing Agency

Considering that the Study Roads are primary or secondary trunk roads in Juba and that the Ministry of Physical Infrastructure (MOPI) currently does not have the capability to construct the urban streets under this Study, the Implementation of the construction of the Study Roads shall be under the responsibility of the Ministry of Transport and Roads (MTR). However, once the projects are completed, their maintenance shall be done under the responsibility of MOPI.

19.8.2 Project Implementation Activities and Schedule

The proposed project implementation schedule is presented in Table 19.8.2-1.

(1) Feasibility Study

A Feasibility Study is recommended to be done to:

- prepare preliminary design to determine the project scope for budgetary purposes and fund preparation.
- determine the road alignment and bridge location for preparation for right-of-way acquisition, staking of the road reserve limits and conducting parcellary surveys.
- prepare the construction plan including procurement plan, construction method and construction schedule.
- conduct environmental impact assessment including project affected persons and structures.
- determine the economical and financial viability of the project.

(2) Fund Preparation

Once the project scope and funding requirements are determined in the feasibility study, fund preparation can be done to determine the possible sources of funds and fund allocation for the project implementation.

If the project cost falls outside the budget of MTR, it will be necessary to look for other alternative sources of funds including foreign aids such as grants or loans.

(3) Consultant Selection

During the conduct of the feasibility study, MTR proceeds with the procurement of consultant for detailed design and construction supervision.

(4) Detailed Design

Detailed design proceeds after selecting the consultant. The consultant is expected to prepare the design documents and construction drawings, prepare the tender documents for bidding including specifications and project cost estimate, assist MTR in prequalifying and selecting the contractors during bidding, prepare a parcellary survey of the affected lots (in coordination with

MTR), prepare the environmental impact assessment report and resettlement plan.

(5) ROW Acquisition and Resettlement of Residence

MTR shall proceed with the ROW acquisition and resettlement of residence affected by the project based on the results of the feasibility study and detailed design in order to clear the road reserve prior to project construction. This is an important responsibility of MTR and should be executed as early as possible so as not to delay the construction activities and to prevent the increase of structures within the ROW.

(6) Preconstruction Activities

Even during the detailed design, MTR can proceed with short-listing the possible contractors for the project based on an agreed set of prequalification criteria. After the bid documents are prepared by the consultant, the project can be tendered by the prequalified contractors. Bid evaluation shall be done by MTR with the assistance of the consultant.

(7) Construction and Supervision

The construction schedule for C2, C3, CSA and CSB is presented in Table 19.8.2-1. On behalf of the MTR, the consultant shall supervise the contractor's works to control the time, cost and quality of the works for a successful completion of the project.

(8) Opening of Traffic and Turn-Over to MOPI for Road Maintenance

Once completed, the road projects can be opened to traffic and utilized by the public. Since the project is an urban road project, maintenance work shall be done by MOPI with the assistance of MTR. In the beginning when MOPI has not enough capacity for maintenance of such roads, MTR shall assist initially MOPI in conducting the maintenance work until MOPI is capable of doing such work by itself.

Road maintenance shall be done in accordance with the maintenance system discussed in Chapter 16. It is necessary for MOPI to allocate funds for maintaining these roads.

Table 19.8.2-1 Proposed Implementation Schedule

Major Activities		Cost (Million US$)	Year 2010				Year 2011				Year 2012				Year 2013				Year 2014				Year 2015			
Feasibility Study																										
Fund Preparation																										
Consultant selection																										
Detailed Design		6.95			0.87	1.74	1.74	1.74	0.86																	
ROW Acquision and Resettlement of Resident																										
Preconstruction Activities																										
Construction *	C2	69.43								5.79	5.79	5.79	5.79	5.79	5.79	5.79	5.79	5.79	5.79	5.79	5.74					
	C3	106.19								8.85	8.85	8.85	8.85	8.85	8.85	8.85	8.85	8.85	8.85	8.85	8.84					
	Nile River Br.	81.80								5.11	5.11	5.11	5.11	5.11	5.11	5.11	5.11	5.11	5.11	5.11	5.11	5.11	5.11	5.11	5.15	
	CSA	31.22													5.20	5.20	5.20	5.20	5.20	5.22						
	CSB	19.07													3.81	3.81	3.81	3.81	3.83							
Construction Supervision		11.59								0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.79	
Opening to Traffic																				▲ CSB	▲ CSA	▲ C2 & C3				▲ Nile Br.
Annual Fund Requirement		326.25	2.61				24.81				81.88				117.92				81.43				17.60			

Note: * Construction cost includes construction cost, contractor overhead, administration cost and contingency.

PART IV

BRIDGES AND CULVERTS RECONSTRUCTION PROJECT

CHAPTER 20

SELECTION OF BRIDGES AND CULVERTS

CHAPTER 20 SELECTION OF BRIDGES AND CULVERTS

20.1 BACKGROUND AND PROJECT OBJECTIVES

The Ministry of Transport and Roads (MTR) is currently undertaking the Emergency Road Rehabilitation Project (ERRP) to improve the existing road conditions within Juba urban area. The project calls for the improvement of about 65kms of road structure and road geometry. The road surface is being paved with asphalt concrete with provisions for parking lanes and pedestrian sidewalks. Figure 20.1-1 illustrates the scope of the on-going Emergency Road Rehabilitation Project in Juba. The project, with about 10kms of road paved as of November 2009, is being undertaken by two separate contractors for Lot 1 and Lot 2.

