ReCAP
Research for Community Access Partnership

UKaid
from the British people

Development of Guidelines and Specifications for Low Volume Sealed Roads through Back Analysis

Phase 3 Fieldwork Report

TRL Ltd

ReCAP Reference Number: RAF2069A

September 2019

TRL THE FUTURE OF TRANSPORT

Preferred citation: Otto, A., Mukura, K., Mayanja, M., Musenero, L., Leal, D., Rolt, J., TRL Ltd (2019). Development of Guidelines and Specifications for Low Volume Sealed Roads through Back Analysis, Phase 3 Fieldwork Report, RAF2069A. London: ReCAP for DFID.

For further information, please contact: Andrew Otto, aotto@trl.co.uk

ReCAP Project Management Unit
Cardno Emerging Market (UK) Ltd
Clarendon Business Centre

Level 5, 42 Upper Berkeley Street

Marylebone, London W1H5PW

Cover photo: Field Testing in Mozambique / Francis Dangare

Quality assurance and review table

Version	TRL Author(s)	Reviewer(s)	Date
1.0	Otto, A., Mukura, K., Mayanja, M., Musenero, L., Leal, D., Rolt, J.	Gershkoff, D.	25 April 2019
		N Leta, ReCAP PMU	2 May 2019
2.0	Otto, A., Mukura, K., Mayanja, M., Musenero, L., Leal, D., Rolt, J.	N Leta, ReCAP PMU	31 July 2019
3.0	Otto, A., Mukura, K., Mayanja, M., Musenero, L., Leal, D., Rolt, J.	Gershkoff, D.	20th September 2019
		N Leta, ReCAP PMU	27 September 2019
		Technical Panel	
4.0	Otto, A., Mukura, K., Mayanja, M., Musenero, L., Leal, D., Rolt, J.		03/10/2019
		Technical Panel	
5.0	Otto, A., Mukura, K., Mayanja, M., Musenero, L., Leal, D., Rolt, J.		6th November 2019

ReCAP Database Details: Development of Guidelines and Specifications for Low Volume Sealed Roads through Back Analysis

Reference No:	RAF2069A	Location	AFRICA REGIONAL PROJECT
Source of Proposal	ReCAP	Procurement Method	OPEN TENDER
Theme	INFRASTRUCTURE	Sub-Theme	LOW VOLUME SEALED ROADS
Lead Implementation Organisation	TRL LTD	Partner Organisation	NA
Total Approved Budget	£700,525	Total Used Budget	£626,743
Start Date	01/12/2018	End Date	30/06/2020
Report Due Date	23/09/2019	Date Received	23/09/2019

Contents

Tables and Figures

Abstract

Development of Guidelines and Specifications for Low Volume Sealed Roads (LVSR) through Back Analysis is a project being carried out in three phases. Phase 1 and Phase 2 were completed whereas Phase 3 started in December 2018 and is scheduled for completion in June 2020.

Phase 1 involved the identification of data sources; collection of historical performance data from previous studies; processing of the data; and creation of a database for Low Volume Roads (LVRs).

Phase 2 involved refining of, and addition of more data into, the database; training of counterparts from the participating road agencies of the 12 Africa Community Access Partnership (AfCAP) partner countries on how to use the database; and identifying gaps for further studies to refine standards and design catalogues.

Phase 3 involves field and laboratory investigations to fill the critical knowledge gaps that were identified in Phase 2; data analysis, corroboration or revision of existing specifications in guidelines and catalogues for pavement design for LVSRs; further population of the database; capacity building of participating road agencies counterpart staff who will be involved in the project activities; dissemination of findings; and production of a scientific paper.

This report describes the activities undertaken during the fieldwork stage of Phase 3 including site measurements, sampling of materials for laboratory testing, laboratory testing, and gathering any useful existing data related to the roads and capacity building. The report is an update of previous versions submitted in April and July 2019.

Key words

Regional Back Analysis, Sub-Saharan Africa, Low Volume Sealed Roads, Performance of Low Volume Roads.

