JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

GOVERNMENT OF SOUTHERN SUDAN

JUBA URBAN TRANSPORT INFRASTRUCTURE AND CAPACITY DEVELOPMENT STUDY IN THE SOUTHERN SUDAN

FINAL REPORT (2)

PART III	PRE-FEASIBILITY STUDY OF HIGH PRIORITY PROJECTS
PART IV	BRIDGES AND CULVERTS RECONSTRUCTION PROJECTS
PART V	CAPACITY DEVELOPMENT THRU PILOT PROJECT
PART VI	CONCLUSION AND RECOMMENDATION

JULY 2010

CTI ENGINEERING INTERNATIONAL CO., LTD.
YACHIYO ENGINEERING CO., LTD.

PREFACE

In response to the request from the Government of Southern Sudan (GOSS), the Government of Japan decided to conduct the "Juba Urban Transport Infrastructure and Capacity Development Study" and entrusted the Study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched the Study Team headed by Mr. Tsuneo Bekki of CTI Engineering International Co., Ltd. in association with Yachiyo Engineering Co., Ltd. from August 2008 to June 2010.

The Study Team held discussions with the officials of the Ministry of Transport and Roads, the Land Commission and other concerned agencies of GOSS as well as the Ministry of Physical Infrastructure of Central Equatoria State (CES), and conducted field surveys, data gathering and analysis, formulation of the Master Plan and Pre-Feasibility Study. In addition, the stakeholders' meetings were conducted nine times in total to solicit opinions from various actors concerning the Study. Upon returning to Japan, the team prepared this Final Report to summarize the results of the Study.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Southern Sudan and the Central Equatoria State for their close cooperation and help extended to this Study.

July 2010

Kiyohumi KONISHI
Director General
Economic Infrastructure Department
Japan International Cooperation Agency

Mr. Kiyohumi KONISHI
Director General
Economic Infrastructure Department
Japan International Cooperation Agency

Dear Sir,

LETTER OF TRANSMITTAL

We are pleased to submit herewith the Final Report of the "Juba Urban Transport Infrastructure and Capacity Development Study" in Juba urban area in Southern Sudan. The report includes the advice and suggestions of the authorities concerned of the Government of Japan and your Agency, as well as the comments made by the Ministry of Transport and Roads and other concerned agencies of the Government of Southern Sudan (GOSS) and the Ministry of Physical Infrastructure of the Central Equatoria State (CES).

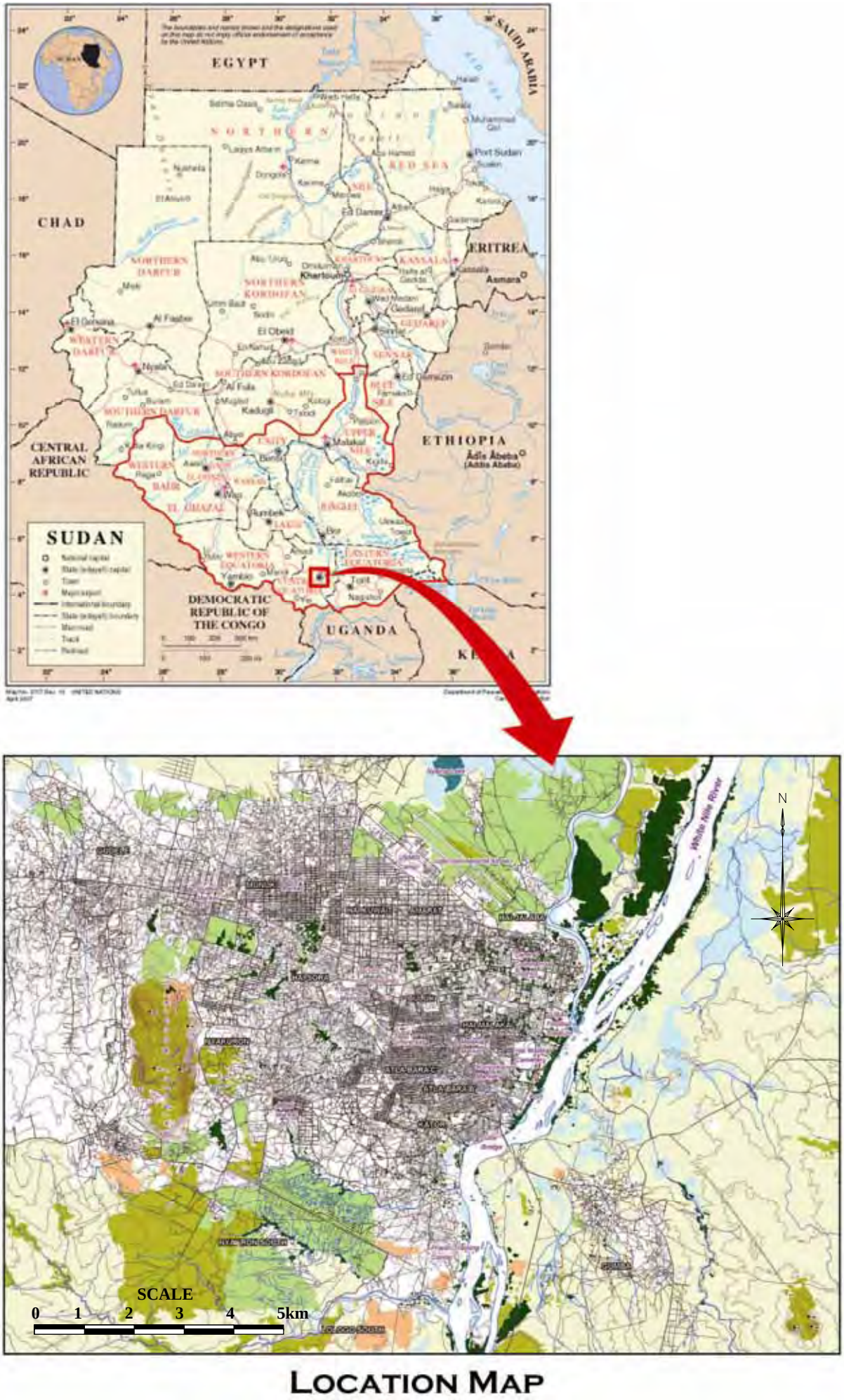
This report analyses the present setting and future conditions and demand of urban transport infrastructure in Juba urban area. It comprehensively covers the issues of transport including road development and policy, urban street improvement, public transport, traffic management, urban street maintenance system, capacity development throughout the pilot project, road institution and urban environment. The report established a Road Network Master Plan for Juba and surrounding areas until the year 2025 and the Capacity Development Plan for the Ministry of Physical Infrastructure of CES. The outcome of the Study concludes that the established plans are technically, economically, environmentally and socially feasible and will contribute to the development of Juba urban area.

In view of urgency of the development of transport infrastructure in Juba urban area and the needs for socio-economic development of Southern Sudan, we recommend that the GOSS implements the projects with utmost urgency.

We wish to take this opportunity to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs and the Ministry of Land, Infrastructure and Transport in the Government of Japan. Further, we wish to express our deep gratitude to the Ministry of Transport and Roads and other agencies concerned in the GOSS, and the Ministry of Physical Infrastructure of CES for their close cooperation and assistance extended to us during the course of the Study.

Very truly yours,

Tsuneo BEKKI
Team Leader
Juba Urban Transport Infrastructure
and Capacity Development Study



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ACRONYMS AND ABBREVIATIONS

AADT	:	Annual Average Daily Traffic
AASHTO	:	American Association of State Highway and Transportation Officials
AC	:	Asphalt Concrete
AIDS	:	Acquired Immunodeficiency Syndrome
ASTM	:	American Society for Testing and Materials
B/C	:	Benefit/Cost Ratio
BCRP	:	Bridges and Culverts Reconstruction Project
CAI	:	Clean Air Initiative
CBD	:	Central Business District
CBR	:	California Bearing Ratio
CCD	:	Central Commercial District
CCG	:	Community Construction Group
C/D	:	Capacity Development
CES	:	Central Equatoria State
CPA	:	Comprehensive Peace Agreement
DBST	:	Double Bituminous Surface Treatment
DEM	:	Digital Elevation Model
DMR	:	Department of Road Maintenance
EB	:	Equipment Based
EIA	:	Environmental Impact Assessment
EIRR	:	Economic Internal Rate of Return
ERRP	:	Emergency Road Rehabilitation Project
ESAL	:	Equivalent Single Axle Load
GDP	:	Gross Domestic Product
GIS	:	Geographic Information System
GNI	:	Gross National Income
GOJ	:	Government of Japan
GONU	:	Government of National Unity
GOSS	:	Government of Southern Sudan
GRDP	:	Gross Regional Domestic Product
HCM	:	Highway Capacity Manual
HIV	:	Human Immunodeficiency Virus
HR	:	Human Resources

ICAO	:	International Civil Aviation Organization
IDA	:	International Development Association
IDP	:	Internally Displaced Person
IEE	:	Initial Environmental Examination
IMCT	:	Inter-Ministry Committee for Transport
IOM	:	International Organization for Migration
I/S	:	Intersection
JAM	:	Joint Assessment Mission
JICA	:	Japan International Cooperation Agency
JRA	:	Japan Road Association
LB	:	Labor Based
LOS	:	Level of Service
MAD	:	Mean Absolute Difference
MBA	:	Maintenance by Administration
MBC	:	Maintenance by Contract
MDTF	:	Multi Donor Trust Fund
M&E	:	Monitoring and Evaluation
MEWCT	:	Ministry of Environment, Wildlife, Conservation and Tourism
MFEHR	:	Ministry of Finance, Economy and Human Resources
MFEP	:	Ministry of Finance and Economic Planning
MHPPE	:	Ministry of Housing, Physical Planning and Environment
MHLPU	:	Ministry of Housing, Land and Public Utilities
MOH	:	Ministry of Health
MOPI	:	Ministry of Physical Infrastructure
MSL	:	Mean Sea Level
MTR	:	Ministry of Transport and Roads
MWRI	:	Ministry of Water Resources and Irrigation
NGO	:	Non-Governmental Organization
NMIMT	:	Non-Motorized and Intermediate Means of Transport
NMT	:	Non-Motorized Transport
NPV	:	Net Present Value
NSCSE	:	New Sudan Centre for Statistics and Evaluation
OD	:	Origin-Destination
OJT	:	On-the-Job Training
PCM	:	Project Cycle Management
PCP	:	Physically Challenged People

PCU	:	Passenger Car Unit
PDM	:	Project Design Matrix
PM	:	Periodic Maintenance
PMT	:	Project Management Team
P/P	:	Pilot Project
PSI	:	Present Serviceability Index
QCBS	:	Quality- and Cost-Based Selection
R/A	:	Roundabout
RCPC	:	Reinforced Concrete Pipe Culvert
RM	:	Routine Maintenance
ROW	:	Right of Way
RR	:	Road Rehabilitation
RTC	:	River Transport Corporation
RTSMU	:	Road Traffic and Safety Management Unit
SARPS	:	Standards and Recommendation Practices
SDG	:	Sudani Pounds (Monetary Unit)
SETIDP	:	Sudan Emergency Transport and Infrastructure Development Project
SN	:	Structural Number
SNAP	:	Sudanese National AIDS Control Programme
SOSUS	:	Southern Sudan SPLM Areas
SPLA	:	Sudan Peoples Liberation Army
SPLM	:	Sudan Peoples Liberation Movement
SRA	:	State Road Agency
SSAC	:	Southern Sudan AIDS Commission
SSCCSE	:	Southern Sudan Commission for Census, Statistics and Evaluation
SSCRA	:	Southern Sudan County Road Agency
SSEC	:	Southern Sudan Electricity Corporation
SSRA	:	Southern Sudan Road Agency
SSRB	:	Southern Sudan Road Board
SSURA	:	Southern Sudan Urban Road Agency
SSUWC	:	Southern Sudan Urban Water Corporation
STD	:	Sexually Transmitted Disease
TA	:	Technical Assistance
TAST	:	Technical Assistance Team
TNA	:	Training Needs Analysis
TRL	:	Transport Research Laboratory
UN	:	United Nations
UNDP	:	United Nations Development Program

UNICEF	:	United Nations International Children's Fund
UNOPS	:	United Nations Office for Project Services
USAID	:	United States Agency for International Development
USD	:	US Dollar
USGS	:	United States Geological Survey
UTM	:	Universal Transverse Mercator
VCR (V/C)	:	Volume-Capacity Ratio
WB	:	World Bank
WFP	:	World Food Programme
WG	:	Working Group
WGS	:	World Geodetic System

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Part III

Pre-feasibility study of high priority projects

CHAPTER 16

FORMULATION OF URBAN STREET MAINTENANCE SYSTEM

CHAPTER 16 FORMULATION OF URBAN STREET MAINTENANCE SYSTEM

16.1 OBJECTIVE AND APPROACH OF THE STUDY

(1) Objectives of the Study

The Master Plan recommends that urban street system in Juba shall be functionally classified into three categories: Arterial Streets, Collector Streets and Local Streets, and an Arterial Streets shall be managed by the Ministry of Transport and Roads (the MTR), GOSS, including design, construction and maintenance, while Collector and Local Streets are managed by the Ministry of Physical Infrastructure (the MOPI), State.

The present conditions and networks of streets in Juba urban area are very poor so that urban street development are in urgent need on proposed in the Master Plan. It shall be also emphasized that efficient maintenance of street be simultaneously executed just after the completion of improvement of streets. Otherwise, huge investments spent for improvement will be wasted.

However, the capacity of the road administrators, especially the MOPI, is quite inadequate due to unclear duties/responsibilities, weak organization, insufficient technical skills, inadequate equipment, lack of funds, etc. Therefore, it is of urgent necessity to establish an efficient urban street maintenance system to properly maintain urban streets in operational condition.

The objectives of the study is to formulate the urban street maintenance system, including estimation of road length to be maintained, required maintenance work volume, necessary equipment/materials/manpower, annual budgeting plan and execution system/organization. The study focuses the maintenance system of the MOPI, covering only collectors and local streets, on the following particular years for the preparation of annual maintenance plan.

Fiscal Year 2012:

According to the Master Plan, Circumferential Road 1 (C-1), and Radial Roads and Collector Streets within C-1 will be completed by 2011 and these roads shall have to be duly maintained from 2012. Hence, the maintenance system for the year 2012 is studied as a sample year.

Fiscal Year 2016:

The Short Term in the Master Plan ends by the year 2015. During the Short Term, C-2 and Radial Roads and Collector Streets within C-2, and Local Streets within C-1 are planned to be completed. The year 2016 is the starting year to maintain these roads.

Fiscal Year 2026:

Up to 2025, the road network of Juba urban area will be almost completed. To have a rough idea on the requirements after completion of the road network, including execution system/organization, budget, equipment/materials/manpower, etc., the maintenance system in 2026 is studied.

(2) Approach to the Study

The Flow Chart of Approach to the Study is shown in **Figure 16.1-1**.

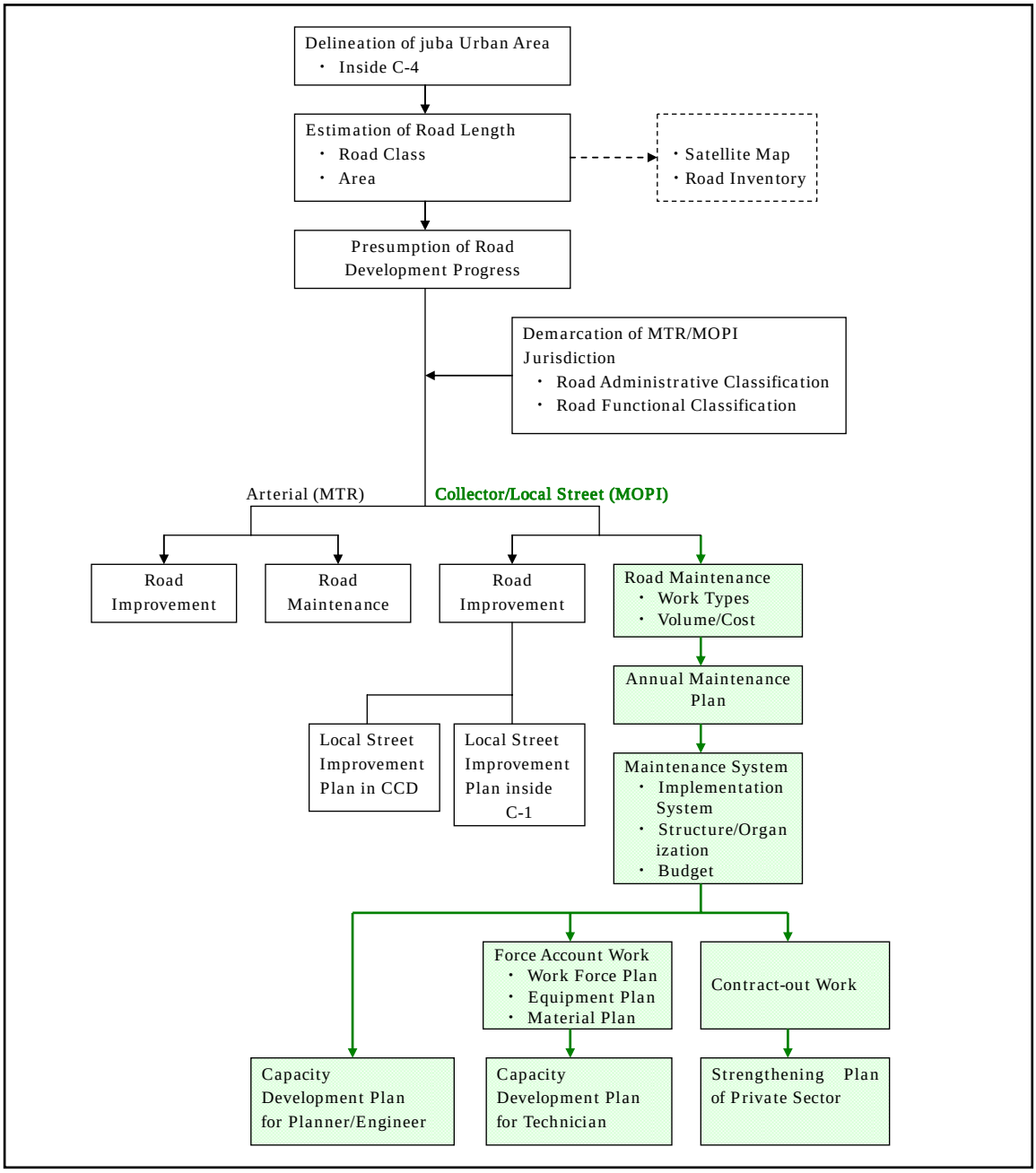


Figure 16.1-1 Flow Chart of Approach to the Study

To formulate the Urban Street Maintenance System, the collector/local streets targeted to be administered by the MOPI are firstly clarified, and the progress of road development is presumed as well.

The annual maintenance plan showing the work type, volume and cost, is secondly prepared to formulate a maintenance system describing the implementation system, organizational structure and budgeting procedures. Finally, the work methods by the force-account work or the contract-out work are proposed, and the capacity development of the MOPI and the strengthening of the private sector are recommended as well.

To formulate an effective urban street maintenance system, the road length and condition proposed in the Master Plan as delineated within Circumferential Road C-4 in the Juba urban area is firstly elaborated in comparison with the existing road length and condition. The demarcation of the MTR and the MOPI is also clarified to ensure that the proposed urban street improvement system is sustainable.

The road improvement and maintenance plan is presumed to develop and sustain the road network proposed in the Master Plan effectively with some specific improvement options. The implementation schedule of the road improvement and maintenance works is prepared as well. All costs for the road improvement works targeted in the Master Plan are estimated based on the presumed implementation schedule according to road classification and area between the boundaries of Circumferential Roads C-1, C-2, C-3 and C-4.

To formulate a practical urban street improvement system, the annual maintenance cost in the near future is estimated based on the required maintenance works, their frequency and the unit costs. The years 2012 and 2016 are selected to estimate the required maintenance costs after completing the road improvement works of the target years 2011 and 2015, which are the most urgent projects within C-1 and the Short Term project respectively, as explained above.

The urban street improvement system is formulated, aiming to conduct the improvement and maintenance works effectively in consideration of the recommended organizational setup and the equipment/materials procurement plan based on an implementation strategy. The annual maintenance plan is formulated to execute, practically, the proposed urban street improvement system.

To activate the urban street improvement system, a road maintenance capacity development plan for the public sector is proposed together with the strengthening action plan for the private sector, because the present capacity of both the public and private sectors to implement and maintain the proposed road network has become very poor after the long period of domestic conflict in Sudan.

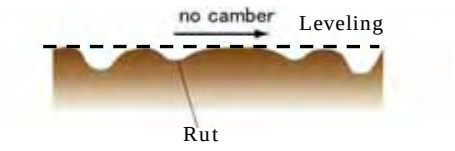
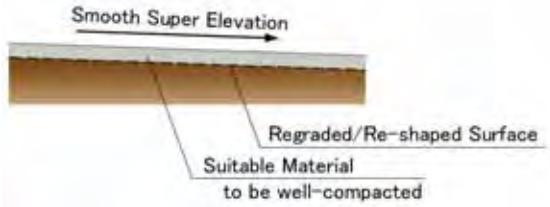
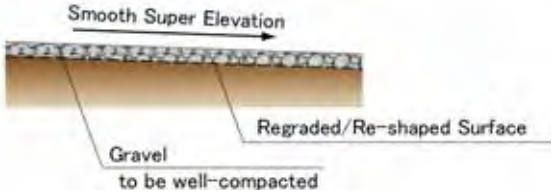
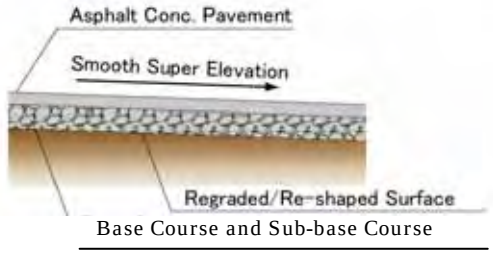
16.2 PRESUMPTION OF ROAD IMPROVEMENT PROGRESS

16.2.1 Improvement Type for Urban Street

(1) Road Improvement Types

Road condition of the corrector and local streets are presently earth road except some streets in the city center of Juba. The earth road has generally corrugation, deep rut, erosion and no camber. Existing road condition can be improved by 3 types: re-surfacing, gravel pavement and asphalt pavement as shown in **Table 16.2.1-1**, while the leveling could be conducted temporarily for making a function of the road traffic without improvement.

Table 16.2.1-1 Road Improvement Types

Type 0: Leveling To level road surfaces temporally on the corrugation, deep rut, loss of camber, and erosion with minimum materials.	
Type 1: Re-surfacing To secure the smoothness of corrugated road surfaces with suitable material such as a mixture of thin gravel (5cm).	
Type 2: Gravel Pavement To secure the smoothness of corrugated road surfaces with a mix of gravel (15 cm).	
Type 3: Asphalt Pavement To secure the smoothness of corrugated road surfaces with an asphalt concrete pavement (60 cm). Surface course:10 cm, base course:20cm And sub-base course 30cm	

(2) Application of Improvement Types for Urban Streets

The existing condition and above improvement types of urban street in Juba are featured in the view of the cost requirement for 20 years, life cycle cost of 30 years, land characteristics and social acceptance, which gives the proposed application of these improvement type for the collector and local streets as shown in **Table 16.2.1-2**.

Cost requirement for 20 years which covers the initial road improvement and maintenance costs,

is bigger in order of re-surfacing, gravel pavement and asphalt pavement because of accumulated maintenance cost. A life cycle cost for 30 years which includes improvement and maintenance costs and user's cost such as vehicle operation cost and time value cost, also indicates a bigger cost in order of re-surfacing, gravel pavement and asphalt pavement.

In densely developed area, asphalt pavement is recommendable, though the re-surfacing and gravel pavement are not suitable. Gravel pavement is applicable in fast developing area. In fast developing area, re-surfacing is only applicable in case of low traffic. But, it is not suitable in case of high traffic. Earth road is acceptable in remote area only.

Social acceptance (ability of the road users and the community to accept and tolerate the road type and condition) from both the public and private on the road condition was confirmed through the meeting and/or the hearing with stakeholder. On the social acceptance from the public, resurfacing is acceptable in case of low traffic, and gravel pavement is acceptable in case of high traffic. The private has opinion to accept gravel pavement in fast developing area, to accept re-surfacing in low traffic an to accept earth road in remote area.

Based on the above information, collector street which is main road with a high traffic volume, is applicable asphalt pavement. But, it is not applicable gravel pavement and re-surface. With regard to local street, asphalt pavement is applicable in densely developed areas; gravel pavement can be applied in case of fast developing area with heavy traffic; re-surfacing is applicable in low traffic; and earth road can be applied in remote area.

Table 16.2.1-2 Application of Road Improvement Types for Urban Streets

Type of Road Conditions	Cost Required for 20 yrs (USD Million)	Life Cycle Cost for 30 yrs (USD Million)	Land Characteristic				Social Acceptance		Proposed Application	
			Densely Developed Areas	Fast Develop-ing Areas (High Traffic)	Fast Develop-ing Areas (Low Traffic)	Remote Areas	Public	Private	Collector Streets	Local Streets
Existing Condition (Earth Road)	-	8.72 /km	NS	NS	NS	Ac	NS	Ac-Remote Area	NS	Ac- in Remote areas
Resurfacing	2.86/km	3.43 /km	NS	NS	Ap	Ap	Ac-Low Traffic	Ac-Fast Develop-ing Area	NS	Ap-Low Traffic
Gravel Pavement	2.51/km	3.28 /km	NS	Ap	Ap	Ap	Ac-High Traffic	Ac-Fast Developing Area	NS	Ap-Heavy Traffic in Fast Developing Areas
Asphalt Pavement	2.10/km	3.08 /km	R	R	R	P	P	P	Ap- All Collector	Ap-Densely Developed Areas

R: Recommendable, P: Preferable, Ap: Applicable, Ac: Acceptable, NS: Not Suitable

16.2.2 Assumed Progress of Improvement and Maintenance

(1) Assumed Improvement Progress

The study on adequate road improvement methods for the very poor urban street condition at present is urgently required under such circumstances as lack of human resources, poor technological know-how and financial constraint.

4 options of stepwise road improvement works are proposed in the Study as follows:

Table 16.2.2-1 Assumed Stages of Road Improvement

Option	Existing Road Condition (EC)	Re-surfacing (RS)	Gravel Road (GR)	Asphalt Pavement (AC)
Option I	EC →			AC
Option II	EC →		GR →	AC
Option III-1	EC →	RS →		AC
Option III-2	EC →	RS →	GR →	AC

(2) Application of Road Improvement Progress (Option I to Option III)

Standard applications for these road improvement options are given in **Table 16.2.2-2**, in consideration of the land use and traffic conditions along the road to be improved.

Table 16.2.2-2 Application of Road Improvement Options for Urban Streets

Option	Improvement	Land Use Condition	Traffic Condition
Option I	AC	Densely Developed Areas	Heavy
Option II	GR - AC	Fast Developing Areas	Heavy
Option III-1	RS - AC	Fast Developing Areas	Light
Option III-2	RS - GR - AC	Remote Areas	Light

Option I which applies the asphalt concrete pavement directly to improve the existing condition is adopted for all urban streets composed of collector and local streets. Option II is adopted for major/heavy traffic local streets in fast developing areas, which are improved with gravel pavement before applying the asphalt concrete pavement. Option III (Resurfacing Method) is generally adopted for local streets in light traffic condition; namely., Option III-1 is adopted for light traffic local streets in fast developing areas requiring the re-surfacing method before the application of asphalt concrete pavement, while Option III-2 is adopted for light traffic local streets in remote areas which are improved firstly by re-surfacing, secondly by gravel pavement, and finally by asphalt concrete pavement.

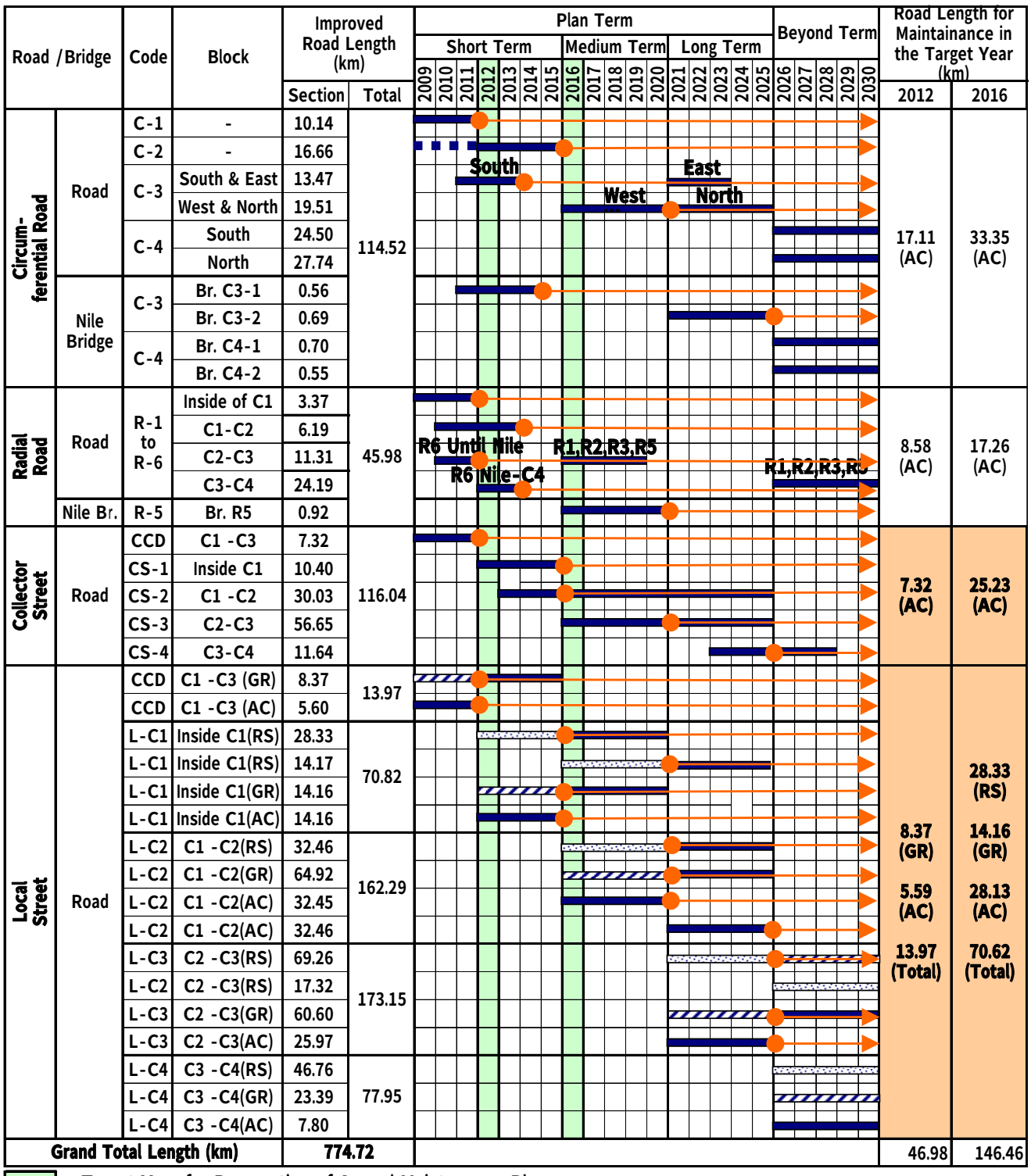
(3) Assumed Progress of Road Improvement and Maintenance

Assumed progress of road improvement and maintenance is tabulated in **Table 16.2.2-3** following overall implementation schedule in the Master Plan. The road length to be maintained in the target year 2012 and 2016 are 46.98 km and 146.46 km respectively in total. The road length of collector and local streets to be maintained by the MOPI in these target years are shown in the table.

The required length to be maintained in Target Year, 2012 and 2016, are shown in **Table 16.2.2-4**, which break up the length of re-surfacing, gravel pavement and asphalt concrete pavement.

Table 16.2.2-3 Assumed Progress of Road Improvement and Maintenance

Road /Bridge		Code	Block	Improved Road Length (km)		Road Length for Maintainance in the Target Year (km)	
				Section	Total	2012	2016
Circum-ferential Road	Road	C-1	-	10.14	114.52	17.11 (AC)	33.35 (AC)
		C-2	-	16.66			
		C-3	South & East	13.47			
			West & North	19.51			
		C-4	South	24.50			
			North	27.74			
	Nile Bridge	C-3	Br. C3-1	0.56			
			Br. C3-2	0.69			
		C-4	Br. C4-1	0.70			
			Br. C4-2	0.55			
Radial Road	Road	R-1 to R-6	Inside of C1	3.37	45.98	8.58 (AC)	17.26 (AC)
			C1-C2	6.19			
			C2-C3	11.31			
			C3-C4	24.19			
	Nile Br.	R-5	Br. R5	0.92			
Collector Street	Road	CCD	C1 -C3	7.32	116.04	7.32 (AC)	25.23 (AC)
		CS-1	Inside C1	10.40			
		CS-2	C1 -C2	30.03			
		CS-3	C2-C3	56.65			
		CS-4	C3-C4	11.64			
Local Street	Road	CCD	C1 -C3 (GR)	8.37	13.97	8.37 (GR)	14.16 (GR)
		CCD	C1 -C3 (AC)	5.60		5.59 (AC)	28.13 (AC)
		L-C1	Inside C1(RS)	28.33	70.82	13.97 (Total)	70.62 (Total)
		L-C1	Inside C1(RS)	14.17			28.33 (RS)
		L-C1	Inside C1(GR)	14.16			
		L-C1	Inside C1(AC)	14.16			
		L-C2	C1 -C2(RS)	32.46	162.29		
		L-C2	C1 -C2(GR)	64.92			
		L-C2	C1 -C2(AC)	32.45			
		L-C2	C1 -C2(AC)	32.46			
		L-C3	C2 -C3(RS)	69.26	173.15		
		L-C2	C2 -C3(RS)	17.32			
		L-C3	C2 -C3(GR)	60.60			
		L-C3	C2 -C3(AC)	25.97			
		L-C4	C3 -C4(RS)	46.76	77.95		
		L-C4	C3 -C4(GR)	23.39			
		L-C4	C3 -C4(AC)	7.80			
Grand Total Length (km)				774.72		46.98	146.46



: Target Year for Preparation of Annual Maintenance Plan

: Road Length of Collector and Local Streets for Maintenance works in the Target Years of 2012 and 2016

: Re-surfacing (RS) : Gravel Pavement : Asphalt Concrete Pavement

: Maintenance Work

Table 16.2.2-4 Required Length to be Maintained in Target Years 2012 and 2016

Road Improvement Stretch					2012						2016						Resposible Agency
Class	Code	Block	Section	Total	RS	GR	AC	Sub-total		Not Improved	RS	GR	AC	Sub-total		Not Improved	
Circum-ferential	C-1	-	10.14	114.52	0.00	0.00	10.14	10.14	17.11	97.41	0.00	0.00	10.14	10.14	33.35	81.17	MTR
	C-2	-	16.66		0.00	0.00	4.70	4.70			0.00	0.00	16.66	16.66			
	C-3	-	34.23		0.00	0.00	2.27	2.27			0.00	0.00	6.55	6.55			
	C-4	-	53.49		0.00	0.00	0.00	0.00			0.00	0.00	0.00	0.00			
Radial	R-1 to R-6	Inside C1	3.37	45.98	0.00	0.00	3.37	3.37	8.58	37.40	0.00	0.00	3.37	3.37	17.26	28.72	
		C1-C2	6.19		0.00	0.00	3.09	3.09			0.00	0.00	6.19	6.19			
		C2-C3	12.23		0.00	0.00	2.12	2.12			0.00	0.00	2.12	2.12			
		C3-C4	24.19		0.00	0.00	0.00	0.00			0.00	0.00	5.58	5.58			
Collector	CCD	C1 -C3	7.32	116.04	0.00	0.00	7.32	7.32	7.32	108.72	0.00	0.00	7.32	7.32	25.23	90.81	MOPI
	CS-1	Inside C1	10.40		0.00	0.00	0.00	0.00			0.00	0.00	10.40	10.40			
	CS-2	C1 -C2	30.03		0.00	0.00	0.00	0.00			0.00	0.00	7.51	7.51			
	CS-3	C2-C3	56.65		0.00	0.00	0.00	0.00			0.00	0.00	0.00	0.00			
	CS-4	C3-C4	11.64		0.00	0.00	0.00	0.00			0.00	0.00	0.00	0.00			
Local	CCD	C1 -C3	13.97	498.18	0.00	8.37	5.60	13.97	13.97	484.21	0.00	0.00	13.97	13.97	70.62	427.56	
	L-C1	Inside C1	70.82		0.00	0.00	0.00	0.00			28.33	14.16	14.16	56.65			
	L-C2	C1 -C2	162.29		0.00	0.00	0.00	0.00			0.00	0.00	0.00	0.00			
	L-C3	C2-C3	173.15		0.00	0.00	0.00	0.00			0.00	0.00	0.00	0.00			
	L-C4	C3-C4	77.95		0.00	0.00	0.00	0.00			0.00	0.00	0.00	0.00			
Grand Total Length (km)			**774.72**		0.00	8.37	38.61	46.98	46.98	727.74	28.33	14.16	103.97	146.46	146.46	628.26	

: **Required road length of the collector and local streets to be maintained by the MOPI.**

16.3 ESTIMATION FOR ROAD MAINTENANCE WORKS

16.3.1 Required Maintenance Works

(1) Basic Maintenance Works

Road maintenance work can be generally divided into 4 categories, i.e., i) routine maintenance work; ii) periodic maintenance work; iii) emergency maintenance work; and iv) rehabilitation / reconstruction work.

Routine maintenance work requires road condition survey, road surface cleaning, drainage cleaning, and repairing of ruts or potholes, corrugations, erosions and cracks. Routine maintenance is carried out monthly, quarterly or half-yearly depending on the classification of road.

Periodic maintenance work covers partial overlay and partial rehabilitation, which should be conducted in every 5 years or every 10 years depending on the classification of road.

Emergency maintenance involves immediate repair of roads affected by heavy rainfall, flooding, landslide, earthquakes and so on. The required emergency maintenance work could be determined after these disasters or during the routine and periodic maintenance. For this type of maintenance, some special maintenance activities are required because most of the urgent repair works are for traffic recovery.

Rehabilitation/reconstruction work covers structural overlay and full-depth reconstruction to restore the function of the original road structure. Results of road condition survey and maintenance work are to be recorded in a database for future maintenance plans.
The basic maintenance works by road classification are shown in **Table 16.3.1-1.**

(2) Required Maintenance Works

Road maintenance work is required for road structures of asphalt pavement (AC), gravel pavement (GR) and resurfacing (RS) after the completion of road improvement. The maintenance work activities for these road structures are cleaning, patching, sealing, re-shaping/re-grading, re-gravelling, re-surfacing, partial overlay, partial rehabilitation, structural overlay, and full-depth reconstruction, as shown in **Table 16.3.1-1.** These maintenance works could be conducted by machine/equipment or manual labor. Labor-based maintenance works could generate employment for the high rate of unemployed in Juba. Labor-based maintenance works are adopted in this Study as much as possible.