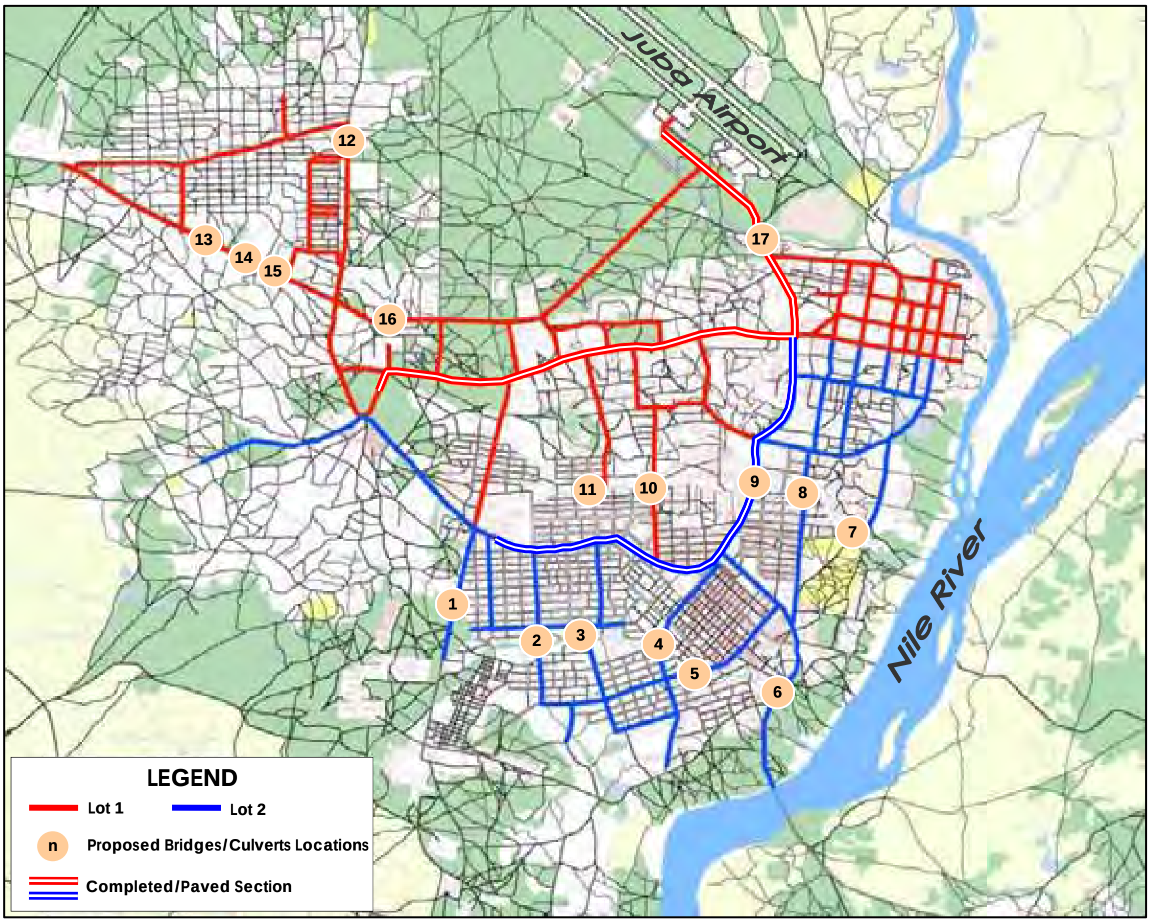


Figure 20.1-1 On-Going Emergency Road Rehabilitation Project and Proposed Bridges and Culverts Locations

The project, once completed is expected to:

- enhance mobility within Juba urban area and minimize travel time,
- improve accessibility to business, commercial, institutional and residential areas,
- improve traffic safety among road users including motorists and pedestrians, and
- reduce the cost of vehicle operation and maintenance.