Acknowledgements

The authors are grateful to the individuals from the road agencies in Ghana, Mozambique, Uganda and Zambia for providing their support during the study. These road agencies include: Ghana – Ministry of Roads and Highways (MRH), Ghana Highway Authority (GHA), and Department of Feeder Roads (DFR); Mozambique – National Road Administration (ANE); Uganda – Uganda National Roads Authority (UNRA); Zambia – Road Development Agency (RDA), and National Road Fund Agency (NRFA).

Acronyms, Units and Currencies

AASHTO	American Association of State Highway and Transportation Officials
ACV	Aggregate Crushing Value
AIV	Aggregate Impact Value
ADT	Average Daily Traffic
AfCAP	Africa Community Access Partnership
ALD	Average Least Dimension
ANE	National Road Administration of Mozambique
CBR	California Bearing Ratio
CMA	Cold Mix Asphalt
DCP	Dynamic Cone Penetrometer
DFID	Department for International Development
DFR	Department of Feeder Roads (Ghana)
DSD	Double Surface Dressing
DSS	Double Sand Seal
ESDAC	European Soil Data Centre
FI	Flakiness Index
FWD	Falling Weight Deflectometer
GHA	Ghana Highway Authority
GM	Grading Modulus
HMS	Highway Management System
IGAD	Intergovernmental Authority for Development
Km	Kilometre
LAA	Los Angeles Abrasion
LHS	Left Hand Side
LTPP	Long Term Pavement Performance
LVR	Low Volume Roads
LVSR	Low Volume Sealed Roads
MDD	Maximum Dry Density
MERLIN	Machine for Evaluation of Roughness using Low-cost INstrumentation
MESA	Million Equivalent Standard Axles
Mm	Millimetres
MoU	Memorandum of Understanding
MRH	Ministry of Roads and Highways (Ghana)
M-S-K	Matugga – Semuto – Kapeeka
NRFA	National Road Fund Agency (Zambia)
OMC	Optimum Moisture Content

OWP	Outer Wheel Path
PI	Plasticity Index
PMO-RALG	Prime Minister's Office-Regional Administration and Local Government of Tanzania
PSD	Particle Size Distribution
RAFU	Road Agency Formulation Unit
RDA	Road Development Agency (Zambia)
ReCAP	Research for Community Access Partnership
ReCAP PMU	Research for Community Access Partnership Programme Management Unit
RHS	Right Hand Side
RRC	Road Research Centre
SSD	Single Surface Dressing
TMH1	Technical Methods for Highways Part 1
TFV	Ten per cent Fines Value
TRL	Transport Research Laboratory
UNRA	Uganda National Roads Authority
UKAid	United Kingdom Aid (Department for International Development, UK)
VCI	Visual Condition Index
VEF	Vehicle Equivalence Factor
Vpd	Vehicles per day

Executive summary

This report covers the fieldwork stage of Phase 3 of the project on Development of Guidelines and Specifications for Low Volume Sealed Roads (LVSRs) through Back Analysis. Phase 3 of this project commenced in December 2018 and is scheduled to be completed in June 2020.

Phase 3 is focussing on bridging the knowledge gaps that were identified in Phase 2, through field and laboratory investigations in selected countries (Ghana, Mozambique, Uganda and Zambia). This will subsequently lead to analysis, update and/or corroboration of specifications in existing guidelines and catalogues for pavement design of LVSRs; capacity building, and finally dissemination activities. The knowledge gaps that were identified include: knowledge on the use of non-conventional surfacings at higher traffic levels (> 0.5 Million Equivalent Standard Axles, MESA); the limiting strength of base layer material at higher levels of traffic (>0.5 MESA) in areas of high rainfall (> 1000 mm); the performance of very weak and moderate strength subgrades in areas of high rainfall (> 1000 mm); the impact of maintenance on the performance of LVSRs; and durability and expected age of pavements and surfacings.