Table 16.3.1-1 Basic Maintenance Works by Road Classification

Major Maintenance Works Distress (Level/Extent) ⇒ Action				Proposed Frequency		
				Arterial Street	Collector Street	Local Street
Earth Road	Routine Maintenance	Solid-waste Vegetation	Cleaning	once/month	once/month	4 times/year
		Silted/Scoured Drain	Cleaning/Repairing of Drain	4 times/year	4 times/year	2 times/year
		Ruts/Pot-holes/ Corrugation/ Erosion Gullies	Re-shaping/Re-grading	4 times/year	4 times/year	2 times/year
		Loss of Surface Materials	Re-surfacing（5 cm）	4 times/year	4 times/year	2 times/year
Gravel Roads	Routine Maintenance	Solid-waste/ Vegetation	Cleaning	4 times/year	4 times/year	4 times/year
		Silted/Scoured Drain	Cleaning/Repairing of Drain	4 times/year	2 times/year	2 times/year
		Ruts/Pot-holes/ Corrugation/Erosion Gullies	Re-shaping/Re-grading	4 times/year	2 times/year	2 times/year
		Loss of Gravel	Re-gravelling	twice/year	twice/year	once/year
Asphalt Road	Routine Maintenance	Solid-waste/ Vegetation	Cleaning	once/month	once/month	4 times/year
		Silted/Scoured Drain	Cleaning/Repairing of Drain	4 times/year	4 times/year	2 times/year
		Potholes	Patching	10 spots/km/year	5 spots/km/year	5 spots/km/year
		Cracking	Crack Sealing	4 times/year	4 times/year	2 times/year
	Periodic Maintenance	Damage of Surface Pavement Rutting (≧1cm) Raveling / Weathering / Corrugation	Partial Overlay	once/5 years	once/10 years	once/10 years
		Damage of Base Course/ Sub-base Course	Partial Rehabilitation	10 %/ 10 years	10 %/ 10 years	10 %/ 10 years
	Rehabilitation/ Reconstruction	Damage of Base-course/ Sub-base course/Sub-grade	Structural Overlay	once/15 years	once/20 years	once/20 years
			Full Depth Reconstruction	once/15 years	once/20 years	once/20 years

Note: Emergency maintenance is excluded.

16.3.2 Unit Cost for Maintenance Works

(1) Unit Cost of Man-power, Equipment and Materials

Table 16.3.2-1 shows the unit cost of labor, equipment and materials estimated by contractors in Juba.

Table 16.3.2-1 Unit Cost of Labor, Equipment, and Materials

Item	Unit	Unit Price (US$)
Labour		
Supervisor	day	50
Skilled	day	40
Unskilled	day	10
Equipment		
Heavey Equipment		
Pickup Car	day	150
Small Truck	day	150
Tipper Truck	day	478
Grader	day	1123
Roller	day	300
Wheel Loader	day	490
Water Truck	day	300
Hand Ramer	day	50
Tool*		
Pick-axe	LS	-
Shovel		-
Hoe		-
Cutlasses		-
Broom		-
Wheelbarrow		-
Asphalt Sprayer		-
Drum for water		-
Camber Board		-
Material		
Asphalt Mixture	cu.m	500
Asphalt Emulsion	liter	4
Gravel	cu.m	40
Selected Subgrade Material	cu.m	10

*: Tool Price is estimated at 15% of Labour Cost

(2) Maintenance Cost Per Kilometer

Based on these unit costs, the annual costs per kilometer for the road maintenance works on earth road (re-surfacing), gravel road and asphalt road are estimated as shown in **Table 16.3.2-2**, which is categorized into arterial, collector and local. In consideration of target year, 2012 and 2016, for preparation of annual maintenance works on the collector and local streets, the unit costs of routine maintenance work are tabulated in the table, while the periodic maintenance will be started after 10 years of the road improvement works.

Table 16.3.2-3 shows the ratio of unit maintenance cost divided by the unit construction cost. On the routine maintenance cost, the ratio of asphalt concrete pavement is less than 0.2%, while the maintenance cost of gravel and re-surfaced pavement requires around 5 % of the construction cost. In case of periodic maintenance, the ratio varies from 3 % to 7 % based on the road classification. Cost of rehabilitation/reconstruction shares higher from one-third to one-half of the construction cost.

Table 16.3.2-2 Road Maintenance Cost per Kilometer

Pave -ment	Maintenace Activity		Distress	Proposed Annual Frequency			Maintenance Cost per km		
				Arterial Street	Collector Street	Local Street	Arterial Street	Collector Street	Local Street
Earth Road	Routine Maintenance	Cleaning	Solid-waste/Vegetation	-	-	4 times/year	-		1,920
		Cleaning/Repairing of Drain	Silted/Scoured Drain	-	-	2 times/year			960
		Re-shaping/Re-grading	Rutting/Pot-holes/Corrugation/ Erosion Gullies	-	-	2 times/year			24,000
		Re-surfacing（5 cm）	Loss of Surface Materials	-	-	2 times/year			29,200
		Sub-total							**56,080**
Gravel Roads	Routine Maintenance	Cleaning	Solid-waste/Vegetation	-	-	4 times/year			1,920
		Cleaning/Repairing of Drain	Silted/Scoured Drain	-	-	2 times/year			960
		Re-shaping/Re-grading	Rutting/Pot-holes/Corrugation/ Erosion Gullies	-	-	2 times/year			36,000
		Re-gravelling (15cm)	Loss of Gravel	-	-	once/year			15,000
		Sub-total							**53,880**
Asphalt Road	Routine Maintenance	Cleaning	Solid-waste/Vegetation	once/month	once/month	4 times/year	5,640	2,880	480
		Cleaning/Repairing of Drain	Silted/Scoured Drain	4 times/year	4 times/year	2 times/year	960	960	480
		Patching	Potholes	5 spots/ km/year	5 spots/ km/year	5 spots/ km/year	1,100	550	550
		Crack Sealing	Cracking	4 times/year	4 times/year	2 times/year	720	360	180
		Sub-total					8,420	**4,750**	**1,690**
	Periodic Maintenance	Partial Overlay	Damage of Surface Pavement Rutting (≧1cm) Raveling / Weathering / Corrugation	once/ 5 years	once /10 years	once /10 years	79,000	50,000	24,000
		Partial Rehabilitation	Damage of Base-course/ Sub-base course	10 %/ 10 years	10 %/ 10 years	10 %/ 10 years	239,000	97,000	45,000
	Rehabilitation/ Reconstructio	Structural Overlay	Damage of Base-course/ Sub-base course/Sub-grade	once/ 15 years	once/ 20 years	once/ 20 years	766,000	478,000	213,000
		Full Depth Reconstruction		once/ 15 years	once/ 20 years	once/ 20 years	2,367,000	944,000	421,000

: Routine maintenance work for the collector and local streets

Table 16.3.2-3 Comparison of Road Maintenance and Improvement Cost per Kilometer

Maintenace Activity			Cost (USD 1000/km)		(1) /(2)
			(1) Maintenance	(2) Improvement	
Routine Maintenance					
	Arterial	AC	8.42	4,700	0.2%
	Collector	AC	4.75	4,100	0.1%
	Local	AC	1.69	2,000	0.1%
	Local	GR	53.88	1300	4%
	Local	ER	56.08	1100	5%
Periodic Maintenance					
	Arterial	AC	318	4,700	7%
	Collector	AC	147	4,100	5%
	Local	AC	69	2,000	3%
Rehabilitation / Reconstruction					
	Arterial	AC	3,133	4,700	67%
	Collector	AC	1,422	4,100	35%
	Local	AC	634	2,000	32%

An assumed annual cost per kilometer for the preparation of maintenance plan in the target years, 2012 and 2016, is described in **Table 16.3.2-4** on the routine maintenance works for the earth road (re-surfacing), gravel pavement, and asphalt pavement. The required resources such as equipment/tools, materials, man-power for each maintenance works are also explained.

Table 16.3.2-4 Assumed Annual Cost and Resources (Equipment/Tools, Materials, Man-power) on Road Maintenance Works

Major Maintenance Works			Estimated Frequency	Annual Cost per km (USD)	Resources		
					Equipment and Tools	Materials	Man-power
Local Street	Re-surfacing (Earth Road)	Cleaning (**LB**)	4 times/year	1,920	Pick-up Truck, Shovel, Hoe, Cutlass, Broom, Wheelbarrows, Signs and Safety Equipment, etc.	Fuel	Supervisor, Driver, Workmen, Traffic Controller
		Cleaning/Repairing of Drain (**LB**)	2 times/year	960	Pick-up Truck, Shovel, Hoe, Cutlass, Broom, Wheelbarrows, Signs and Safety Equipment, etc.	Fuel	Supervisor, Drivers, Workmen, Traffic Controllers
		Re-shaping/Re-grading (**LB**)	2 times/year	24,000	Pick-up Truck, Tipper Truck, Hand Ramer, Pick-axe, Shovel, Hoe, Cutlass, Broom, Wheelbarrows, Camber Board, Signs and Safety Equipment, etc.	Fuel, approved soil / gravel	Supervisor, Operator, Driver, Workmen, Traffic Controller
		Re-surfacing（5 cm）(**EB**)	2 times/year	29,200	Tipper Truck, Grader, Roller, Wheel Loader, Water Truck, Hand Ramer, Shovel, Camber Board, Signs and Safety Equipment, etc.	Fuel, gravel	Supervisor, Operator, Driver, Workmen, Traffic Controller
		Sub-total		**56,080**	Pick-up Truck, Tipper Truck, Grader, Roller, Wheel Loader, Water Truck, Hand Ramer, Pick-axe, Shovel, Hoe, Cutlass, Broom, Wheelbarrows, Camber Board, Signs and Safety Equipment, etc.	Fuel, approved soil / gravel	Supervisor, Operator, Driver, Workmen, Traffic Controller
	Gravel Pavement	Cleaning (**LB**)	4 times/year	1,920	Pick-up Truck, Shovel, Hoe, Cutlass, Broom, Wheelbarrows, Signs and Safety Equipment, etc.	Fuel	Supervisor, Driver, Workmen, Traffic Controller
		Cleaning/Repairing of Drain (**LB**)	2 times/year	960	Pick-up Truck, Shovel, Hoe, Cutlass, Broom, Wheelbarrows, Signs and Safety Equipment, etc.	Fuel	Supervisor, Drivers, Workmen, Traffic Controllers
		Re-shaping/Re-grading (**EB**)	2 times/year	36,000	Tipper Truck, Grader, Roller, Wheel Loader, Water Truck, Hand Ramer, Shovel, Camber Board, Signs and Safety Equipment, etc.	Fuel, approved soil / gravel	Supervisor, Operator, Driver, Workmen, Traffic Controller
		Re-gravelling (15cm) (**EB**)	once/year	15,000	Tipper Truck, Grader, Roller, Wheel Loader, Water Truck, Hand Ramer, Shovel, Camber Board, Signs and Safety Equipment, etc.	Fuel, gravel	Supervisor, Operator, Driver, Workmen, Traffic Controller
		Sub-total		**53,880**	Pick-up Truck, Tipper Truck, Grader, Roller, Wheel Loader, Water Truck, Hand Ramer, Pick-axe, Shovel, Hoe, Cutlass, Broom, Wheelbarrows, Camber Board, Signs and Safety Equipment, etc.	Fuel, approved soil / gravel	Supervisor, Operator, Driver, Workmen, Traffic Controller
	Asphalt Pavement	Cleaning (**LB**)	4 times/year	480	Pick-up Truck, Shovel, Hoe, Cutlass, Broom, Wheelbarrows, Signs and Safety Equipment, etc.	Fuel	Supervisor, Driver, Workmen, Traffic Controller
		Cleaning/Repairing of Drain (**LB**)	2 times/year	480	Pick-up Truck, Shovel, Hoe, Cutlass, Broom, Wheelbarrows, Signs and Safety Equipment, etc.	Fuel	Supervisor, Drivers, Workmen, Traffic Controllers
		Patching (**EB**)	5 spots /km/year	550	Pick-up Truck, Hand Ramer, Asphalt Sprayer, Pic-axe, Shovel, Broom, Drum for Water, Signs and Safety Equipment, etc.	Fuel, Gravel, Asphalt Mixture, Emulsion, etc	Supervisor, Operator, Driver, Workmen, Traffic Controller
		Crack Sealing (**EB**)	2 times/year	180	Pick-up Truck, Asphalt Sprayer, Broom, Signs and Safety Equipment, etc.	Fuel, Emulsion, etc	Supervisor, Operator, Driver, Workmen, Traffic Controller
		Sub-total		**1,690**	Pick-up Truck, Hand Ramer, Asphalt Sprayer, Pic-axe, Shovel, Broom, Drum for Water, Signs and Safety Equipment, etc.	Fuel, Gravel, Asphalt Mixture, Emulsion, etc	Supervisor, Operator, Driver, Workmen, Traffic Controller
Collector Street	Asphalt Pavement	Cleaning (**LB**)	once/month	2,880	Pick-up Truck, Shovel, Hoe, Cutlass, Broom, Wheelbarrows, Signs and Safety Equipment, etc.	Fuel	Supervisor, Driver, Workmen, Traffic Controller
		Cleaning/Repairing of Drain (**LB**)	4 times/year	960	Pick-up Truck, Shovel, Hoe, Cutlass, Broom, Wheelbarrows, Signs and Safety Equipment, etc.	Fuel	Supervisor, Drivers, Workmen, Traffic Controllers
		Patching (**EB**)	5 spots /km/year	550	Pick-up Truck, Hand Ramer, Asphalt Sprayer, Pic-axe, Shovel, Broom, Drum for Water, Signs and Safety Equipment, etc.	Fuel, Gravel, Asphalt Mixture, Emulsion, etc	Supervisor, Operator, Driver, Workmen, Traffic Controller
		Crack Sealing (**EB**)	4 times/year	360	Pick-up Truck, Asphalt Sprayer, Broom, Signs and Safety Equipment, etc.	Fuel, Emulsion, etc	Supervisor, Operator, Driver, Workmen, Traffic Controller
		Sub-total		**4,750**	Pick-up Truck, Hand Ramer, Asphalt Sprayer, Pic-axe, Shovel, Broom, Drum for Water, Signs and Safety Equipment, etc.	Fuel, Gravel, Asphalt Mixture, Emulsion, etc	Supervisor, Operator, Driver, Workmen, Traffic Controller

Note: EB: Equipment Based, LB: Labor Based

16.3.3 Cost Estimation for Maintenance Works

Table 16.3-6 shows the length of collector and local street maintenance required to be undertaken annually by the MOPI in 2012 and 2016, respectively, based on the proposed road network development master plan targeting the year 2025. The total length roads that require maintenance in 2012 is estimated at around 20 km (21.29 km) after the completion of improvement of collector and local streets inside of CCD and the collector road inside of circumferential road, C1. The collector street inside of C-2 and the local street inside of C-1 are scheduled to be completed by the year of 2015. The target road length for the maintenance works will be around 90 km (88.34 km).

The costs required for maintenance work are estimated based on **Table 16.3.3-1**, Road Maintenance Cost per Kilometer, tabulated above in consideration of the required number of equipment and manpower described above. The maintenance costs required in 2012 and 2016 are USD 0.5 million and USD 2.5 million as summarized below, while the estimated construction costs required in 2012 and 2016 are USD 35.7 million and USD 87.0 million, respectively. In 2012, the maintenance cost will be only 1% of the required total cost for construction and maintenance, while that in 2016 is also only 3%, as shown in **Table 16.3.3-2**. Details of the required construction in 2012 and 2016 are described in the Overall Implementation Schedule.

Table 16.3.3-1 Maintenance Cost Required in 2012 and 2016 (Collector and Local Streets)

Road Improvement Stretch			Length(km)		Pavement	Unit Cost (USD 1,000)	Cost (USD 1,000)	
Code		Block	2012	2016			2012	2016
Collector Street	CCD	C1-C3	7.32	7.32	AC	4.75	35	35
	CS-1	Inside C1	0.00	10.40	AC	4.75	0	49
	CS-2	C1 -C2	0.00	7.51	AC	4.75	0	36
	Total		7.32	25.23			35	120
Local Street	CCD	C1-C3	8.37	0.00	GR	53.88	451	0
			5.60	13.97	AC	1.69	9	24
	L-C1	Inside C1	0.00	28.33	RS	56.08	0	1,589
			0.00	14.16	GR	53.88	0	763
			0.00	14.16	AC	1.69	0	24
	Total		13.97	70.62			460	2,400
Grand Total			21.29	95.85			495	2,520

Note: RS: Re-surfacing, GR: Gravel Pavement, AC: Asphalt Concrete Pavement

Table 16.3.3-2 Maintenance and Construction Costs Required in 2012 and 2016 (Collector and Local Streets)

(USD million)

Cost Items	2012	2016
Maintenance Cost	0.50 (1%)	2.52 (3 %)
Construction Cost	35.70(99%)	87.00 (97%)
Total	36.20	89.52

16.4 URBAN STREET MAINTENANCE SYSTEM

The results of the study on the maintenance system of collector and local streets are as hereinafter described.

16.4.1 Implementation Strategy

(1) Jurisdiction

The MTR of GOSS is in charge of the management of arterial roads, including the maintenance work; whereas, the State MOPI is in charge of the management of collector and local streets, including the maintenance work.

(2) Type of Contract

Contracts are classified according to the type of road improvement, as follows:

- Leveling : Force-account with labor intensity contract
- Re-surfacing : Force-account with community-based group
- Gravel Pavement : Contract-out to small-size contractor such as local contractor
- Asphalt Pavement : Contract-out to large-size contractor such as international contractor

(3) Work Method

- Labor Intensity : Leveling, Re-surfacing
- Equipment with Maximum Labor Force : Gravel Pavement
- Equipment Intensity : Asphalt Pavement

(4) Requirement of the MOPI

- Maintenance Engineer
- Skilled Maintenance Walker
- Equipment Intensity
- Contract System (Labor , Community-based group, contract-out)

16.4.2 Organizational Structure of the MOPI

(1) Proposed Function of the MOPI

The MOPI should be authorized and be fully responsible for the maintenance and operation of collector and local streets in Juba covering the following 5 stages of maintenance work as illustrated in **Figure 16.4.2-1**.

- Inspection Stage
- Planning Stage
- Budgeting Stage
- Engineering Stage
- Biding / Contracting Stage
- Execution Stage
- Monitoring Stage.

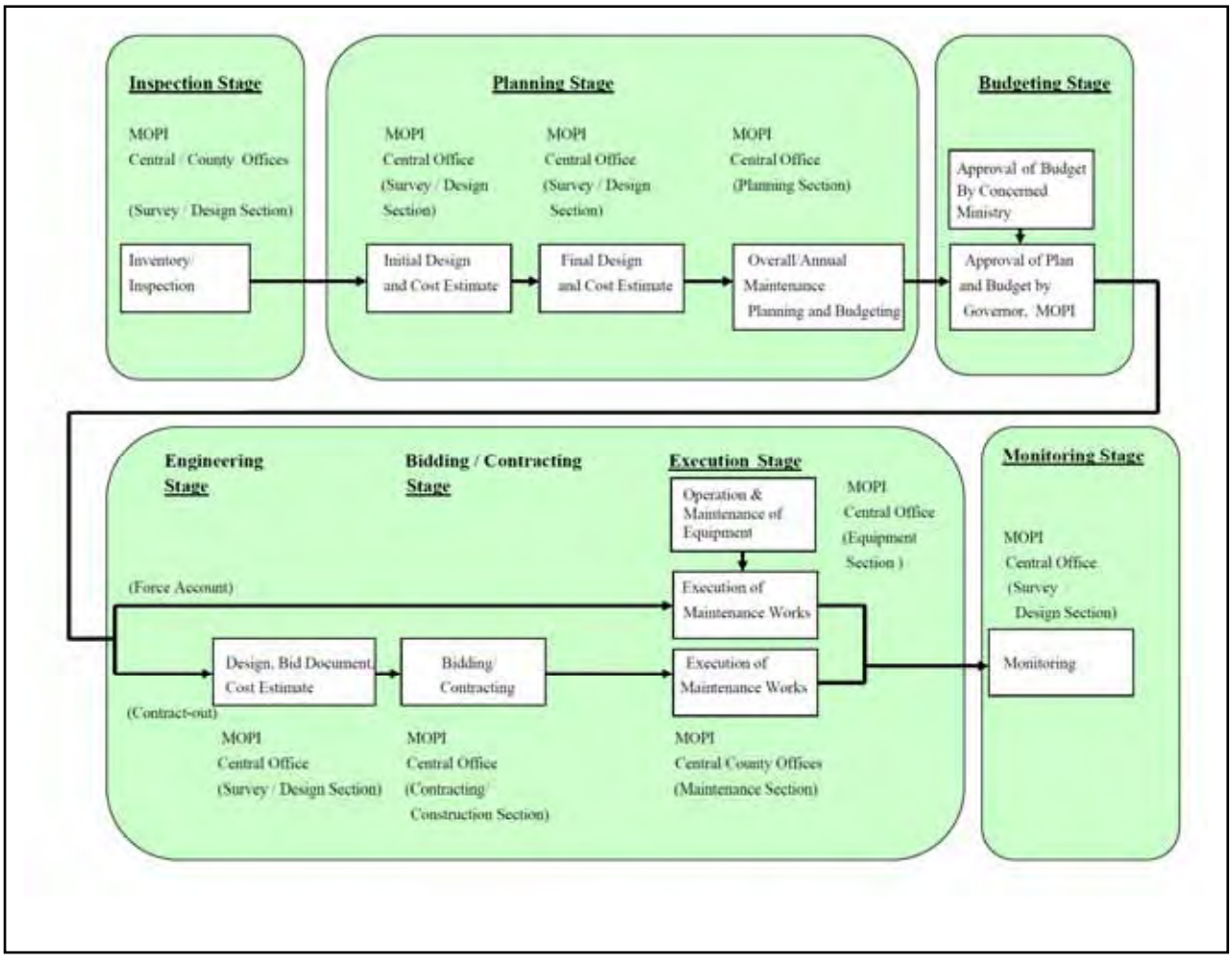


Figure 16.4.2-1 Implementation Cycle and Proposed Function of MOPI

Table 16.4.2-1 Proposed Function of the MTR and MOPI

	MTR	MOPI	County Office of MOPI
Policy and Planning	-Formulation of Road Development Policy and Strategy -Planning and Budgeting of Road Development.	-Planning and Budgeting of Road Maintenance and Operation	-
Inspection, Monitoring and Design	-Formulation of Design Construction Standard	-Preparation of Maintenance Standards. -Road Inventory Condition Survey, Traffic Survey, and Axle Load Survey. -Final Design and Cost Estimate of Maintenance Works.	-Initial Road Inventory/Inspection/ Monitoring of Collector/Local Streets -Initial Design and Cost Estimate of Maintenance Works
Maintenance Work	-Approval of Budgeting for Maintenance Work	-Responsible for Management of all Maintenance Works. -Responsible for Donors Funded Maintenance Project.	-Responsible for Locally Funded Maintenance Work of Collector/Local Streets
Contracting	-Contracting of Road Improvement Projects	-Contracting of Larges-size Maintenance Project	-Contracting of Medium-size Maintenance Project
Maintenance Equipment and Tools	-Approval of Budgeting of Equipment Procurement	-Procurement Plan and Budgeting for Maintenance Equipment and Tools	-Minimum Equipment for Routine/Emergency Maintenance of Collector/Local Streets -Minimum Equipment for Routine and Emergency Maintenance of Collector/Local Streets

(2) Proposed Organizational Structure of the MOPI

The proposed organizational chart of the MOPI is as shown in **Figure 16.4.2-2**

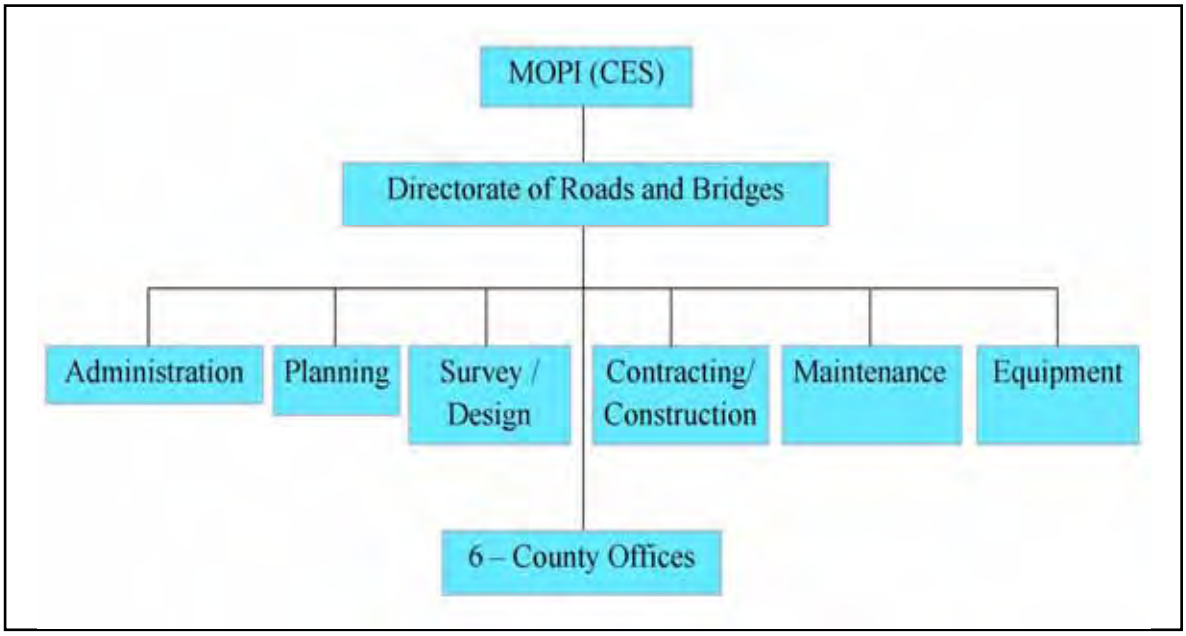


Figure 16.4.2-2 Proposed Organizational Set-up of MOPI

The Planning Division shall be required to evaluate and prioritize the required maintenance works, and to conduct budgeting of maintenance works for succeeding years based on the survey of road and traffic condition, the decision of required maintenance works, and the cost. The Survey/Design Division shall conduct the survey of roads and traffic, as well as the design works, if required.

The Maintenance Division shall execute the maintenance works on either the contract-out or the force–account basis, and it shall also undertake the monitoring work of road conditions. In case of contract-out to the private sector, the Contracting/Construction Division shall be responsible for the works. Furthermore, the Contracting/Construction Division shall undertake the design works for periodic maintenance, rehabilitation and reconstruction.

The Equipment Division shall maintain the construction equipment and procure spare parts for maintenance works by force-account. The MOPI has a limited number of equipment at present.
The proposed responsibilities on management, development, rehabilitation and maintenance of urban roads classified as collector and local roads are as described in **Table 16.4.2-2**.

Table 16.4.2-2 Proposed Management and Maintenance Responsibilities for the MOPI

Existing Department	Proposed Department	Proposed Responsibility
Planning	Planning	Planning is to be undertaken to evaluate and prioritize the required works and to conduct budgeting for the succeeding year based on the results of road survey, required maintenance works and cost estimation.
Road Survey	Survey/ Design	Survey works shall be conducted to identify the existing condition of roads and to maintain proper records in a database for efficient utilization in planning. Design works shall be undertaken based on adequate knowledge and analysis of existing conditions obtained from the road survey. Cost estimation also shall be conducted for the required works.
Road & Bridges		
Construction	Contracting/ Construction	Improvement, rehabilitation and new construction works shall be executed by the force-account and/or contract-out basis.
Maintenance	Maintenance	Maintenance works shall be executed by the force-account and/or contract-out basis.
Mechanical/ Equipment	Equipment	Equipment shall be allocated to conduct the maintenance works economically, to maintain the equipment in the workshop, and to procure spare parts timely.

16.4.3 Annual Maintenance Plan for the Years 2012, 2016 and 2026

(1) Man-power

The annually required days of maintenance work for the year 2012, 2016 and 2026 is calculated based on one-team daily capacity for the routine maintenance work shown in **Appendix**, as summarized in **Table 16.4.3-1**. Details of the required annual days of maintenance work are shown in **Table 16.4.3-2**. Annually required number of manpower are tabulated in **Table 16.4.3-3** computed from the annually required days of maintenance work and the required number of manpower of one team per day. The required number of manpower and equipment for one maintenance team are given in **Table 16.4.3-4**.

Table 16.4.3-1 Annually Required Days of Maintenance Works (2012, 2016 and 2026)

Maintenance Works	Pavement	Construction Method	Required Days		
			2012	2016	2026
1. Un-skilled Work Cleaning of Road Surface and Drain	AC,GR,ER	LB	116	430	1,966
2. Skilled Work					
2.1 Patching	AC	EB	17	68	480
2.2 Sealing	AC	EB	12	44	250
2.3 Re-gravelling and Re-shaping	GR	EB	35	59	249
2.4 Re-surfacing	ER	EB	0	44	108
2.5 Re-shaping	ER	LB	0	568	1,386
Sub-total Days of Skilled Maintenance Works			64	783	2,473
Total Days of Maintenance Works			180	1,213	4,439

Table 16.4.3-2 (1) Required Days of Maintenance Works for Year 2012

Classification			Length (km)	Frequency and Required days for Maintenance		Required No. of Maintenance Days/Team												Total	Monthly Required Days and Team
						Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
I. Un-skilled Work																			
Collector	AC	Road Surface	7.32	Monthly	7.32km/(2km/day)=4 days	4	4	4	4	4	4	4	4	4	4	4	4	48	1 team x 20 days
		Drains		Quarterly	7.32km/(2km/day)=4 days		4			4			4			4		16	
Local	AC	Road Surface	5.59	Quarterly	5.59km/(4km/day)=2 days		2			2			2			2		8	
		Drains		Half-yearly	5.59km/(2km/day)=3 days			3						3				6	
Local	ER/GR	Road Surface	8.37	Quarterly	8.37km/(2km/day)=5 days		5			5			5			5		20	
		Drains		Half-yearly	8.37km/(1km/day)=9 days			9						9				18	
						Sub-total												116	1 team x 10 days
II. Skilled Work																			
2-1 Patching																			
Collector	AC		7.32	Yearly	7.32km x 5spots/(4spots/day)=10 days	10												17	1 team x 2 days
Local	AC		5.59	Yearly	5.59km x 5spots/(4spots/day)=7 days	7													
2-2 Sealing																			
Collector	AC		7.32	Quarterly	7.32km x 1spot/(4spots/day)=2 days		2			2			2			2		12	1 team x 2 days
Local	AC		5.59	Half-yearly	5.59km x 1spot/(4spots/day)=2 days			2						2					
2-3 Re-shaping and Re-graveling of Gravel Road																			
Local	GR	Re-graveling	8.37	Yearly	8.37km /(1.3km/day)=7 days	7												35	1 team x 3 days
	GR	Re-shaping	8.37	Half-yearly	8.37km /(0.6km/day)=14 days			14						14					
2-4 Re-shaping and Re-surfacing of Earth Road																			
Local	ER	Re-surfacing	0	Half-yearly	-			0						0				0	-
2-5 Re-shaping and Re-surfacing of Earth Road																			
Local	ER	Re-shaping		Half-yearly	-													0	-
						Sub-total												64	1 team x 6 days
						Grand Total												180	1 team x15 days

Table 16.4.3-2 (2) Required Days of Maintenance Works for Year 2016

Classification			Length (km)	Frequency and Required days for Maintenance		Required No. of Maintenance Days/Team												Total	Monthly Required Days and Team
						Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
I. Un-skilled Work																			
Road Cleaning																			
Collector	AC	Road Surface	25.23	Monthly	25.23km/(2km/day)=13 days	13	13	13	13	13	13	13	13	13	13	13	13	156	2 team x 19 days
		Drains		Quarterly	25.23km/(2km/day)=13 days	13			13			13			13			52	
Local	AC	Road Surface	28.13	Quarterly	28.13km/(4km/day)=8 days	8			8			8			8			32	
		Drains		Half-yearly	28.13km/(2km/day)=15 days	15						15						30	
Local	ER/GR	Road Surface	42.49	Quarterly	42.49km/(2km/day)=22 days	22			22			22			22			88	
		Drains		Half-yearly	42.49km/(1km/day)=43 days	43						43						86	
						Sub-total												444	2 team x 19 days
II. Skilled Work																			
2-1 Patching																			
Collector	AC		25.23	Yearly	25.23km x 5spots/(4spots/day)=23 days	32												68	1 team x 6 days
Local	AC		28.13	Yearly	28.13km x 5spots/(4spots/day)=36 days	36													
2-2 Sealing																			
Collector	AC		25.23	Quarterly	25.23km x 1spot/(4spots/day)=7 days	7			7			7			7			44	1 team x 4 days
Local	AC		28.13	Half-yearly	28.13km x 1spot/(4spots/day)=8 days	8						8							
2-3 Re-shaping and Re-graveling of Gravel Road																			
Local	GR	Re-graveling	14.16	Yearly	14.16km /(1.3km/day)=11 days	11												59	1 team x 5 days
	GR	Re-shaping	14.16	Half-yearly	14.16km /(0.6km/day)=24 days	24						24							
2-4 Re-shaping and Re-surfacing of Earth Road																			
Local	ER	Re-surfacing	28.33	Half-yearly	28.33km /(1.3km/day)=22 days	22						22						44	1 team x 4 days
2-5 Re-shaping and Re-surfacing of Earth Road																			
Local	ER	Re-shaping	28.33	Half-yearly	28.33km /(0.1km/day)=284 days	284						284						568	2 team x 24 days
						Sub-total												783	3 team x 22 days
						Grand Total												1227	4 team x 26 days

Table 16.4.3-2 (3) Required Days of Maintenance Works for Year 2026

Classification			Length (km)	Frequency and Required days for Maintenance		Required No. of Maintenance Days/Team												Monthly Required Days and Team
						Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	
I. Un-skilled Work																			
Road Cleaning																			
Collector	AC	Road Surface	110.22	Monthly	110.22km/(2km/day)=56 days	56	56	56	56	56	56	56	56	56	56	56	56	672	6 team x 28 days
		Drains		Quarterly	110.22km/(2km/day)=56 days		56			56			56			56		224	
Local	AC	Road Surface	273.05	Quarterly	273.05km/(4km/day)=69 days		69			69			69			69		276	
		Drains		Half-yearly	273.05km/(2km/day)=137 days			137					137					274	
Local	ER/GR	Road Surface	129.86	Quarterly	129.86km/(2km/day)=65 days		65			65			65			65		260	
		Drains		Half-yearly	129.86km/(1km/day)=130 days			130					130					260	
						Sub-total												1966	6 team x 28 days
II. Skilled Work																			
2-1 Patching																			
Collector	AC		110.20	Yearly	110.2km x 5spots/(4spots/day)=138 days	138												480	2 team x 20 days
Local	AC		273.10	Yearly	273.1km x 5spots/(4spots/day)=342 days	342													
2-2 Sealing																			
Collector	AC		110.20	Quarterly	110.2km x 1spot/(4spots/day)=28 days		28			28			28			28		250	1 team x 21 days
Local	AC		273.10	Half-yearly	273.1km x 1spot/(4spots/day)=69 days			69					69						
2-3 Re-shaping and Re-graveling of Gravel Road																			
Local	GR	Re-graveling	60.60	Yearly	60.6km /(1.3km/day)=47 days	47												249	1 team x 21 days
	GR	Re-shaping	60.60	Half-yearly	60.6km /(0.6km/day)=101 days			101					101						
2-4 Re-surfacing of Earth Road																			
Local	ER	Re-surfacing	69.26	Half-yearly	69.26km /(1.3km/day)=54 days			54					54					108	1 team x 9 days
2-5 Re-shaping of Earth Road																			
Local	ER	Re-shaping	69.26	Half-yearly	69.26km /(0.1km/day)=693 days			693					693					1386	4 team x 29 days
						Sub-total												2473	7 team x 30 days
						Grand Total												4439	13 team x 29 days

Table 16.4.3-3 Annually Required Number of Man-power (2012, 2016 and 2026)

Work Items	2012			2016			2026		
	Super-visor	Driver/ Opeator	Un-skilled	Super-visor	Driver/ Opeator	Un-skilled	Super-visor	Driver/ Opeator	Un-skilled
I Labor-based									
Cleaning	116	116	2,320	444	444	8,880	1,966	1,966	39,320
II Equipment-based									
1. Asphlt Works									
Patching	17	34	85	68	136	340	480	960	2,400
Sealing	12	24	36	44	88	132	250	500	750
2. Earch Works									
Re-gravelling Re-shaping	35	455	700	59	767	1,180	249	3,237	4,980
Re-surfacing	0	0	0	44	572	880	108	1,404	2,160
Re-shaping	0	0	0	568	1,704	11,360	1,386	4,158	27,720
Sub-total	64	513	821	783	3,267	13,892	2,473	10,259	38,010
Total	180	629	3,141	1,227	3,711	22,772	4,439	12,225	77,330

Table 16.4.3-4 Number of Labor and Equipment Required for One Maintenance Team

Maintenance Activity			Number of Labour and Equipment Required for One (1) Maintenance Team																			
			Labour			Equipment																
						Heavey Equipment							Tool									
			Supervisor	Skilled	Unskilled	Pick-up Truck	Tipper Truck	Grader	Roller	Wheel Loader	Water Truck	Hand Ramer (Compactor)	Pick-axe	Shovel	Hoe	Cutlass	Broom	Wheelbarrow	Asphalt Sprayer	Drum for water	Camber Board	Sprit Level
Un-skiled Work																						
Cleaning of Road Surface and Drains	Pave-ment	Work Method	1	1	20	1								2	2	2	20	2				
Skilled Work																						
Patching	AC	EB	1	2	5	1						1	1	1			1		1	1		
Sealing	AC	EB	1	2	3	1											1		1			
Re-shaping	GR	EB																				
Re-gravelling	GR	EB	1	13	20		9	1	1	1	1			1							1	
Re-surfacing	ER	EB																				
Re-shaping	ER	LB	1	3	20	1	1.5					1	1	1	1			1			1	1

LB: Labour-based, EB: Equipment-based

The Directorate of Roads and Bridges under the MOPI, which is in charge or road management, has 12 engineers, 60 classified staff and 565 unclassified staff, or a total of 637 personnel at present. This number of personnel is the highest among the CES ministries.

Table 16.4.3-5 Number of Personnel in the Directorate of Roads & Bridges

Department	Engineer	Classified	Unclassified	Total
Planning	1	0	0	0
Road Survey	3	0	0	3
Road & Bridges	2	20	314	336
Construction	2	8	66	76
Maintenance	2	0	0	2
Mechanical /Equipment	1	15	156	172
Administration	1	17	29	47
Total	12	60	565	637

Required number of engineers and engineer's assistants such as inspectors of road conditions / damages, preparation of road inventory, surveyors of traffic condition and natural condition (topographic, geotechnical and hydrological conditions); computer operators for reporting and drawing, and inspectors during and after the maintenance works; planners for planning/budgeting; designers for repairing; and implementation manager for maintenance works are estimated for the road maintenance work of ten (10) km long as shown in **Table 16.4.3-6**. Based on this number of engineers and assistants required for a 10 km long road maintenance, required engineers in 2012, 2016 and 2026 are tabulated due to the required length of road maintenance as shown **Table 16.4.3-7**.

Table 16.4.3-6 Required Number of Engineers for the Road Maintenance (per 10 km long)

Stages	Maintenance Items	Maintenance Activities	Required Engineers	
			Engineer	Assistant
Inspection (Monitoring) and Planning (Budgeting)	Inventory preparation / Inspection (Monitoring)	Inspection of existing road condition Identification of road defect/damage Estimation of traffic volume	5	10
	Evaluation of Condition	Evaluation of damage/defect Identification of needs for maintenance (cleaning, repair, etc.)	3	3
	Planning and Budgeting	Planning of implementation schedule. Preparing of budget	3	3
Design	Design of repair	Design of patching, sealing, re-shaping, re-gravelling, resurfacing, etc.	3	3
Execution	Execution of Maintenance Work	Management of maintenance work and equipment	5	5
Total			19	24

Table 16.4.3-7 Required Number of Engineers for the Road Maintenance

(2012, 2016 and 2026)

	2012	2016	2026
Required Length for Maintenance (km)	21.29	95.85	513.13
Engineer	40	182	975
Engineer's Assistant	51	230	1232

(2) Equipment

Under the proposed master plan, the MOPI will require 9 major maintenance equipment in 2012, 21 in 2016 and 58 in 2016 aside from the presently owned one bulldozer and two motor-graders as shown in **Table 16.4.3-8**.

From the economical aspect it would be better for the MOPI to procure heavy equipment from equipment suppliers because it might be difficult to rent from a private company in case of emergency. Another alternative is to forge an agreement with the MTR to rent heavy equipment, specifically, in case of emergency situations. At present the MTR owns 19 major equipment, as shown in **Table 16.4.3-9**.