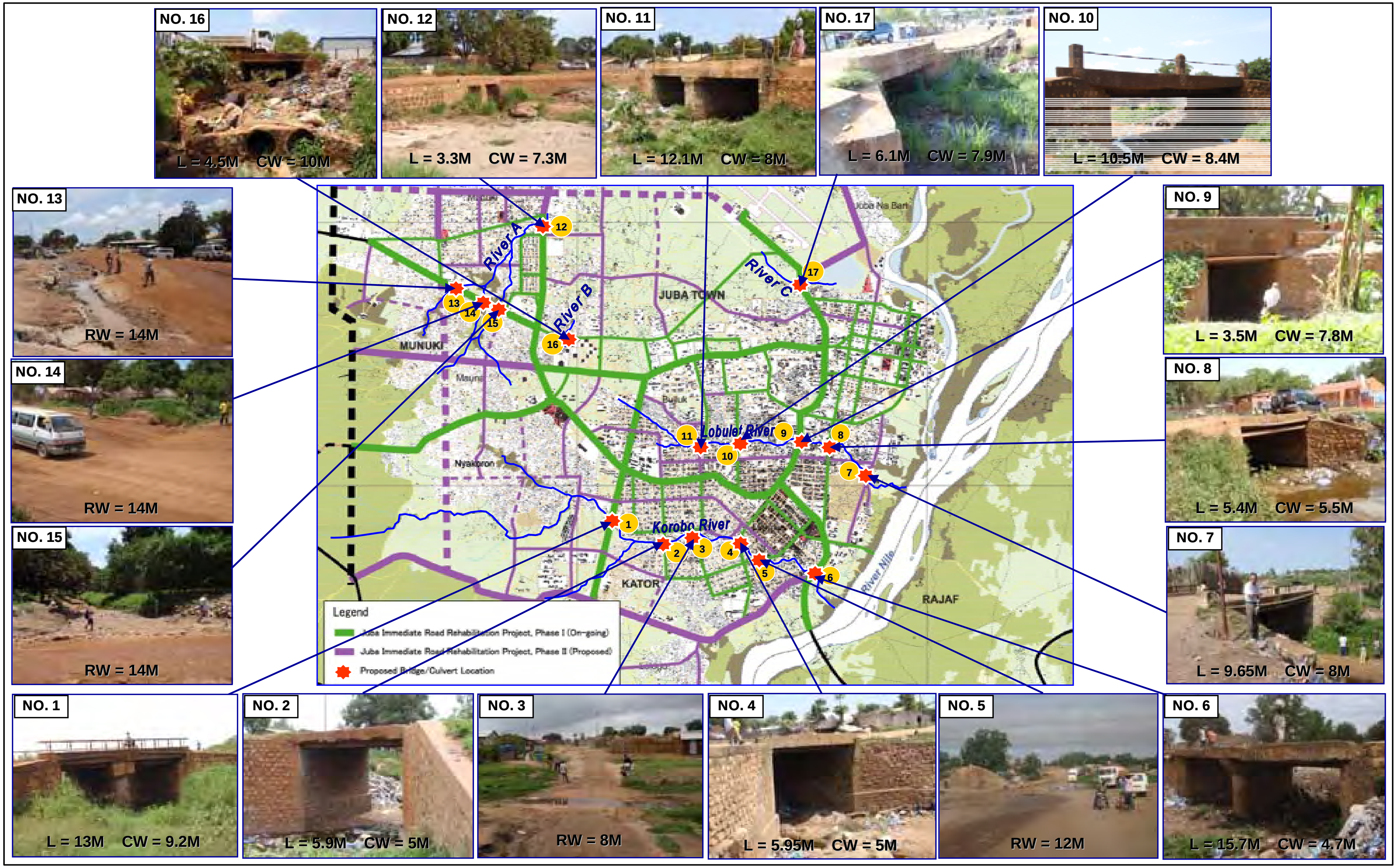


Figure 20.1-2 Existing Bridges and Culverts Proposed for Bridges and Culverts Reconstruction Project

Table 20.1-1 Summary of Existing Bridge and Culverts Conditions

No.	Bridge/ Culvert Name	Road Name	River	Road Class	Rehab. Project	Bridge/Culvert Superstructure & Substructure Type	Bridge vs River				Road vs Carriageway, CW		Year Built
							Bridge/ Culvert Length (m)	Bridge Opening (m)	River Width (m)	Free-board (m)	Road Width (m)	Bridge Width (m)	
1	Shuhada	Mayo	Korobo	C	P1	2-Span RCDHB on Masonry Abutment	13.0	10	10	2.00	12	9.2	1991
2	Tombror	Tombror	Korobo	C	P1	1-Span RCDHB on Masonry Abutment	5.9	4	10	0.75	12	5.0	1974
3	Salam	Salam	Korobo	C	P1	No Structure	-	-	12	-	8	-	-
4	Albino	Albino	Korobo	C	P1	1-Span RCDHB on Masonry Abutment	5.95	4	12	0.60	12	5.0	1974
5	Lilasmafi	Tombror	Korobo	C	P1	No Structure	-	-	13	-	12	-	-
6	Madra	Nglilo	Korobo	A	P1	2-Span RCDHB on Masonry Abutment	15.7	14	20	0.80	12	4.7	1972
7	Salakana	Salakana	Lobulet	A	P1	1-Span RCDHB on Masonry Abutment	9.65	7.6	14	0.80	12	8.0	1995
8	Hai Malakar	Cinema	Lobulet	C	P1	1-Span RCDHB on Masonry Abutment	5.4	4	13	0.30	12	5.5	
9	Korobo	Unity	Lobulet	A	P1	1-Span RCDHB on Masonry Abutment	5.5	3.5	12.5	0.10	13.5	7.8	1960
10	Kokora	Kokora	Lobulet	C	P1	1-Span RCDHB on Masonry Abutment	10.5	8.5	12	0.90	12	8.4	1983
11	Lukabadi	Lukabadi	Lobulet	C		2-Span RCDHB on Masonry Abutment	12.1	10	12	1.00	12	8.0	1999
12	Terekeka	Terekeka	A	A	P1	2-Cell RC Slab on Masonry Abutment	3.3	2.5	14	OF	10.5	7.3	1950
13	Munuki 1	Salvation	A	A	P1	No Structure	-	-	4	-	14	-	-
14	Munuki 2	Salvation	A	A	P1	No Structure	-	-	3.5	-	14	-	-
15	Munuki 3	Salvation	A	A	P1	No Structure	-	-	6	-	14	-	-
16	Gonya	Salvation	B	A	P1	1-Cell RC Slab on Masonry Abutment	4.5	3.3	3.3	1.00	14	10	
17	Lodoro	Lay	C	A	P1	1-Cell RC Slab on Masonry Abutment	6.1	4	8	0.20	12	7.9	1986

Notes:

1. P1 : Phase 1 – Road Rehabilitation Project
2. A : Urban Arterial
3. C : Urban Collector
4. CW : Carriageway Width
5. RCDHB : Reinforced Concrete Deck on Steel H-Beam
6. OF : Overflow

However, the ERRP covers only road improvement and rehabilitation of major urban arterial and collector roads and does not include the rehabilitation or reconstruction of bridges and major culverts. Existing bridges and culverts will thus remain unimproved and roads crossing streams and rivers without fix link will remain impassable during heavy rains. Under this condition, although the roads are improved, the efficiency and safety of the road network are still deficient.