Fieldwork was carried out on sections of the following roads selected during the inception stage of this phase.

In Ghana:

- Cape Coast – Twifo Praso road.
- Mpataba Junction – Half Assini road.
- Koforidua – Adukrom road.

In Mozambique:

- Boane – Namaacha road.
- Boane – Moamba road.
- Macia – Chokwe road.

In Uganda;

- Kikorongo – Mpondwe road.
- Ishaka – Kasese road.
- Matugga – Semuto – Kapeeka road.

In Zambia:

- Samfya – Musaila road (off the D451).
- Mansa – Bahati road (M3).
- Mukuku Bridge – Samfya road (D235).

Visual condition surveys, DCP testing, test pits and cross-section levels were undertaken on all sections in all four countries. Deflection tests and roughness measurements were carried out in the countries where functional equipment exists (Uganda and Zambia). From the field studies, poor drainage is one of the main factors that affected the performance of the some of the sections studied.

The Roads Administration of Mozambique (ANE) is to be highly commended for providing resources towards the fieldwork despite the country being hit by two tropical cyclones during the fieldwork stage.

In order to enhance capacity and knowledge transfer, the fieldwork was undertaken jointly with counterparts from the participating roads agencies. The overall capacity building aim was to develop a culture of systematic research that leads to revision or development of standards and preservation of study data. This was exercised through involvement of the counterparts in all activities being undertaken. The counterparts from the participating roads agencies have been assisted towards writing scientific papers for conference or journal publication to help in enhancing and retaining the skills acquired. Tables of contents for these papers have been discussed with the participating countries.

1 Introduction

This report covers the fieldwork stage of Phase 3 of the project entitled Development of Guidelines and Specifications for Low Volume Sealed Roads through Back Analysis (referred to as the 'Back Analysis' project throughout this report). The data presented in this report will be used for analysis to revise material specifications and pavement structure catalogues. The revisions will be presented in the Final Project Report due to be produced by end of October 2019.

The data will be stored for future use in the database developed during Phase 2 of this project.

1.1 Background

The Back Analysis project is implemented under the Africa Community Access Partnership (AfCAP), a research programme that is funded by the UKAID - Department for International Development (DFID) and managed by Cardno.

The overall objective of the project is to undertake a review of the performance of Low Volume Sealed Roads (LVSRs) constructed in the last four decades in order to achieve the following:

Provide a database of existing LVSRs that have been investigated in relation to pavement type and materials, performance and environmental conditions, and consequently:

- Refine existing generic guidelines for selection of surfacing type as well as pavement design based on life-cycle costs.
- Corroborate and refine existing catalogues for pavement design of LVSRs in order to ensure their applicability to a wider range of materials and geographic conditions.

Provide a base level for information on the performance of non-standard designs and material specifications in comparison with conventional designs and specifications for roads carrying high traffic volume.

The project is divided into three phases. Phases 1 and 2 are complete whereas Phase 3 is ongoing. A summary of the activities for each of the phases is listed below.

- Phase 1 involved the identification and compilation of data sources; collection of historical performance data from previous studies; processing of the data; and the creation of a database for Low Volume Roads (LVRs). The link to the database that was developed is: www.lvroadsdata.com.
- Phase 2 involved refining of, and addition of more data into, the database; training of counterparts from the Road Research Centres (participating road agencies) of the 12 AfCAP partner countries on how to use the database; and identifying knowledge gaps for further studies to refine standards and design catalogues.
- Phase 3 (current phase) involves field and laboratory investigations to fill the critical gaps that were identified in Phase 2; analysis of the field and laboratory data, revision of specifications for guidelines and catalogues for pavement design; further population of the database; capacity building of participating road agencies counterpart staff who are involved in the project activities; dissemination of findings; and production of a scientific paper.