Table 16.4.3-8 Annual Number of Major Equipment Required for Maintenance Works

Unit: vehicle-day (vehicle-year)

Major Equipment	2012	2016	2026
Pick-up Truck	145 (1)	1,110 (5)	4,082 (17)
Tipper Truck	315 (2)	1,779 (8)	5,292 (22)
Grader	35 (1)	103 (1)	357 (2)
Roller	35 (1)	103 (1)	357 (2)
Wheel Loader	35 (1)	103 (1)	357 (2)
Water Truck	35 (1)	103 (1)	357 (2)
Hand Ramer	17 (1)	636 (3)	1,866 (8)
Asphalt Sprayer	29 (1)	112 (1)	730 (3)
Total	646 (9)	4,049 (21)	13,398 (58)

*: Annual operational days is assumed 250 days

Table 16.4.3-9 Major Equipment Owned by the MTR

Major Equipment	Number
Excavator	2
Loader Linkage	1
Motor Grader	2
Backhoe Loader	1
Wheel Loader	2
Roller	3
W-shopmobile	1
Turk Actros	5
Water Tank	2
Total	19

(3) Materials

Major materials for road maintenance work originally come from Uganda, Kenya, Khartoum and Juba, as shown in **Table 16.4.3-10.** These materials are available for procurement from material suppliers in Juba.

Table 16.4.3-10 Major Materials Required for Road Maintenance

Materials	Country of Origin
Straight Asphalt/Bitumen	Uganda, Kenya, Khartoum
Fuel	Uganda, Kenya, Khartoum
Cement	Uganda
Reinforcing Bar	Uganda
Admixture	Uganda, Kenya
PVC Pipe	Uganda
Coarse/Fine Aggregate/Gravel	JUBA

(4) Annual Maintenance Budget for 2012 and 2016

1) MOPI Budget

The total budget of the Central Equatorial State Government in 2009 is SGD 221.2 million or US$81.9 million as shown in **Table 16.4.3-11**. The budget for physical infrastructures administered by the MOPI is around 6% of the total state budget or SGD 13.8 million.

The allocated budget for the roads & bridges sector is only SGD 5.4 million or US$2.0 million annually, while the budget for the transport & communication sector is around US$0.5 million. Salary, operational cost and capital expenditures are shared at 43%, 5%, and 52%, respectively, in the budget for roads & bridges. The capital budget is SGD 2.8 million (around US$1 million), while the SGD 2.3 million for salary is shared as a major requirement of the budget for the roads & bridges sector.

Table 16.4.3-11 Annual Budget for Year 2009, Central Equatorial State Government

Unit: million SD (million US$)

1. State Revenue				
- State Revenue				98.2
- Block Grant from GOSS				44.1
- Conditional Grant from GOSS				85.5
Total				227.8 (84.3)
2. Budget Allocation by Sector				
1. Public Administration & Law Enforcement				137.7
2. Accountability & Economic Functions				29.8
3. Education				16.5
4. Health				7.4
5. Natural Resources, Social Development & Humanitarian Affairs				15.9
6. Physical Infrastructures				13.8
Total				221.2 (81.9)
3. Budget Allocation for Roads & Bridges and Transport & Com.				
	Salary	Operational Cost	Capital Expenditure	Total
1.Roads & Bridges	2.3	0.3	2.8	5.4 (2.0)
2.Transport & Com	0.9	0.2	0.3	1.4 (0.5)

Source; Central Equatorial State Government Annual Budget For Year 2009, Juba-April 2009
Notes: US$ 1.0 = SDG 2.7

2) Proposed Annual Budget

(a) Maintenance for Improved Streets

The location map of improved collector and local streets to be maintained in 2012 and 2016 is shown in **Figure 16.4.3-1**.

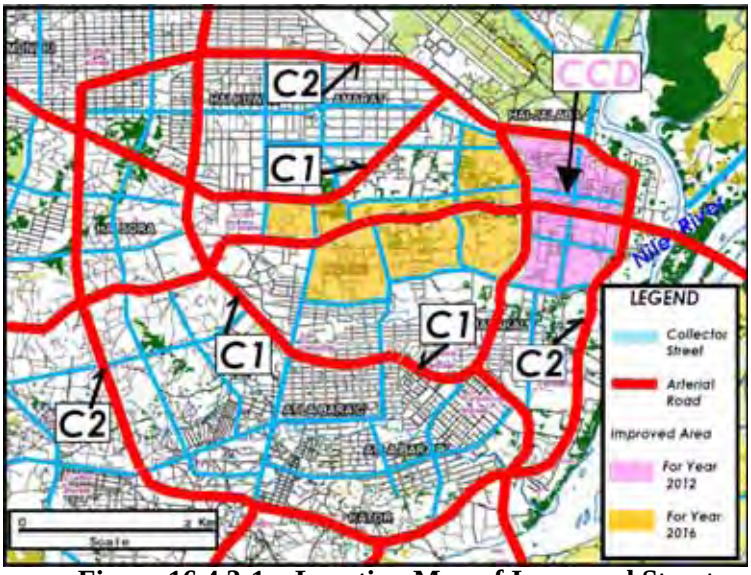


Figure 16.4.3-1 Location Map of Improved Streets

The annual budgets for the proposed maintenance works on the above targeted streets in 2012 and 2016 as well as the streets in Juba in 2026 are shown in **Table 16.4.3-12.**

Table 16.4.3-12 Proposed Annual Budget for Maintenance Work in 2012, 2016 and 2026

Unit: USD 1,000

Streets	Total Length (km)	2012				2016				2026			
		Improved		Not-Improved		Improved		Non-Improved		Improved		Non-Improved	
		Length	Cost	Length	Cost	Length	Cost	Length	Cost	Length	Cost	Length	Cost
Collector	116.04	7.32	35	108.72	-	25.23	120	90.81	-	110.22	524	5.82	-
Local	498.18	13.97	460	484.21	-	70.62	2,400	427.56	-	402.91	7,749	95.27	-
Total	614.22	21.29	495	592.93	800	95.85	2,520	518.37	800	513.13	8,273	101.09	4,000

(b) Temporary Leveling for Non-Improved Streets

Temporary leveling for non-improved streets is practically required under the budgetary constraint in consideration of the capacity development of maintenance engineer/technician of the MOPI, the job opportunity of community people and the urgent repair of streets to protect the daily activities of the community.

The maintenance costs of the collector and local streets for temporary leveling in the years 2012, 2016 and 2026 are assumed in the following table due to the budgetary constraint in the MOPI.

Table 16.4.3-13 Assumed Maintenance Cost for Temporary Leveling in 2012, 2016 and 2026

Unit: in thousand USD

Unit Cost per km	2012		2016		2026	
	Length	Cost	Length	Cost	Length	Cost
40	10 km	400	20 km	800	100km	4,000

(c) Major Equipment Required for Maintenance Works

It is recommended that the MOPI should own the following equipment for: a) Capacity development of the MOPI; b) Emergency maintenance work on collector and local streets; and c) Daily upgrading of community road conditions, taking into consideration the capacity development of maintenance engineers/technicians of MOPI under the budgetary constraint, job opportunity of community people and urgent repair of streets to protect the daily activities of the community.

Table 16.4.3-14 Required Equipment for Maintenance Work in 2012, 2016 and 2026

Unit: USD 1,000

Major Equipment	Unit Price	2012		2016		2026	
		No.	Amount	No.	Amount	No.	Amount
1. Pick-up Truck	50	1	50	5	250	20	5,000
2. Tipper Truck	120	2	240	10	1,200	25	3,000
3. Motor Grader	120	1	120	2	240	3	360
4. Roller	100	1	100	2	200	3	300
5. Wheel Loader	200	1	200	2	400	3	600
6. Water Truck	50	1	50	2	100	3	150
7. Hand Ramer	10	1	10	4	40	10	100
8. Asphalt Sprayer	2	1	2	2	4	5	10
Total			772		2,432		9,520

Note: Unit purchase price of major equipment is based on Japanese market price.

(d) Summary of Budget Requirement

Proposed annual budget for the street maintenance in Juba is summarized as well as the required major equipment and major man-power due to the above study results as shown in **Table 16.4.3-15**. In the view of equipment and man-power, force account maintenance activity is available to conduct in 2012, But, partial contract out is required in 2016. Contract out is indispensable to conduct maintenance work in 2026.

Table 16.4.3-15(1) Summary of Budget Requirement for Street Maintenance Work

(Years 2012 and 2016)

Maintenance Work	Year 2012 (Area: Within CCD)					Year 2016 (Area: Within CCD and C1)				
	Length (km)	Maintenance Cost (USD 1,000)		Major Equipment	Major Man-Power	Length (km)	Maintenance Cost (USD 1,000)		Major Equipment	Major Man-Power
		Unit Cost	Cost				Unit Cost	Cost		
1. Maintenance for Improved Streets Collector ⇒ Local ⇒ Sub-Total ⇒	 7.32 13.97 21.29	 Collector 4.75 (AC) Local 58.08 (RS) 53.88 (GR) 1.69 (AC)	 35 460 495	145-Pickup Truck 315-Tipper Truck 35-Grader 35-Roller 35-Wheel Loader 17-Water Truck 3-Hand Ramer 29-Asphalt Sprayer	40-Engineer 51-Assitant Eng. 180-Supervisor 629-Driver/ Operator 3,141-Unskilled	 25.23 70.62 95.85	 Collector 4.75 (AC) Local 58.08 (RS) 53.88 (GR) 1.69 (AC)	 120 2,400 2,520	1,110-Pickup Truck 1,779-Tipper Truck 103-Grader 103-Roller 103-Wheel Loader 103-Water Truck 636-Hand Ramer 112-Asphalt Sprayer	182-Engineer 230-Assistant Eng. 1,227-Supervisor 3,711-Driver/ Operator 22,772-Unskilled
2. Temporary Leveling for Non-improved Streets Collector ⇒ Local ⇒ Sub-Total ⇒	10 * 108.72 484.21 592.93	 40 (GR)	 400	Executed by community group into Labor-intensity method under the guidance of MOPI	Recruited by Community	20 * 90.81 427.56 518.37	 40 (GR)	 800	Executed by community group into Labor-intensity method under the guidance of MOPI	Recruited by Community

*: The figure is assumed improved length for temporary leveling within the non-improved street length due to the budgetary constrain, while the total non-improved street lengths in 2012 and 2016 are estimated at 592.93 km and 518.37 km respectively.

Table 16.4.3-15(2) Summary of Budget Requirement for Street Maintenance Work (Year 2026)

Maintenance Work	Year 2012 (Area: Within CCD)				
	Length (km)	Maintenance Cost (USD 1,000)		Major Equipment	Major Man-Power
		Unit Cost	Cost		
3. Maintenance for Improved Streets Collector ⇒ Local ⇒ Sub-Total ⇒	 110.22 402.91 513.13	 Collector 4.75 (AC) Local 58.08 (RS) 53.88 (GR) 1.69 (AC)	 524 7749 8,273	4,082-Pickup Truck 5,292-Tipper Truck 357-Grader 357-Roller 357-Wheel Loader 357-Water Truck 1,866-Hand Ramer 730-Asphalt Sprayer	975-Engineer 1,232-Assitant Eng. 4,439-Supervisor 12,215-Driver/Operator 77,330-Unskilled
4. Temporary Leveling for Non-improved Streets Collector ⇒ Local ⇒ Sub-Total ⇒	100 * 5.82 95.27 101.09	40 (GR)	4,000	Executed by community group into Labor-intensity method under the guidance of MOPI	Recruited by Community

CHAPTER 17

URBAN STREET IMPROVEMENT IN CENTRAL COMMERCIAL DISTRICT

CHAPTER 17 URBAN STREET IMPROVEMENT IN CENTRAL COMMERCIAL DISTRICT

17.1 OBJECTIVES AND APPROACH OF THE STUDY

(1) Objectives of the Study

The Central Commercial District (CCD) is a historical block spreading in the north and south of the eastern section of May Road with an area of about 1.4 km in north-south and about 1.0 km in east-west. This area has been developed as a center of Juba town in commercial, business and institutional activities, where Juba Town Market and many State Government offices and private business entities are situated.

However, the roads in this area have been heavily deteriorated due to negligence of maintenance, and the traffic is hindered from moving smoothly by improper layout of intersections and ineffective traffic management. The living environment and urban landscape are nasty due to absence of sidewalk and drainage, disposal of wastes on roads, etc. The on-going Emergency Road Rehabilitation Project (ERRP) includes trunk roads and semi-trunk roads in CCD but local streets in support of daily life are not covered.

Under such situation, it is of urgent necessity to rehabilitate/improve the roads, provide sidewalk and drainage, and improve the intersections in order to make the traffic flow smooth and to improve the living environment and urban landscape. Therefore the rehabilitation/improvement of the roads in CCD is given top priority in the urban transport development master plan.

The objectives of the study in this Chapter is to prepare a basic plan of the street improvement in CCD and conduct a pre-feasibility study thereof as a preparatory work for early implementation of the project. The study includes road inventory, basic strategies and plan, preliminary design, construction plan and cost estimate, environmental impact assessment, economic evaluation and implementation plan at preliminary levels.

CCD is the biggest downtown in Juba and therefore its improvement is expected to act as a trigger of activation of the whole Juba urban area. Moreover, this project can be employed as a model case applicable and spreadable to other areas.

(2) Study Methodology

Figure 17.1-1 shows the procedural flow of the study on the urban street improvement in

the Central Commercial District (CCD), which is briefly discussed below:

Present Road Condition (Road Inventory)

The present condition of CCD such as topography, land use, road network, road condition, etc. is surveyed and the transport issues are identified. Based on the road condition survey, the road inventory data are compiled, including section length, width of cross-sectional elements, pavement type and condition, drainage type and condition, etc. This data are employed as an initial database not only for this study but also for the future road management.

Urban Street Improvement Policy

The roles of CCD expected to play in Juba urban area are discussed and development requirements to fulfill the roles are identified. Then, the level of improvement to meet the requirements is established, referring to the cases of advanced countries.

Basic Plan

In accordance with the urban street improvement policy, the basic plan for street improvement in CCD are established, including functional road classification, preparation of standard cross-sections by road class, pavement type and traffic management plan.

Preliminary Design

In accordance with the improvement policy and basic plan, preliminary design is prepared including general plan, pavement design, drainage design, traffic management design, intersection design and road facilities design.

Construction Plan and Cost Estimates

The construction method, construction schedule and procurement plan of materials, equipment and labors are discussed and the project cost is roughly estimated.

Environmental Impact Assessment

The environmental impact is assessed at preliminary level.

Simplified Economic Evaluation

Comparing the project cost with the expected benefits accruing from the project, the simplified economic evaluation is made.

Implementation Plan

Taking into consideration the capacity development in the course of the project implementation and possibility of donor assistance, the implementation plan is prepared including system, schedule and annual fund requirements.

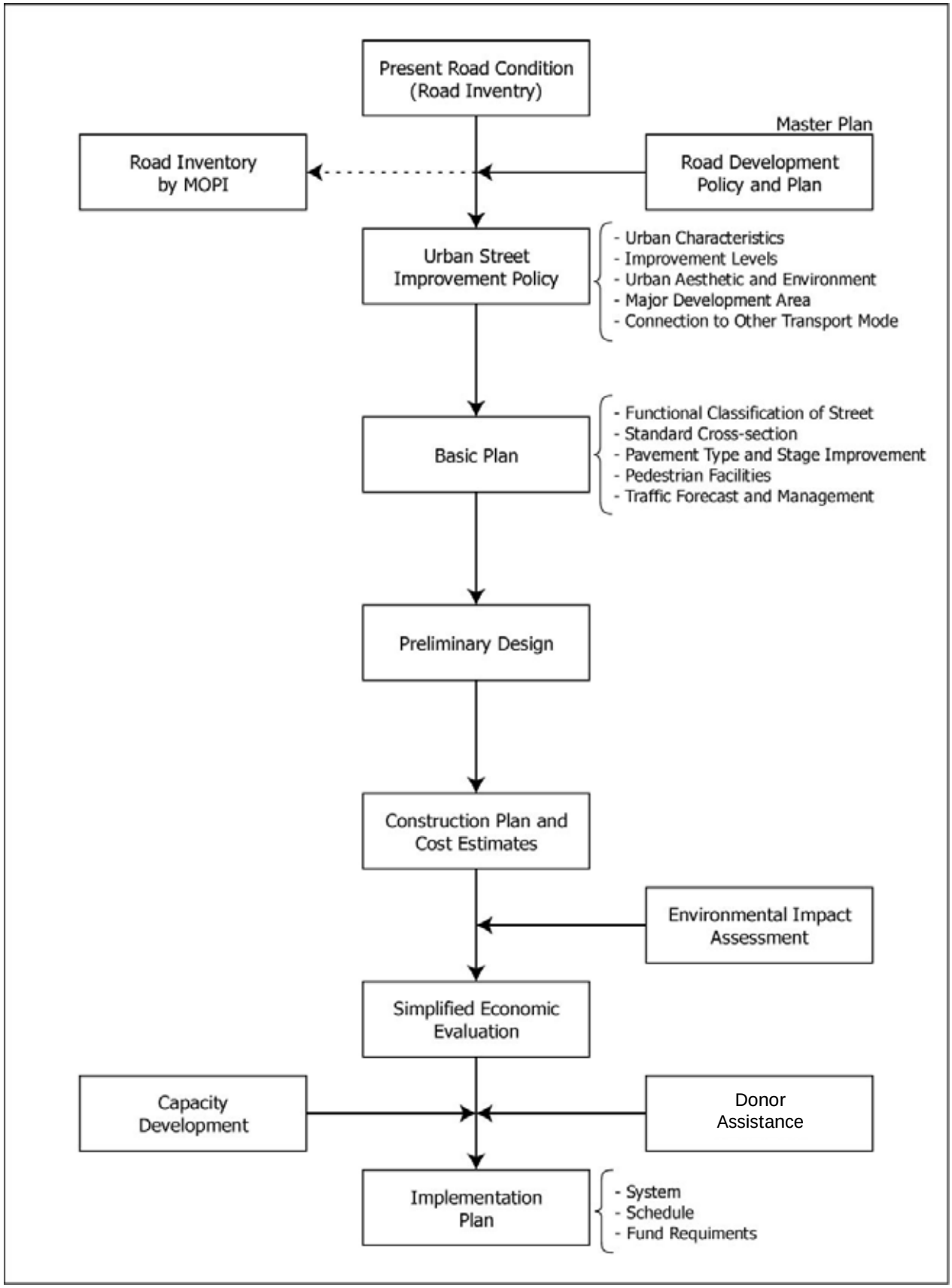


Figure 17.1-1 Study Flow of Urban Street Improvement

17.2 PRESENT ROAD CONDITION

17.2.1 Study Area and Existing Road Network

(1) Location of Study Area

The study area, Central Commercial District (CCD), is located on the eastern side of the Circumferential Street No.1 (C1). There is the Juba International Airport on the northwestern side and the Juba River Port on the southern side as shown in Figure 17.2.1-1.

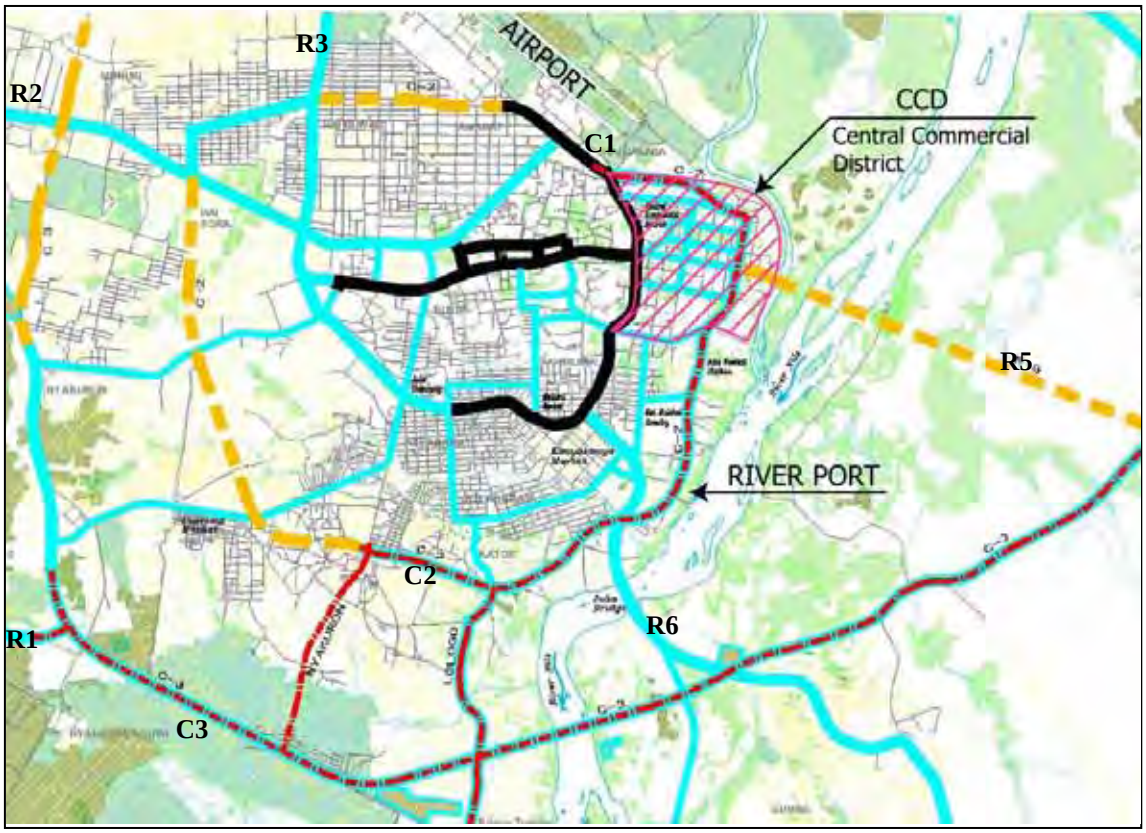


Figure 17.2.1-1 Location of CCD

(2) Road Network in CCD

Figure 17.2.1-2 shows the road network in CCD. It abuts on the Circumferential Street No.1 (C1) on the west side and the Nile River on the east side. The Circumferential Street No.2 (C2) runs through CCD on the eastern side of CCD in the north-south direction and the Radial Street No.5 (R5) in the middle of CCD in the east-west direction.

Classification	Total Length
Arterial Street	3.91 km
Collector Street	8.84 km
Major Local Street	4.24 km
Minor Local Street	9.73 km

Figure 17.2.1-2 Road Network in CCD

17.2.2 Road Inventory

The road inventory survey was conducted by JICA Study Team in May 2009 to get the necessary information for the road improvement planning.

(1) Sectioning and Numbering

All existing roads are divided into sections and individual sections are put the numbers.

In numbering, functional road classification is considered, i.e. put the initial letters “C1”, “C2” and “R5” to arterial streets, “CR” to collector streets, and “L” to local streets.

(2) Survey Items

The survey items are as follows:

i. General Item

- Road name (only to the streets with commonly known name)
- Road Classification
  - > Administrative Classification : International Road, Interstate Road, State Road, County Road
  - > Functional Classification : Arterial Street, Collector Street, Local Street *

    *further sub-classified into Major Local Street and Minor Local Street

ii. Road Cross-section Components/Road Width

- Width of the existing travelled way
- Width of the existing shoulder
- Width of the existing sidewalk
- Width of the existing road drain/side ditch
- Total width of road way
- Available right-of-way width : the existing roadway width including the spaces on the fringes if any, i.e. fence-to-fence width which is regarded as the right-of-way.

iii. Type and Condition of Road Surface

- Surface Type : Earth, Gravel, Asphalt Concrete
- Surface Condition : Good, Fair, Bad, Very bad

iv. Type and Condition of Road Facilities

- Shoulder Type : Earth, Gravel, Asphalt Concrete
- Shoulder Condition : Good, Fair, Bad, Very bad
- Sidewalk Type : Earth, Gravel, Asphalt Concrete
- Sidewalk Condition : Good, Fair, Bad, Very bad
- Side Ditch Type : Earth Ditch, Masonry Ditch, Concrete Ditch, Concrete Pipe, Steel Pipe
- Side Ditch Condition : Good, Damaged, Collapsed, Clogged

17.2.3 Present Road Conditions

(1) Length of Roads

Total road length in CCD is 26.7km. Table 17.2.3-1 shows the road length by classification.

Table 17.2.3-1 Road Length in CCD

Road Class	Length (km)
Arterial Street	3.91
Collector Street	8.84
Major Local Street	4.24
Minor Local Street	9.73
Total	26.72

(2) Road Width

The range of roadway width and right-of-way (ROW) width is shown in Table 17.2.3-2 and graphically shown in Figure 17.2.3-1.

Table 17.2.3-2 Range of Roadway and ROW Width

Road Class	Existing Roadway Width (m)	ROW Width (m)
Arterial Street	12.0 – 17.5	16.0 – 22.6
Collector Street	10.0 – 17.5	14.8 – 25.0
Major Local Street	3.7 – 14.7	12.0 – 25.0
Minor Local Street	2.0 – 10.0	3.40 – 15.0

Figure 17.2.3-1 Present ROW Width

(3) Road Surface Type and Condition

Table 17.2.3-3 shows the road length by surface type and Table 17.2.3-4 shows the present condition of the road surface. Earth and gravel roads account for 88% while asphalt roads are only 12%. About half of the asphalt roads are in good condition and the remaining half are in bad condition. All earth and gravel roads are in either bad or very bad condition.

Table 17.2.3-3 Road Length by Surface Type and Road Classification (as of May 2009)

Pavement Type	Asphalt Road (km)	Earth/Gravel Road (km)	Total (km)
Arterial Street	3.12	0.79	3.91
Collector Street	-	8.84	8.84
Local Street	-	13.97	13.97
Total (%)	3.12 (11.7 %)	23.60 (88.3 %)	26.72 (100.0) %

Table 17.2.3-4 Present Condition of Road Surface (as of May 2009)

		Good	Fair	Bad	Very Bad	Total
Asphalt Road	Arterial Street	1.47	-	1.65	-	3.12
	Collector Street	-	-	-	-	-
	Local Street	-	-	-	-	-
	Total (%)*	1.47 (5.5%)	-	1.65 (6.2%)	-	3.12 (11.7%)
Earth/Gravel Road	Arterial Street	-	-	-	0.79	0.79
	Collector Street	-	-	-	8.84	8.84
	Local Street	-	-	2.19	11.78	13.97
	Total (%)*	-	-	2.19 (8.2%)	21.41 (80.1%)	23.60 (88.3%)

* percentage of the total road length

Figure 17.2.3-2 shows the road surface type and condition and Photo 17.2.3-1 shows the typical examples.

Figure 17.2.3-2 Present Road Conditions in CCD (as of May 2009)

Arterial Road	 C2(Earth, Very Bad)	 R5(Asphalt, Very Bad)
Collector Road	 CR3-2(Earth, Very Bad)	 CR8-1(Earth, Very Bad)
Local Street	 L(A)2 (Earth, Very Bad) beside school	 L(B)8 (Earth, Very Bad)

Photo 17.2.3-1 Present Road Condition

(4) Drainage Type and Condition

The existing drainages are located only along R5-1～5 (May Road), C2-1～2 (Circumferential Street C2), CR-1～3, CR2-3, CR3-1～5 and CR7-2 while other roads have no drainage, as shown in Figure 17.2.3-3. The existing types are concrete ditch, masonry ditch or earth ditch. Water flows into small river (a tributary of the White Nile River) along L(E)1.

Figure 17.2.3-3 Present Drainage Type (as of May 2009)

17.3 URBAN STREET IMPROVEMENT POLICY

17.3.1 Urban Characteristics

Figure 17.3.1-1 illustrates the existing land use in CCD, based on the field survey conducted in July 2009 and referring to the satellite image. Table 17.3.1-1 shows the percentage share of each land use category. The CCD is mainly composed of three major categories, namely Commercial Area, Governmental Area and Residential Area, accounting for 87 % in total. Thus, the CCD has multiple functions.

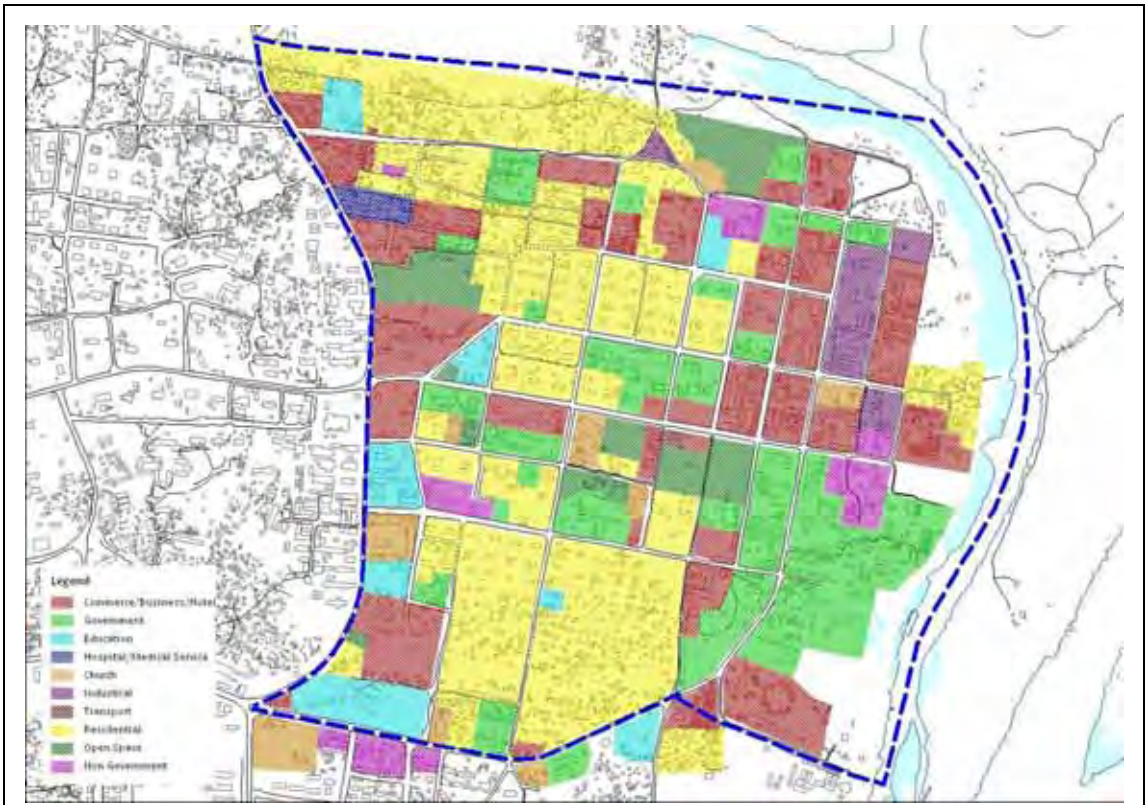


Figure 17.3.1-1 Existing Land Use in CCD

Table 17.3.1-1 Percentage of Land Use in CCD

Land Use	Percentage
Commerce/Business/Hotel	24.5 %
Government	25.0 %
Education	5.0 %
Hospital/Medical Service	0.6 %
Church	2.3 %
Industrial	2.8 %
Residential	37.9 %
Non Government	1.9 %
Total	100.0 %

Role of CCD

The CCD plays and is expected to play the following roles:

- CCD plays the role of a center of economic activities in Juba as commercial and business center.
- CCD plays the role as a center of administrative function as the capital of Central Equatoria State while the capital function of the Southern Sudan is concentrated in

the GOSS Compound at the west side of May Road.

- CCD is expected to be a model area for urban development. If this area is successfully developed, the other areas will follow.

For CCD to fully play the expected roles, the urban infrastructure, especially road network shall be well developed because the accessibility is a key issue of the urban development.

17.3.2 Level of Improvement

(1) Development Policy

The basic policy is to develop the CCD following international level of standards, environmental friendly, comfortable and pleasant area attracting visitors and investors.

(2) Requirements for Development of CCD to Play its Roles

The requirements for CCD to fully play its roles as mentioned above are considered as follows:

- **Accessibility**

  The CCD is expected to be developed as a center of the economic activities as well as a center of administrative function as the capital of Central Equatoria State. For CCD to fully play the roles, the improvement of accessibility is of vital importance. Especially the following improvements are required:

  - Improvement of road network to secure a smooth and safe traffic.
  - Development of public transport to facilitate the access from outside.
  - Provision of parking spaces, on-street and/or off-street, to meet the high parking demand.
  - Improvement of pedestrian facilities.

- **Land Use**

  Since economic and administrative facilities are concentrated in CCD, a densely developed land use will be directed.

- **Environment and Amenity**

  Since the CCD is expected to be a model area for urban development, it shall be environmentally friendly, comfortable and pleasant. To be so, provision of sidewalk with greenbelt and street lighting, proper treatment of garbage, provision of drainage facilities, etc. are required.

(3) Level of Improvement

Taking into consideration of the requirements for development mentioned above and peculiar conditions of CCD such as many pedestrians, limitation of available space, etc.,

the level of improvement of the streets are decided dependent on the road class as shown in Table 17.3.2-1.

Table 17.3.2-1 Improvement Level

		Road Class							
		Arterial Street		Collector Street		Local Street			
						Major Local Street		Minor Local Street	
		A	B	A	B	A	B	A	B
Cross-Sectional Element	Number of Lanes	4 or 6	2	2 or 4	2	2	2	2	2 or 1
	Lane Width (m)	3.6	3.6	3.3	3.3	3.0	3.3	3.0	3.0 (4.0 for 1-lane)
	Median (m)	5.0	None	4.0 or None	None	None	None	None	None
	Multi-purpose Lane (m)	3.5	3.5 or None	3.5	3.5 or None	3.0 or None	3.5 or None	3.0 or None	None
	Sidewalk (m)	2.5-3.0	3.0-4.0	2.5	2.0-4.0	2.5	1.5-2.5	2.5	0-2.5
Road Surface Type		Asphalt	Asphalt	Asphalt	Asphalt	Asphalt	Depends	Depends	Gravel
Roadside Drainage		Pipe	Pipe	Pipe	Pipe	Pipe	Ditch	Depends	Ditch
Road Facilities	Street Lighting	Depends	With	Depends	With	Depends	If possible	Depends	None
	Planting	With	With	With	With	None	None	None	None
	Traffic Signal	As necessary							
	Traffic Sign								
	Pavement Marking	With	With	With	With	Depends	With	Depends	None
	Bus Stop	As necessary							

A : Standard cross-section common to all urban area

B : Adopted cross-section considering peculiar condition of CCD such as many pedestrians, limitation of available space, etc.

17.3.3 Urban Aesthetics and Environment Amenity

As mentioned in 17.3.2 (2) above, improvement of aesthetics and environment is one of the major issues and considerations for CCD development. The measures to enhance the aesthetics and environment include the following:

- provision of sidewalk and greenbelt area for the safety of pedestrians and public convenience,
- provision of street lighting for pedestrians and road users,
- proper drainage facilities and waste disposal,
- facilities for handicapped and physically disadvantaged road users,
- facilities for vehicle parking,
- improvement of parks and public places,

- considerations for urban aesthetics thru proper design of buildings and structures, and
- proper arrangement and layout of utilities such as water pipes, electricity, sewerage, etc.

It is necessary to enhance the aesthetics and environment in a manner harmonized with customs, climates, economics, etc. of the Southern Sudan.

17.3.4 Major Development Area

The CCD is characterized by the land use which is mixture of commercial, business, administrative and residential uses. It is forecast that more densely developed land use will be promoted in the future by the following way :

- Conversion from residential use to commercial or business use, initially from the center toward north and south.
- Development of the areas abutting the Nile River, which are not so highly developed yet at present.

17.4 BASIC PLAN

17.4.1 Functional Classification of Street Network

As mentioned in Chapter 9.2, the urban streets are hierarchically composed of three classes of streets, i.e. arterial street, collector street and local street. Considering the characteristics of the CCD such as high road density and many local streets, the local streets are further subdivided into two categories, i.e. major local streets and minor local streets. Table 17.4.1-1 shows the definition of the functional classification of streets in the CCD.

Table 17.4.1-1 Definition of Urban Street Classification in CCD

Classification		Definition
Arterial Street		Mainly serves for the longer trips and the high traffic volume as major corridor, and functions as trunk line for public transport.
Collector Street		Mainly serves for access from arterial streets to other arterial streets and/or other major areas, and functions as major traffic circulations within residential and commercial areas.
Local Street	Major Local Street	Mainly serves for access from arterial or collector streets to local areas as the lower mobility level roads. It may be included in the public transport route.
	Minor Local Street	Mainly serves for access from arterial, collector or major local streets to limited local areas as the lowest mobility level roads. It is not included in the public transport route.

Figure 17.4.1-1 shows the functional classification of the streets in CCD.

Figure 17.4.1-1 Functional Classification of Streets in CCD

17.4.2 Design Criteria

Table 17.4.2-1 shows the proposed design criteria.

Table 17.4.2-1 Proposed Design Criteria

	Arterial Street	Collector Street	Major Local Street	Minor Local Street
Function	A part of trunk road network in the whole Juba urban area. Primary Distributer	Local distributor	Major local access	Minor local access
Flow Condition	Possibly uninterrupted flow except at intersections	Interrupted flow	Interrupted flow	Interrupted flow
Design Traffic by lane (ADT)	10,000 – 12,000	9,000	9,000	Less than 9,000
Design Speed (km/h)	60	50	40	30
Level of Service	C	D	D	D
Number of Lanes	2	2	2	2 or 1
Lane Width (m)	3.6	3.3	3.3	3.0 for 2-lane 4.0 for 1-lane
Median (m)	None	None	None	None
Multi-purpose Lane* or Shoulder (m)	3.5 (Multi-purpose Lane) or 1.5 (Shoulder)	3.5 (Multi-purpose Lane) or 1.5 (Shoulder)	3.5 (Multi-purpose Lane) or 1.2 (Shoulder)	None
Sidewalk (m)	3.0 – 4.0	2.0 – 4.0	1.5 – 2.5	0 – 2.5
Planting	Within Sidewalk	Within Sidewalk	None	None

* **Multi-purpose lane** is used for exclusive space for bus bays, on-street parking, loading/ unloading areas, etc. depending on the demands.

17.4.3 Standard Cross-sections

Two types of standard cross-sections are proposed for each class of street as follows:

- Arterial Streets： **Arterial-1** (with multi-purpose lane) and
  Arterial-2 (without multi-purpose lane)
- Collector Streets： **Collector-1** (with multi-purpose lane) and
  Collector-2 (without multi-purpose lane)
- Major Local Streets： **Major-1** (with multi-purpose lane) and
  Major-2 (without multi-purpose lane)
- Minor Local Streets： **Minor-1** (2-lane) and
  Minor-2 (1-lane)

The selection of the type depends mainly on the available width for road.

Table 17.4.3-1 shows the standard cross-sections.