In this regard, the Bridges and Culverts Reconstruction Project (BCRP) is being formulated to complement the objectives of the ERRP and thus improve the overall road network efficiency in Juba urban area. Seventeen (17) bridges and culverts crossing five (5) river basins are originally proposed to be included in the BCRP (see Figure 20.1-2). However, one of these bridges (Bridge No.16) is being undertaken with the on-going road rehabilitation project. This number covers the scope of the on-going ERRP and once completed, will be sufficient for the overall improvement of the major road network in Juba.

The objectives of the BCRP will then be to:

- improve mobility and accessibility within Juba by providing fix links in places where roads cross rivers and streams and thus making the roads accessible throughout the year,
- improve road capacity by providing traveled way/carriageway with the same width as the road section,
- enhance traffic movement and safety by providing smooth transitions in the horizontal and vertical alignment of the roads at the bridge locations,
- improve traffic safety and reduce traffic accidents by separating motorized with non-motorized transport modes and providing sidewalks with sufficient width, and
- improve structural safety by reconstructing bridges and culverts with sufficient capacity to resist the increasing live loads and loads due to natural calamities.

20.2 EXISTING CONDITIONS OF THE PROPOSED BRIDGES AND CULVERTS LOCATIONS

A summary of the existing conditions of bridges and culverts is presented in Table 20.2-1.

20.2.1 Rivers/Streams and Bridge Opening

The proposed 17 locations of the bridges and culverts cover about 5 river basins in Juba urban area (Korobo River, Lobulet River, River A, River B and River C), as seen in Figure 20.1-2. 6 bridge sites cross over Korobo River – Nos. 1 to 6, 5 bridge sites cross over Lobulet River – Nos. 7 to 11, 4 bridge sites cross over River A – Nos. 12 to 15, 1 site cross over River B – No.16 and 1 site cross over River C – No. 17.

The number of proposed bridges and culverts are deemed sufficient to cover the major arterial and collector roads, which are now being rehabilitated under the ERRP, and will render the basic road network accessible in all weather.

Figure 20.2.1-1 illustrates the layout of the bridges and culverts in relation to rivers and bridge/culvert openings while Photo 20.2.1-1 shows the conditions of the rivers and bridge openings. Debris and garbage are basically observed in bridge/culvert openings thus reducing their discharge capacities.