1.2 Gaps to be addressed in phase 3 of the project

Critical knowledge gaps in regard to the performance of LVSRs were identified in Phase 2. These included:

- Insufficient data on durability and expected age of pavements and surfacings.
- Insufficient data on performance of LVSRs subjected to traffic loading ranging between 0.5 and 1 Million Equivalent Standard Axles (MESA).
- Insufficient data on the impact of high rainfall on the performance of the base and surfacing layers in LVSRs.
- Lack of data on maintenance and its impacts on performance of LVSRs – maintenance regime vs. type of surfacing vs. environment.

- Insufficient data on dealing with weak to moderate strength subgrades in LVSRs.
- Insufficient data on unconventional road bases in different environments.
- Insufficient data on locally-available materials (types and properties) and their performance under heavy traffic loading.
- Insufficient data on non-conventional surfacings (Otta seal, Sand seals, combinations seals, Road Mix, Cold Mix Asphalt – CMA, etc.).

In order to bridge the above knowledge gaps, the following investigation matrices were suggested:

- Non-conventional surfacing versus traffic, environment and age.
- Bases versus traffic loading and environment.
- Maintenance versus climate, traffic loading, age and type of surfacing.
- Weak subgrades versus traffic loading, climate and age.

A detailed description of the knowledge gaps and investigation matrices was provided in the Phase 2 Report. This phase (Phase 3) of the project will go a step towards bridging these gaps through studies in selected AfCAP partner countries, data analysis, and dissemination.

1.3 Countries of study in Phase 3 of the project

During the inception stage of Phase 3 of the project, reconnaissance visits were undertaken, and four countries were identified as having prospective study areas that would be suitable for detailed investigations in Phase 3. Table 1 presents the countries that were selected and the main reasons for their selection. Road network, soil and climatic characteristics of the study sections are presented in Annex 1. These sections do not represent the full matrix of climatic conditions in each of the study countries. However, the combination of the conditions in the different countries vary from low to very high rainfall.

Table 1 Proposed study countries for Phase 3 and the corresponding justification

Country	Reasons for selection
Ghana	▪ Rainfall of 1250 – 2000 mm/year in a large part of the country. ▪ Weak subgrades.
Mozambique	▪ A large percentage of the road network was constructed using marginal materials that have generally performed well for several years past their design life. ▪ Highly varied climate.
Uganda	▪ A large variety of non-conventional surfacings were constructed in the eastern and northern part of the country between 2011 and 2014. ▪ High quantity of rainfall with many areas receiving more than 1250 mm/year. ▪ Large areas of swampy subgrades. The likelihood of finding weak subgrades is therefore high.
Zambia	▪ Average rainfall conditions (750 – 1500 mm/year) in a large part of the country. ▪ A large variety of subgrade soils. The likelihood of finding very weak to medium strength subgrades is therefore high.

1.4 Structure of this Report

The main purpose of this report is to collate the data collected in the field and laboratories during Phase 3 of this study and to provide a summary of the capacity building activities. The report will assist in putting into context the data from the fieldwork that will be stored in the Back Analysis Database.

The report is structured as follows:

- Section 1 presents the project objectives, the knowledge gaps that were identified in Phase 2, and the countries that were selected for the Phase 3 investigations.
- Section 2 presents data of the fieldwork and laboratory testing that was carried out in the four countries during Phase 3 (this phase) of the project.
- Section 3 discusses the capacity building activities carried out during Phase 3.
- Section 4 outlines the summary and way forward.

2 Field Measurements and Laboratory Tests

2.1 General

Fieldwork was carried out in Ghana, Mozambique, Uganda and Zambia and was completed on 15th April 2019. The sections below collate the data collected on a country by country basis. The data will be combined with previous studies and used to propose revisions to existing standards and specifications for low volume roads.

On all sections, visual condition survey, DCP testing, test pits and cross-section levels have been undertaken. Deflection tests were undertaken in Uganda and Zambia; whereas these measurements were not undertaken in Ghana and Mozambique due to equipment malfunction. Roughness measurements have been carried out in Uganda; it has not been measured in Zambia due to a lack of any roughness measurement equipment and it has not been carried out in Ghana and Mozambique due to faulty equipment. The roughness measurements in Uganda were made using an automated vehicle with roughness accelerometers. The vehicle was calibrated using a MERLIN. The measurements were made at 100 m intervals (Information Quality Level 2).