Table 17.4.3-1(1) Standard Cross-sections of Streets in CCD (1/2)

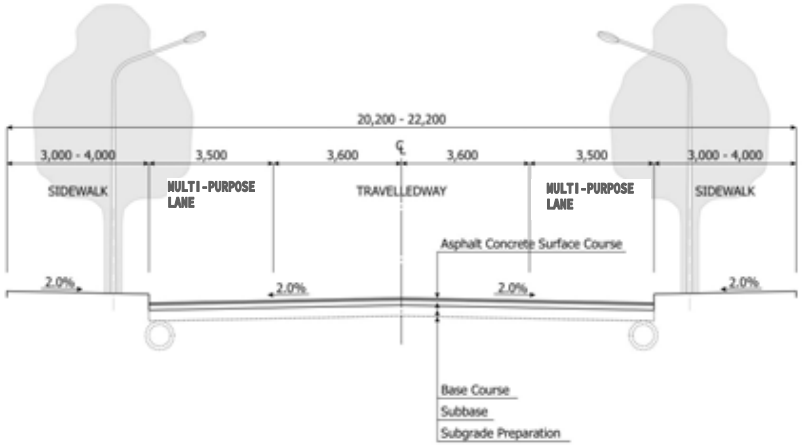
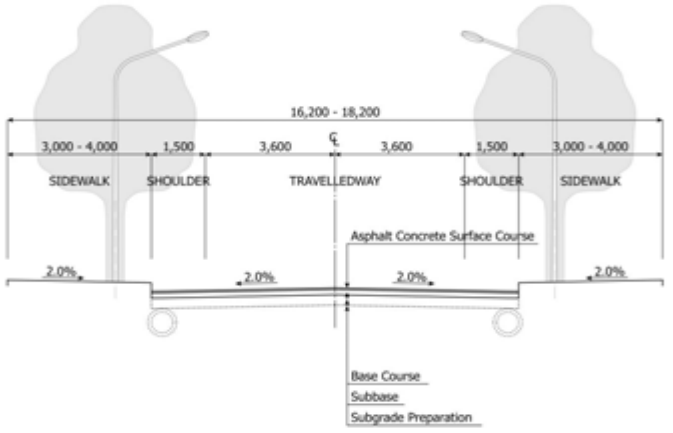
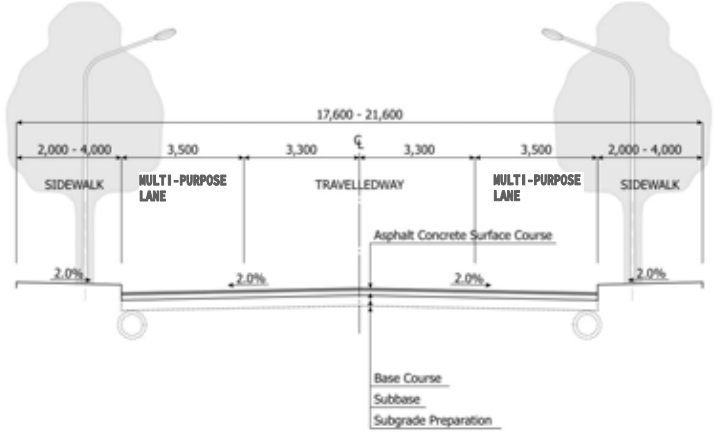
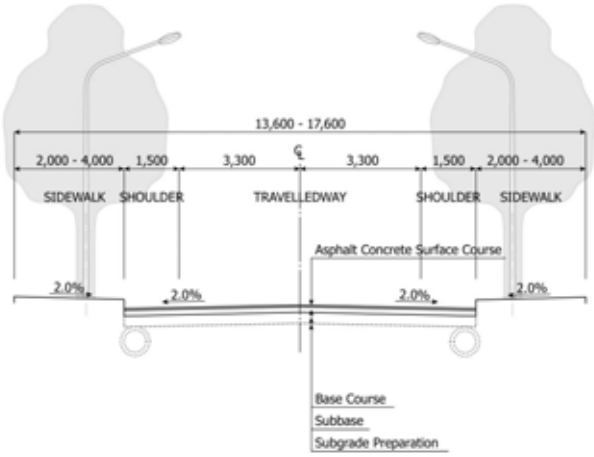
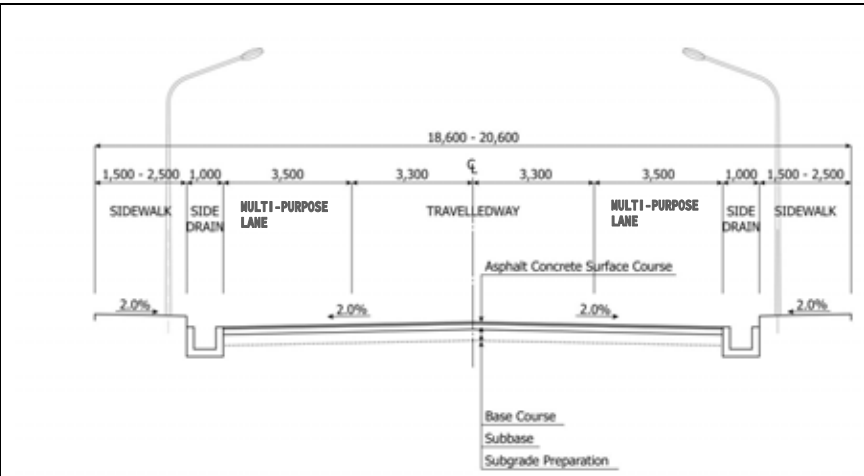
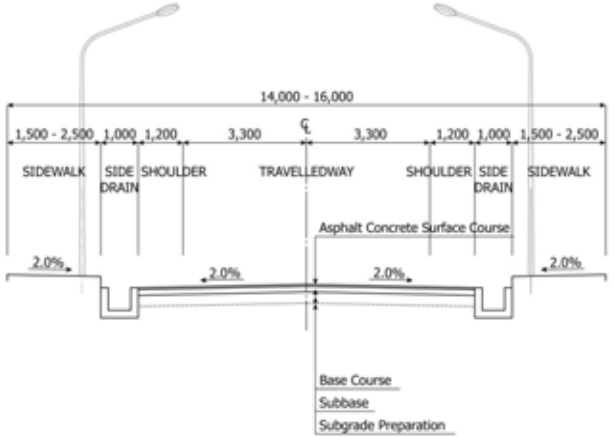
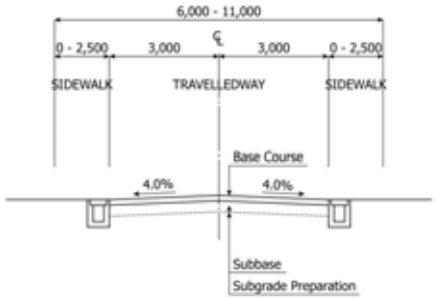
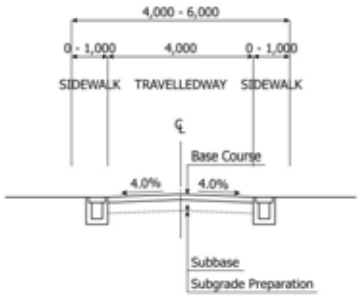
Arterial Street	 **Arterial-1**	 **Arterial-2**
Collector Street	 **Collector-1**	 **Collector-2**

Table 17.4.3-1(2) Standard Cross-sections of Streets in CCD (2/2)

Major Local Street	 **Major-1**	 **Major-2**
Minor Local Street	 **Minor-1**	 **Minor-2**

17.4.4 Pavement Type and Stage Improvement

As shown in Chapter 9.6, arterial streets and collector streets are proposed to be improved to asphalt concrete pavement (AC) while local streets are to be AC, gravel pavement (GR) or resurfacing (RS) depending on fund availability and importance of road. In line with this policy, the streets in CCD are proposed as follows:

- Arterial, Collector and Major Local Streets : AC
- Minor Local Streets : GR initially and upgrading to AC in the future

17.4.5 Traffic Demand Forecast and Management

(1) Traffic Demand Forecast

Approach

The traffic demand is forecast in the following way:

- **Arterial Streets** : Present and future traffic of arterial streets are estimated in Chapter 8 by the four steps approach (trip generation, trip distribution, modal split and traffic assignment) for future traffic.

- **Collector and Major Local Streets** : Present traffic is estimated based on the 5-minute traffic counts at site, conducted by the Study Team in May 2009. Future traffic is projected applying the growth rate of the trip generation of the arterial streets. The assumed traffic growth rate is shown in Table 17.4.5-1.

Table 17.4.5-1 Assumed Traffic Growth Rate of Collector and Major Local Streets

	Motor Bike	Car	Bus	Truck
From 2009 to 2015	8.3 % p.a.	6.5 % p.a.	5.0 % p.a.	11.2 % p.a.
From 2015 to 2025	5.7 % p.a.	4.5 % p.a.	3.4 % p.a.	7.7 % p.a.

- **Minor Local Streets** : Present and future traffic is estimated on the analogy of the traffic volume of major local streets considering the actual condition of the present traffic.

Estimated Traffic Volume

The estimated present and future traffic volume is shown in Table 17.4.5-2.

Table 17.4.5-2 Estimated Traffic Volume of the Streets in CCD

(unit : veh/day)

Road Class	Road Section	2009					2015					2025				
		Motor bike	Car	Bus	Truck	Total	Motor bike	Car	Bus	Truck	Total	Motor bike	Car	Bus	Truck	Total
Arterial Streets	C1-2	2,955	2,919	3,105	2,991	11,969	4,870	3,186	3,726	2,022	13,804	5,582	3,162	3,223	5,011	16,977
	C1-3	1,803	1,635	129	795	4,362	4,055	2,663	3,032	3,002	12,751	4,818	2,776	2,790	6,845	17,229
	C2-1	991	976	1,784	430	4,182	7,142	5,315	6,434	5,722	24,613	16,136	11,050	9,743	4,598	41,527
	C2-3	2,088	2,108	1,740	1,294	7,230	3,555	2,311	2,714	4,599	13,179	12,991	8,954	6,546	9,987	38,477
	R5-2	2,755	2,522	3,383	1,622	10,282	3,864	2,558	3,307	5,568	15,297	6,915	4,210	4,802	6,786	22,713
	R5-5	2,845	2,630	3,553	1,672	10,701	3,864	2,558	3,307	5,568	15,297	5,288	3,187	3,354	749	12,579
Collector Streets	CR1	1,800	1,825	616	1,159	5,400	2,899	2,667	823	2,194	8,583	5,054	4,152	1,154	4,619	14,979
	CR2	1,800	1,064	359	676	3,899	2,899	1,555	480	1,280	6,214	5,054	2,421	673	2,695	10,843
	CR3	450	1,064	359	676	2,549	725	1,555	480	1,280	4,040	1,264	2,421	673	2,695	7,053
	CR4	150	228	77	145	600	242	333	103	274	952	422	518	144	577	1,661
	CR5	1,500	380	128	242	2,250	2,416	555	171	458	3,600	4,212	864	240	964	6,280
	CR6	450	608	205	386	1,649	725	889	274	731	2,619	1,264	1,384	384	1,539	4,571
	CR7	600	760	257	483	2,100	966	1,111	343	914	3,334	1,684	1,730	481	1,924	5,819
	CR8	150	228	77	145	600	242	333	103	274	952	422	518	144	577	1,661
	CR9	1,800	1,064	359	676	3,899	2,899	1,555	480	1,280	6,214	5,054	2,421	673	2,695	10,843
Major Local Streets	L(A)2	750	322	60	68	1,200	1,208	471	80	129	1,888	2,106	733	112	272	3,223
	L(B)4	750	322	60	68	1,200	1,208	471	80	129	1,888	2,106	733	112	272	3,223
	L(E)1	450	536	100	114	1,200	725	783	134	216	1,858	1,264	1,219	188	455	3,126
	L(F)1	450	429	80	91	1,050	725	627	107	172	1,631	1,264	976	150	362	2,752
	L(F)2	900	429	80	91	1,500	1,449	627	107	172	2,355	2,526	976	150	362	4,014
	L(G)2	450	429	80	91	1,050	725	627	107	172	1,631	1,264	976	150	362	2,752
	L(H)1	450	429	80	91	1,050	725	627	107	172	1,631	1,264	976	150	362	2,752
	L(I)1	300	2,358	442	500	3,600	483	3,446	591	946	5,466	842	5,365	829	1,992	9,028
	L(I)2	300	1,179	221	250	1,950	483	1,723	295	473	2,974	842	2,682	414	996	4,934
	L(J)2	150	322	60	68	600	242	471	80	129	922	422	733	112	272	1,539
	L(J)9	150	322	60	68	600	242	471	80	129	922	422	733	112	272	1,539
	L(N)1	450	536	100	114	1,200	725	783	134	216	1,858	1,264	1,219	188	455	3,126
	L(N)2	300	429	80	91	900	483	627	107	172	1,389	842	976	150	362	2,330
	L(R)1	450	536	100	114	1,200	725	783	134	216	1,858	1,264	1,219	188	455	3,126
	L(R)2	300	429	80	91	900	483	627	107	172	1,389	842	976	150	362	2,330
	L(S)1	150	214	40	45	449	242	313	53	85	693	422	487	74	179	1,162
	L(S)6	150	214	40	45	449	242	313	53	85	693	422	487	74	179	1,162
	L(U)1	300	429	80	91	900	483	627	107	172	1,389	842	976	150	362	2,330

(2) Traffic Management Plan

Present Condition of Traffic Management in CCD

Present traffic management in CCD is as follows:

- **Traffic management at intersections :** There are three roundabouts : C1/R5, C1/CR1 and R5/L(I)2-L(N)2 intersections. There is no signal controlled intersection. At C1/R5 intersection, traffic is controlled by the police at the peak hours.
- **One-way Operation :** There are three short sections under one-way operation : eastern section of R5-5 (May Road), C2-3 and L(N)2.
- **Roadside Parking :** There is no designated parking area on the road. Since the roadside parking is not controlled, many vehicles park on roadside irregularly.

Traffic Management Plan

The traffic management plan is proposed as follows:

- **Traffic management at intersections :** Some intersections cause the bottlenecks of the traffic flow due to insufficient capacities. The intersection traffic management is planned as follows:

- Existing roundabout type intersections: At first, the capacity of roundabout type is examined for the estimated traffic in 2015. If the roundabout is judged to be well operational, the same type is proposed. If not, the signalized intersection is proposed.
- Not roundabout type intersections: Considering the limited capacity of roundabout type, the signalized intersection is proposed.

- **One-way Operation and Traffic Circulation Plan :** In the area with traffic congestion, the traffic circulation plan by one-way operation and left-turning prohibition is necessary to alleviate the traffic congestion. However, since the traffic congestion does not occur at present in CCD except at intersections, the traffic circulation plan is not considered necessary provided that the intersections causing bottlenecks are improved with sufficient capacities.

  When traffic increases so much and the circulation plan becomes necessary in the future, the traffic circulation plan shall be prepared based on the survey of the traffic movement after the road improvement projects are completed, because it is very difficult to precisely estimate the traffic movement after road improvement.

- **Roadside Parking :** The multi-purpose lane is included in the proposed standard cross-sections in arterial, collector and major local streets in case the available road width can afford it. The multi-purpose lane is used for parking space, except the sections near the major intersections, bus bays, loading/unloading areas and major public buildings/facilities such as hospitals, schools, etc.

  The parking areas shall be clearly designated by road marking and signs. The roadside parking should be strictly controlled to allow only within the designated parking areas.

17.5 PRELIMINARY DESIGN

17.5.1 General Plan

(1) Road Alignment

Since the existing roads are located in flat terrain and road alignment is acceptable, no change is proposed in road alignment.

(2) Cross-section

Eight standard cross-sections are prepared as shown in Table 17.4.3-1. Figure 17.5.1-1 shows the adopted standard cross-section to each road.

Figure 17.5.1-1 Adopted Standard Cross-sections

(3) Pavement Type

The proposed pavement type is as follows:

- Arterial Streets : Asphalt concrete pavement (AC)
- Collector Streets : Asphalt concrete pavement (AC)
- Major Local Streets : Asphalt concrete pavement (AC)
- Minor Local Streets ; Gravel surfaced (GR)

(4) Layout of Road Facilities

The road facilities are proposed as shown in Table 17.5.1-1.

Table 17.5.1-1 Road Facilities Plan

Item	Installation Plan	Quantity
Roadside Drainage	All sections	26.72km
Street Lighting	Arterial and Collector Streets	12.75km
Planting on Sidewalk	Arterial and Collector Streets	12.75km
Pavement Marking	All AC sections (Arterial, Collector and Major Local Streets)	16.99km
Traffic Sign	As shown in Figure 15.5.1-2	4
Bus Terminal	As shown in Figure 15.5.1-2	1
Bus Stop	As shown in Figure 15.5.1-2	5
Traffic Signal	As shown in Figure 15.5.1-2	2
Pedestrian Crossing	At intersections, and in front of bus bays, markets, hospitals, schools, religious facilities and other locations with high demand of pedestrians' crossing	

Figure 17.5.1-2 shows the layout plan of road facilities.

Figure 17.5.1-2 Layout Plan of Road Facilities

17.5.2 Pavement Design

The pavement design calculation is presented in Appendix 11, which is summarized in this Section.

(1) Design Sections and Pavement Type

The streets in the CCD are functionally classified into 4 categories: Arterial Street, Collector Street, Major Local Street and Minor Local Street. The sections with high traffic volume or relatively weak roadbed soil of each class of street are selected as design sections. Table 17.5.2-1 shows the selected design sections and proposed pavement type.

Table 17.5.2-1 Design Sections and Proposed Pavement Type

Functional Road Class	Design Section	Proposed Pavement Type
Arterial Street	C2-3 (high traffic volume in C-2) R5-2 (high traffic volume in R-5)	Asphalt Concrete Pavement
Collector Street	CR1 (high traffic volume) CR3 (low roadbed CBR)	Asphalt Concrete Pavement
Major Local Street	L(I)1 (high traffic volume)	Asphalt Concrete Pavement
Minor Local Street	Not specified	Gravel Surfaced Road

(2) Methodology

Pavement design is carried out based on "AASHTO Guide for Design of Pavement Structures 1993" (AASHTO Guide).

Asphalt Pavement

The AASHTO Guide gives the basic design equation for flexible pavement (asphalt pavement) as follows:

Basic Design Equation for Flexible Pavement

$$\log_{10}(W_{18}) = Z_R \times S_0 + 9.36 \times \log_{10}(SN + 1) - 0.20 + \frac{\text{Log}_{10}\left(\frac{\triangle PSI}{4.2\text{-}1.5}\right)}{0.40 + \frac{1094}{(SN+!)^{5.19}}} + 2.32 \times \log_{10}(M_R) - 8.07$$

where

W_{18}	=	predicted number of 18-kip equivalent single axle load (ESAL) applications,
Z_R	=	standard normal deviate corresponding to level of reliability,
S_o	=	combined standard error of the traffic prediction and performance prediction,
△PSI	=	difference between the initial design serviceability index, p_o, and the design terminal serviceability index, p_t, and
M_R	=	resilient modulus of roadbed soil (psi).

SN is equal to the structural number indicative of the total pavement thickness required:

$$SN = a_1D_1 + a_2D_2m_2 + a_3D_3m_3$$

where

a_i	=	i^{th} layer coefficient,
D_i	=	i^{th} layer thickness (inches), and
m_i	=	i^{th} layer drainage coefficient.

i=1 : Surface Course
i=2 : Base Course
i=3 : Subbase Course

Gravel Pavement

The AASHTO Guide gives the design procedure with nomograph for the design of the aggregate surfaced roads, and also provides the design catalog that may be used for the design of low-volume roads. The catalog shows the recommended aggregate base thickness, according to the relative quality of roadbed soil, traffic level and U.S. Climate Region*. The design catalog is applied to the pavement design in this Study,

* The United States are divided into six climate regions depending on the meteorological characteristics.

(3) Design Inputs

The design inputs are shown in Table 17.5.2-2.

Table 17.5.2-2 Design Inputs

Item	Description	Design Condition	Design Input					
			Arterial Street (C2-3)	Arterial Street (R5-2)	Collector Street (CR1)	Collector Street (CR3)	Major Local Street (L(I)1)	Minor Local Street
Performance Period	The period of time that an initial pavement structure will last before it needs rehabilitation.	Asphalt pavement : 10 years Gravel pavement : 3years	10 years (2012-2021)	10 years (2012-2021)	10 years (2012-2021)	10 years (2012-2021)	10 years (2012-2021)	3 years (2012-2014)
Traffic Load	The traffic load is expressed by cumulative number of 18-kip equivalent single axle load (ESAL) applications (w_{18}) during the performance period.	w_{18} is calculated based on the future truck volume which is converted to 18-kip ESALs applying the axle load equivalency factors given in the AASHTO Guide.	w_{18} =12,088,000	w_{18} =12,647,000	w_{18} =3,854,000	w_{18} =2,249,000	w_{18} =869,000	w_{18} =45,000
Reliability	Means of incorporating some degree of certainty into the design process.	The level of reliability (R): - Arterial & Collector Streets : 80% - Local Street : 60%	R=80% Z_R=-0.841 S_o=0.45	R=80% Z_R=-0.841 S_o=0.45	R=80% Z_R=-0.841 S_o=0.45	R=80% Z_R=-0.841 S_o=0.45	R=60% Z_R=-0.253 S_o=0.45	-
Performance Criteria	The Present Serviceability Index (PSI) is used to represent pavement performance. The total change in PSI (△PSI) is defined as the difference between initial serviceability index (p_0: value immediately after construction) and terminal serviceability index (p_t: lowest index that will tolerate before rehabilitation, resurfacing or reconstruction)	p_0 = 4.2 (for all asphalt pavement) pt = 2.5 (for Arterial & Collector Streets) 2.0 (for Major Local Street)	p_0=4.2 pt=2.5 △PSI=1.7	p_0=4.2 pt=2.5 △PSI=1.7	p_0=4.2 pt=2.5 △PSI=1.7	p_0=4.2 pt=2.5 △PSI=1.7	p_0=4.2 pt=2.0 △PSI=2.2	
Roadbed Soil Property	The resilient modulus (M_R) is used. The AASHTO Guide introduces the equation estimating M_R from CBR as M_R = 1,500 x CBR (CBR is regarded as 10 in case of CBR more than 10)	Other sections than CR3 :CBR≥10 Section CR3 : CBR=7	M_R =15,000psi (CBR≥10)	M_R =15,000psi (CBR≥10)	M_R =15,000psi (CBR≥10)	M_R =10,500psi (CBR=7)	M_R =15,000psi (CBR≥10)	M_R=10,500 ～15,000psi
Pavement Layer Material Properties	The pavement strength is expressed by the structural number (SN) which is calculated as : $SN = a_1D_1 + a_2D_2m_2 + a_3D_3m_3$ where a_i=i^{th} layer coefficient D_i=i^{th} layer thickness (inches) m_i=i^{th} layer drainage coefficient	Asphalt concrete surface course: a_1=0.390 (E_{AC}=350,000 psi) Granular base course: a_2=0.135 (CBR=80) Granular subbase course: a_3=0.094 (CBR=20)	a_1=0.390 a_2=0.135 a_3=0.094	a_1=0.390 a_2=0.135 a_3=0.094	a_1=0.390 a_2=0.135 a_3=0.094	a_1=0.390 a_2=0.135 a_3=0.094	a_1=0.390 a_2=0.135 a_3=0.094	a_2=0.135 a_3=0.094
Drainage Condition	The factor to modify the SN considering the effects of drainage.	m_2=m_3=1.0 (water removed within 1 week, and pavement structure is exposed to moisture levels approaching saturation during 5% of the year)	m_2=1.0 m_3=1.0	m_2=1.0 m_3=1.0	m_2=1.0 m_3=1.0	m_2=1.0 m_3=1.0	m_2=1.0 m_3=1.0	m_2=1.0 m_3=1.0

(4) Flexible Pavement (Asphalt Pavement) Design

Required Structural Number

Table 17.5.2-3 shows the required structural number.

Table 17.5.2-3 Required Structural Number

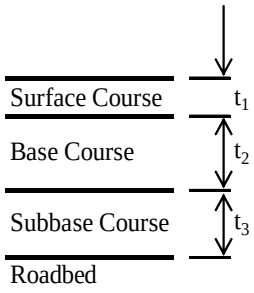
Road Class		Arterial Street		Collector Street		Major Local
Section		C2-3	R5-2	CR1	CR3	L(I)1
Inputs	W_{18}	12,088,000	12,647,000	3,854,000	2,249,000	869,000
	Z_R	-0.841	-0.841	-0.841	-0.841	-0.253
	S_o	0.45	0.45	0.45	0.45	0.45
	△PSI	1.7	1.7	1.7	1.7	2.2
	M_R	15,000	15,000	15,000	10,500	15,000
Required SN		**3.724**	**3.751**	**3.087**	**3.238**	**2.148**

Selection of Layer Thicknesses

Table 17.5.2-4 shows the thicknesses selected.

Table 17.5.2-4 Layer Thicknesses Selected

		Arterial Street (Section C2-3 & Section R5-2)	Collector Street (Section CR1 & Section CR3)	Major Local St. (Section L(I)1)
Thickness	Surface Course (t_1)	10 cm	10 cm	5 cm
	Base Course (t_2)	20 cm	15 cm	15 cm
	Subbase Course (t_3)	35 cm	25 cm	25 cm
	Total	65 cm	50 cm	45 cm
Structural Number (SN)		3.893	3.257	2.490
Required Structural Number		3.724 (C2-3) 3.751 (R5-2)	3.087 (CR1) 3.238 (CR3)	2.148

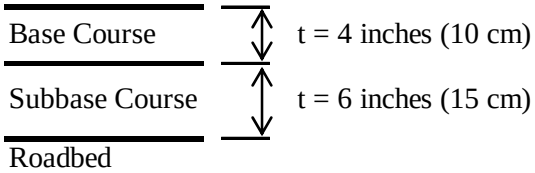


The structural number (SN) is superior to the required.

(5) Aggregate-Surfaced Road (Gravel Pavement) Design for Minor Local Street

The AASHTO Guide provides the design catalog to give the thickness of aggregate base required for the given three factors: U.S. Climate Region, relative quality of roadbed soil and traffic level. Assuming U.S. Climate Region IV (dry, no freeze), relative quality of roadbed soil as Good (M_R≥7,900 psi), and traffic level as Medium (18-kip ESALs 30,000 to 60,000), the base thickness required is given 7 inches. Out of 7 inches, 3 inches are converted to the equivalent thickness of subbase, which is 6 inches.

The layer thickness is as follows:



17.5.3 Drainage Design

(1) Design Procedure for Road Drainage

Figure 17.5.3-1 illustrates the procedural flow of the road drainage design in the urban area.

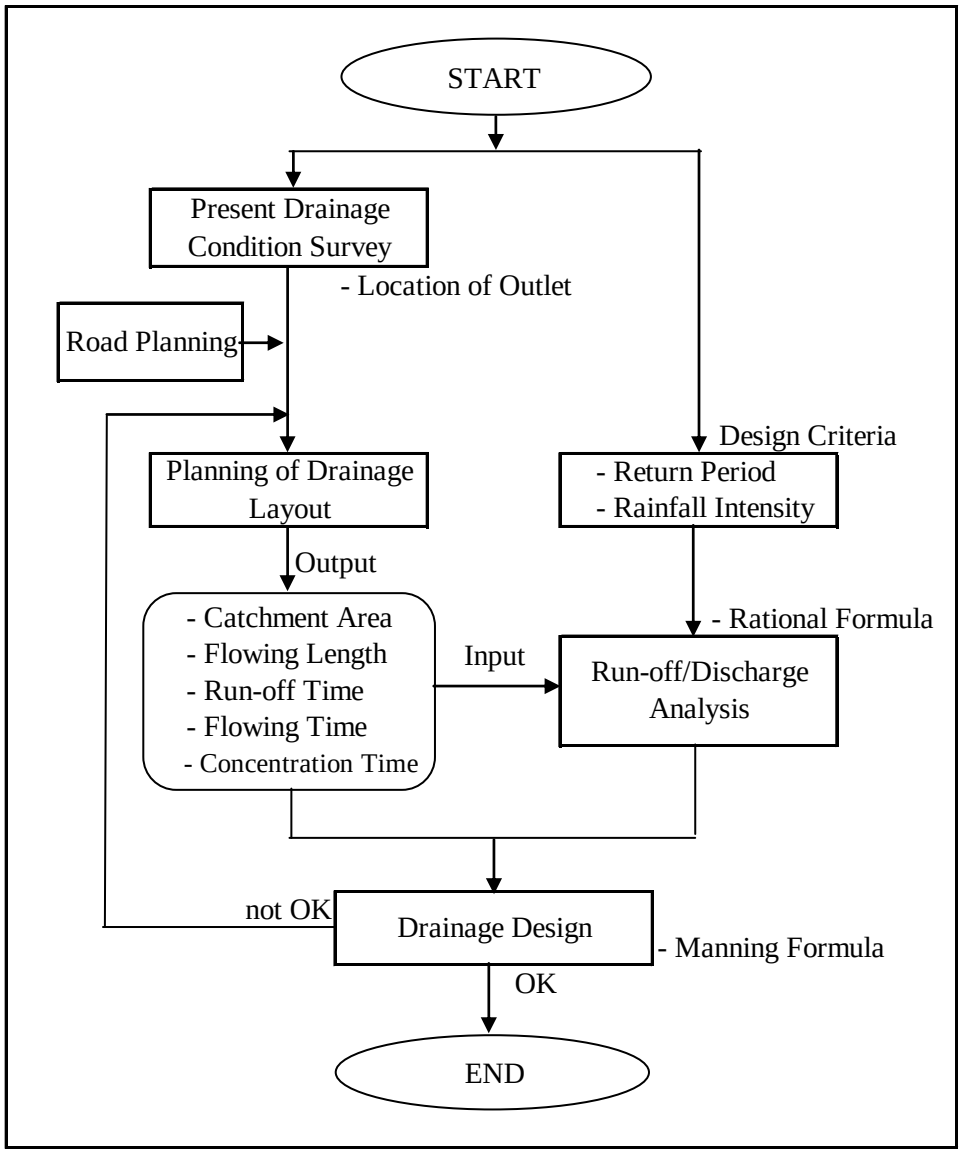


Figure 17.5.3-1 Procedural Flow of Road Drainage Design

Present Drainage Condition Survey

In connection with road drainage planning, the present condition of CCD is surveyed, especially on the matters relevant to the existing tributaries and the locations of outlets for the road drainage. Based on the condition survey, the best locations for the outlets are identified.

Planning of Drainage Layout

Base on the present drainage condition survey and the prepared road plan, the road drainage layout is planned as shown in Figure 17.5.3-2, taking into consideration the following:

- The pipe drains are installed on both sides of the arterial streets and collector streets.
- The open concrete ditches are installed on both sides of the local streets.
- The length of drainage between start point and the outlet shall be minimized as much as possible.

Figure 17.5.3-2 Road Drainage Layout Plan in CCD

Return Period and Rainfall Intensity

Generally the design storm frequency and the design rainfall intensity as design criteria refer to the official design criteria prepared based on the cumulative information and data. However, the design criteria are not issued officially yet. In this connection, Table 17.5.3-1 is proposed in this Study.

Table 17.5.3-1 Design Storm Frequency and Rainfall Intensity for Design of Road Drainage

Item \ Road Class	Arterial Street	Collector Street	Local Street
Design Storm Frequency	10 years	5 years	5 years
Average Rainfall Intensity	65 mm/hr	50 mm/hr	50 mm/hr

Run-off/Discharge Analysis

The Rational Method is commonly used for estimating the design storm peak runoff for areas up to 50 hectares. The Rational Formula is expressed as:

$$Q = 0.00278\ C\ I\ A$$

where:

Q : maximum rate of runoff, m^3/sec

C : runoff coefficient representing a ratio of runoff to rainfall

I : average rainfall intensity for the duration equal to the time of concentration, for a selected return period, mm/hr

A : catchment area of the design location, ha

Design of Drainage

The discharge capacity of drain is given by Manning's Equation expressed as:

$$Qc = (1/n)\ A\ R^{2/3}\ S^{1/2}$$

where:

Qc : Discharge capacity, m^3/sec

A : Cross-sectional area of flow, m^3

n : Manning roughness coefficient

R : hydraulic radius = A/P, m

P : wetted perimeter, m

S : slope of water flow line, m/m

(2) Run-off/Discharge Analysis

Tables 17.5.3-2 to 17.5.3-4 show the analyzed discharges by using the Rational Formula, where only road surface including travelled way and sidewalk is considered as the catchment area.

Table 17.5.3-2 Run-off/Discharge on Arterial Streets

Road Classification	Road Width (m)	Half Road Width (m)	Length (m)	Catchment Area (ha)	Runoff Coefficient	Average Rainfall mm/hr	Dischage litter/sec
Arterial Street	22.200	11.100	100.000	0.11100	0.80	65	16.046
			200.000	0.22200	0.80	65	32.092
			300.000	0.33300	0.80	65	48.138
			400.000	0.44400	0.80	65	64.185
			500.000	0.55500	0.80	65	80.231
			600.000	0.66600	0.80	65	96.277
			700.000	0.77700	0.80	65	112.323
			800.000	0.88800	0.80	65	128.369
			900.000	0.99900	0.80	65	144.415
Arterial Street	18.200	9.100	100.000	0.09100	0.80	65	13.155
			200.000	0.18200	0.80	65	26.310
			300.000	0.27300	0.80	65	39.465
			400.000	0.36400	0.80	65	52.620
			500.000	0.45500	0.80	65	65.775
			600.000	0.54600	0.80	65	78.930
			700.000	0.63700	0.80	65	92.085
			800.000	0.72800	0.80	65	105.240
			900.000	0.81900	0.80	65	118.395

Table 17.5.3-3 Run-off/Discharge on Collector Streets

Road Classification	Road Width	Half Road Width	Length	Catchment Area	Runoff Coefficient	Average Rainfall Intensity	Dischage
	(m)	(m)	(m)	(ha)		mm/hr	litter/sec
Collector Street	21.600	10.800	100.000	0.10800	0.80	50	12.010
			200.000	0.21600	0.80	50	24.019
			300.000	0.32400	0.80	50	36.029
			400.000	0.43200	0.80	50	48.038
			500.000	0.54000	0.80	50	60.048
			600.000	0.64800	0.80	50	72.058
			700.000	0.75600	0.80	50	84.067
			800.000	0.86400	0.80	50	96.077
			900.000	0.97200	0.80	50	108.086
Collector Street	17.600	8.800	100.000	0.08800	0.80	50	9.786
			200.000	0.17600	0.80	50	19.571
			300.000	0.26400	0.80	50	29.357
			400.000	0.35200	0.80	50	39.142
			500.000	0.44000	0.80	50	48.928
			600.000	0.52800	0.80	50	58.714
			700.000	0.61600	0.80	50	68.499
			800.000	0.70400	0.80	50	78.285
			900.000	0.79200	0.80	50	88.070

Table 17.5.3-4 Run-off/Discharge on Major Local Street

Road Classification	Road Width	Half Road Width	Length	Catchment Area	Runoff Coefficient	Average Rainfall Intensity	Dischage
	(m)	(m)	(m)	(ha)		mm/hr	litter/sec
Major Local Street	20.600	10.300	100.000	0.10300	0.80	50	11.454
			200.000	0.20600	0.80	50	22.907
			300.000	0.30900	0.80	50	34.361
			400.000	0.41200	0.80	50	45.814
			500.000	0.51500	0.80	50	57.268
			600.000	0.61800	0.80	50	68.722
			700.000	0.72100	0.80	50	80.175
			800.000	0.82400	0.80	50	91.629
			900.000	0.92700	0.80	50	103.082
Major Local Street	16.000	8.000	100.000	0.08000	0.80	50	8.896
			200.000	0.16000	0.80	50	17.792
			300.000	0.24000	0.80	50	26.688
			400.000	0.32000	0.80	50	35.584
			500.000	0.40000	0.80	50	44.480
			600.000	0.48000	0.80	50	53.376
			700.000	0.56000	0.80	50	62.272
			800.000	0.64000	0.80	50	71.168
			900.000	0.72000	0.80	50	80.064

(3) Discharge Capacity

The discharge capacity is computed for various pipes and channels and presented in Appendix 12.

(4) Design Example

The right side drainage of the collector street CR1-1 to CR1-3 is designed below as a design example (See Table 17.5.3-5 and Figure 17.5.3-3).

Table 17.5.3-5 Design Example: Design Computation

Section	Length (m)	Catchment Area (ha)	Dischage (litter/sec)	Drainage	Grade (%)	Velocity (m/sec)	Discharge Capacity (litter/sec)	Allowable Discharge (litter/sec)	
SEC-1	200.000	0.21600	24.019	PC-600	1.75%	2.87	812.26	649.81	OK
SEC-2	400.000	0.43200	48.038	PC-600	0.20%	0.97	274.59	219.68	OK
SEC-3	600.000	0.64800	72.058	PC-600	0.20%	0.97	274.59	219.68	OK
SEC-4	800.000	0.86400	96.077	PC-600	1.90%	2.99	846.36	677.09	OK
SEC-5	1,000.000	1.08000	120.096	PC-600	1.90%	2.99	846.36	677.09	OK
SEC-6	1,100.000	1.18800	132.106	PC-600	1.90%	2.99	846.36	677.09	OK

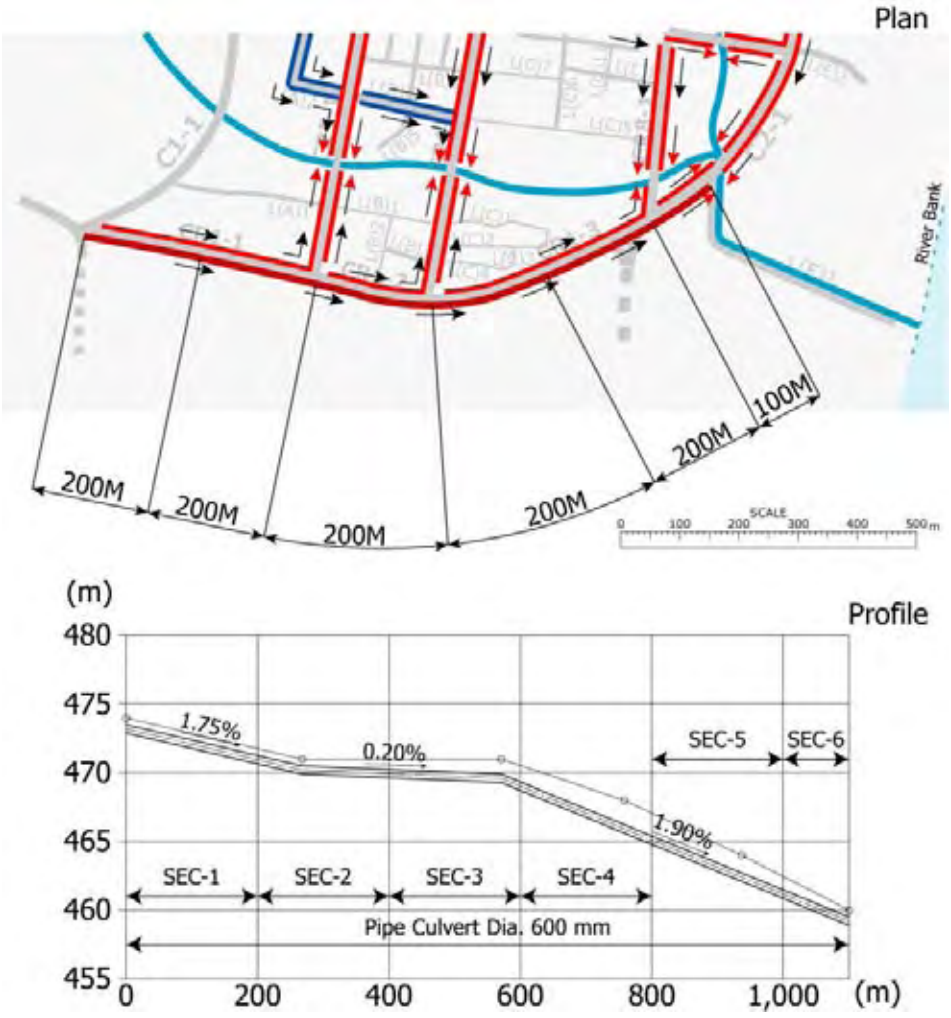


Figure 17.5.3-3 Design Example: Plan & Profile

17.5.4 Intersection Design

(1) Design Intersections and Types

4 major intersections shown in Figure 17.5.4-1 are discussed.