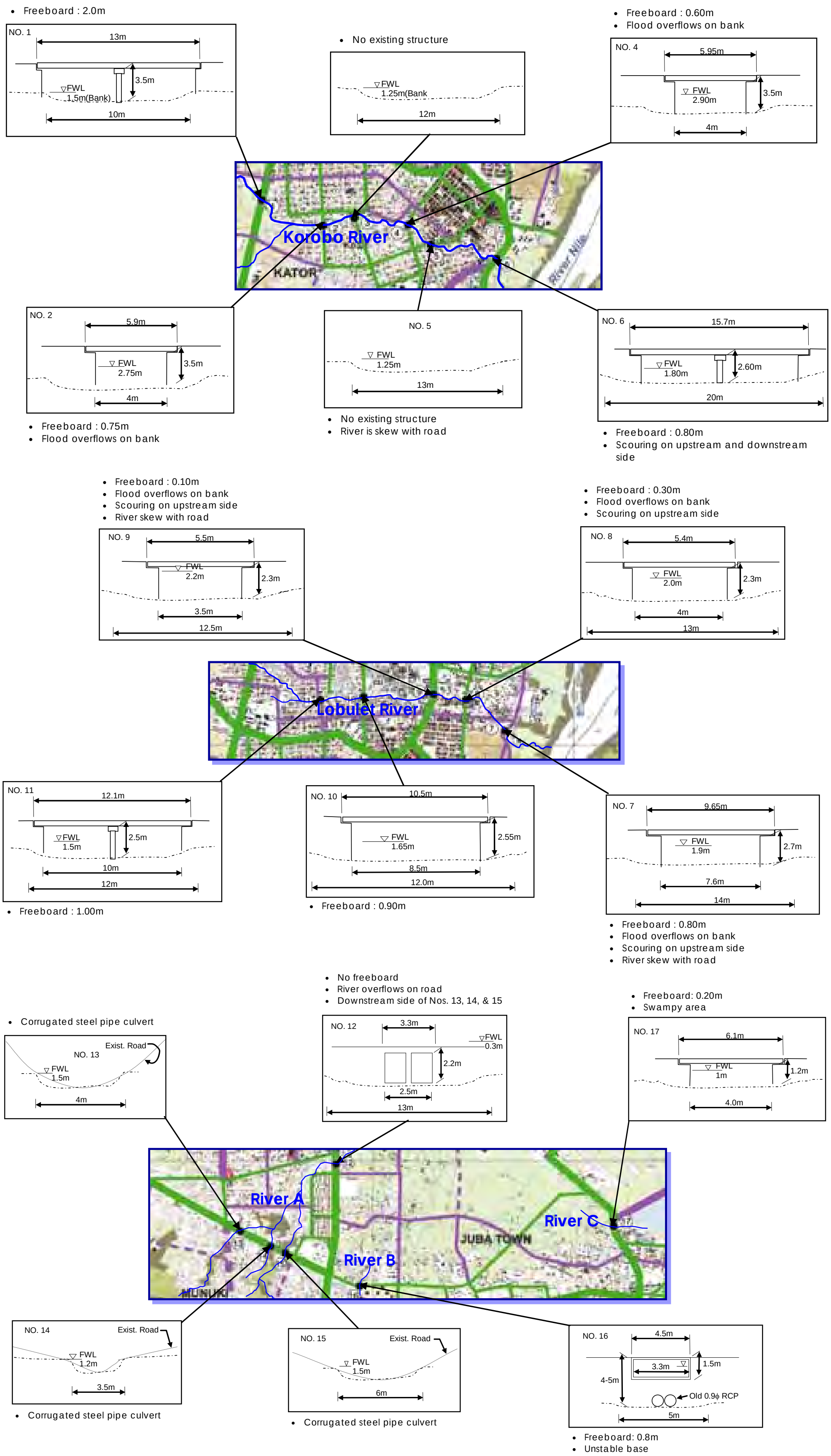


Figure 20.2.1-1 Bridge Openings and River Conditions

Debris/Garbage Blocking the Upstream Opening (No.12)

Floodwater Overtopping Bridge During Rain (No.12)

Vehicle Crossing Flooded Road without Bridge/Culvert (No.13)

Vehicle Unable to Cross Flooded Road without Bridge/Culvert (No.5)

Insufficient Freeboard on Culverts During Rain (No.17)

Scouring of Upstream Bank During Rain (No.9)

Scouring of Road and Abutment at Upstream Side (No.6)

Debris/Garbage Accumulating at Upstream Side (No.6)

Photo 20.2.1-1 Conditions of Rivers and Bridge/Culvert Openings

20.2.2 Road and Bridge Geometry

The following conditions are observed in the proposed bridge and culvert sites:

- Existing bridge widths are basically narrower (mostly one-lane bridge) than the existing road widths thus reducing road capacities and increasing risks of traffic accidents at bridge sites.
- Most existing bridges/culverts are not provided with sidewalks which render safety risks for pedestrians and non-motorized transport modes.
- Since most bridges are narrower than the road, the bridge traveled ways/carriageways are basically offset from the road which increases risks for traffic accidents.
- In road sections where no structures are provided, continuous passage is prevented during heavy rains.

Photo 20.2-2 illustrates the typical geometric problems described above.

20.2.3 Bridge and Culverts Structures

As presented in Table 20.2-1, the existing structures are basically categorized as one-span and two-span reinforced concrete deck on steel H-beam and masonry abutments and one-cell and two-cell reinforced concrete slab culvert on masonry walls/abutments, Most structures are basically old with some defects and damages on concrete decks and corrosion with section loss on steel H-beams. The increasing demand in live loading necessitates strengthening of these structures or replacement with sufficient capacity. Moreover, the masonry walls, piers and abutments may not be sufficient to resist large lateral forces caused by seismic excitations.

Photo 20.2-3 shows some typical existing structures.

20.3 OVERALL ASSESSMENT OF EXISTING CONDITIONS

The overall assessment of the existing bridges and culvert site conditions are presented in Table 20.3-1. Basically, 12 existing bridges and culverts are proposed to be reconstructed and, in areas where none exist, 5 new bridges and culverts are proposed to be constructed. This will make most of Juba urban area accessible throughout the year and is considered sufficient under the on-going road rehabilitation project.

Narrow Bridge with Offset Center (No. 2)

Narrow Bridge on Arterial Road without Pedestrian Sidewalk (No. 6)

No Existing Structure (No. 5)

No Existing Structure (No. 13)

Embankment Erosion at Temporary Steel Pipe Culvert Narrows Road (No. 14)

Road Narrows at Culvert Section of Paved Road (No. 17)

Road Narrows at Culvert Section of Paved Road (No. 9)

Narrow Bridge without Pedestrian Sidewalk (No. 4)

Photo 20.3-1 Conditions of Road and Bridge Geometry


2-Span 2-Lane RC Slab on Steel H-Beam Bridge with Masonry Abutments and Pier (No.1)


1-Span 1-Lane RC Slab on Steel H-Beam Bridge with Masonry Abutments (No.2)


2-Span 1-Lane RC Slab on Steel H-Beam Bridge with Masonry Abutments and Pier (No.6)


1-Span 2-Lane RC Slab on Steel H-Beam Bridge with Masonry Abutments (No.7)


RC Slab on Steel H-Beam Culvert with Masonry Abutments (No.9)


Steel H-Beam with Corroded Section/Section Loss (No.10)


2-Cell RC Slab Culvert on Masonry Walls and Abutments (No.12)