Test pits were excavated on all road sections and samples were collected for laboratory testing. Aggregate-related tests and bitumen-related tests were not carried out in Mozambique because of the bitumen extraction machine was not operational. In Ghana and Zambia, the extraction of bitumen from the aggregate-bitumen matrix was carried out but separation of the solvent from the bitumen was not possible due to machine malfunction.

The samples were subjected to the following laboratory tests:

- Soils related tests (all 4 countries)
  - CBR.
  - Maximum Dry Density (MDD) / Optimum Moisture Content (OMC).
  - Moisture contents.
  - Atterberg Limits.
  - Particle Size Distribution (PSD).
  - Unconfined Compressive Strength.
- Aggregate related tests (Ghana, Uganda, and Zambia)
  - PSD.
  - Aggregate Crushing Value (ACV) / Ten per cent Fines Value (TFV) / Aggregate Impact Value (AIV).
  - Los Angeles Abrasion (LAA).
  - Average Least Dimension (ALD).
  - Flakiness Index (FI).
  - Specific gravity and water absorption.
- Tests on recovered bitumen (Uganda)
  - Penetration.
  - Softening point.

The data has been collated and is presented in the following sections. In addition, summary data tables are provided in Annex 2 and Annex 3. These sets of data will also be entered into the Back Analysis Database for future use.

In Ghana, Uganda, and Zambia laboratory testing was conducted using the British Standards test methods whereas in Mozambique the tests were conducted using AASHTO test methods for soils, and TMH1 for aggregates.

Visual condition assessment was carried out using the ReCAP Visual Condition Index (VCI) system modified from the method described in Technical Recommendation for Highways 22 (TRH 22).

Raw data to levels more basic than what has been provided in this report, can be obtained from the database lvroadsdata.com.

2.2 Traffic data

In all cases, axle load surveys and traffic counts were conducted, or historical data obtained. The axle masses were then converted to vehicle equivalence factors (VEF). The compounding power (n) used was 4.0 in all cases – as recommended by several low volume roads manuals. The traffic growth rates were obtained from the respective country GDP and these were used to compute the cumulative equivalent standard axles that the roads had carried.

In some cases (see subsequent sections), a pessimistic estimate of the traffic carried to date was computed by assuming that all loaded trucks were within the legal axle load limits. A range (pessimistic to realistic) is therefore quoted in such cases.

2.3 Ghana

The study roads in Ghana are: Mpataba junction – Half Assini Road in Western Region, Cape Coast – Twifo Praso Road in the Central Region, and Koforidua – Adukrom Road in Eastern Region.

Rainfall data, the age of the roads, and traffic loading for the study roads are shown in Table 2. The traffic loading growth rate is based on the average GDP over the last 30 years for Cape Coast – Twifo Praso road and Koforidua – Adukrom road, and the last 20 years for Mpataba junction – Half Assini Road. The characteristics of the surfacing materials of the study sections are shown in Table 3. There are sections with surfacing aggregates of very high flakiness – these sections are known to have performed poorly.

Table 2 Key data for the Ghana roads

Road Name	Age (Yrs)	Estimated Traffic Loading to date (MESA)	Growth Rate used for Traffic Load Computation (%)	Mean Annual Rainfall (mm)
Mpataba Junction – Half Assini	12	0.6-1.2	6.0	2139
Cape Coast – Twifo Praso	>20	0.6	5.3	1282
Koforidua - Adukrom	>20	3.5-6.9	5.3	1368