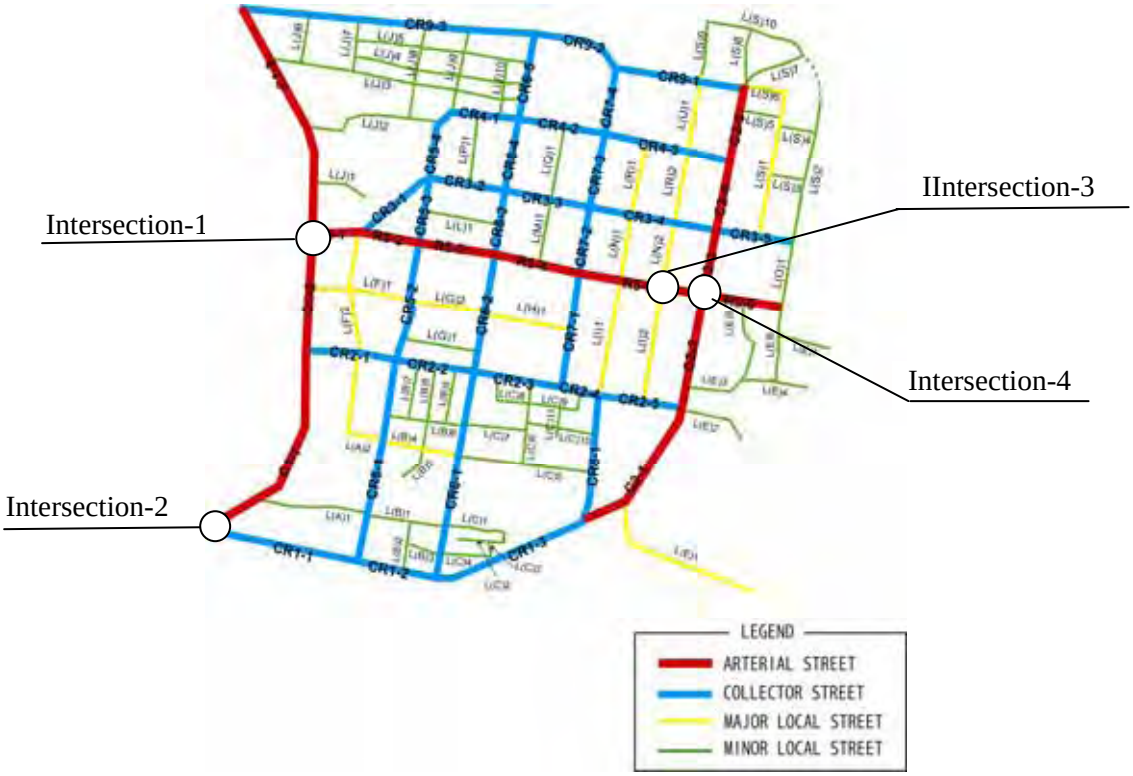


Figure 17.5.4-1 Design Intersections

The intersections are designed for the estimated traffic in 2015. The intersection types to be considered are as follows:

- Intersections-1, 2 and 3 (roundabout type at present) :
  At first, the capacity of roundabout type is examined for the estimated traffic in 2015. If the roundabout is judged to be well operational, the same type is proposed. If not, the signalized intersection is designed.
- Intersections-4 (not roundabout type at present) :
  Considering the limited capacity of roundabout type, the signalized intersection is designed.

(2) Methodology and Conditions

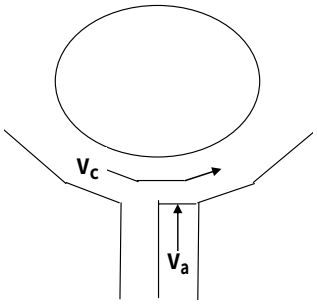
Reference

"Highway Capacity Manual, 2000" (HCM2000) is used as reference.

Roundabout

The capacity of each approach is estimated by the following equation:

$$c_a = \frac{v_c \exp(-v_c t_c / 3600)}{1 - \exp(-v_c t_f / 3600)}$$



where

c_a = Approach capacity (veh/h),
v_c = Conflicting circulating traffic (veh/h),
t_c = Critical gap (s), and
t_f = Follow-up time (s).

Table 17.5.4-1 shows the critical gap, t_c and follow-up time, t_f which are recommended in the HCM2000.

Table 17.5.4-1 Critical Gap and Follow-up Times for Roundabouts

	Critical Gap (second)	Follow-up Time (second)
Upper Bound	4.1	2.6
Lower Bound	4.6	3.1

In this design, the critical gap and follow-up time are assumed to be 4.6 and 3.1 seconds respectively, applying the lower boundary considering the Sudanese drivers' manueuver.

Signalized Intersection

The capacity of each lane group is given by the following equation :

$$c_i = s_i \, g_i / C$$

$$s_i = s_o \, N \, f_W \, f_{HV} \, f_g \, f_p \, f_{bb} \, f_a \, f_{LU} \, f_{LT} \, f_{RT} \, f_{Lpb} \, f_{Rpb}$$

where

c_i = Capacity for lane group i (veh/h),
s_i = Saturation flow rate for lane group i (veh/h),
g_i = Effective green time for lane group i (second),
C = Cycle length (second),
s_o = Base saturation flow rate per lane (pc/h/lane),
N = Number of lanes in lane group,
f_W = Adjustment factor for lane width,
f_{HV} = Adjustment factor for heavy vehicles in traffic stream,
f_g = Adjustment factor for approach grade,
f_p = Adjustment factor for existence of a parking lane and parking activity adjacent to lane group,
f_{bb} = Adjustment factor for blocking effect of local buses that stop within intersection area,
f_a = Adjustment factor for area type,
f_{LU} = Adjustment factor for lane utilization,
f_{LT} = Adjustment factor for left turns in lane group,
f_{RT} = Adjustment factor for right turns in lane group,
f_{Lpb} = Pedestrian adjustment factor for left-turn movements, and
f_{Rpb} = Pedestrian-bicycle adjustment factor for right-turn movements.

In this design, base saturation flow rate is assuemed to be 1,900 passenger cars per hour per lane (pc/h/lane) and adjustment factors, f_g, f_p, f_{bb}, f_{LU}, f_{Lpb} and f_{Rpb} are assumed to be 1.0. Other adjustment factors are given by the equations shown in table 17.5.4-2.

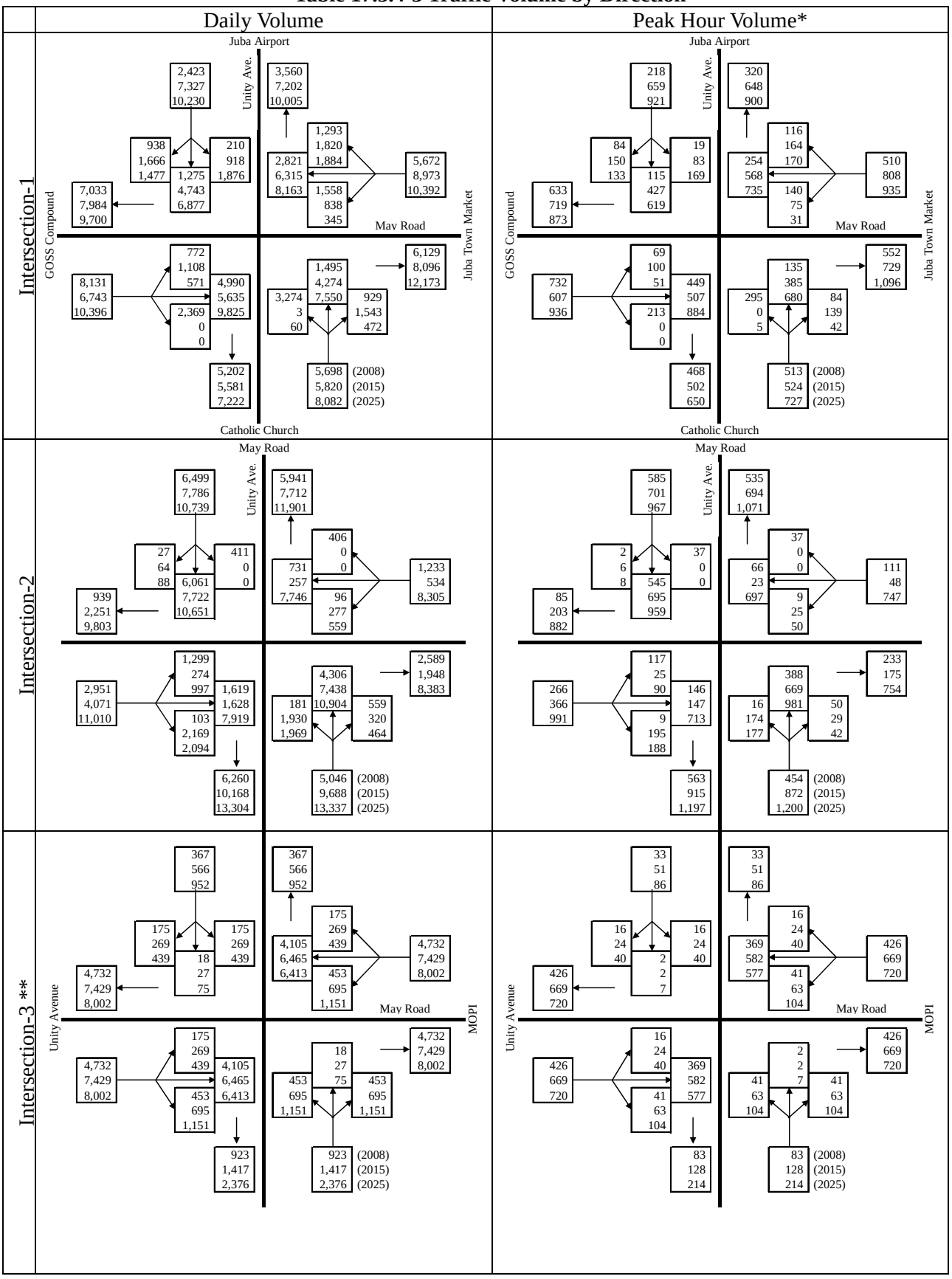
Table 17.5.4-2 Adjustment Factors

Factor	Formula	Definition of Variables
Lane width	$f_W = 1+(W-3.6)/9$	W = lane width (m)
Heavy vehicles	$f_{HV} = \frac{100}{100+HV(E_T-1)}$	HV = % heavy vehicles E_T = car equivalent factor of truck (1.38)
Area type	f_a = 0.900 in CBD f_a = 1.000 in other areas	
Left turns	Protected phasing Exclusive lane: f_{LT} = 0.95 Shared lane : $f_{LT} = 1/(1+0.05P_{LT})$	P_{LT} = proportion of left turns in lane group
Right turns	Exclusive lane : f_{RT} = 0.85 Shared lane : f_{RT} = 1.0-0.15 P_{RT} Single lane : f_{RT} = 1.0-0.135 P_{RT}	P_{RT} = proportion of right turns in lane group

(3) Directional Traffic Volume

Traffic volume by direction is shown in Table 17.5.4-3.

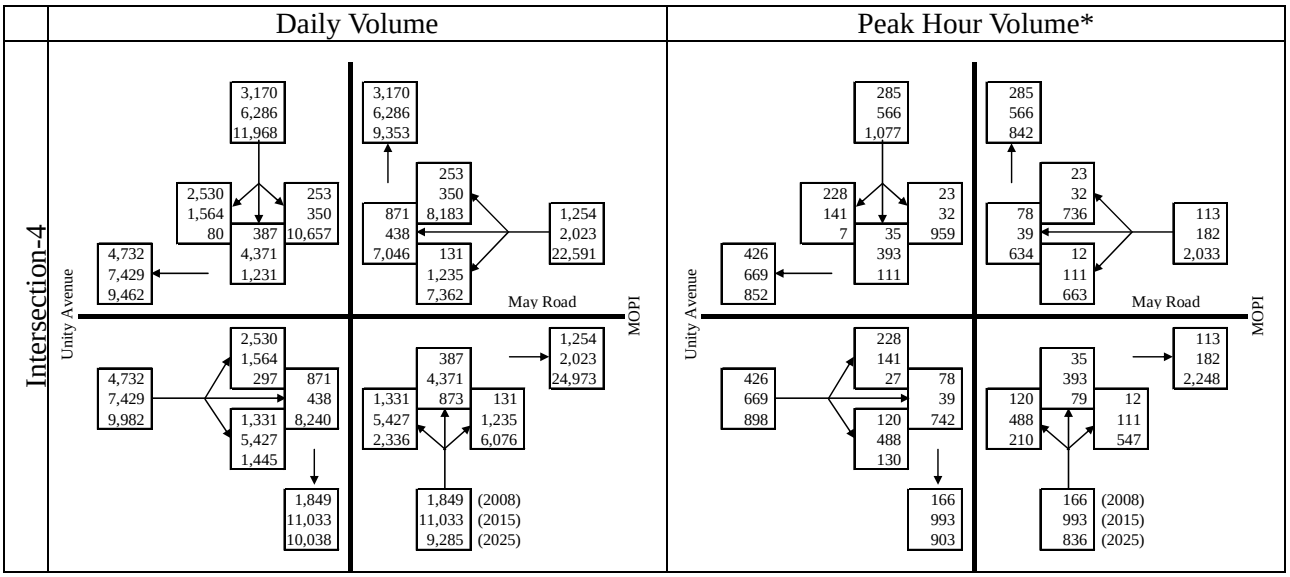
Table 17.5.4-3 Traffic Volume by Direction



* The peak rate is assumed to be 9.0 %.

** Estimated traffic volume without one-way operation.

Table 17.5.4-3 Traffic Volume by Direction (Continued)



* The peak rate is assumed to be 9.0 %.

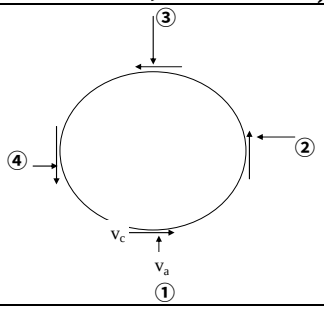
(4) Design of Intersection-1

Roundabout

Table 17.5.4-4 shows the intersection capacity analysis in case of roundabout type.

Table 17.5.4-4 Intersection Capacity Analysis (Intersection-1, Roundabout, 2015 Traffic)

Approach No.	Conflicting Circulating Traffic, v_c (veh/h)	Approach Capacity, c_a (veh/h)	Traffic Flow, v_a (veh/h)	Volume to Capacity Ratio, v_a/c_a
①	690	638	524	0.82
②	485	764	808	1.06
③	643	665	659	0.99
④	585	700	607	0.87



The traffic demand exceeds the capacity at Approach② and the demands are close to the capacities at all other approaches. Furthermore, the radius of the existing roundabout is very small, providing a little space for storage of vehicles. Thus, the roundabout type of intersection is not considered to be able to manage the 2015 traffic demand. Consequently, a signalized intersection is proposed for this intersection.

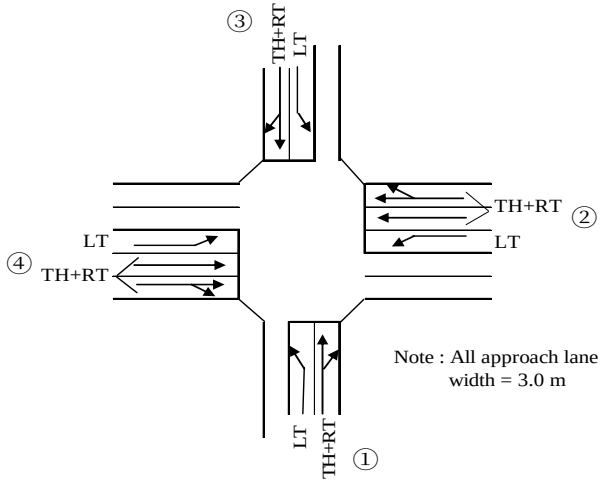
Signalized Intersection

Table 17.5.4-5 shows the intersection capacity analysis in case of signalized intersection type.

Table 17.5.4-5 Intersection Capacity Analysis (Intersection-1, Signalized, 2015 Traffic)

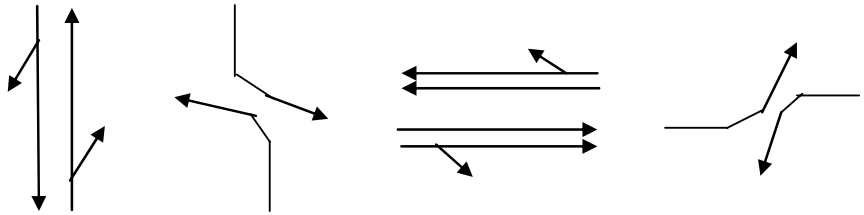
Assumptions

Number of Lanes and Lane Group



Signal Phasing

Cycle=120 sec



Green+(Yellow)	56+(2)	10*+(2)	35+(2)	11+(2)

* Minimum green time is set at 10 seconds.

Note : The signal phasing shall be determined based on the actual traffic volume. The above plan is just trial based on the estimated traffic volume.

Capacity Analysis

Approach	Lane Group	Capacity								Effective Green Rate	Capacity (veh/h)	Traffic Demand (veh/h)	v/c Ratio
		s_o (pc/h/lane)	N	Adjustment Factors					S_i (veh/h)				
				f_W	f_{HV}	f_a	f_{LT}	f_{RT}					
①	LT	1,900	1	W=3.0m f_W = 0.933	HV=47 % f_{HV} = 0.848	Area = CBD f_a = 0.900	Exclusive f_{LT} = 0.95	-	s = 1,285	10 / 120	107	0	0.00
	TH+RT	1,900	1	W=3.0m f_W = 0.933	HV=26 % f_{HV} = 0.910	Area = CBD f_a = 0.900	-	P_{RT} = 0.265 f_{RT} = 0.960	s = 1,394	56 / 120	651	524	0.80
②	LT	1,900	1	W=3.0m f_W = 0.933	HV=15 % f_{HV} = 0.946	Area = CBD f_a = 0.900	Exclusive f_{LT} = 0.95	-	s = 1,434	11 / 120	131	75	0.57
	TH+RT	1,900	2	W=3.0m f_W = 0.933	HV=31 % f_{HV} = 0.895	Area = CBD f_a = 0.900	-	P_{RT} = 0.224 f_{RT} = 0.966	s = 2,759	35 / 120	805	732	0.91
③	LT	1,900	1	W=3.0m f_W = 0.933	HV=20 % f_{HV} = 0.929	Area = CBD f_a = 0.900	Exclusive f_{LT} = 0.95	-	s = 1,408	10 / 120	117	83	0.71
	TH+RT	1,900	1	W=3.0m f_W = 0.933	HV=33 % f_{HV} = 0.889	Area = CBD f_a = 0.900	-	P_{RT} = 0.260 f_{RT} = 0.961	s = 1,363	56 / 120	636	577	0.91
④	LT	1,900	1	W=3.0m f_W = 0.933	HV=44 % f_{HV} = 0.857	Area = CBD f_a = 0.900	Exclusive f_{LT} = 0.95	-	s = 1,299	11 / 120	119	100	0.84
	TH+RT	1,900	2	W=3.0m f_W = 0.933	HV=41 % f_{HV} = 0.865	Area = CBD f_a = 0.900	-	P_{RT} = 0.000 f_{RT} = 1.000	s = 2,760	35 / 120	805	507	0.63

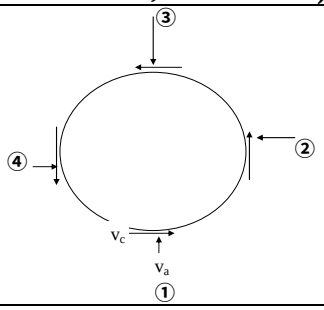
(5) Design of Intersection-2

Roundabout

Table 17.5.4-6 shows the intersection capacity analysis in case of roundabout type.

Table 17.5.4-6 Intersection Capacity Analysis (Intersection-2, Roundabout, 2015 Traffic)

Approach No.	Conflicting Circulating Traffic, v_c (veh/h)	Approach Capacity, c_a (veh/h)	Traffic Flow, v_a (veh/h)	Volume to Capacity Ratio, v_a/c_a
①	172	1003	872	0.87
②	868	544	48	0.09
③	222	961	701	0.73
④	720	621	366	0.59



The traffic demand in 2015 is within the capacity at every approach and the existing roundabout has relatively big radius. Thus, existing roundabout is considered to accomodate the 2015 traffic demand. Therefore, no improvement is proposed.

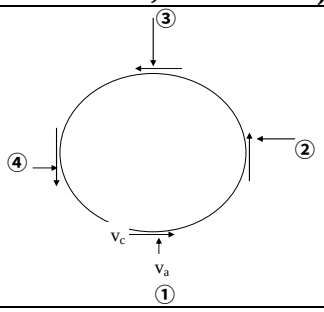
(6) Design of Intersection-3

Roundabout

Table 17.5.4-7 shows the intersection capacity analysis in case of roundabout type.

Table 17.5.4-7 Intersection Capacity Analysis (Intersection-3, Roundabout, 2015 Traffic)

Approach No.	Conflicting Circulating Traffic, v_c (veh/h)	Approach Capacity, c_a (veh/h)	Traffic Flow, v_a (veh/h)	Volume to Capacity Ratio, v_a/c_a
①	630	673	128	0.19
②	89	1,077	669	0.62
③	708	628	51	0.08
④	89	1,077	669	0.62



Since the traffic demand in 2015 is within the capacity at every approach with enough allowance although the existing roundabout has a small radius, it is proposed to leave the existing type for the time being.

(7) Design of Intersection-4

This intersection is not roundabout type at present. A signalized intersection is proposed.

Signalized Intersection

Table 17.5.4-8 shows the intersection capacity analysis in case of signalized intersection type.

(8) Summary

Table 17.5.4-9 summarizes the intersection design.

Table 17.5.4-9 Summary of Intersection Design

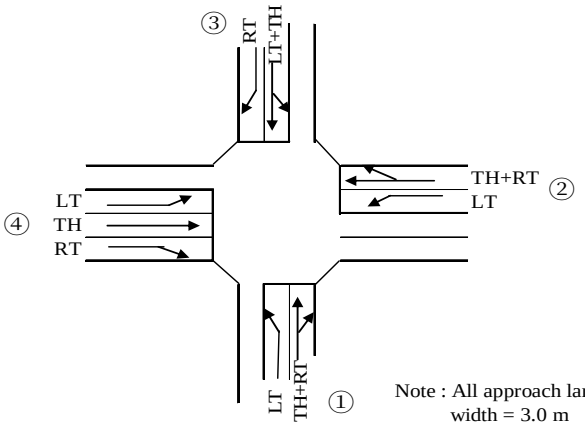
Intersection	Existing Type	Proposed Type	Maximum volume/capacity Ratio (2015)
Intersection-1	Roundabout	Signalized Intersection	0.91
Intersection-2	Roundabout	Roundabout	0.87
Intersection-3	Roundabout	Roundabout	0.62
Intersection-4	-	Signalized Intersection	0.91

Figure 17.5.4-2 shows the example of intersection design (Intersection-1). Figure 17.5.4-3 shows the typical traffic signal.

Table 17.5.4-8 Intersection Capacity Analysis (Intersection-4, Signalized, 2015 Traffic)

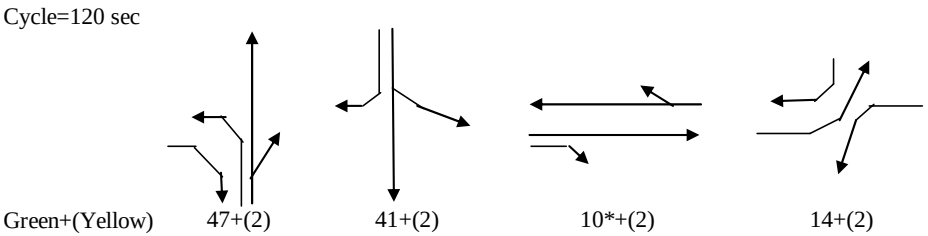
Assumptions

Number of Lanes and Lane Group



Note : All approach lane width = 3.0 m

Signal Phasing



* Minimum green time is set at 10 seconds.

Note : The signal phasing shall be determined based on the actual traffic volume. The above plan is just trial based on the estimated traffic volume.

Capacity Analysis

Approach	Lane Group	Capacity									Traffic Demand (veh/h)	v/c Ratio
				Adjustment Factors						Effective Green Rate	Capacity (veh/h)		
		s_o (pc/h/lane)	N	f_W	f_{HV}	f_a	f_{LT}	f_{RT}	s_i (veh/h)				
①	LT	1,900	1	W=3.0m f_W = 0.933	HV=23 % f_{HV} = 0.920	Area = CBD f_a = 0.900	Exclusive f_{LT} = 0.950	-	s = 1,394	47 / 120	546	488	0.89
	TH+RT	1,900	1	W=3.0m f_W = 0.933	HV=23 % f_{HV} = 0.920	Area = CBD f_a = 0.900	-	P_{RT} = 0.220 f_{RT} = 0.967	s = 1,419	47 / 120	556	504	0.91
②	LT	1,900	1	W=3.0m f_W = 0.933	HV=32 % f_{HV} = 0.892	Area = CBD f_a = 0.900	Exclusive f_{LT} = 0.950	-	s = 1,352	14 / 120	158	111	0.70
	TH+RT	1,900	1	W=3.0m f_W = 0.933	HV=32 % f_{HV} = 0.892	Area = CBD f_a = 0.900	-	P_{RT} = 0.451 f_{RT} = 0.932	s =1,326	10 / 120	111	71	0.64
③	LT+TH	1,900	1	W=3.0m f_W = 0.933	HV=35 % f_{HV} = 0.883	Area = CBD f_a = 0.900	P_{LT}= 0.075 f_{RT} =0.996	-	s = 1,403	41 / 120	479	425	0.89
	RT	1,900	1	W=3.0m f_W = 0.933	HV=35 % f_{HV} = 0.883	Area = CBD f_a = 0.900	-	Exclusive f_{RT} = 0.850	s = 1,197	55 / 120	549	141	0.26
④	LT	1,900	1	W=3.0m f_W = 0.933	HV=36 % f_{HV} = 0.880	Area = CBD f_a = 0.900	Exclusive f_{LT} = 0.950	-	s = 1,334	14 / 120	156	141	0.90
	TH	1,900	1	W=3.0m f_W = 0.933	HV=36 % f_{HV} = 0.880	Area = CBD f_a = 0.900	-	-	s = 1,404	10 / 120	117	39	0.33
	RT	1,900	1	W=3.0m f_W = 0.933	HV=36 % f_{HV} = 0.880	Area = CBD f_a = 0.900	-	Exclusive f_{RT} = 0.850	s = 1,193	57 / 120	567	488	0.86

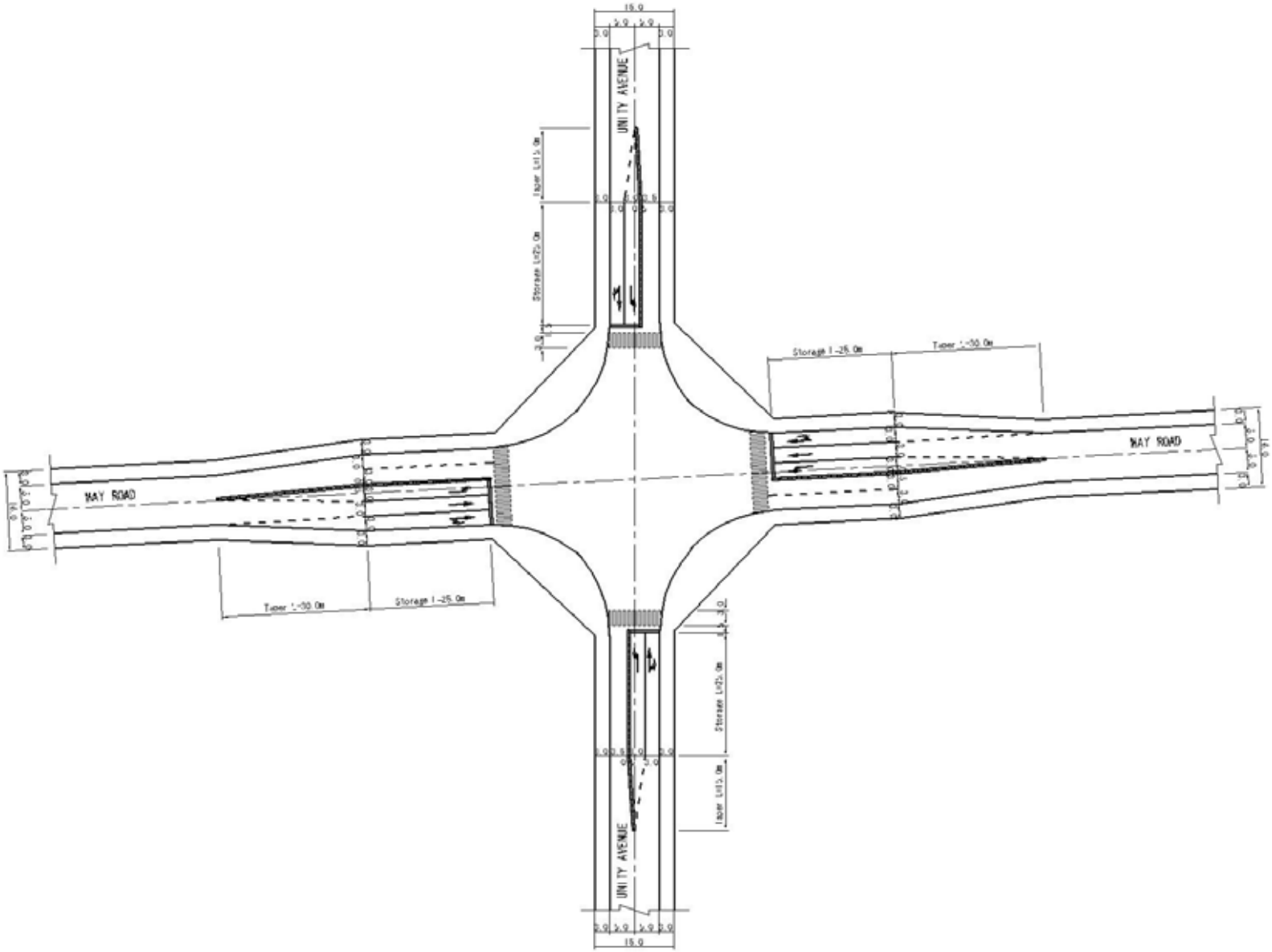


Figure 17.5.4-2 Intersection Design Example (Intersection-1)

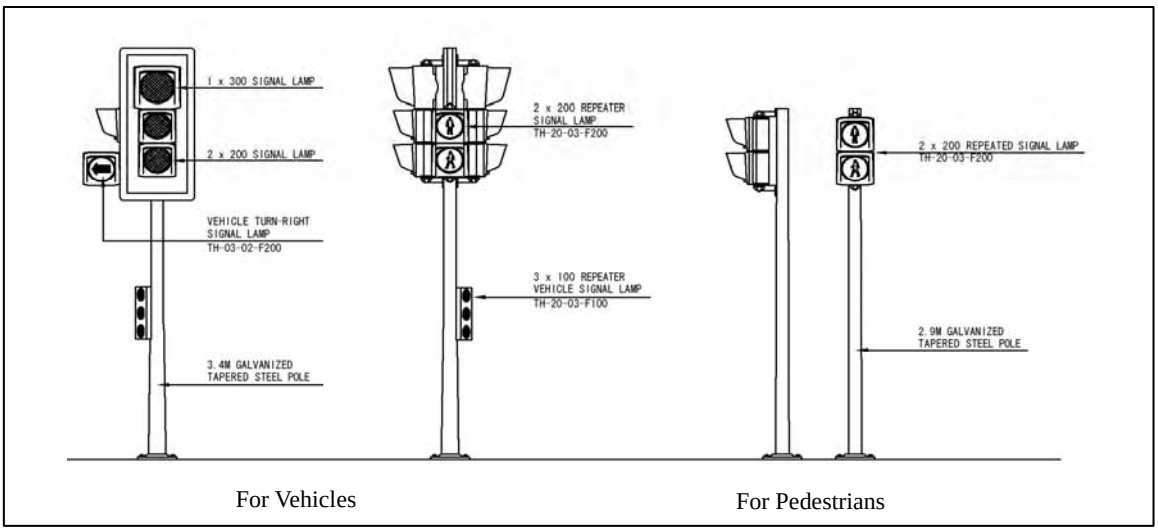


Figure 17.5.4-3 Typical Traffic Signal

17.5.5 Road Ancillary Facilities

The layout plan of the road facilities is shown in Figure 17.5.1-2.

(1) Street Lighting

The objectives of street lighting are to maintain the streets in good driving condition, to reduce night time traffic accidents and to decorate roads and bridges and thus attract potential road users. Street lighting shall be thus provided for all streets except Minor Local Streets.

(2) Pavement Marking

In order to encourage safe operation of traffic and to reduce traffic accident, pavement markings as mentioned below are provided on all streets except Minor Local Streets which will be constructed initially with gravel surfacing.

- 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)

(3) Traffic Sign

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 17.5.5-1 shows the example of traffic sign.

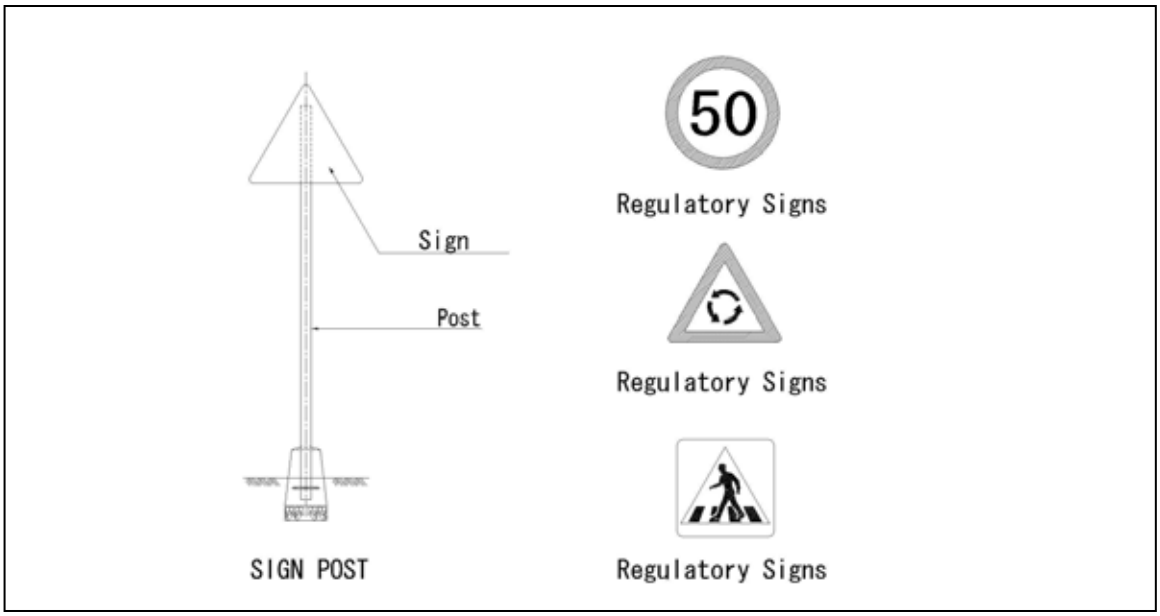


Figure 17.5.5-1 Example of Traffic Signs and Sign Post

(4) Bus Bay

Microbus is one of the most commonly operated public transportation in Juba. Currently, there are microbuses operating in the Arterial Streets. 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.

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.

The provision of bus bays/stops 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 bays/stops should be determined after consulting with the relevant authorities.

Figure 17.5.5-2 illustrates the standard bus bay and road markings to be applied.

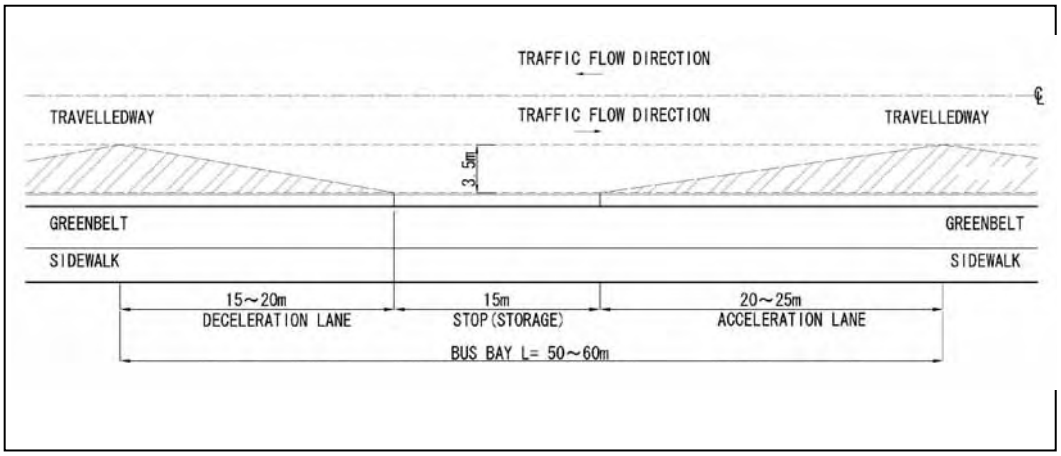


Figure 17.5.5-2 Plan of Typical Bus Bay

(5) 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 17.5.5-3 are recommended to be provided at intersections, roundabouts, bus bays/stops, markets, hospitals, schools, religious facilities and other public areas.

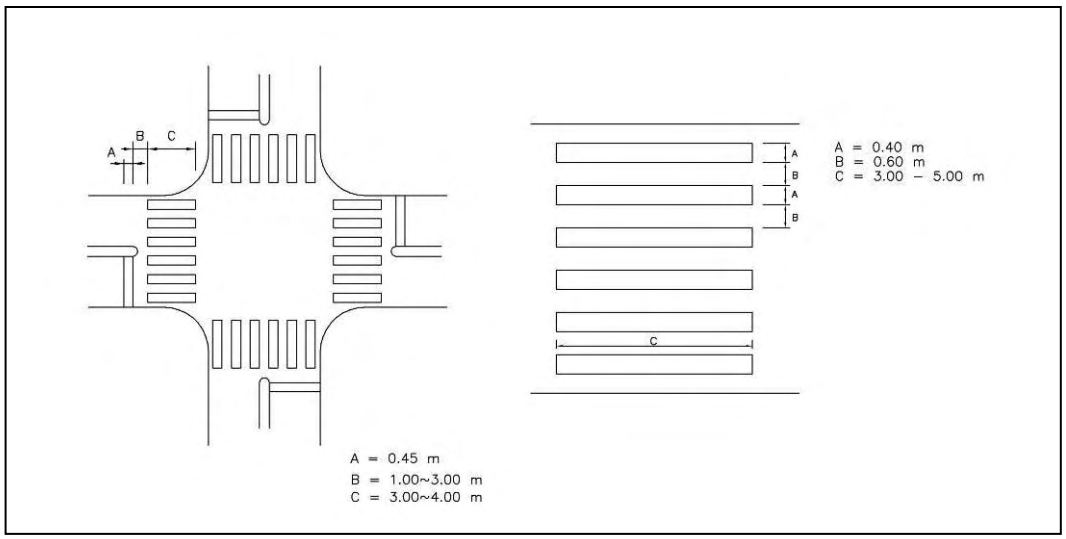


Figure 17.5.5-3 Typical Pedestrian Crossing

17.6 COST ESTIMATE

Project cost is composed of the followings:

- Right-of-way acquisition and compensation cost
- Detailed design cost
- Construction cost, including contractor overhead and contingency
- Construction supervision cost, including government administration cost

17.6.1 Right-of-way Acquisition and Compensation Cost

Since this project is planned to be executed basically within the existing available road space and therefore no relocation of houses is required, no or little cost if any, for right-of-way acquisition and compensation is necessary.

17.6.2 Detailed Design Cost

The detailed design includes the engineering surveys, detailed design, detailed cost estimate and preparation of bidding documents in case contracting-out or preparation of implementation system in case of force-account. For simplicity, the detailed design cost is assumed to be 4% of the construction cost.

17.6.3 Construction Cost

(1) Unit Cost

There is no official rates for construction cost estimate. The unit costs in this Study are estimated based on the bidding rate of the on-going Emergency Road Rehabilitation Project (ERRP) implemented by the MTR. The unit costs of major construction items used in this Study are shown in Table 17.6.3-1.

(2) Construction Cost per km

The construction costs per kilometer are calculated by tallying up the unit cost times quantity of each construction item. Table 17.6.3-2 shows the construction costs per kilometer of the road by types of typical cross-sections shown in Table 17.4.3-1.