Photo 20.3-2 Existing Bridge and Culvert Structures

Table 20.3-1 Overall Assessment of Existing Conditions

No.	River and Bridge/Culvert Opening	Bridge/Culvert Geometry	Bridge/Culvert Structure
1	• Bridge opening is sufficient	• 2-Lane carriageway narrower than road • Insufficient width for urban collector road	• Masonry abutment not strong with seismic demand • Deck structure may not be sufficient with increasing live load demand • Some defects/damage on superstructure
2	• Freeboard is insufficient (0.75m) • Flood overflows on banks	• Carriageway only 5m, too narrow • Bridge centerline offset with road • Insufficient width for urban collector road	• Masonry abutment not strong with seismic demand • Deck structure may not be sufficient with increasing live load demand • Some defects/damage on superstructure • Old structure
3	• Road flooded during rain, not passable	• No existing structure	• No existing structure
4	• Freeboard is insufficient (0.60m) • Flood overflows on bank	• Carriageway only 5m, too narrow • Bridge centerline offset with road • Insufficient width for urban collector road	• Masonry abutment not strong with seismic demand • Deck structure may not be sufficient with increasing live load demand • Some defects/damage on superstructure • Old structure
5	• Road flooded during rain, not passable	• No existing structure	• No existing structure
6	• Freeboard is insufficient (0.80m) • Scouring at abutment on upstream and downstream side	• Carriageway only 4.7m, too narrow • Bridge width insufficient for Urban Arterial function • Bridge centerline offset with road	• Masonry abutment not strong with seismic demand • Deck structure may not be sufficient with increasing live load demand • Some defects/damage on superstructure, abutment and pier • Old structure
7	• Freeboard is insufficient (0.80m) • Flood overflows on bank • Scouring at abutment on upstream side • River slightly skew with road	• Carriageway only 8m, narrower than road • Bridge width insufficient for Urban Arterial function • Bridge centerline offset with road	• Masonry abutment not strong with seismic demand • Deck structure may not be sufficient with increasing live load demand • Some defects/damage on superstructure
8	• Insufficient freeboard (0.30m) • Flood overflows on bank • Scouring at abutment on upstream side	• Carriageway only 5.5m, too narrow • Bridge centerline offset with road • Insufficient width for urban collector road	• Masonry abutment not strong with seismic demand • Deck structure may not be sufficient with increasing live load demand • Some defects/damage on superstructure • Old structure
9	• Insufficient freeboard (0.10m) • Flood overflows on bank • Scouring on upstream side • River skew with road	• Carriageway only 7.8m, narrower than road • Bridge width insufficient for Urban Arterial function	• Masonry abutment not strong with seismic demand • Deck structure may not be sufficient with increasing live load demand • Some defects/damage on superstructure • Old structure
10	• Freeboard less than 1m (0.90)	• Carriageway only 8.4m, narrower than road • Insufficient width for urban collector road	• Masonry abutment not strong with seismic demand • Deck structure may not be sufficient with increasing live load demand • Some defects/damage on superstructure • Old structure
11	• Freeboard is 1.0m	• Carriageway only 8.4m, narrower than road • Insufficient width for urban collector road	• Masonry abutment not strong with seismic demand • Deck structure may not be sufficient with increasing live load demand • Some defects/damage on superstructure

No.	River and Bridge/Culvert Opening	Bridge/Culvert Geometry	Bridge/Culvert Structure
12	• No freeboard, very small opening • River overflows on road • Downstream side of Bridge Nos. 13, 14 & 15	• Carriageway only 7.3m, narrower than road • Bridge width insufficient for Urban Arterial function • Bridge centerline offset with main road alignment	• Masonry abutment not strong with seismic demand • Deck structure may not be sufficient with increasing live load demand • Some defects/damage on superstructure • Old structure
13	• Road flooded during rain, with temporary culvert	• Road section narrower at culvert location	• Temporary steel pipe culvert
14	• Road flooded during rain, with temporary culvert	• Road section narrower at culvert location	• Temporary steel pipe culvert
15	• Road flooded during rain, with temporary culvert	• Road section narrower at culvert location	• Temporary steel pipe culvert
16	• Freeboard is 0.8m	• Carriageway only 10m, narrower than road • Bridge width insufficient for Urban Arterial function • Bridge centerline offset with road	• Masonry abutment not strong with seismic demand • Deck structure may not be sufficient with increasing live load demand • Some defects/damage on superstructure • Unstable base condition
17	• Insufficient freeboard (0.20m) • Swampy area	• Carriageway only 7.9m, narrower than road • Bridge width insufficient for Urban Arterial function • Bridge centerline offset with road	• Masonry abutment not strong with seismic demand • Deck structure may not be sufficient with increasing live load demand • Some defects/damage on superstructure • Old structure

The identified bridges and culverts locations for the bridge rehabilitation and reconstruction project are proposed to be undertaken to improve mobility, accessibility, traffic safety and transportation cost in Juba urban area.

CHAPTER 21

NATURAL CONDITION SURVEY

CHAPTER 21 NATURAL CONDITION SURVEY

21.1 TOPOGRAPHIC SURVEY AT BRIDGES AND CULVERTS SITES

Topographic surveys were conducted at the 17 bridge and culvert sites (shown in Figure 20.1-1 of Chapter 20) to plan for the scale of bridges and approach roads. The following items are included in the scope of topographic survey:

- Survey Area. The survey area covers 100m in length on either side of the bridge for a total length of 200m and 25m on either side of the road centerline for a total width of 50m.
- Establishment of Control Points. Control points are established on permanent landmarks with descriptions of locations, coordinates and elevations. The control points are tied with the on-going road rehabilitation control points.
- Road Centerline and Profile Survey. Road centerline and profile are surveyed at maximum intervals of 25m. Every change in road horizontal and vertical alignment is taken at the road centerline.
- Road Cross-Section Survey. The road cross-sections are surveyed perpendicular to the road centerline at 25m intervals and at changes in road sections.
- River Cross-Section Survey. River cross-sections are taken in the upstream and downstream sides of the rivers.
- Road Facilities and Structures Survey. All structures such as houses, buildings, electric posts, side ditches, cross drainage facilities and other facilities are surveyed and indicated in the topographic plans.