Table 3 Surfacing characteristics of the study roads in Ghana

Road Section	Type of Surfacing	Aggregate Characteristics			
		Flakiness Index (%)	Elongation Index (%)	Water Absorption (%)	Dust (< P0.075 mm)
Mpataba Junction – Half Assini 1	Double Surface Dressing	47	19	0.6	3
Mpataba Junction – Half Assini 2	Double Surface Dressing	12	17	0.4	2
Cape Coast – Twifo Praso 2	Double Surface Dressing	19	23	0.6	4
Koforidua – Adukrom 1	Double Surface Dressing	33	11	0.0	3
Koforidua – Adukrom 2	Double Surface Dressing	9	13	0.6	2

2.3.1 Cape Coast – Twifo Praso Road

On Cape Coast – Twifo Praso road (71 km), two study sections whose surface condition was fairly good were identified between km 35+000 and 60+000 of the road. On one of the identified sections (Section 1), signs of a rising water table were observed during the rainy season. This section has performed well to date but does have the potential to deteriorate to a poor state due to the rising water table. The second section (Section 2) was considered as a 2-in-1 section. The start of the section had very low rutting but the middle part had rutting and cracking in the outer wheel track of the Left Hand Side (LHS). The visual condition assessment of the sections is shown in Table 4. The Visual Condition Index (VCI) values indicate that the sections are performing in a similar way.

Table 4 Visual condition summary of Cape Coast – Twifo Praso sections

Section	Crack Index (crack Intensity x Extent)	Potholed Area (m^2)	Patched Area (m^2)	Mean Rut Depth (mm)		VCI	Drainage Indication
				LHS	RHS		
Section 1 (Good/Fair) (33+500 – 33+850)	8	0.52	0.05	14	2	78	Fair
Section 2 (Fair) (36+300 – 36+475)	10	0	0	15	0	75	Fair

The test pit logs (Table 5 and Table 6, and Figure 1 and Figure 2) show a number of layers and therefore the possibility of a pavement constructed over an existing pavement. Construction records could not however be obtained to verify this.

Table 5 Test pit log of Section 1 Cape Coast – Twifo Praso

TEST PIT LOGGING FORM					
Project Title:	ReCAP Back Analysis Project			**Survey Number:**	TP-1
Province:	Central		**Road Name:**	Cape Coast - Twifo Praso	
Section:	Fair (33+500 - 33+850)		**Date:**	26/03/2019	
Length (m):	350		**Chainage**	33+600	**Test Position:** 4 (OWT)
Lane:	1 LHS (Cape Coast bound)		**Surveyors:**	LM, EB, JM, EA	
Surface Condition at point of test:			Ravelled		

Layer	Depth Reading (mm)		Thickness (mm)	Layer/Material Description/Defect	Sampled for:
Surfacing	Top	0	19		
	Bottom	19		Bituminous seal	Binder extraction, aggregate testing
Base	Top	19	130		
	Bottom	149		Brown gravelly material	Full characterisation
Sub-base	Top	149	110		
	Bottom	259		Reddish clayey gravel	Full characterisation
Capping	Top	259	20		
	Bottom	279		Brown gravelly material	Not sampled
Subgrade	Top	279			
	Bottom	1019	740	Reddish brown clayey silt	Full characterisation
Total Thickness			1019		
Other Notes:					

Figure 1 Test Pit 1 Section 1 Cape Coast – Twifo Praso

Table 6 Test pit log of Section 2 Cape Coast – Twifo Praso

TEST PIT LOGGING FORM						
Project Title:	ReCAP Back Analysis Project			**Survey Number:**	TP-2	
Province:	Central		**Road Name:**	Cape Coast - Twifo Praso		
Section:	Fair (36+300 - 36+475)		**Date:**	27/03/2019		
Length (m):	175		**Chainage**	36+425	**Test Position:**	9 (OWT)
Lane:	2 RHS (Twifo Praso bound)		**Surveyors:**	LM, EB, JM, EA		
Surface Condition at point of test:			Crocodile cracks of medium intensity; longitudinal crack			