Table 17.6.3-1 Unit Construction Costs

Item	Unit	Unit Cost (US$)
SITE CLEARANCE		
SITE CLEARANCE	SQ.M	6.50
EARTHWORKS		
EMBANKMENT	CU.M	7.00
FILL IN SOFT MATERIAL	CU.M	7.00
FILL IN HARD MATERIAL	CU.M	65.00
SPOIL IN SOFT MATERIAL	CU.M	6.00
SPOIL IN HARD MATERIAL	CU.M	55.00
COMPACTION OF EXISTING GROUND	SQ.M	2.50
COMPACTION OF 300mm BELOW FORMATION LEVEL	SQ.M	11.25
TOP SOIL	SQ.M	2.50
GRASSING	SQ.M	2.50
EXCAVATION AND FILLING FOR STRUCTURES		
EXCAVATE FOR STRUCTURES IN SOFT MATERIAL	CU.M	18.00
SELECTED GRANULAR FILL	CU.M	65.00
CULVERT AND DRAINAGE WORKS		
EXCAVATION FOR CULVERT/DRAINAGE IN SOFT MATERIAL	CU.M	18.00
SELECTED BACKFILLING	CU.M	14.00
PRECAST CONCRETE PIPE (DIA. 600)	M	265.00
PRECAST CONCRETE PIPE (DIA. 900)	M	400.00
PRECAST CONCRETE PIPE (DIA. 1200)	M	450.00
CONCRETE 20/20	CU.M	456.10
REINFORCING BAR (LESS THAN 16mm DIA.)	T	1,950.00
FORMWORK	SQ.M	32.00
TRAFFIC MANAGEMENT DURING CONSTRUCTION		
SIGN, BARRIER, MAINTENANCE AND ACCESS ROAD	KM	39,700.00

Item	Unit	Unit Cost (US$)
SIDEWALK		
COMPACTION OF EXISTING GROUND	SQ.M	2.50
NATURAL GRAVEL SUBBASE FOR SIDEWALK	CU.M	18.00
CONCRETE PAVING BLOCK (T=60mm)	SQ.M	32.00
SUBGRADE, SUBBASE, BASE COURSE AND GRAVEL WEARING COURSE		
SUBGRADE PREPARATION	SQ.M	6.88
SUBBASE (CBR>40)	CU.M	24.00
BASE COURSE (CBR>80)	CU.M	81.20
PAVEMENT		
PRIME COAT	SQ.M	4.50
TACK COAT	SQ.M	2.95
BINDER COURSE, WEARING COURSE	CU.M	505.00
CONCRETE WORK		
CONCRETE CLASS 30/20 FOR DECK SLAB	CU.M	475.00
CONCRETE CLASS 15/40	CU.M	325.00
FORMWORK	SQ.M	40.00
REINFORCING BAR (LESS THAN 16mm)	T	1,980.00
REINFORCING BAR (MORE THAN 16mm)	T	2,035.00
ROAD FURNITURE'S		
SIGNS AND ETC.	KM	75,200.00
DAY WORKS		
MATERIAL	KM	6,700
EQUIPMENT	KM	10,000
LABOR	KM	1,150
HIV /AIDS AWARENESS AND EDUCATION		
HIV /AIDS AWARENESS AND EDUCATION	KM	3,000
STREET LIGHTING		
STREET LIGHTING	KM	110,000

Table 17.6.3-2 Construction Costs per Kilometer

(Unit : 1,000 US$/km)

Road Class	Standard Cross-section Type & Cost per km	
Arterial Streets	Arterial-1: 2,981	Arterial-2 : 2,446
Collector Streets	Collector-1 : 2,791	Collector-2 : 2,118
Major Local Streets	Major-1 : 2,668	Major-2 : 1,809
Minor Local Streets	Minor-1 : 635	Minor-2 : 552

(3) Construction Cost by Road Class

The construction costs are calculated as shown in Table 17.6.3-3

Table 17.6.3-3 Construction Costs by Road Class

Road Class	Type-1			Type-2			Total	
	Length (km)	Cost/km (1,000US$ /km)	Cost (1,000US$)	Length (km)	Cost/km (1,000US$ /km)	Cost (1,000US$)	Length (km)	Cost (1,000US$)
Arterial Streets *	Arterial-1 2.10	2,981	6,269	Arterial-2 0.33	2,446	805	Total 2.43	7,074
Collector Streets	Collector-1 4.73	2,791	13,191	Collector-2 4.11	2,118	8,709	Total 8.84	21,900
Major Local	Major-1 0.58	2,668	1,547	Major-2 3.66	1,809	6,621	Total 4.24	8,168
Minor Local	Minor-1 8.16	635	5,182	Monor-2 1.57	552	867	Total 9.73	6,049
Total	15.57		26,189	9.67		17,002	25.24	43,191

* Excluding Unity Avenue and Airport Road (total length 1.48 km)

17.6.4 Construction Supervision Cost

For simplicity, the construction supervision cost is assumed to be 8% of the construction cost.

17.6.5 Summary of Project Cost

The project costs are summarized as shown in Table 17.6.5-1.

Table 17.6.5-1 Summary of Project Costs

(unit : 1,000 US$)

	ROW Acquisition and Compensation	Detailed Design Cost	Construction Cost	Construction Supervision Cost	**Total**
Arterial Streets	0	283	7,074	566	**7,923**
Collector Streets	0	876	21,900	1,752	**24,528**
Major Local Streets	0	327	8,168	653	**9,148**
Minor Local Streets	0	242	6,049	484	**6,775**
Total	**0**	**1,728**	**43,191**	**3,455**	**48,374**

17.7 ENVIRONMENTAL IMPACT ASSESSMENT

The street network in CCD is formed in a grid pattern, composed of 4 classes of streets: arterial street, collector street, major local street and minor local street. Most of streets are 2-lane road, except a part of minor local streets which are 1-lane. The indigenous houses are located in the area where minor local streets run.

The environmental elements to be considered in the street improvement planning are discussed below.

17.7.1 Natural Environment

There are plenty of trees on roadside. This environment should be preserved as much as possible. Typical landscape is shown in Photos 17.7.1-1 and 17.7.1-2.

Photo 17.7.1-1 Landscape of R3-1

Photo 17.7.1-2 Landscape of R1-1～3

17.7.2 Social Environment

(1) Involuntary resettlement

The roadside land use is diverse, including government facilities, educational facilities, commercial and business facilities, markets, parks, churches, mosques, hotels, hospitals etc. as well as houses. The electric wires and poles are located on one side of most of arterial streets, collector streets and major local streets. There are also wells and other water facilities. Fortunately, those facilities will not be obstacles to road improvement. The problem of involuntary resettlement will arise scarcely because the road improvement is planned to be made within the available road spaces. Figures 17.7.2-1, 17.7.2-2 and 17.7.2-3 shows the location of the electric wires and poles, roadside facilities including wells and other water facilities, and water pipes respectively. Photo 17.7.2-1 and 17.7.2-2 show the well and water facility respectively.

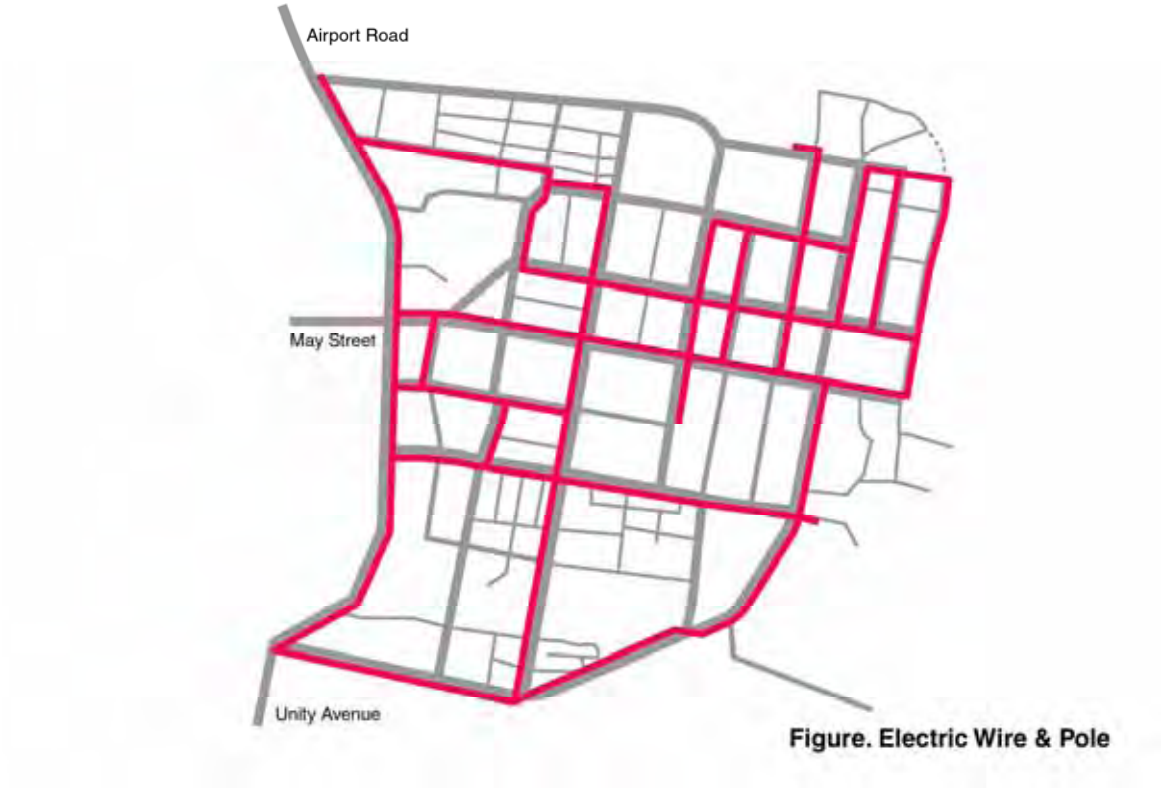


Figure 17.7.2-1 Electric Wires and Poles

Figure 17.7.2-2 Roadside Facilities

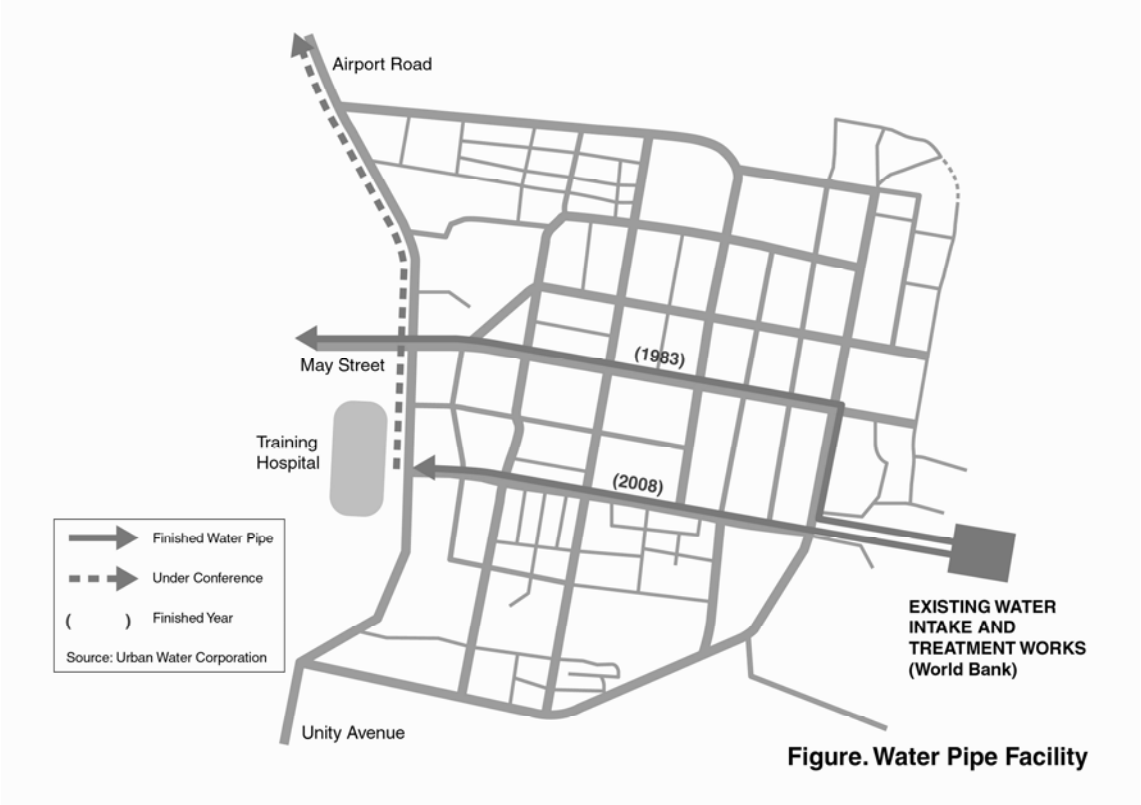


Figure 17.7.2-3 Water Pipe Facility

Photo 17.7.2-1 Well along CR9-2

Photo 17.7.2-2 Water facility (Automatic Valve）along CR2-4

Photos 17.7.2-3 and 17.7.2-4 show the condition of Collector Streets which have relatively narrow road width.

Photo 17.7.2-3 Intersection along CR6-2 **Photo 17.7.2-4 Intersection along CR8-1**

(2) Traffic Accident

Education for Traffic Safety

By improving the road surface condition, road traffic will be smoothed and run at higher speed. It is possible that traffic accidents will increase due to speeding up. Therefore it is necessary to give priority to measures for the regulation of traffic and safety education.

Parking Control

C2-3, a eastern part of R5-5 and L(N)2 are operated as one-way streets (Photos 17.7.2-5 and 17.7.2-6) . But, since C2-3 is a part of circumferential road No.2 (C-2), one-way operation will not be appropriate in the future. The side lanes on both sides of the one-way sections are presently used as parking spaces. It is necessary to take proper measures for parking control.

Photo 17.7.2-5 One-way Street (C2-3) **Photo 17.7.2-6 One-way Street (L(N)2)**

Improvement of Pedestrian Environment

In order to improve the pedestrian environment, it is necessary to provide the sidewalk separated from the carriageway. Various educational facilities are located in southeastern area of CCD, where children cross the streets leaded by the policewoman for safety. It is necessary to keep the school zone safety and to establish the traffic control system. Photo 17.7.2-7 shows the educational facilities along C1-1. Photo 17.7.2-8 shows the traffic

control by policeman and Photo17.7.2-9 shows a handicapped person passing the road.

Photo 17.7.2-7 Educational Facilities along C1-1

Photo 17.7.2-8 Traffic Control by Policewoman (R5-2&3)

Photo 17.7.2-9 Handicapped Person on CR5-3

17.7.3 Pollution

(1) Air Pollution

The streets in CCD are mostly earth roads (as of May 2009) except C1-1 to 3 and R5-1 to 5 which are paved roads. The pavement of R5-1 to 5 are old. These earth roads and old paved roads are very dusty affecting the healthy condition of the roadside inhabitants and pedestrians. The improvement of the roads with asphalt pavement will solve these problem.

(2) Waste

The garbage such as pet bottles and others are dumped on many streets in Juba urban area. The streets in CCD are also in the same condition. Most of ditches are filled with the waste, soil, weed and debris, hindering the ditches to function. It needs to strengthen the waste collection and treatment services and the sanitary education of the people not to dump the waste on the roads and ditches. Photo 17.7.3-1 shows the waste on the streets and Figure 17.7.3-2 shows the condition of ditch.

(1) CR7-3 **(2) CR4-2**

Photo 17.7.3-1 Waste Dumped on Roads

(1) C2-2 **(2) R5-2**

(3) CR7-1 **(4) C2-1**

Photo 17.7.3-2 Conditions of Ditch

17.7.4 Environmental Evaluation

The evaluation results for environmental elements are summarized in Table 17.7.4-1.

The project is evaluated as B(some impacts) in terms of “traffic accidents”, as stated in Section 17.7.2 (2).

Table17.7.4-1 Evaluation Results for Environmental Elements

Environmental Elements	Evaluation Results
Social Environment	
1. Involuntary resettlement	D
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

17.8 SIMPLIFIED ECONOMIC EVALUATION

17.8.1 Approach

The economic evaluation is made by comparing costs with benefits accruing from the road improvement project. The costs and benefits are measured in terms of economic prices, i.e., financial costs minus transfer costs (mainly taxes and duties).

The costs are all expenses necessary to complete the project and to maintain the project in good condition, including right-of-way acquisition and compensation costs, detailed design costs, construction costs, construction supervision costs, administration costs, maintenance costs, etc.

The benefits are all values directly and indirectly accruing from the project, including vehicle operating cost savings, passengers' travel time savings, reduction of accident costs, decrease of cargo damages, etc. as direct benefit, and regional development effects, improvement of roadside environment, improvement of driving comfort, generation of job opportunities, etc. as indirect benefits.

The evaluation results are indicated as following evaluation indicators:

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

Major Assumptions

Items of Costs and Benefits :

For simplicity, the costs and benefits taken into account are limited to those considered to be major parts and countable in monetary terms, which are as follows:

- Costs : construction cost, engineering cost (detailed design and construction supervision), maintenance cost (routine maintenance and periodic maintenance)
- Benefits : vehicle operating cost savings and travel time savings

Analysis Period : 20 years after completion of the project

Discount Rate (Opportunity Cost) : 8 % p.a.

17.8.2 Economic Cost

Major assumptions in calculating the economic costs are as follows:

- Conversion rate from financial cost to economic cost : 0.907*
- Engineering Cost : detailed design cost (4% of construction cost) & construction supervision cost (8% of construction cost), totaling 12 %
- Routine Maintenance Cost : 1% of construction cost (every year)
- Periodic Maintenance Cost : 10% of construction cost (every 10 years)

The economic costs are shown in Table 17.8.2-1.

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

Table 17.8.2-1 Financial and Economic Cost of the Project

(unit : million US$)

		Arterial Streets	Collector Streets	Major Local Streets	Minor Local Streets	Total	Remarks
Total Length		2.43 km*	8.84 km	4.24 km	9.73 km	25.24 km	
Financial Cost	Construction Cost	7.07	21.90	8.17	6.05	43.19	See Chaper 17.6.3
	Engineering Cost	0.85	2.63	0.98	0.73	5.18	
	Routine Maintenance Cost	0.07	0.22	0.08	0.06	0.43	every year
	Periodic Maintenance Cost	0.71	2.19	0.82	0.61	4.32	every 10 years
Economic Cost	Construction Cost	6.41	19.86	7.41	5.49	39.17	
	Engineering Cost	0.77	2.38	0.89	0.66	4.70	
	Routine Maintenance Cost	0.06	0.20	0.07	0.05	0.39	every year
	Periodic Maintenance Cost	0.64	1.99	0.74	0.55	3.92	every 10 years

* excluding Unity Avenue and Airport Road (total length 1.48 km)

17.8.3 Economic Benefit

(1) Traffic Volume

For simplicity, the traffic volume is assumed to depend on the functional road class and to be uniform in all roads of the same class. Table 17.8.3-1 shows the assumed traffic volume by road class.

Table 17.8.3-1 Assumed Traffic Volume

Functional Road Class	Year	Traffic Volume (vehicles/day)					Sample Road
		Motor Cycle	Car	Bus	Truck	Total	
Arterial Street	2009	2,755	2,522	3,383	1,622	10,282	CR5-2
	2015	3,864	2,558	3,307	5,568	15,297	
	2025	6,915	4,210	4,802	6,786	22,713	
Collector Street	2009	450	1,064	359	676	2,549	CR3
	2015	725	1,555	480	1,280	4,040	
	2025	1,264	2,421	673	2,695	7,053	
Major Local Street	2009	300	1,179	221	250	1,950	L(I)2
	2015	483	1,723	295	473	2,974	
	2025	842	2,682	414	996	4,934	
Minor Local Street	2009	210	825	155	175	1,365	0.7 x Major Local Street
	2015	338	1,206	207	331	2,082	
	2025	589	1,877	290	697	3,453	

(2) Basic Vehicle Operating Cost and Passenger Time Cost

The traffic costs are composed of vehicle operating cost and passenger time cost, and the former subdivided into two components: running cost dependent on travel distance and fixed cost dependent on travel time. Considering the road condition in Juba, the basic traffic costs are estimated by the Study Team as shown in Table 17.8.3-2.

Table 17.8.3-2 Basic Vehicle Operating Cost and Passenger Time Cost

Case	Vehicle Type	Vehicle Operating Cost		Passenger Time Cost (US$/hr)	Assumed Condition
		Running Cost (US$/km)	Fixed Cost (US$/hr)		
Without Case	Motor Cycle	0.082	0.052	1.200	Unpaved, Bad, Ave Speed. =20 km/hr
	Car	0.249	0.621	3.230	
	Bus	0.212	0.088	11.250	
	Truck	0.385	0.485	0	
With Case (Asphalt)	Motor Cycle	0.044	0.052	1.200	Paved, Good, Ave Speed. =50 km/hr
	Car	0.186	0.621	3.230	
	Bus	0.149	0.088	11.250	
	Truck	0.303	0.485	0	
With Case (Gravel)	Motor Cycle	0.063	0.052	1.200	Gravel, Fair, Ave Speed. =35km/hr
	Car	0.217	0.621	3.230	
	Bus	0.180	0.088	11.250	
	Truck	0.344	0.485	0	

Source: the Study Team

(3) Estimated Benefits

The Traffic costs in W/O case (the case the project is not implemented) and WITH case (the case the project is implemented) in terms of US$ per day per kilometer are shown in Table 17.8.3-3.

Table 17.8.3-3 Traffic Cost

Year	W/O Case (US$/day/km)				WITH Case (US$/day/km)			
	Arterial Street	Collector Street	Major Local	Minor Local	Arterial Street	Collector Street	Major Local	Minor Local
2012	5,428	1,355	1,024	717	3,090	825	605	529
2013	5,729	1,457	1,095	767	3,314	890	648	567
2014	6,096	1,569	1,172	821	3,588	962	695	607
2015	6,543	1,689	1,254	878	3,923	1,040	745	651
2016	6,777	1,780	1,315	921	4,056	1,098	783	683
2017	7,022	1,875	1,380	966	4,193	1,160	823	717
2018	7,276	1,977	1,448	1,014	4,336	1,226	865	753
2019	7,540	2,084	1,519	1,064	4,485	1,296	909	791
2020	7,816	2,198	1,595	1,116	4,640	1,371	955	832
2021	8,103	2,319	1,674	1,172	4,800	1,450	1,005	874
2022	8,402	2,447	1,757	1,230	4,968	1,534	1,057	918
2023	8,714	2,582	1,845	1,292	5,142	1,623	1,111	965
2024	9,038	2,726	1,938	1,357	5,323	1,719	1,169	1,015
2025	9,376	2,879	2,036	1,425	5,511	1,820	1,231	1,068
2026	9,729	3,041	2,139	1,497	5,707	1,927	1,295	1,123
2027	10,096	3,213	2,248	1,573	5,912	2,042	1,364	1,181
2028	10,479	3,396	2,363	1,654	6,124	2,164	1,436	1,243
2029	10,879	3,590	2,484	1,738	6,346	2,294	1,512	1,309
2030	11,296	3,796	2,612	1,828	6,576	2,432	1,593	1,378
2031	11,730	4,016	2,747	1,922	6,816	2,579	1,679	1,450

The benefit is calculated as the difference in traffic costs between W/O case and WITH case in terms of US$ per day per kilometer. Then, multiplying them by number of days in a year and total length of the road, total benefits are obtained. Table 17.8.3-4 shows the daily benefits per kilometer and total benefits.

Table 17.8.3-4 Estimated Benefits

Year	Benefit per day per km (US$/day/km)				Total Benefit (1,000 US$/year)				
	Arterial Street	Collector Street	Major Local	Minor Local	Arterial Street	Collector Street	Major Local	Minor Local	Total
					TL =2.43 km	TL=8.84 km	TL=4.24 km	TL=9.73 km	TL=25.24km
2012	2,339	530	419	188	2,074	1,710	649	668	5,101
2013	2,415	567	447	200	2,142	1,829	692	712	5,375
2014	2,508	607	477	214	2,224	1,958	738	758	5,678
2015	2,619	650	509	228	2,323	2,096	787	808	6,014
2016	2,722	681	532	238	2,414	2,199	824	845	6,281
2017	2,828	715	557	249	2,509	2,307	862	884	6,562
2018	2,940	750	583	260	2,607	2,421	903	924	6,855
2019	3,055	788	611	272	2,710	2,542	945	967	7,164
2020	3,176	827	639	285	2,817	2,669	989	1,012	7,487
2021	3,303	869	669	298	2,929	2,803	1,036	1,058	7,826
2022	3,434	913	701	312	3,046	2,945	1,085	1,107	8,183
2023	3,572	959	734	326	3,168	3,094	1,136	1,159	8,557
2024	3,715	1,008	769	342	3,295	3,251	1,190	1,213	8,950
2025	3,865	1,059	806	358	3,428	3,418	1,247	1,270	9,362
2026	4,022	1,114	844	374	3,567	3,594	1,306	1,329	9,796
2027	4,185	1,171	884	392	3,712	3,779	1,369	1,392	10,251
2028	4,355	1,232	927	410	3,863	3,975	1,435	1,457	10,730
2029	4,533	1,296	972	430	4,021	4,183	1,504	1,526	11,234
2030	4,719	1,364	1,019	450	4,186	4,402	1,577	1,599	11,763
2031	4,914	1,436	1,068	472	4,358	4,634	1,653	1,675	12,320

TL=Total Length (km)

17.8.4 Economic Evaluation

Implementation Schedule

The implementation schedule as a condition in calculating the annual costs and benefits stream is assumed as shown in Table 17.8.4-1, although the project has completed partly and is on-going partly.

Table 17.8.4-1 Implementation Schedule

Year	2010	2011	2012	2013	- - - - -	2021	- - - - -	2031
Design & Construction	■	■						
Routine Maintenance			═	═	═	═	═	═
Periodic Maintenance						○		○
Benefit Generation			■	■	■	■	■	■

Costs and Benefits Stream

In accordance with the above implementation schedule, the annual costs and benefits stream are calculated as shown in Table 17.8.4-2. Based on the costs and benefits stream, the economic indicators are obtained as shown in Table 17.8.4.-2, which are summarized as shown in Table 17.8.4-3.

Table 17.8.4-2(1) Benefit-Cost Stream (1/2)

Arterial Streets (unit : 1,000 US$)

Year	Undiscounted Benefit-Cost Stream				Discounted Benefit-Cost Stream			
	Cost		Benefit	Benefit -Cost	Cost		Benefit	Benefit -Cost
	Const-ruction	Mainte-nance			Const-ruction	Mainte-nance		
2010	3,590			-3,590	3,590			-3,590
2011	3,590			-3,590	3,324			-3,324
2012		60	2,074	2,014		51	1,778	1,727
2013		60	2,142	2,082		48	1,700	1,653
2014		60	2,224	2,164		44	1,635	1,591
2015		60	2,323	2,263		41	1,581	1,540
2016		60	2,414	2,354		38	1,521	1,483
2017		60	2,509	2,449		35	1,464	1,429
2018		60	2,607	2,547		32	1,408	1,376
2019		60	2,710	2,650		30	1,356	1,326
2020		60	2,817	2,757		28	1,305	1,277
2021		700	2,929	2,229		300	1,256	956
2022		60	3,046	2,986		24	1,210	1,186
2023		60	3,168	3,108		22	1,165	1,143
2024		60	3,295	3,235		20	1,122	1,101
2025		60	3,428	3,368		19	1,081	1,062
2026		60	3,567	3,507		18	1,041	1,024
2027		60	3,712	3,652		16	1,003	987
2028		60	3,863	3,803		15	967	952
2029		60	4,021	3,961		14	932	918
2030		60	4,186	4,126		13	898	885
2031		700	4,358	3,658		139	866	727
Total	7,180	2,480	61,393	51,733	6,914	947	25,288	17,427

Net Present Value (1,000 US$)	17,427
B/C Ratio	3.22
EIRR	28.0%

Collector Streets (unit : 1,000 US$)

Year	Undiscounted Benefit-Cost Stream				Discounted Benefit-Cost Stream			
	Cost		Benefit	Benefit -Cost	Cost		Benefit	Benefit -Cost
	Const-ruction	Mainte-nance			Const-ruction	Mainte-nance		
2010	11,120			-11,120	11,120			-11,120
2011	11,120			-11,120	10,296			-10,296
2012		200	1,710	1,510		171	1,466	1,295
2013		200	1,829	1,629		159	1,452	1,293
2014		200	1,958	1,758		147	1,439	1,292
2015		200	2,096	1,896		136	1,427	1,290
2016		200	2,199	1,999		126	1,386	1,260
2017		200	2,307	2,107		117	1,346	1,229
2018		200	2,421	2,221		108	1,308	1,200
2019		200	2,542	2,342		100	1,272	1,172
2020		200	2,669	2,469		93	1,236	1,144
2021		2,190	2,803	613		939	1,202	263
2022		200	2,945	2,745		79	1,170	1,090
2023		200	3,094	2,894		74	1,138	1,064
2024		200	3,251	3,051		68	1,107	1,039
2025		200	3,418	3,218		63	1,077	1,014
2026		200	3,594	3,394		58	1,049	991
2027		200	3,779	3,579		54	1,021	967
2028		200	3,975	3,775		50	995	945
2029		200	4,183	3,983		46	969	923
2030		200	4,402	4,202		43	944	902
2031		2,190	4,634	2,444		435	921	486
Total	22,240	7,980	59,809	29,589	21,416	3,067	23,924	-559

Net Present Value (1,000 US$)	-559
B/C Ratio	0.98
EIRR	7.7%

Table 17.8.4-2(2) Benefit-Cost Stream (2/2)

Major Local Streets (unit : 1,000 US$)

Year	Undiscounted Benefit-Cost Stream				Discounted Benefit-Cost Stream			
	Cost		Benefit	Benefit -Cost	Cost		Benefit	Benefit -Cost
	Const-ruction	Mainte-nance			Const-ruction	Mainte-nance		
2010	4,150			-4,150	4,150			-4,150
2011	4,150			-4,150	3,843			-3,843
2012		70	649	579		60	556	496
2013		70	692	622		56	549	494
2014		70	738	668		51	542	491
2015		70	787	717		48	536	488
2016		70	824	754		44	519	475
2017		70	862	792		41	503	462
2018		70	903	833		38	488	450
2019		70	945	875		35	473	438
2020		70	989	919		32	458	426
2021		810	1,036	226		347	444	97
2022		70	1,085	1,015		28	431	403
2023		70	1,136	1,066		26	418	392
2024		70	1,190	1,120		24	405	381
2025		70	1,247	1,177		22	393	371
2026		70	1,306	1,236		20	381	361
2027		70	1,369	1,299		19	370	351
2028		70	1,435	1,365		18	359	342
2029		70	1,504	1,434		16	348	332
2030		70	1,577	1,507		15	338	323
2031		810	1,653	843		161	328	167
Total	8,300	2,880	21,927	10,747	7,993	1,101	8,841	-252

Net Present Value (1,000 US$)	-252
B/C Ratio	0.97
EIRR	7.7%

Minor Local Streets (unit : 1,000 US$)

Year	Undiscounted Benefit-Cost Stream				Discounted Benefit-Cost Stream			
	Cost		Benefit	Benefit -Cost	Cost		Benefit	Benefit -Cost
	Const-ruction	Mainte-nance			Const-ruction	Mainte-nance		
2010	3,075			-3,075	3,075			-3,075
2011	3,075			-3,075	2,847			-2,847
2012		50	668	618		43	573	530
2013		50	712	662		40	565	526
2014		50	758	708		37	557	520
2015		50	808	758		34	550	516
2016		50	845	795		32	532	501
2017		50	884	834		29	516	487
2018		50	924	874		27	499	472
2019		50	967	917		25	484	459
2020		50	1,012	962		23	469	446
2021		600	1,058	458		257	454	196
2022		50	1,107	1,057		20	440	420
2023		50	1,159	1,109		18	426	408
2024		50	1,213	1,163		17	413	396
2025		50	1,270	1,220		16	400	385
2026		50	1,329	1,279		15	388	373
2027		50	1,392	1,342		14	376	363
2028		50	1,457	1,407		13	365	352
2029		50	1,526	1,476		12	354	342
2030		50	1,599	1,549		11	343	332
2031		600	1,675	1,075		119	333	214
Total	6,150	2,100	22,363	14,113	5,922	800	9,036	2,314

Net Present Value (1,000 US$)	2,314
B/C Ratio	1.34
EIRR	11.9%

All Streets (unit : 1,000 US$)

Year	Undiscounted Benefit-Cost Stream				Discounted Benefit-Cost Stream			
	Cost		Benefit	Benefit -Cost	Cost		Benefit	Benefit -Cost
	Const-ruction	Mainte-nance			Const-ruction	Mainte-nance		
2010	21,935			-21,935	21,935			-21,935
2011	21,935			-21,935	20,310			-20,310
2012		380	5,101	4,721		326	4,373	4,047
2013		380	5,375	4,995		302	4,267	3,965
2014		380	5,678	5,298		279	4,173	3,894
2015		380	6,014	5,634		259	4,093	3,834
2016		380	6,282	5,902		239	3,959	3,719
2017		380	6,562	6,182		222	3,829	3,607
2018		380	6,855	6,475		205	3,704	3,498
2019		380	7,164	6,784		190	3,584	3,394
2020		380	7,487	7,107		176	3,468	3,292
2021		4,300	7,826	3,526		1,844	3,356	1,512
2022		380	8,183	7,803		151	3,250	3,099
2023		380	8,557	8,177		140	3,146	3,007
2024		380	8,949	8,569		129	3,047	2,917
2025		380	9,363	8,983		120	2,952	2,832
2026		380	9,796	9,416		111	2,859	2,748
2027		380	10,252	9,872		103	2,771	2,668
2028		380	10,730	10,350		95	2,685	2,590
2029		380	11,234	10,854		88	2,603	2,515
2030		380	11,764	11,384		82	2,524	2,442
2031		4,300	12,320	8,020		854	2,447	1,593
Total	43,870	15,440	165,492	106,182	42,245	5,914	67,090	18,930

Net Present Value (1,000 US$)	18,930
B/C Ratio	1.39
EIRR	12.4%

Table 17.8.4-3 Economic Indicators

	Arterial Streets	Collector Streets	Major Local Streets	Minor Local Streets	All Roads
Net Present Value (NPV) (million US$)	17.43	-0.56	-0.25	2.31	18.93
Benefit Cost Ratio (B/C)	3.22	0.98	0.97	1.34	1.39
Economic Internal Rate of Return (EIRR)	28.0 %	7.7 %	7.7 %	11.9 %	12.4 %

Result of Economic Evaluation

The project with 8.0%* or more of the economic internal rate of return is judged to be economically feasible. All classes of streets are feasible or almost feasible, although only vehicle operating cost savings and travel time savings are taken into account and other benefits such as accident cost savings, decrease of cargo damages, improvement of driving comfort, improvement of road environment, etc. are not counted.

* Opportunity Cost, assumed referring to the "Feasibility Study for Improvement Works of the Juba to Nimule Road, USAID/Sudan Infrastructure Service Project, May 2007".

17.9 IMPLEMENTATION PLAN

(1) Implementation System

The following factors are taken into consideration in proposing the implementation system:

- The MTR has been implementing the "Emergency Road Rehabilitation Project " (ERRP) since 2006. This Project is scheduled to be completed by the end of 2010. This Project covers about half length of the streets in CCD including all of arterial streets and most of collector streets (Chapter 4.3.2).
- It is recommended that the planning, design, construction and maintenance of arterial streets be undertaken by the MTR, while those of collector and local streets be undertaken by the MOPI (Chapter 13).
- It is recommended that the improvement/construction of the asphalt concrete road (AC) are implemented by contracting-out to the construction companies while the gravel roads are constructed by the force-account as transition period during short term until 2015 (Chapter 13).
- The improvement of the streets in CCD is of urgent necessity and expected to be completed by 2011.

The project implementation system as shown in Table 17.9-1 is proposed.

Table 17.9-1 Proposed Implementation System

Road Category	Pavement Type	Length (km)	Implementing Agency		Implementation Type for Construction
			Planning, Design & Construction	Maintenance	
Streets under the Emergency Road Rehabilitation Project					
Arterial Streets	AC	3.91	MTR	MTR	Contracting-out
Other Streets	AC	10.20	MTR	MOPI	Contracting-out
Remaining Streets					
Collector Streets	AC	0.50	MOPI	MOPI	Contracting-out
Major Local Streets	AC	3.02	MOPI	MOPI	Contracting-out
Minor Local Streets	Gravel	9.09	MOPI	MOPI	Force-account

(2) Materials and Equipment Procurement Plan

Materials

- Embankment materials and aggregates for concrete and pavement are locally procured.
- Other materials will be procured from other countries as follows:
  - from Kenya or Uganda : Cement, reinforcing bar, concrete additives, pipe culvert, asphalt, plywood, scaffolding, welding rod, oxygen, acetylene, etc.
  - from developed country : traffic signal, street light, hot paint for pavement marking, etc.

Equipment

- Most of the construction equipment required for the project is available in Juba under the ownership of local contractors. Many of them are second hand equipment imported from other countries. Usually spare parts of the equipment are not available in Juba and have to be procured from neighboring countries.

(3) Implementation Schedule

The streets covered by on-going "Emergency Road Rehabilitation Project" and remaining streets are as shown in Figure 17.9-1 and Table 17.9-2.

Figure 17.9-1 Streets Covered by On-going Project and Others

Table 17.9-2 Streets Covered by On-going Project and Others

Road Class	Length (km)			Estimated Construction Cost of Remaining Streets (1,000 US$)
	Total	On-going	Remaining	
Arterial Streets	3.91	3.91	0	0
Collector Streets	8.84	8.34	0.50	1,063
Major Local St.	4.24	1.22	3.02	5,712
Minor Local St.	9.73	0.64	9.09	5,643
Total	26.72	14.11	12.61	12,418

The project implementation schedule is proposed as shown in Table 17.9-3

Table 17.9-3 Proposed Project Implementation Schedule

Road Class		Length	Project Cost (1,000 US$)				2010				2011			
		(km)	D/D	Construction	Const. Supervision	Total								
Emergency Road Rehabilitation Project (on-going)							■	■	■	■				
Remaining Streets	Collector Streets	0.50	43	1,063	85	1,191	43	1,148						
	Major Local St.	3.02	228	5,712	457	6,397		228	3,084		3,085			
	Minor Local St.	9.09	226	5,643	451	6,320				226		6,094		
	Total	12.61	497	12,418	993	13,908	4,729				9,179			

Legend □ Detailed Design
■ Construction & Construction Supervision

(4) Annual Fund Requirements

In addition to the on-going "Emergency Road Rehabilitation Project", the improvement of the remaining streets needs the following funds:

- Year 2010 : 4,729,000 US$
- Year 2011 : 9,179,000 US$
- Total : 13,908,000 US$

CHAPTER 18

ROUTE LOCATION STUDY OF MAJOR ARTERIALS

CHAPTER 18 ROUTE LOCATION STUDY OF MAJOR ARTERIALS

18.1 OBJECTIVES AND APPROACH OF THE STUDY

The proposed road network development plan, as shown in Figure 18.1.1-1, is discussed in details in Chapter 9. The road network basically covers three functional classifications which include: arterial, collector and local streets. The arterial streets in Juba urban area consist of radial streets which serve as intercity/interstate roads connecting Juba to other urban centers in South Sudan and circumferential streets serving as primary/district distributor around Juba and surrounding areas.

Among the major arterials, there are 6 existing Radial Streets connecting Juba with the other States and urban centers in Southern Sudan, namely:

- R1 : Juba-Yei Road
- R2 : Juba-Mundri Road
- R3 : Juba-Terekeka Road
- R4 : Juba-Bor Road
- R5 : Juba-Lafon Road (connection from Central Commercial District to C3 is not existing), and
- R6 : Juba-Nimule Road

Moreover, 4 circumferential streets are identified and proposed with the following conditions:

- C1 : Circumferential road formed by Unity Ave. and the Old Airport Road surrounding Buluk and Hai Malakal.
- C2 : Covering the area from C1 to Central Commercial District, Atla Bara, Kator, Hai Malakal, Hai Sora, Hai Kuwait and Amarat; C2 overlaps C1 at the airport area,
- C3 : The area from C2 extending to the east of the Nile River, Kator, Lologo, Nyakuron, Munuki, and the Nyaing Lake north of Juba International Airport, and
- C4 : Area beyond C3.

Arterial Streets are proposed, at the ultimate stage, to convey 4 to 6 lanes of road carriageway, as illustrated in Figure 18.1.1-1(b) and (c). The road sections conveying 4-lanes requires at least 50m of road reserve or right-of-way (ROW) while that conveying 6-lanes requires 60m of ROW.