Results of the topographic surveys are prepared as plans and sections drawings (see Figure 21.1-1 for typical topographic site drawings).

Photo 21.1-1 Topographic Survey

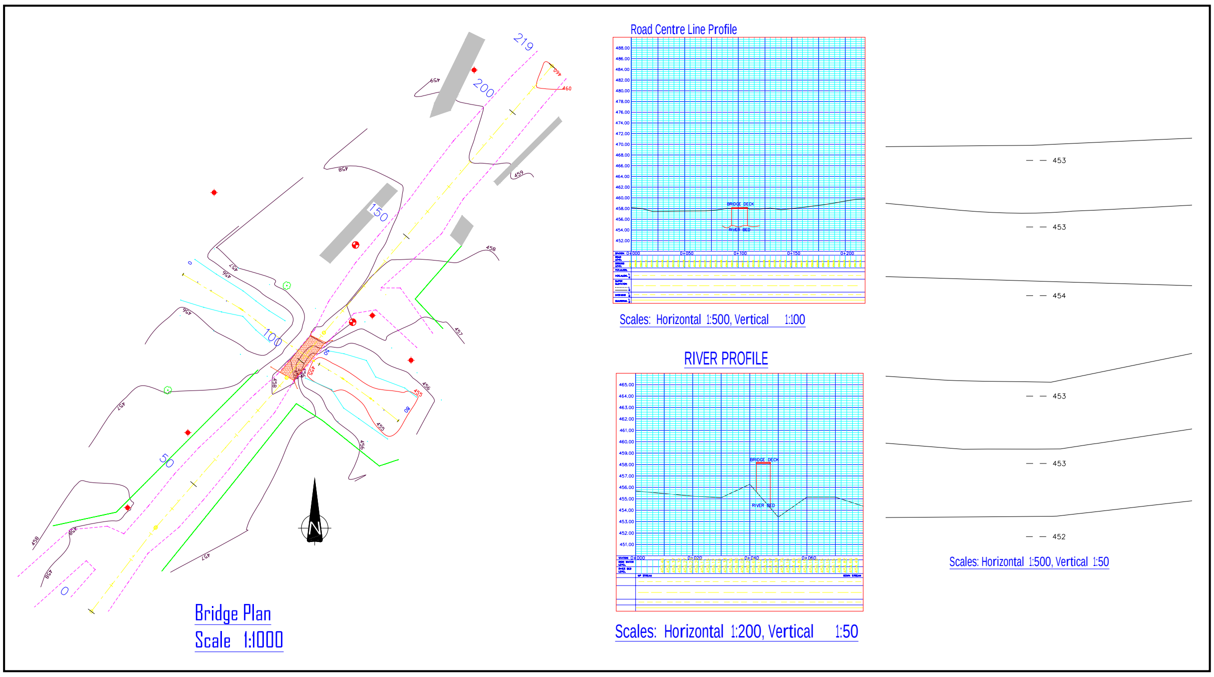


Figure 21.1-1 Typical Topographic Survey Results

BRIDGE NO 1:(P22) E: 343389.000 N: 534628.000 H: 486.000	**BRIDGE NO 6: (P29)** E: 345728.000 N: 534028.000 H: 458.000
	

Photo 21.1-2 Typical Topographic Survey Control Points

21.2 GEOTECHNICAL SURVEY FOR BRIDGES AND CULVERTS

Geotechnical surveys for bridge and culvert sites (as shown in Figure 21.2-1) are conducted for the purpose of determining the overall ground condition of the area at the level of project formation. A limited number of boreholes (total of four) are conducted to plan for the scale of foundation for budgetary purposes. The following scope is conducted for the geotechnical survey for bridges and culverts:

- Site. 4 boreholes are conducted at different sites to determine the general ground profiles and subsurface conditions of the area for planning the foundation of the structures. The level of geotechnical investigation at the boreholes is equivalent for project formation stage. The coordinates and ground surface elevation of each borehole are noted.

- Drilling and Soil profiling. Drilling is conducted to determine the soil profiles and subsurface conditions at site. Where rock is encountered, drilling is continued to penetrate at least 5 meters in the rock layer. Groundwater encountered at each borehole is noted in the borehole log. Expected depth for each borehole is 20m.

Photo 21.2-1 Drilling and Soil Profiling

- Dynamic Cone Penetration Test. The Dynamic Cone Penetration Test (DCPT) is carried-out at one meter intervals for each borehole to determine the resistive capacities of the different soil layers for foundation design.

- Soil Classification and Disturbed Sampling. Soil classification is done at one meter interval together with disturbed sampling of soil layers.

- Laboratory Tests. Laboratory tests including specific gravity, atterberg limit, sieve analysis and natural water content are conducted for the samples taken at each borehole site.