Layer	Depth Reading (mm)		Thickness (mm)	Layer/Material Description/Defect	Sampled for:
Surfacing	Top	0	20	Bituminous seal	Binder extraction, aggregate testing
	Bottom	20			
Base	Top	20	100	Brown gravel	Full characterisation
	Bottom	120			
Intermediate	Top	120	20	Reddish brown silty material	Full characterisation
	Bottom	140			
Sub-base	Top	140	340	Brown clayey gravel	Full characterisation
	Bottom	480			
Subgrade	Top	480			
	Bottom	740	260	Reddish brown clayey silt	Full characterisation
Total Thickness			740		

Other Notes:
It appears that the lower pavement layers have higher moisture content. 2 sub-base layers (with a split of 140 mm and 200 mm totalling up to the 340 mm represented in the test pit log above) were encountered. Although the materials composition of both layers was the same, the two layers appeared different due to the difference in moisture content. They will be dried separately to ascertain the similarity in material. For the sake of this logging, they have been represented as one layer

Figure 2 Test Pit 2 Cape Coast Twifo - Praso

The in-situ DCP-CBRs (Table 7) indicate that the good performing section is stronger than the fair performing section. The laboratory CBRs show similar base layer strengths, grading and plasticity characteristics between the two sections. Values in brackets are laboratory soaked CBRs at 98% for base – all at BS Heavy Compaction. This method of presentation of CBR values is used throughout the report.

Table 7 Materials characteristics for Cape Coast – Twifo Praso

Layer	Section 1 (33+500 – 33+850) Good/Fair				Section 2 (36+300 - 36+475) Fair			
	Average CBR (%)	DN (mm/blow)	GM	PI	Average CBR (%)	DN (mm/blow)	GM	PI
Base	100 (85)	2.8	2.0	23	80 (87)	3.5	1.9	23
Sub-base	146	2.0	-	-	123	2.3	-	-
Subgrade	50	5.5	-	-	50	5.5	-	-

The camber and crown heights (Table 8) of the sections are low compared to existing standards (3% and 0.75 m respectively)

Table 8 Geometric parameters of the Cape Coast – Twifo Praso sections

Section	Maximum Gradient (%)	Mean Camber (%)	Mean Crown Height (m)
Section 1 (Good/Fair)	1.7	1.5	0.4
Section 2 (Fair)	0.1	1.9	0.3

The ADT and VEF of the vehicles that use Cape Coast – Twifo Praso road was obtained from the regional office and is presented in Table 9.

Table 9 ADT and VEF of vehicles on Cape Coast – Twifo Praso sections

Vehicle Type	Total ADT	VEF (CC-TP Direction)	ESA/day (CC-TP Direction)
Cycles	33	0	0
Motor bikes	230	0	0
Cars	104	0	0
Taxis	98	0	0
Pick-up / Van/ 4WD Vehicle	82	0	0

Small bus	400	0	0
Med. bus/ Mammy wagon	4	0	0
Large bus	3	0	0
Light truck	110	0	0
Medium truck	16	9.9	66
Heavy truck	6	9.4	31.3
Semi-trailer (light)	4	25.5	153
Semi-trailer (heavy)	3		
Truck trailer	7		
Extra large truck & construction equipment	2	1.8	2.4
Tractor	1	0	0
Tractor with trailer	0	0.2	0
Total	**1103**		**253**

2.3.2 Mpataba Junction – Half Assini Road

Two sections were studied on this road, one "poor" with a large number of failures (potholes and patching) and the other in good condition. A visual condition survey (VCS) was carried out on the two sections and the summary results are presented in Table 10. The detailed visual condition assessment for Ghana is presented in Annex 2. Severe cracking and inadequate drainage provision (such as functioning side drains and mitres) was poor suggesting this to be the cause of the defects observed.