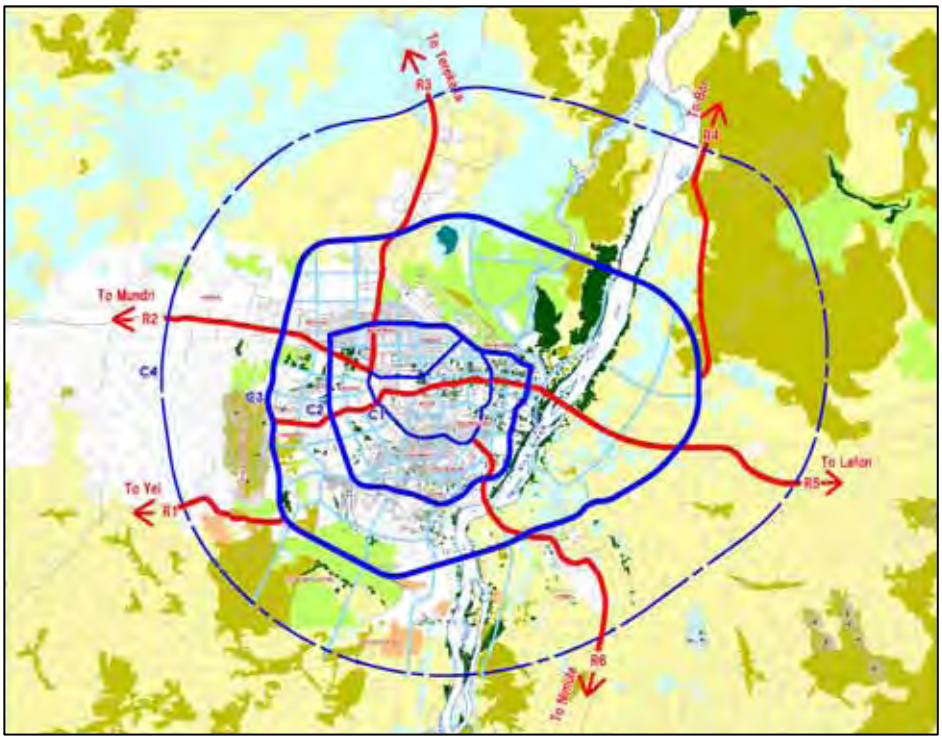
18.1.1 Objectives of Route Location Study

Although Figure 18.1.1-1 illustrates the schematic routes for the arterial streets, it is necessary to determine a more definitive route location for the proposed circumferential and radial streets considering various control points and technical requirements. This section then focuses on the following objectives:

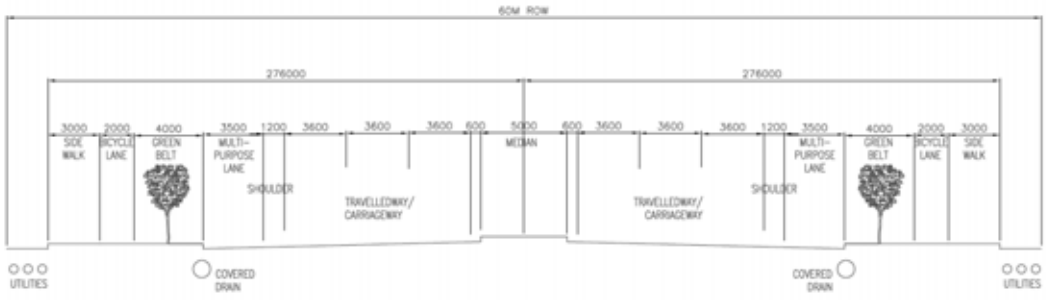
(1) To establish the route locations and corridors of C2, C3 and R5 (crossing the Nile river and eastward), since C1 and the other radial streets (R1-R6) alignments are basically defined,
(2) Identify the control points that may influence the choice of the selected routes,

(3) Determine the most probable location of the C3 White Nile River Crossing, and

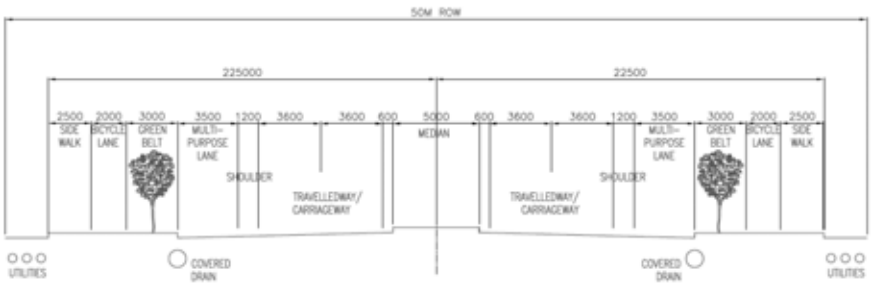
(4) Utilize the established routes as reference of the MTR and the CES in delineating and staking the road reserve right-of-way to minimize costly future land acquisition.



(a) Proposed Road Network



(b) 6-Lane Arterial Street Section with 60m ROW



(c) 4-Lane Arterial Street Section with 50m ROW

Figure 18.1.1-1 Proposed Road Network and Standard Cross-Sections for Arterial Streets

18.1.2 Process of Route Location Selection

The flow of the process for route location selection of C2, C3 & R5 is illustrated in Figure 18.1.2-1 and explained below.

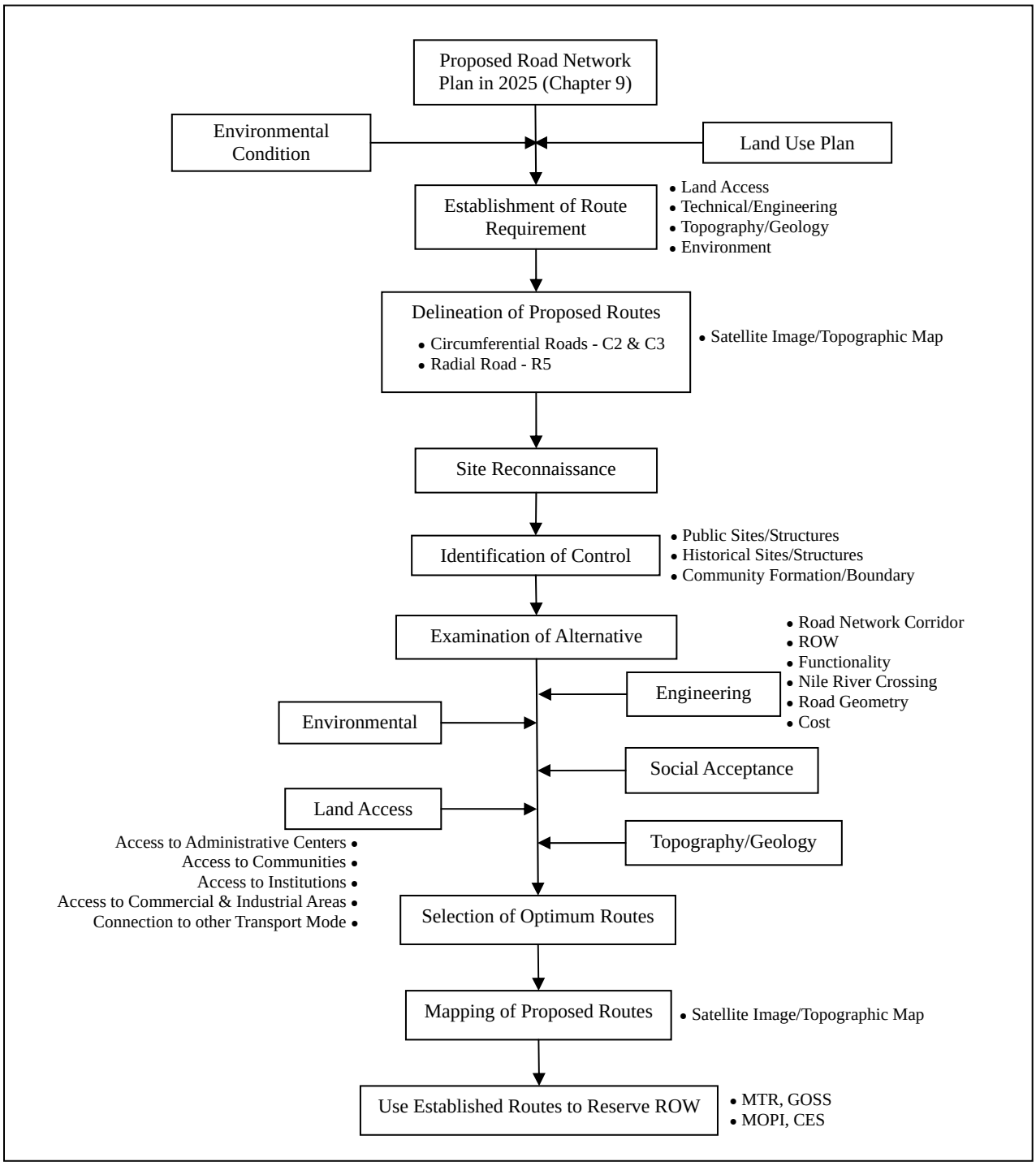


Figure 18.1.2-1 Route Location Study Procedure for Major Arterials

(1) Proposed Road Network Master Plan for 2025

The proposed Road Network Master Plan for 2025, established based on land use, transport infrastructure demand, social and environmental requirements, is used as the starting point to delineate the routes of the proposed C2, C3 and R5 roads.

(2) Establishment of Route Requirements

The route locations are then decided based on the requirements of:

- Land Accessibility: providing access to important sites including administrative centers (government offices), city/community centers, institutions (schools, churches, etc.), commercial and industrial areas and connection to other transport modes such as airport, river port and proposed railways,
- Technical/Engineering: the proposed route shall comply with the minimum design requirements based on the road functional class,
- Topography/Geology: as much as possible, the route shall be selected in areas with minimal topographic or geologic constraint to minimize project costs, and
- Environment: the proposed route should have minimal social and environmental impact.

(3) Delineation of Proposed Routes

Proposed routes can be delineated using the latest topographic maps or satellite images showing different constraints, obstacles and structures that may be affected by the proposed road. In this case, the basis of route delineation is the topographic map prepared for the Study using satellite images of Juba and surrounding areas acquired in March of 2009.

(4) Site Reconnaissance

The route locations and alternatives identified in the satellite images are then verified on site noting the important control points and topographic or geologic constraints, including existing ground slopes and soil formations, streams and river crossings, and existing structures that may be affected by the proposed route.

(5) Identification of Control Points

Using the topographic maps and satellite images and thru site reconnaissance, the control points are identified and used to establish the limit of the alignment of the proposed route – this may include public sites and structures, historical sites, community formations, cemeteries, national parks, reserved areas, etc.

(6) Examination of Alternative Routes

In some cases, several alternative routes are identified as possible route alignment for the proposed road. These alternative routes are then examined and compared considering a set of criteria including the requirements of engineering, land accessibility, environment, topography and social acceptability. In majority of cases, social acceptance plays a major role in deciding the final route alignment.

(7) Selection of Optimum Routes

The most probable optimum route is then selected based on the criteria established above.

(8) Mapping of the Proposed Route

The chosen optimum route is then plotted in the topographic map or satellite image and used as a guide in preparing detailed plans for the road network.

(9) Use of Established Routes to Reserve ROW

The road reserve corridor established in the master plan, as shown in this section, has to be acquired by the corresponding agency/ies such as MTR, GOSS and MOPI, CES as early as possible to minimize futures costly acquisitions. Since development and urbanization in Juba is just starting, it is the right time to reserve and stake the corridors for the right-of-way.

18.1.3 Policy on Route Location Selection

The following policies govern the selection of the proposed routes for the major arterials:

(1) Assure Mobility by Maintaining the Design Speed and Functionality

The proposed arterial street network provides service to major urban centers and functions as primary and district distributor in and around Juba and the surrounding areas. As such, mobility is the primary objective of the network which requires provision of proper road geometry and efficient connection (by proper intersection layout, etc.) with other arterial and collector streets.

- Design Speed: As proposed in Chapter 9, the design speed considered for the arterial streets is 50-60 km/hr. To attain this, the route location should consider proper design geometry in the road alignment that will assure this design speed.
- Functionality: Since major arterials are expected to service high traffic volumes, access shall be controlled by providing efficient intersection layout or avoiding direct access by local traffic (such as provision of frontage roads, etc.).

(2) Minimum Right-of-Way Take

In order to minimize additional right-of-way take for the road reserve, the proposed route shall utilize as much as possible, existing road reserves.

(3) Minimum Adverse Social Impact

The proposed route shall, as much as possible, be selected to minimize the number of affected persons and structures to reduce social impact. The route alignment shall be located at the fringes/boundaries of community formations and avoid passing thru the middle of such communities. Moreover, public sites including churches, cemeteries, institutional areas and historical sites shall be avoided.

(4) Preservation of Environment

Preservation of the environment shall be one of the major concerns of the proposed route especially when crossing the Nile River, the alignment near Jebel Kujur mountain and the Nyaing Lake north of the Juba International Airport. Impact to environment shall be properly considered in selecting the route location.

18.2 ESTABLISHMENT OF ROUTE REQUIREMENTS

18.2.1 Engineering Requirements

The design requirements for principal arterials are discussed in Chapter 9 with the design criteria proposed in Table 9.3-1. However, in consideration with the route location study for C2, C3 and R5 arterials Table 18.2.1-1 presents some of the basic engineering requirements for the route alignment.

Table 18.2.1-1 Engineering Requirements for Route Location of C2, C3 and R5

Functional Classification	Arterial Road/Street	
Function	Circumferential – Primary/District Distributor (C2 and C3)	
	Radial – Interstate/Intercity Trunk Road (R5)	
Access Control	• Possibly uninterrupted except at intersection; • Limited access to next lower class (Collector)	
Design Traffic (ADT)	10,000 – 12,000	
Design Speed	50 – 60 km/hr	
Design Radius	Minimum	150 m (AASHTO)
	Desirable	• C2 : 250 m • C3 & R5 : 500 m
Grade	0.5% – 5%	
Minimum Length of Horizontal Curve	80 m	
ROW/Road Reserve Requirement Based on Cross-Section Elements	4 – Lanes Arterial	50 m
	6 – Lanes Arterial	60 m

18.2.2 Land Access Requirements

Although the basic objective of an urban arterial would be mobility with limited or restricted service to local development, it should provide access and serve major activity centers in the urban area. In this regard, the urban street network system comprising of urban arterial streets, collector streets and local streets should be in harmony to serve the traffic demand in the area.

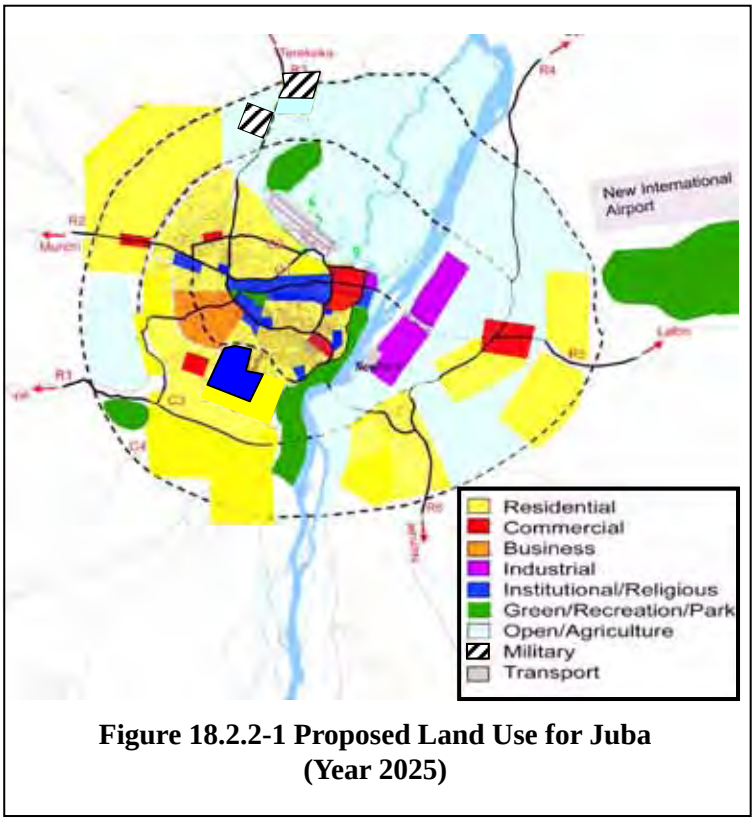


Figure 18.2.2-1 Proposed Land Use for Juba (Year 2025)

The proposed circumferential streets in Juba (under the urban arterial class) are therefore planned to serve the traffic at a desired level of service from major traffic generators in Juba urban area. These circumferential streets shall become the primary or district distributor roads in Juba linking major development zones. Figure 18.2.2-1 illustrates the proposed land use for Juba and the surrounding areas where the planned circumferential streets are designed to cater and distribute the traffic generated from the different urban centers. However, to provide better mobility, access to the urban arterials is limited to the next lower road class, which is the collector street. In which case, proper intersection layout shall be planned.

In planning for the route location for C2, C3 and R5, the following centers were considered for accessibility:

- Community: Access to Payams, communities and residential areas around Juba shall be provided thru collector streets considering community formations/community boundaries. The planned road shall be located so as not to pass thru the center of the community, which disrupts the social and commercial links between the members of the communities.
- Institutions and Administrative Centers: Planned routes shall be located near institutions and administrative centers including GOSS, State Offices, Military Areas, Churches, Schools, etc. to provide faster mobility to such centers. The route alignment shall avoid encroaching over these areas.
- Commercial and Industrial Areas: Traffic generation and attraction to commercial and industrial areas shall be considered in the route location planning without directly affecting the desired level of service of the proposed arterial road. An exception will be parts of C2 and R5 that will pass thru the Central Commercial District.
- Airports, River Ports and other Transport Mode: The route locations of C1 and C2 shall consider access to Juba International Airport and Juba River Port. Planned access to railway stations shall be coordinated with the proposed route alignments.

18.2.3 Environmental and Social Requirements

In identifying the possible route locations for the proposed arterial roads, the following environmental and social considerations are taken into account:

(1) Natural Environment

1) Topographic Features

Although Juba and the surrounding areas are basically flat with some rolling terrains, three craggy mountains can be found in the suburbs of Juba – namely Mt. Jebel Kujur, Mt. Rajaf West and Mt. Rajaf East, which are basically weathered granite craggy mountains.

2) River System

Major water areas in the area covered by the Study include the White Nile River, which runs along the eastern border of the city area, and the small rivers flowing into the Nile. There are five small rivers: the Luri River, the Khorbou River, the Lobulyet River, the Wallan River and the Kor Ramula River from the north to the south. The groundwater, flowing northwards, in the area is extremely high, around five to six meters below the ground.

3) Flora and Fauna Habitats

The area covered by the Study have mixed savannas and forests. However, the vegetations and wildlife in these areas have been greatly transformed because of the civil war. It is said that large sections of the forests have been destroyed and the living conditions of the wildlife greatly affected. Most of the forestry vegetation remains along the Nile River consisting of mango trees, papaya, neem and other fruit trees. Fishes still thrive in the river which is a source of income of the locals. Moreover, water birds and crocodiles can also be seen in the Nile River.

4) Landscapes

Typical landscapes of the are includes: the urban landscape in the central area of Juba City,

rural landscapes with traditional houses called tukuls, the riverside landscapes of the Nile river, the flatland landscape at the west of Munuki Payam and Kator Payam, and the hilly landscapes of Jebel Lodu in the northern part, Bilinyang and Luluriet in the eastern part, Rajaf West in the southern area, and Jebel Kujur in the western section. In addition, other major landscapes include Juba International Airport, Garang Park – monument dedicated to the former vice president, churches, mosques, other religious facilities, Juba soccer stadium, and cemeteries.

5) National Parks

There are no national parks in the Study areas but two game reserves are designated at 20 to 30 kilometers from the center of Juba- the Bandingalo Game Reserves on the northeastern side and the Juba Game Reserves on the southwestern side.

(2) Land Use Along Proposed Routes

The route corridors for the proposed major arterials should consider the environmental and social concerns of existing land use and facilities along the roadside of the alignment, including:

- Government facilities (including ministries and agencies related to GoSS,
- Hotels, banks and other business-related facilities, markets and other commercial facilities,
- Churches and mosques,
- Residential buildings/houses,
- Commercial facilities including stores dealing with construction materials and other light-industry related products, miscellaneous daily goods, restaurants, etc.,
- Educational facilities (Juba University, elementary schools, etc.),
- Medical related facilities like hospitals, clinics, pharmacy stores, etc.,
- Military facilities,
- Sports facilities,
- Cemeteries, etc.

(3) Compensation for Land Acquisition, Resettlement, Utilities and Vegetation

1) Compensation

The “Southern Sudan Proposed Land Bill 2007 (2nd Draft)” as drafted by the Southern Sudan Land Commission outlines the different provisions on land in Southern Sudan including land ownership, land classification, land administration and management, land rights, land use and environmental preservation, etc. Further, the Land Bill stipulates provisions for “Expropriation of Land for Public Purposes” where compensation for land expropriation and resettlement policy is discussed. This provision states that, the compensation shall be just, equitable, and shall take into account the following factors:

- the purpose for which the land is being utilized,
- the market value, and
- the value of investment in it by those affected and their interest.

The land acquisition for public works (by the central and prefectural governments) in Juba is done as follows:

a. the Land Commission reviews the land compensation and scheduling (including costs) at the GoSS level,
b. land surveys related to land acquisition are conducted and relocation destinations reviewed, and
c. stakeholders discuss to make a decision.

Public Participation involving Payam/Local Government Administration like County, Payam Administration and Chiefs, Opinion Leaders is necessary as Clearly Stated in the Land Bill that was approved and passed as a law. Under this activity, proper documentation of Consultation of Meeting with full involvement of all the stake holders including the Ministry of Transport and Roads shall be done. It is then necessary to establish the affected people, identify the degree of impact and the number of villages involved, the number of plots of land, households affected, shops/ trading centers, ancestral/ cultural sites like graveyards and social facilities.

The Compensation Procedure/Framework/Policy for Land and Structures, as stated even in the Comprehensive Peace Agreement (CPA) is not firm. But it is based on the pre-existing circumstances like:

a. Number of people, source of livelihood,
b. Whether the project will improve their livelihood or not, and
c. Existing infrastructure like schools, hospitals, social/communal grounds, systems of agriculture, etc.

However, if the project is based on improving the affected people's livelihood, establishment of better infrastructure, provision of better social services like education, health services and promotion of trade then, compensation can be avoided.

The basic compensation costs for land and structures is presented in Table 18.2.3-1 below.

Table18.2.3 –1 Property and Land Cost (Juba Town)

	Government Area(including Military)	Commercial Area	Business Area	Housing Area	
				High Level	Low Level
Property (SDG)	1,000,000	800,000	1,200,000	40,000	158,000
Land Cost (SDG/m^2)	8,000	48,000	48,000	10,000	5,000

* Housing Area: Low Level →Typical house in juba

	School	Hospital	Water Supply (well etc.)
Property (SDG)	500,000	2,000,000	600,000
Land Cost (SDG/m^2)	15,000	30,000	10,000

Source: MTR(Environmental Protection Unit)

2) Utilities

At the moment, the basic utilities that maybe affected by road improvement include posts for high and low tension electric lines (11KV and 0.415KV respectively). The costs of removing and relocating this utility include:

- The electric poles for both High and Low (HT & LT) tension lines.

  High Tension lines electric poles costs・・・900 SDG.
  Low Tension lines electric poles costs・・・800 SDG.

- The electrical power constructors, cables, and insulators.

  Their real costs are evaluated at the site and depend on the level of damage suffered.

- The H-pole mounted transformer

  If the road construction displaces H-pole mounted transformers, the cost is assessed differently from those of Low and High tension lines electric poles. This is because it involves safe removal of the transformer from the poles before the electric poles are uprooted.

- Damaged materials

  Many materials, including conductors and the electric poles, to mention a few, might permanently get damaged in the shifting process and the cost can be determined on occurrence.

- Labor cost

  The construction company in charge of road improvement work meets the cost labor employed in removing poles to new location and any other cost related to the same.

3) Vegetation

The alternative routes proposed for the roads on both the Eastern and Western bank of the White Nile River is a rich niche of eco-diversity with varieties of Mango and Neem trees in such areas as Lologo, Coria, Judori, etc. However, the Vegetation Compensation is the sole responsibility of Central Equatoria State – Ministry of Agriculture and Forestry together with the Juba County – Commissioner, Payam – Executive Directors and finally the chiefs of the communities and elders (opinion leaders). GOSS – Ministry of Agriculture and Forestry are policy makers and the State Ministry is the implementer of these policies.

18.3 EXAMINATION OF ALTERNATIVE ROUTES

18.3.1 Site Reconnaissance

The delineation of the proposed routes for C2, C3 and R5, as shown in Figure 18.3.1-1 is done using the Geo-Eye Satellite Images acquired in March 2009 with 0.5m resolution.

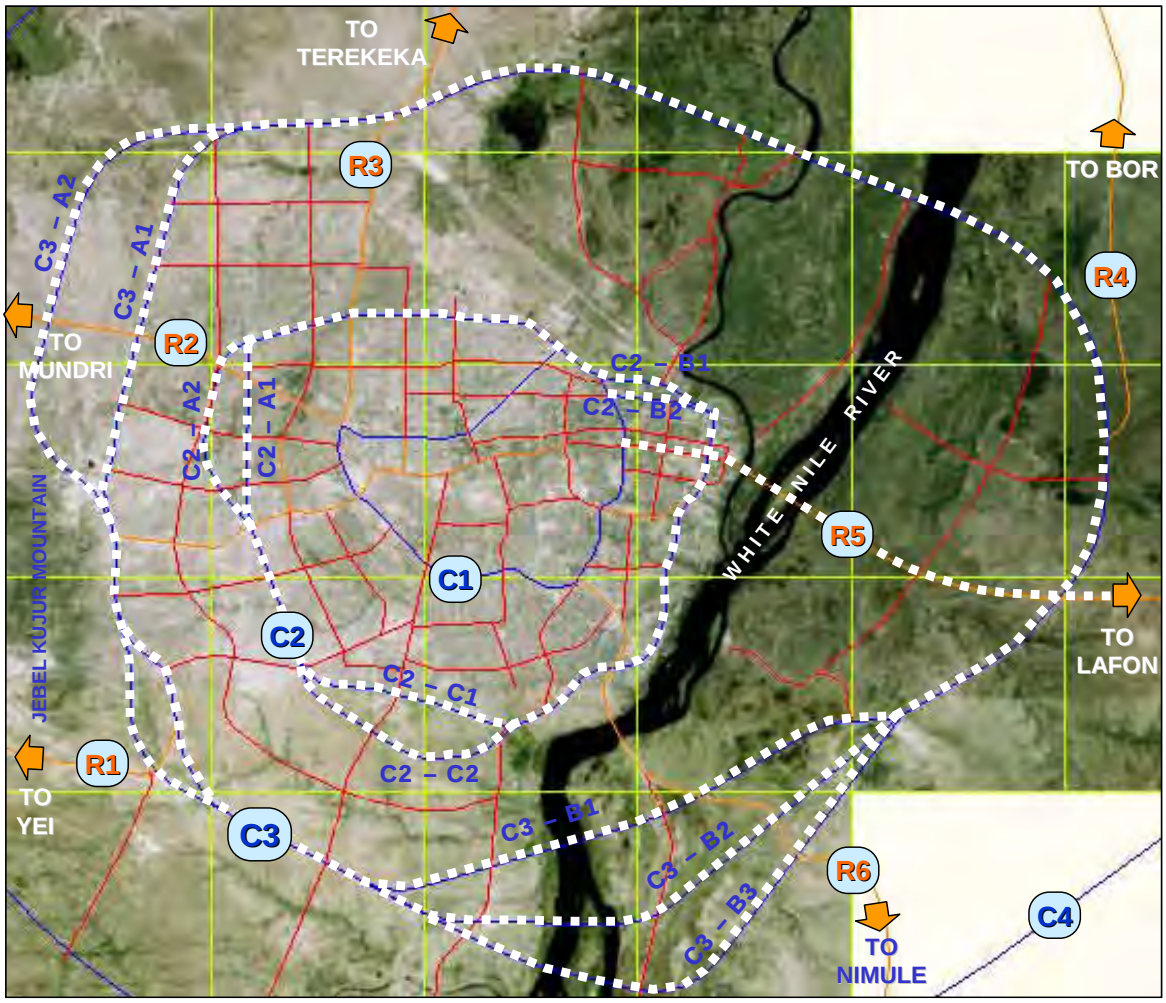


Figure 18.3.1-1 Delineation of the Proposed Routes by Satellite Image

Basically the proposed circumferential streets (C1 to C4), as seen in Figure 18.3.1-1 above covers Juba urban and the surrounding areas.

- Circumferential street C1 follows the existing alignment defined by the Unity Ave. from the Juba International Airport towards Juba University where it meets the Juba-Yei Road and proceeds following the Old Airport Road behind the GoSS Ministry Compound and back to the Airport.
- C2, on the other hand, overlaps with C1, and passes thru the Central Commercial District along the existing road towards south in Kator area and the Military base, then proceeds northwards to Munuki area and eastward to the Airport.
- C3, however, is mostly new alignment with sections of the Juba-Yei Road being utilized.

The route locations identified are verified and checked on site to determine the exiting conditions of the proposed alignment on ground. Photographs shown in Figure 18.3.1-2 present the actual conditions on site.

C2-B1 Alignment Option

C2-B2 Alignment Option

CCD Area

Juba National Stadium Area

Hai Malakal Cemetery Area

Juba River Port

Munuki Market Area

Juba Airport Road

Figure 18.3.1-2 (a) Existing Conditions of C2 Proposed Route

Jebel Kujur Mountain (C3-R1 Intersection)

3-km Road near MTR (Part of C3)

Gudele Market

Nyaing Lake North of Juba Airport

Juba Bridge (Nile River)

Proposed Nile River Crossing Site

C3-R6 Intersection Area

Bor Road Bridge (Proposed C3)

Figure 18.3.1-2 (b) Existing Conditions of C3 Proposed Route

R5-CCD Section (Paved Area)

R5-CCD Section (Unpaved Area)

R5 Nile River Crossing

R5-C3 Intersection (Lafon Road)

Figure 18.3.1-2 (c) Existing Conditions of R5 Proposed Route

18.3.2 Identification of Control Points

The control points presented in Table 18.3.2-1 and shown in Figure 18.3.2-1 were identified from the satellite images and verified on site. These control points are considered in establishing the most appropriate route alignments for C2, C3 and R5.

Table 18.3.2-1 Route Location Control Points

Route	Control Points
Circumferential Street C2	1. Juba International Airport 2. Central Commercial District 3. Juba Football Stadium 4. Hai Malakal Cemetery 5. Port Area 6. Military Area
Circumferential Street C3	1. Juba International Airport 2. Nyaing Lake (North of Juba Airport) 3. Juba Bridge 4. White Nile River Crossing 5. Jebel Kujur Mountain 6. Gudele Church Compound 7. Gudele Market – R2 Intersection
Radial Street R5	1. Central Commercial District 2. White Nile River Crossing

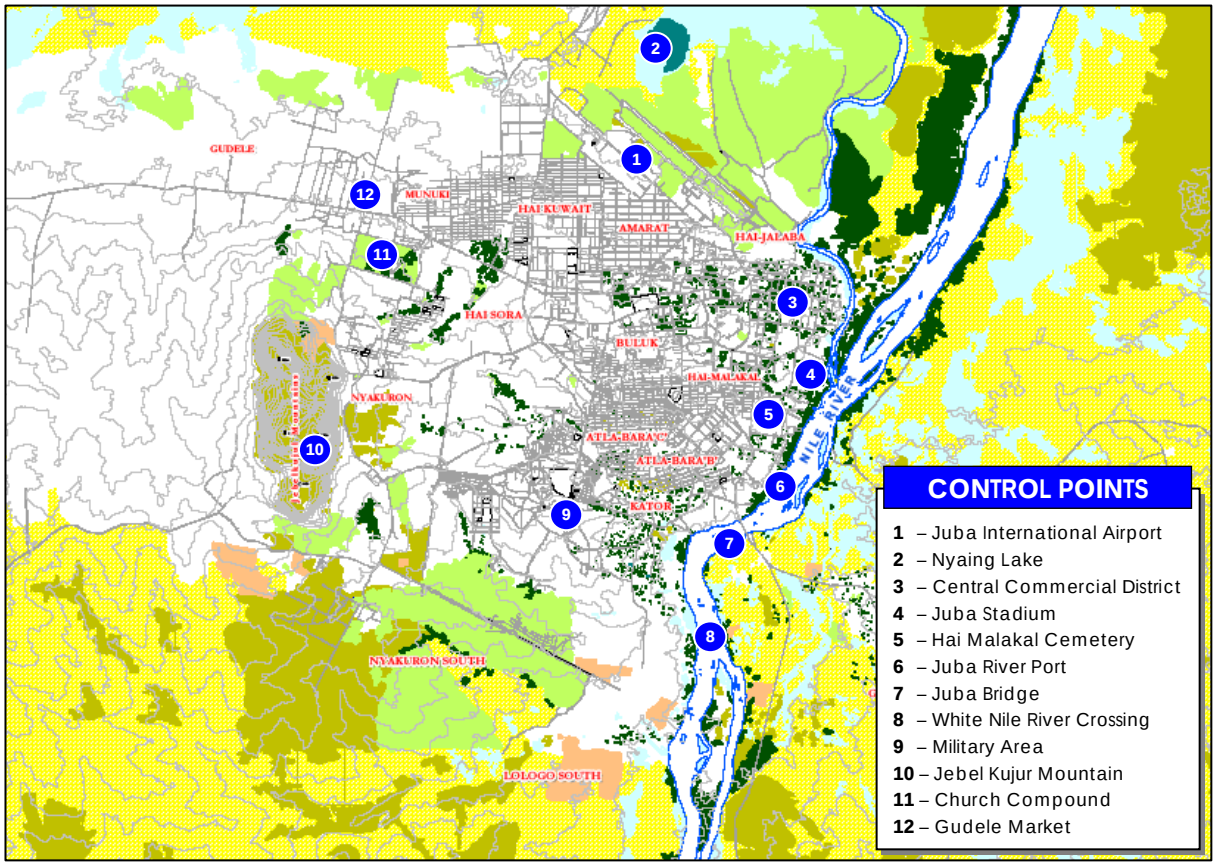


Figure 18.3.2-1 Control Points for Route Location Alternatives

18.3.3 Comparison of Alternative Routes

In sections where there are possible choices of route alignments, the proposed alternatives are examined and compared based on the following criteria:

- Road Alignment/Geometry : smooth alignment meeting minimum geometric requirements will be better alternative,
- Road Length/Cost : shorter route relates to cheaper cost,
- Affected Structure/Houses : less number of affected structures and houses will have less impact problem during implementation, and
- Right-of-Way (ROW) : alternative route with minimum additional right-of-way is recommended.

(1) Circumferential Street C2

The Circumferential Street C2 (see Figure 18.3.1-1), starting from the intersection with Radial Street R1 Street (Yei Road) proceeds north thru Munuki area and turns east at the southern section of Juba International Airport, utilizing the existing road alignment. It then passes thru the Central Commercial District and proceeds southwards towards the Juba River Port, passing near the Juba Stadium and the Hai Malakal Cemetery. On the southern side, it utilizes the existing road of the Military Compound and proceeds towards R1 on the eastern side of the Jebel Market.

Comparisons of alternative routes for Circumferential Street C2 are presented in Table 18.3.3-1 to Table 18.3.3-3.

Table 18.3.3-1 Alternative Section 1: C2 Alignment at CCD

Plan		
Option	Option C2-A1	Option C2-A2
Road Alignment/ Geometry	- forms better geometry at intersection with C1 - circumferential loop/traffic flow is attained smoothly	- forms a T-intersection with C1 and utilizes part of C1 to complete the circumferential loop - needs signalized junction and intersection improvement
Road Length/ Cost	1.2 km	1.37 km
Affected Structures	- structures/houses affected at 30% of the road length; less structures affected	- will affect existing structures at the entire road length due to narrow available ROW; more structures affected
ROW	- 0.70km of road at new alignment	- widening necessary at entire road length (1.37km)
Evaluation	*Recommended* (better alignment, cheaper and less ROW and affected structures)	X

Table 18.3.3-2 Alternative Section 2: C2 Alignment at South Military Area

Plan		
Option	Option C2-B1	Option C2-B2
Road Alignment/ Geometry	- location is almost middle between C1 and C3	- too far from C1 and too close to C3
Road Length/ Cost	2.80 km	3.2 km
Affected Structures	- less structures/houses affected	- affected structures/houses is 5 times of Option C2-B2
ROW	- passes thru existing military road (military plans to relocate the base outside Juba urban area) - 1.3km of new road after existing collector road	- existing road is about 1.2km of total length - remaining new road length is longer, at least 2km
Evaluation	*Recommended* (better alignment, cheaper and less ROW and affected structures)	X

Table 18.3.3-3 Alternative Section 3: C2 Alignment at Munuki Area

Plan		
Option	Option C2-C1	Option C2-C2
Road Alignment/ Geometry	- location is almost middle between C1 and C3 - better intersection geometry with R2	- too far from C1 and too close to C3 - intersection at R2 becomes 5-leg layout
Road Length/ Cost	2.32 km	2.68 km
Affected Structures	- less structures/houses affected	- affected structures/houses 25% more than C2-C1 option
ROW	- 0.45km road exists - less ROW acquisition necessary than C2-C2 option	- entirely new road necessary; need to acquire new ROW
Evaluation	*Recommended* (better alignment, cheaper and less ROW and affected structures)	X

(2) Circumferential Street C3

The Circumferential Street C3 (see Figure 18.3.1-1), starts at the intersection of Radial Street R1 on the eastern side of the Jebel Kujur Mountain and proceeds towards Gudele Area (utilizing the existing road passing thru Gudele Market). It then proceeds north of the Juba International Airport and the Nyaing Lake and eastward crossing the White Nile River until it meets the Radial Street R4 (Bor Road). C3 then proceeds southward, intersecting Radial Streets R5 and R6 and crossing the White Nile River on the southeastern side. It will then utilize the newly constructed 3km earth road at the Nyakuron South area and proceeds east towards the Jebel Kujur Mountain, using partly the existing R1 road alignment.

Comparisons of alternative routes for Circumferential Street C3 are presented in Table 18.3.3-4 to Table 18.3.3-5.

Table 18.3.3-4 Alternative Section 1: C3 Alignment at Gudele Area

Plan		
Option	Option C3-A1	Option C3-A2
Road Alignment/ Geometry	- adjustment of R2 intersection alignment and layout necessary - road alignment in relatively flat terrain	- better intersection alignment - beginning of alignment traverses the foot of Jebel Kujur Mountain - beginning of road alignment at rolling terrain
Road Length/ Cost	5.18 km	6.45 km (needs excavation on rocks)
Affected Structures	- more structures affected specially at R2 intersection (Gudele market) to adjust intersection layout	- lesser structures affected
ROW	- basically follows existing road alignment	- 80% of road on new alignment (more ROW needed)
Evaluation	*Recommended* (cheaper and easier to construct)	X

Table 18.3.3-5 Alternative Section 3: C3 Alignment at Jebel Kujur Area

Plan		
Option	Option C3-C1	Option C3-C2
Road Alignment/ Geometry	- utilizes part of R1 street but needs new road alignment to meet newly constructed earth road - alignment results in too many road curves - intersection with R1 needs adjustment	- simple road alignment - utilizes mostly the newly constructed earth road but requires new road opening near Jebel Kujur mountain - new intersection with R1 proposed
Road Length/ Cost	2.61 km	2.78 km
Affected Structures	- no structure affected but road widening necessary	- no structure affected
ROW	- needs 40% additional new ROW - road widening necessary for the remaining 60% part of ROW	- needs about 60% additional new ROW
Evaluation	X	*Recommended* (better road geometric alignment)

(3) Radial Street R5

The Radial Street R5 starts from the round about at the GOSS Ministry Compound with about 3kms of paved road and proceeds eastward within the Central Commercial District (CCD). It then crosses (following the existing road alignment in CCD) the White Nile River towards the east bank and proceeds to meet C3 on a new road alignment. From C3, R5 follows the existing road to Lafon.

Basically, R5 follows the existing road alignments with a new alignment from the east bank of Nile River to C3.