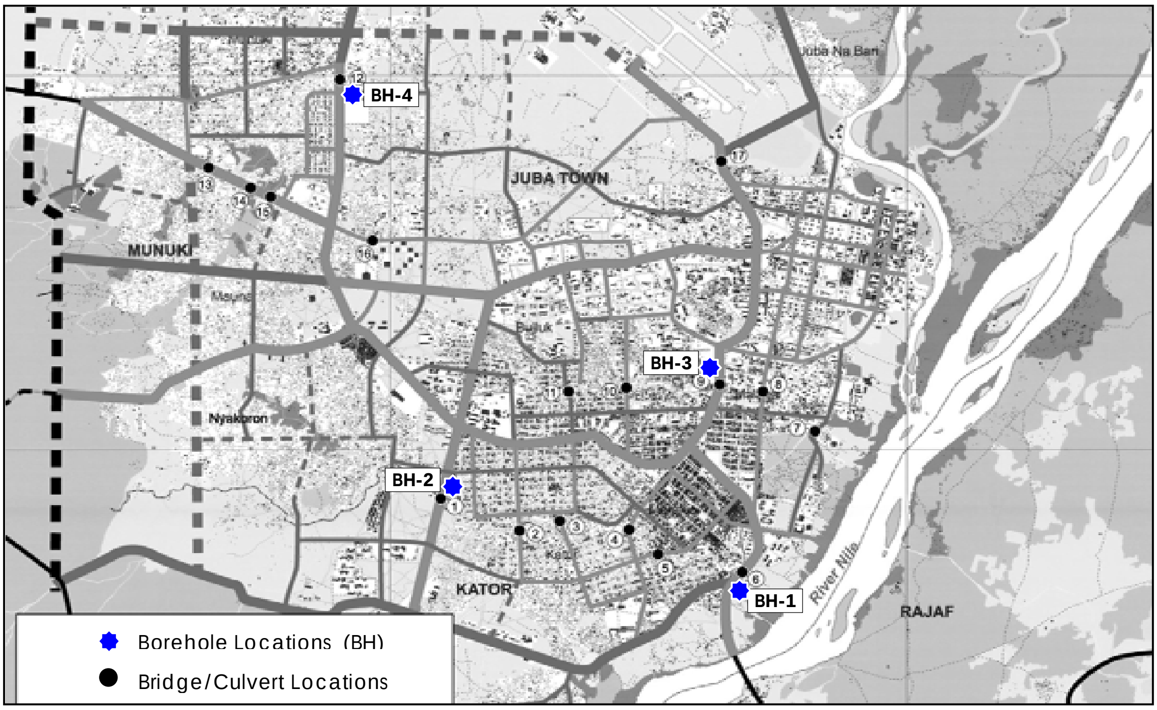


Figure 21.2-1 Borehole Locations

Depth m	Sample Type/ No	Sample SPT N-values	Core Runs Depths m	Ohm-m	Penteratio sec/meter	Reduced Level m	Legend	Depth m	Description	Weathering Grade/ Comments
0						0.00			Relatively Dark Brownish Black Sandy CLAY	
		GL ~ 1.00 N = 13								
1	B1 D2			21.31	9	-1.00		1.00		
		1.00 ~ 2.00 N = 15							Stiff Dark Brownish Black Sandy CLAY with Pebbles of Granite	
2	B3 D4			32.31	10	-2.00		2.00		
		2.00 ~ 3.00 N = 18							Stiff Dark Greyish Clay with Patches of Limonite and Specks of Muscovite	
3	B5 D6			98.22	15	-3.00		3.00		
		3.00 ~ 4.00 N = 31							Dark Greyish to Green Highly weathered with Specks of Hornblende Diorite GNEISS	IV
4	B7 D8			206.7	20	-4.00		4.00		
		4.00 ~ 5.00 N = 43							Dark green Highly Weathered with Specks of Hornblende Diorite GNEISS	IV
5	B9 D10	N = R No Penetration N > 50		227	25	-5.00		5.00	Dark Green Moderately to Slightly weathered Diorite GNEISS	II to I
									Water Encountered at Depth of 4.80 m	
6	B11				26	-6.00		6.00	Dark green Slightly Weathered Plagioclase Rich with Flakes of Mica Granitic GNEISS	
7	B12			260.6	26	-7.00		7.00	Loose Yellowish to Golden Full of Mica and Muscovite Flakes	
8	B13 D14				24	-8.00		8.00	The same as above with increase of water quantity Plagiocalse Feldspar Rich Shiny Schist	
10	B15			479.5	26	-10.00		10.00	Dark Green with Specks of Hornblende Diorite GNEISS water Flow Rate increased to to 360l/hr	
	B16									
11					27	-11.00		11.00	Dark Green Fine Grained Slightly Weathered Diorite GNEISS	I
12					28	-12.00		12.00	Black Slightly to Fresh Diorite GNEISS	I
13					38	-13.00		13.00	Black to Green Massive Diorite GNEISS	I to I
14					40	-14.00		14.00	Black to Green Massive Diorite GNEISS	I
15				665.9	40	-15.00		15.00	Dark Green Diorite GNEISS with Pegmatite and Quartz Vienlet Water Flow Rate increased to 720 l/hr	I
16					74	-16.00		16.00	Black Fresh Massive Diorite GNEISS	I
17					78	-17.00		17.00	Black Massive and Sound Diorite GNEISS with Specks of Hornblende	I
18				865.9	85	-18.00		18.00		
									END OF BOREHOLE	

Figure 21.2-2 Typical Borehole Log (BH-1, Bridge No.6)