18.3.4 Nile River Crossing

(1) Circumferential Street C3

The Circumferential Street C3 crosses the While Nile River at two locations (refer to Figure 18.3.3-1):

- C3 Nile Bridge No.1 - South, and
- C3 Nile Bridge No.2 - North

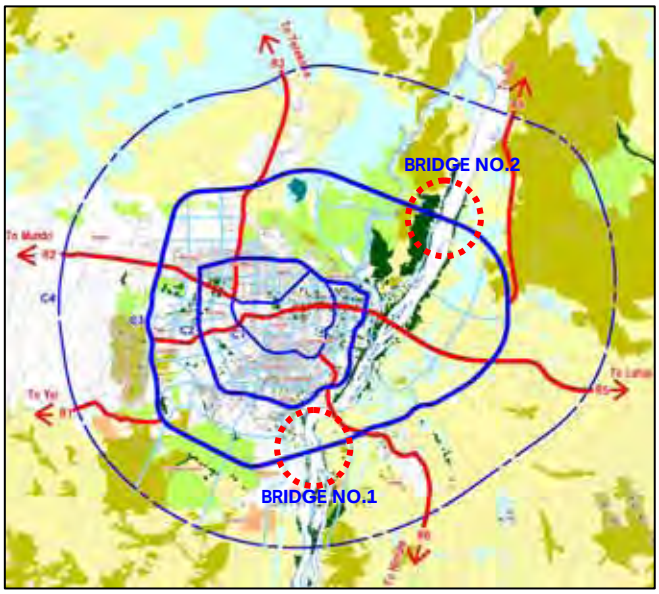


Figure 18.3.3-1 C2 Nile River Bridge Crossings

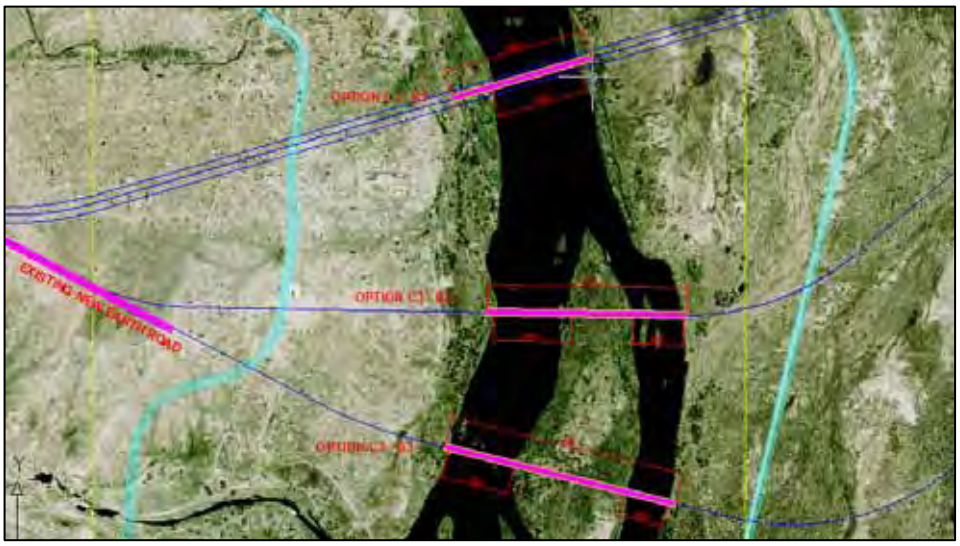
1) C3 Nile Bridge No.1 - South

There are three alternative sites for Nile Bridge No.1 on the southern section of Circumferential Road C3 as follows (refer to Table 18.3.3-6):

- Option C3-B1 – basically located about 1.75 km. south of the existing Juba Bridge with the least waterway width among the other options. The alignment of the new road section which is about 5.85 km long will require about 560m of bridge crossing over the White Nile River at the north side of the confluence of the two channels.
- Option C3-B2 – located at about 1 km. south of option C3-B1, this option connects with the existing new earth road on the west bank and crossing over the White Nile River thru two channels and over the island towards the eastern side. The alignment passes thru the community along the Juba-Nimule road and meets the Juba-Bor road at the end point.
- Option C3-B3 – further 1 km. south of option C3-B3, this option extends the alignment of the existing earth road towards the east side and crossing over the White Nile River and the island. Similar to option C3-B2, this option passes thru the community along the Juba-Nile road and meets the Juba-Bor road at the same point as option C3-B2.

A comparison of the three options is presented in Table 18.3.3-6. Among the three options, option C3-B1 has the shortest new road length and the shortest bridge crossing the White Nile River while option C3-B3 has the longest bridge length and the longest new road length. However, on the west side of the White Nile River, the road alignment of option C3-B1 has the most number of structures affected but on the other hand, has no structure affected on the eastern side.

Table 18.3.3-6 Alternative Bridge Locations for C3 Nile Bridge No.1 – South Section

Plan			
Option	Option C3-B1	Option C3-B2	Option C3-B3
Road Alignment/ Geometry	- road alignment crosses only one channel of the Nile River - alignment pass thru the community boundary on the eastern side - partially utilize the existing new earth road on the west bank	- road alignment crosses the Nile River at two converging channels - alignment cuts through the community on the eastern side - partially utilize the existing new earth road on the west bank	- road alignment crosses the Nile River at two converging channels - alignment cuts through the community on the eastern side - alignment follows the existing new earth road on the west bank
Road Length/ Cost	Road = 5.85 km Nile Bridge = 560m	Road = 6.48 km Nile Bridge = 770 m	Road = 7.02 km Nile Bridge = 910 m
Affected Structures	- affects most number of structures on the western side of Nile River - no structure affected on the eastern side of Nile River	- affects fewer number of structures on the western side of Nile River - most number of structures affected on the eastern side of Nile River	- affects the least number of structures on the western side of Nile River - more structures affected on the eastern side of Nile River
ROW	- shortest length, least additional ROW take	- 10% more ROW take than C3-B1	- longest alignment, greatest ROW take (20% more than C3-B1)
Evaluation	*Recommended* (better alignment, shorter road and bridge and cheaper to construct)	X	X

2) C3 Nile Bridge No.2 - North

The Circumferential Street C3 crosses the White Nile River and a smaller river (tributary to the White Nile) on the north side. Waterway openings during ordinary time at 435m and 112m for the Nile River and the tributary, respectively (see Figure 18.3.3-2). Three bridges are necessary in this area, Bridges No. 1A, 1B and 1C with lengths of 150m, 40m and 500m respectively.

Figure 18.3.3-2 C3 Nile River Bridge No.2 - North

(2) Radial Street R5

The radial street R5 crosses the White Nile River from the Central Commercial District (CCD) on the western side and proceeds towards the Lafon road on the eastern side of the river. The road alignment is basically fixed at the CCD (following the existing road alignment) where the bridge starts and crosses three waterway channels, one tributary and two main channels. The proposed bridge is about 915m long continuous from the west bank to the east bank of the river (see Figure 18.3.3-3).

Figure 18.3.3-3 R5 Nile River Bridge Crossing

18.4 PROPOSED OPTIMUM ROUTES

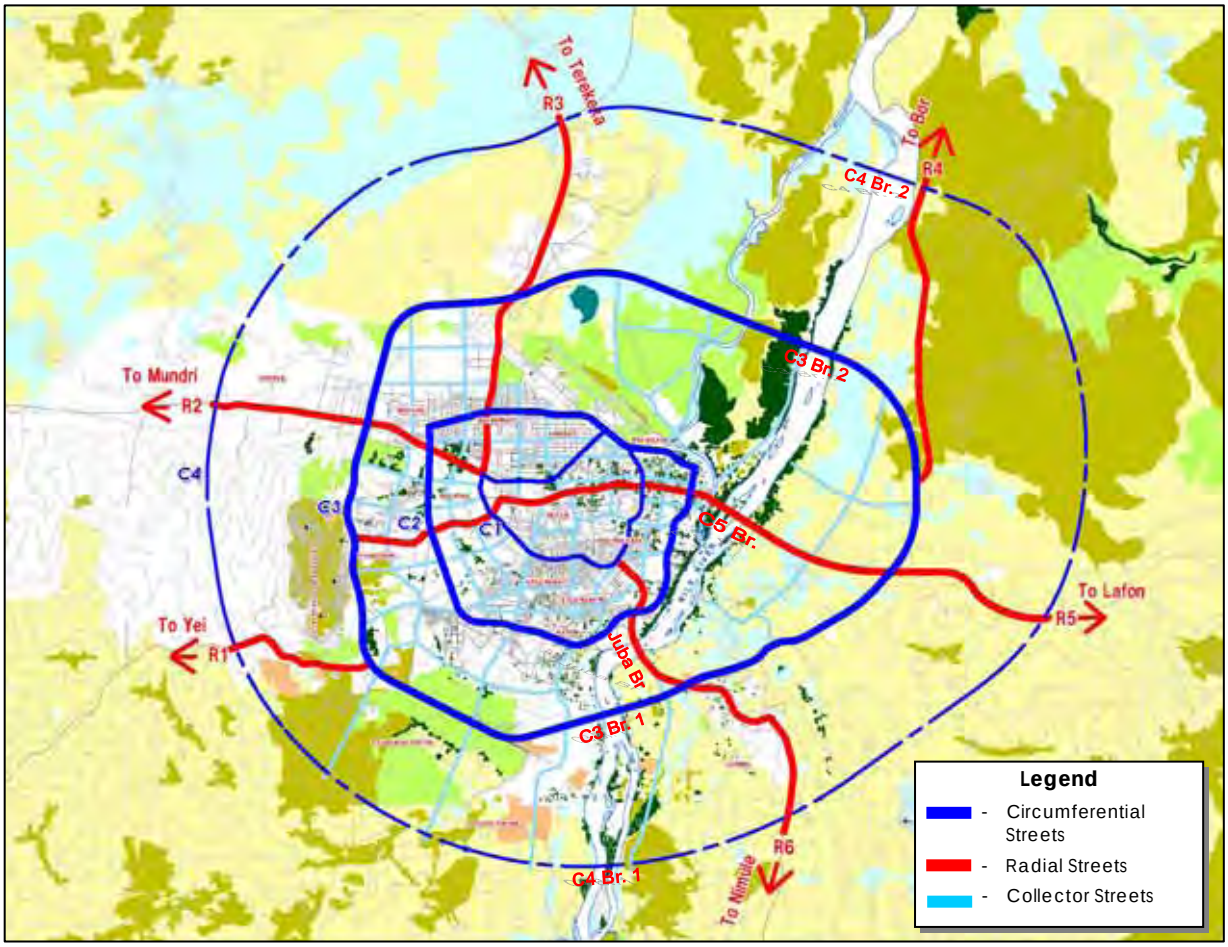


Figure 18.4-1 Proposed Route Locations for Juba Urban Road Network

The proposed Road Network in Juba Urban and Surrounding Areas is illustrated in Figure 18.4-1 showing the circumferential, radial and collector streets. The road network is established following the route location study for the major arterials to determine the optimum routes and corridors. These routes are briefly described in Tables 18.4-1 and 18.4-2 below.

Table 18.4-1 Proposed Circumferential Streets

Street No.	Road Length (km)	Area Enclosed (km^2)	Recommended ROW Width (m)	Description
C-1	10.2	5.1	50	- C-1 road alignment encloses the center of Juba urban area with direct connection to Juba International Airport, the GOSS Ministry Compound and other relevant Government Institutions, Juba University, Garang Memorial Park, Juba Teaching Hospital, Churches, Hotels, Business Establishments, and the eastern side of Central Commercial District.

C-2	16.7	14.9	50	- C-2 road alignment covers the area 1 to 2 km beyond C1 and provides road links to Juba International Airport (with section overlap with C-1), the Central Commercial District, Hotels, Juba National Stadium, Hai Malakal Cemetery, Kator residential area, Jebel Market, Nyakuron area, Munuki area, Hai Kuwait and Amarat areas.
C-3	34.2	64.4	60	- C-3 road alignment covers the area 1.5 to 3 km beyond C-2 passing north of the Juba International Airport, crossing the Nile river towards eastern Juba, utilizing part of the Juba-Bor road alignment, crossing the Nile river 1.75 km south of the existing Juba Bridge, utilizing part of the new earth road at the southern side of Juba, traversing the foot of Jebek Kujur Mountain towards Gudele area and intersecting the Juba-Terekeka road north of the Airport. - Two bridges cross the Nile river – Bridge No.1 (South) is 560m long and Bridge No.2 (North) is 690m long.
C-4	53.5	138.2	60	- C-4 road alignment development is expected to be beyond year 2025 and covers the area 3 to 4 km beyond C-3. - Two bridges will cross the Nile river.

Table 18.4-2 Proposed Radial Streets

Street No.	Road Length* (km)	Recommended ROW Width (m)	Description
R-1	6.5	60	- R-1 basically follows the Juba-Yei Road with some sections overlapping with C-3
R-2	5.8	60	- R-2 is the road alignment of Juba-Mundri Road
R-3	7.7	60	- R-3 is the Juba-Terekeka Road alignment
R-4	6.4	60	- R-4 is the Juba-Bor Road starting from C-3 on the eastern side of the Nile river
R-5	12.0	60	- R-5 starts from the GoSS Ministry Compound utilizing the May Road alignment towards the CCD area and crossing the Nile River towards C3 and follows the Lafon Road alignment. - One bridge, about 915m long, crosses the Nile river.
R-6	7.7	60	- R-6 starts from Unity Road (C-1), crosses the Nile River (Juba Bridge) and follows the Juba-Nimule Road alignment.

Note: *Road length is measured from the beginning of the radial street until circumferential street C-4

The routes identified for the circumferential, radial and collector streets in Figure 18.4-1 consist of existing and proposed new road alignment. Moreover, some of these streets are currently being improved and included in the Emergency Road Rehabilitation Project with part of the

Radial Street R6 being undertaken as part of the Juba-Nimule Road Project. The improvement works necessary for the proposed road network are illustrated in Figure 18.4-2.

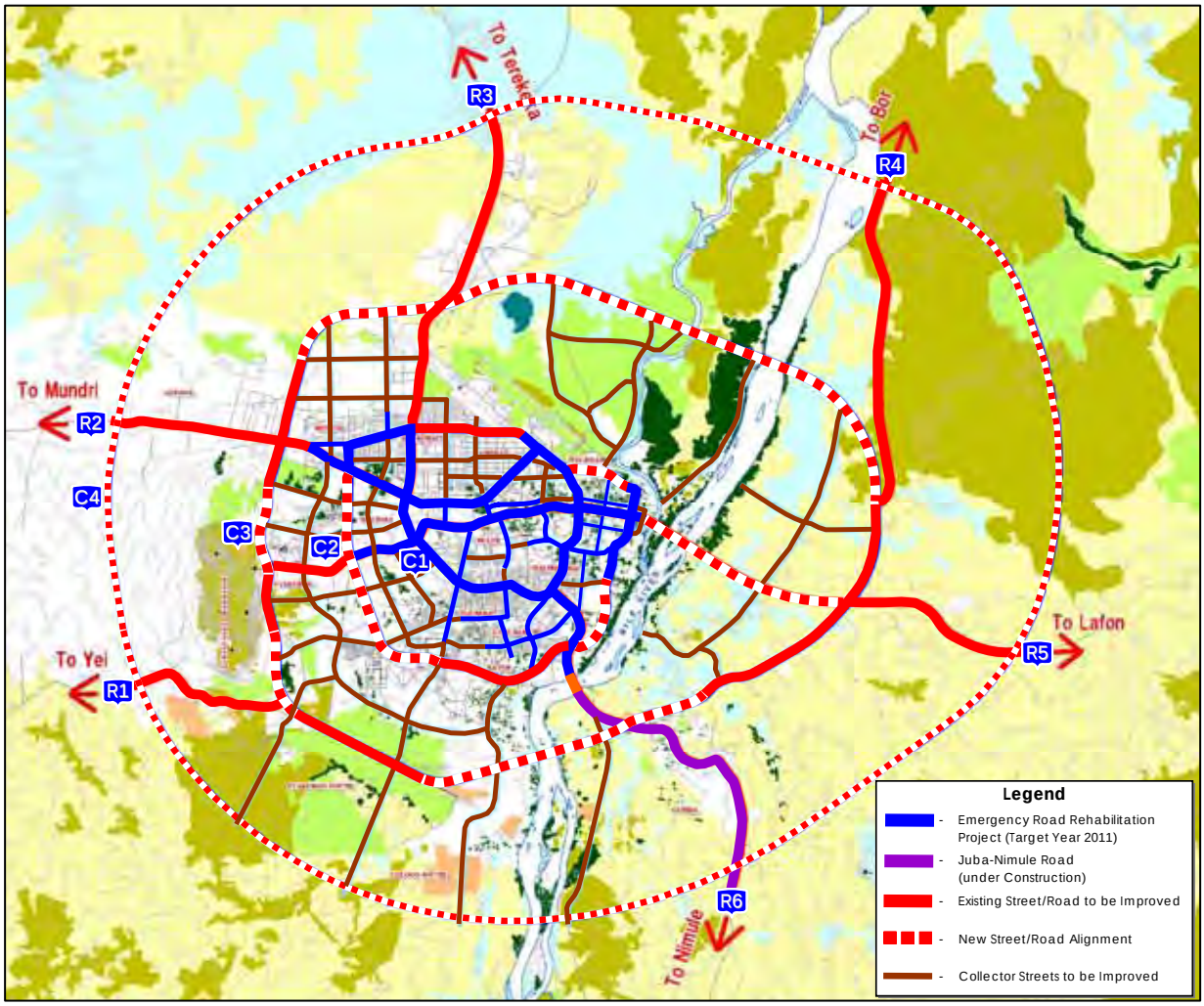


Figure 18.4-2 Work Improvement for the Proposed Juba Urban Road Network

18.5 PREPARATORY WORKS

In this Chapter, the route alignments are established for C2, C3 and R5 since other arterial roads including C1, R1-R4, section of R5 and R6 are basically existing roads. However, some road sections of the route alignments for C2, C3 and R5 do not exist, as indicated in Figure 18.4-2. Moreover, other arterial roads have road reserves less than that required for their functional class.

In this regard, it will be necessary to conduct preparatory works in order to reserve the require right-of-way as soon as possible to minimize further encroachment in the proposed road route alignments. It has been identified thru satellite images that settlements have been built haphazardly along and within the identified arterial road alignments.

The Ministry of Transport and Roads, together with the Ministry of Physical Infrastructure, the Land Commission, the Survey Department and other related offices and agencies should establish a ***Task Force for Road Network Master Plan Implementation*** as early as now to prepare the right-of-way of the identified routes for the proposed arterial roads.

Some of the activities of the working committee may include:

- Identifying and delegating responsibilities of different agencies on implementing the master plan,
- Public information regarding the road network master plan to inform the population of the intended road alignment and proposed land use,
- Staking and identification on site the probable route of the arterials roads, including widening of existing roads,
- Controlling structure development within the identified routes to maintain the required road width,
- Coordinating with utility companies to allocate utility areas, and
- Other related activities to secure the right-of-way.

CHAPTER 19

URBAN STREET NETWORK DEVELOPMENT IN SOUTHERN JUBA

CHAPTER 19 URBAN STREET NETWORK DEVELOPMENT IN SOUTHERN JUBA

19.1 OBJECTIVES AND APPROACH OF THE STUDY

19.1.1 Objectives of the Study

After a 20 year long war, continuous increase in population has arisen in Juba urban area due to the return of refugees/IDPs displaced by the war, as well as migration of a large number of people from rural areas. The area is thus expanding rapidly due to increasing economic activities in and around the area as well as development of temporary/permanent settlement areas for the returnees. The expansion is proceeding towards the south and westward, but without proper land development plan and road network, the development is proceeding in a haphazard manner.

A newly constructed earth road stretching to approximately 3 kilometers from Juba-Yei Road towards the Nile River is planned to be utilized as a part of the Circumferential Street C3. This road was constructed intending to develop the south and west areas of Juba, but the lack of integration with the definite road network plan and the absence of bridge to connect it with the eastern side of the Nile River retard the effective utilization of the road.

Under such circumstances, the demand for the establishment of the road network that would enhance orderly growth of the area which has high potential for development is very high and urgent.

The objectives of this Chapter are then:

- To prepare a basic plan of the road network in the southern area of Juba following the proposed Road Network Master Plan of Juba urban area, and
- To conduct a pre-feasibility study for the major road projects.

This includes selection of optimum routes, basic strategies and plan, preliminary design, construction plan and cost estimate, simplified economic evaluation and implementation plan.

As mentioned above, the study area is expanding rapidly but in a disorderly manner. The street network development in the area including construction of the bridge over the Nile River is expected to facilitate the mobility of traffic, vitalize the economy and enhance the orderly development of the region.

19.1.2 Study Methodology

The study flow of the urban street network development is illustrated in Figure 19.1.1-1.

(1) Present Condition of Southern Juba and Selection of Study Roads

The present condition of Southern Juba (considered as the south side of R1 and R5) such as topography, land use, road network, road condition, etc. is surveyed and the transport issues are identified. Then, reflecting the road development policy and plan established in formulating the

urban transport development master plan, the priority roads are selected for pre-feasibility study (which is discussed as the “Study Roads” in this Chapter).

(2) Design Policy

The improvement level is decided and design policy is established according to the role of the Study Roads and their categories in the functional road classification.

(3) Route Location

Among the Study Roads, the route location of the arterial streets has been determined in Chapter 18, while the route location of the collector streets is discussed in this Chapter in the same manner as applied in Chapter 18.

(4) Future Traffic Demand Forecast and Standard Cross-section

In Chapters 8 and 9, the future traffic demand has been forecasted both for the case when no road network development is done at all (Chapter 8) and for the case when the proposed road network is developed in accordance with the master plan implementation schedule (Chapter 9). Taking into account the traffic demand as well as the role of the road and its functional classification, the appropriate cross-section is determined for each study road. In order to minimize the initial cost, the stage construction (e.g. construct 2-lane road at initial stage and widen it to 4-lane before the traffic demand exceeds the 2-lane road capacity) is considered as necessary.

(5) Preliminary Design

In accordance with the design policy, preliminary design is prepared including alignment, pavement, drainage, major intersections, structures, Nile River Bridge and ancillary facilities.

(6) Construction Plan and Cost Estimate

The construction method, construction schedule and procurement plan of materials, equipment and labors are discussed and the project cost is roughly estimated.

(7) Environmental Impact Assessment

The environmental impact is assessed at the preliminary level.

(8) Simplified Economic Evaluation

The simplified economic evaluation is carried out comparing the project cost with the expected benefits accruing from the project, and

(9) Implementation Plan

Taking into consideration the capacity development in the course of the project implementation and possibility of donor assistance, the implementation plan is prepared including implementing system, schedule and annual fund requirements.

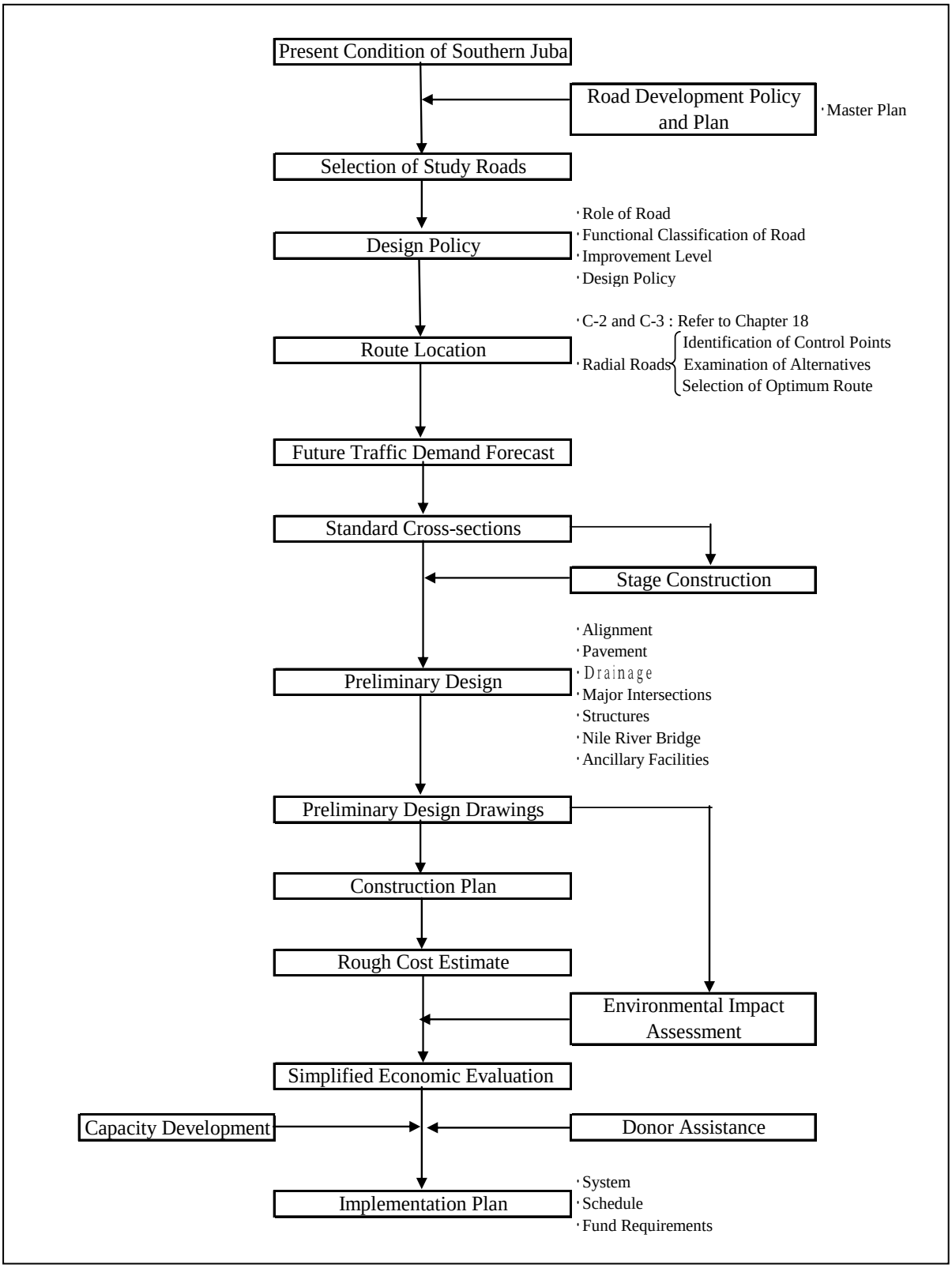


Figure 19.1.1-1 Study Flow on Urban Street Network Development in Southern Juba

19.2 PRESENT CONDITION OF SOUTHERN JUBA AND SELECTION OF STUDY ROADS

19.2.1 Present Condition of Southern Juba

The terrain of the project site (considered as south side of R1 and R5) is relatively flat with the ground elevation ranging from 460m to 490m. A detailed elevation varies in the project site as shown in Figure 19.2.1-1. The Nile River is located across the project site. A tributary is located in the southern area.

The geological condition is very favorable for road construction as CBR values surveyed by the Study Team is in between 7 and 74.

Figure 19.2.1-1 Geographic Condition in Southern Juba

Figure 19.2.1-2 shows the present land use of the southern Juba. The Juba urban area is expanding due to the return of refugees/IDPs after the war and migration from rural areas. Within C2, most of land use is residential, business/commercial and institutional. There is little open space inside C2 while the outside C2 in the southern section of Juba is predominantly open space or green space except Lologo area where small houses are densely located.

In the future, residential areas will expand towards the suburban areas such as Nyakuron South, Lologo South and Gumba in Southern Juba. Industrial areas are planned in the eastern side of the Nile River on the premise of a new port construction in the east bank. The new international airport is also planned in the eastern side of the Nile River (see Figure 19.2.1-3).

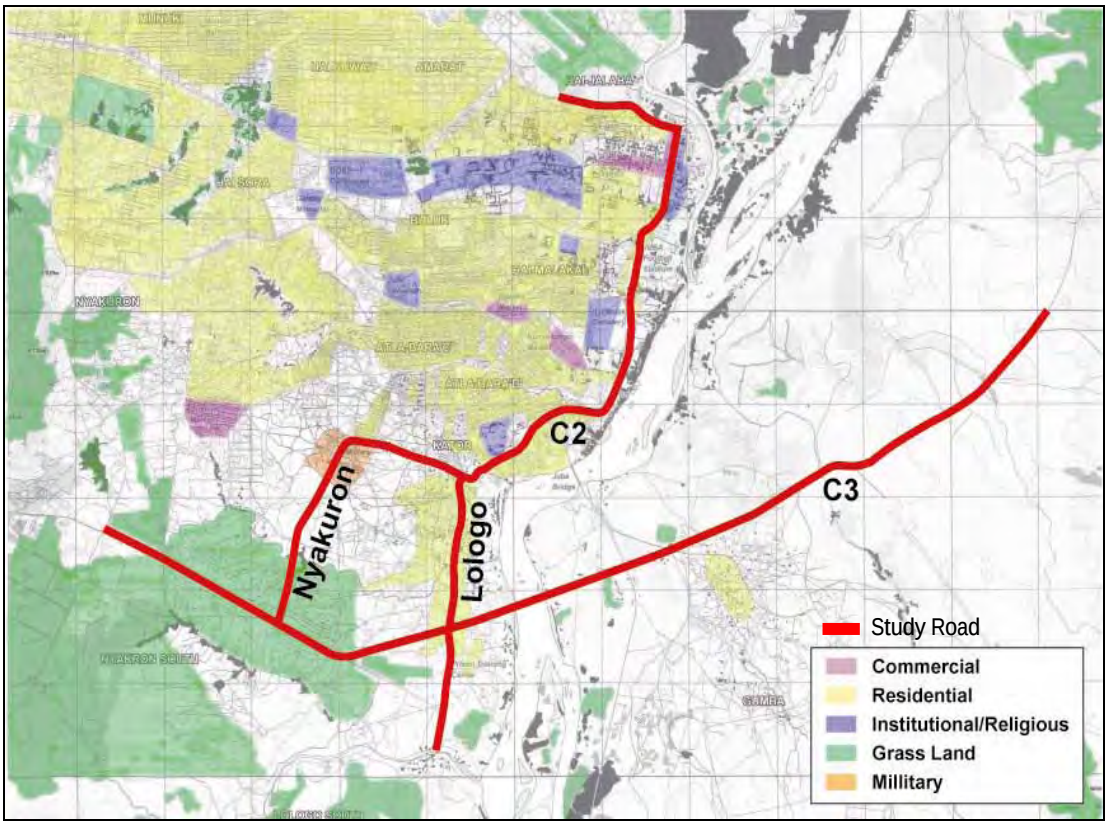


Figure 19.2.1-2 Present Land Use in the Southern Juba

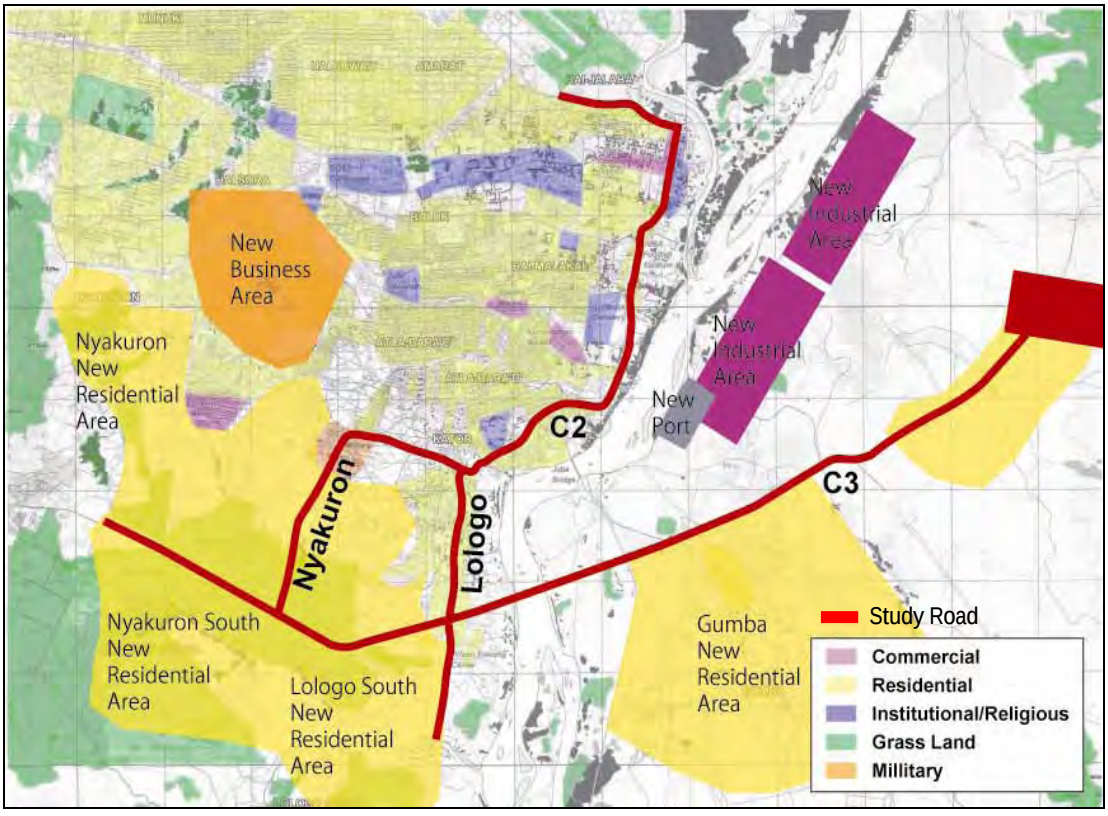


Figure 19.2.1-3 Land Use Plan in Southern Juba (2025)

Figure 19.2.1-4 shows the present road network and proposed Pre-feasibility roads. In southern Juba, all roads are unpaved in poor surface condition. Although many small houses are concentrated in Southern Juba such as Kator and Lologo, the road density in southern area is much lower than that in the central area. To promote the proper urban development in the southern Juba, the construction of major road network will be urgently needed.

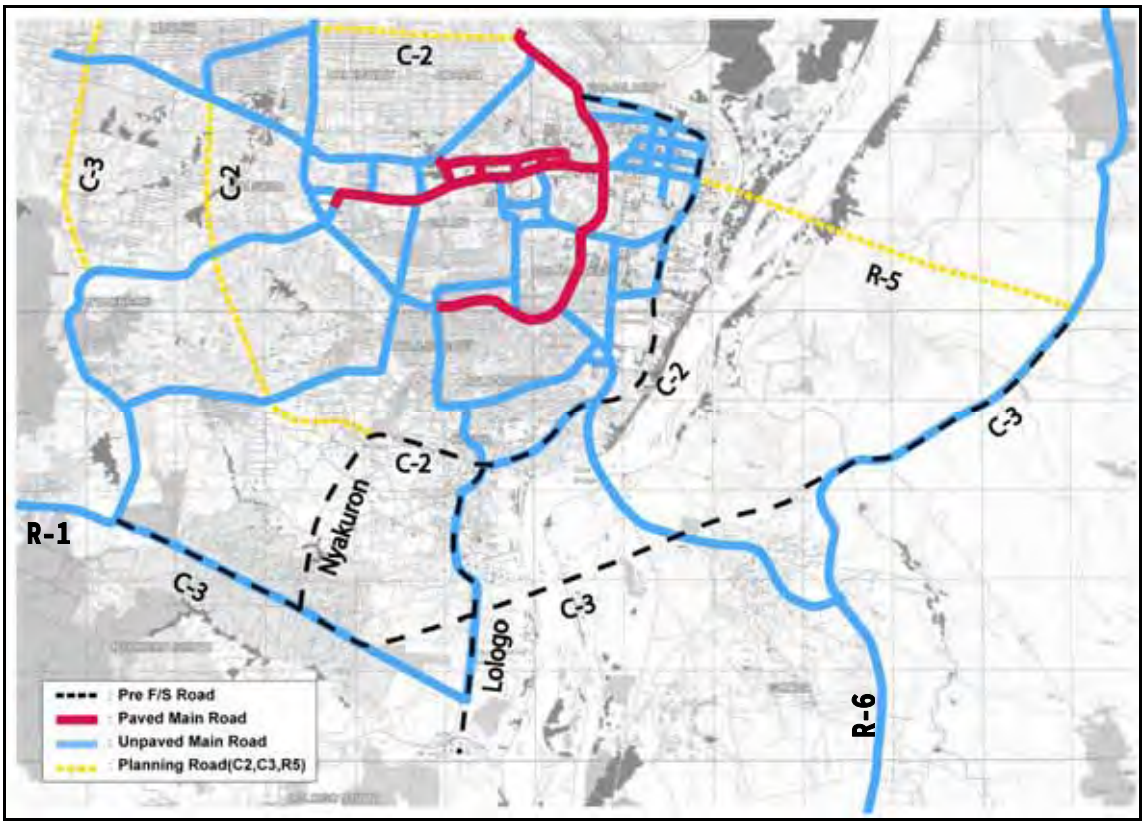


Figure 19.2.1-4 Present Road Network in Southern Juba

19.2.2 Selection of the Study Roads

The Study Roads were selected considering the following:

- Juba urban area is rapidly expanding due to increase in population due to returning refugees/IDPs and migration from rural areas, making it an urgent matter to expand the urbanized and residential areas.
- The expansion is proceeding mainly towards the east and southward. However, especially in the south, disordered development is in progress (see Figure 19.2.1-2 Present Land Use).
- The east area of the Nile River is also expected to be developed with the plan of construction of new international airport, railway station, industrial area and residential areas (see Figure 19.2.1-3 Land Use Plan in 2025).
- To promote the above development, it is necessary to construct the arterial streets traversing these areas first (C2 and C3 southeastern sections), followed by the provision of water and electricity in support of daily life.
- Moreover, the collector roads connecting these arterial streeets should also be constructed to provide a network that will link the settlements in Lologo and Nyakuron areas with the center of Juba.

- At present, the Juba-Nimule and the Juba-Yei-Kaya Roads are important international/ interstate roads connecting Juba to the southern neighboring country of Uganda. These roads are heavily traveled with trucks and busses carrying goods and people coming from Uganda and Kenya to Juba, passing thru the Juba Bridge which is the only link over the Nile River.
- The C3 southeastern section will become an alternate east-west route crossing the Nile River that will provide a direct connection between the Juba-Nimule (R6) and the Juba-Yei-Kaya (R1) roads. Once this section is completed, traffic movements going to the north, west or east of Juba need not pass thru Juba center and can bypass the area thus relieving Juba center from thru traffic passage.
- Moreover, the bridge section of C3 south over the Nile River will provide an alternate link to the only existing Juba Bridge. Additional bridges over the Nile River are necessary for the road network to function continuously without disruption in case of failure of the existing bridge.
- Thus, it is desirable to formulate the project for the construction of the major roads serving the southern area of Juba and the east of the Nile River.

From the above points of view, two circumferential street sections: C2 South Section and C3 South and East Section, and two radial streets connecting the above two circumferential streets: Lologo Radial Street and Nyakuron Radial Street, were selected as the Study Roads. Table 19.2.2-1 summarizes the major role of the selected Study Roads.

Table 19.2.2-1 Major Role of the Selected Roads

Road Name	Section	Road Length	Functional Road Class	Function
C2	From C1 near Airport to Military area (Intersection with Nyakuron Radial Street)	7.9 km	Arterial	• Circumferential Street. • Access to Central Commercial District, present residential area and some major facilities such as football stadium, cemetery, port and military.
C3	From Intersection with R5 to Intersection with R1(Juba-Yei Road)	12.0 km	Arterial	• Circumferential Street. • Bypass road for through traffic to Juba Town. • Alternative route connecting west and east sides of Nile River. • Major road to guide the proper urban development in the southern Juba.
Lologo Radial Road (CSA)	From Intersection with C2 to proposed Water Treatment Plant (passing Lologo residential area)	3.6 km	Collector	• Access road from south section to center of Juba. • Access road to Lologo residential area and new water treatment plant. • Link road with C2 and C3. • Together with C3, alternate route to R6 from west/central Juba.
Nyakuron Radial Road (CSB)	From Intersection with C2 to Intersection with C3	2.2 km	Collector	• Link road connecting C2 and C3. • Access road to Nyakuron area, which is located at new development area. • Together with C3, alternate route to R1 from central Juba.