Table 10 Visual condition assessment summary of Mpataba Junction – Half Assini

Section	Crack Index (Crack Intensity x Extent)	Potholed Area (m^2)	Patched Area (m^2)	Mean Rut Depth (mm)		VCI	Drainage Indication
				LHS	RHS		
Section 1 (Poor) 3+500 – 3+800	11	12.4	224	15	17	26	Inadequate/Poor
Section 2 (Good) 6+200 - 6+600	0	0.3	0.4	5	4	90	Good

One test pit was excavated on each of the study sections. The logs are shown in Table 11 and Table 12 and photographs of the pits are shown in Figure 3 and Figure 4. It is noted that the materials are generally silty and clayey even in the good section and yet the road has performed satisfactorily for several years. Conversely, the poor section, despite having a thick layer of crushed stone material, has performed poorly with several potholes and patching as indicated in Table 11.

Table 11 Test Pit Log Section 1 Mpataba Junction – Half Assini

TEST PIT LOGGING FORM					
Project Title:	ReCAP Back Analysis Project			**Survey Number:**	1
Province:	Western		**Road Name:**	Mpataba Junction - Half Assini	
Section:	Poor section (3+500 - 3+800)		**Date:**	21/03/2019	
Length (m):	300		**Chainage**	3+600	**Test Position:** 8
Lane:	RHS (OWT)		**Surveyors:**	LM	
Surface Condition at point of test:			Heavily ravelled, crocodile cracks, distinct depression (almost a sign of break-away) from the rest of the pavement		

Layer	Depth Reading (mm)		Thickness (mm)	Layer/Material Description/Defect	Sampled for:
Surfacing	Top	0	19	Bituminous seal, defective	Binder extraction, aggregate testing
	Bottom	19			
Base	Top	19	300	Gravelly with crushed stone material	Full Characterisation
	Bottom	319			
Sub-base	Top	319	100	Reddish brown silty material	Full Characterisation
	Bottom	419			
Sub-base	Top	419	180	Dark brown clayey silt material	Full Characterisation
	Bottom	599			
Subgrade	Top	599			Subgrade Characterisation
	Bottom	879	280	Reddish brown silty material	
Total Thickness			879		

Other Notes:
Material just below the surfacing wet, sign of water ingress from the surfacing

Figure 3 Test Pit on Section 1 Mpataba Junction – Half Assini

Table 12 Test Pit Log Section 2 Mpataba Junction – Half Assini

Project Title:	ReCAP Back Analysis Project			**Survey Number:**	2
Province:	Western		**Road Name:**	Mpataba Junction - Half Assini	
Section:	Poor section (6+200 - 6+600)		**Date:**	21/03/2019	
Length (m):	400		**Chainage**	6+395	**Test Position:** 6
Lane:	LHS (OWT)		**Surveyors:**	LM	
Surface Condition at point of test:			Ravelling		

Layer	**Depth Reading (mm)**		**Thickness (mm)**	**Layer/Material Description/Defect**	**Sampled for:**
Surfacing	Top	0	19		
	Bottom	19		Bituminous seal	Binder extraction, aggregate testing
Base	Top	19	400		
	Bottom	419		Brown natural gravel	Full Characterisation
Intermediate	Top	419	50		
	Bottom	469		Gravelly stoney layer	Not sampled
Sub-base	Top	469	470		
	Bottom	939		Reddish brown silty material	Full Characterisation
Subgrade	Top	939			
	Bottom	1009	70	Yellowish brown clayey gravel	Not sampled
Total Thickness			1009		

Other Notes:
50 mm stoney layer between base and sub-base

Figure 4 Test Pit on Section 2 Mpataba Junction – Half Assini

The in-situ strength of the pavement layers of the sections that have performed poorly and those that are still performing well are shown in Table 13. The base and subgrade strengths of the poor section are considerably higher than the good performing section. This could be due to a number of factors yet to be determined. The laboratory characteristics show that the good-performing section has materials generally inferior to the poorer performing section. This can be attributed to the good drainage of the good-performing section.

Table 13 Materials characteristics Mpataba Junction – Half Assini

Layer	Section 1 (3+500 – 3+800) Poor performance				Section 2 (6+200-6+600) Good performance			
	Average CBR (%)	DN (mm/blow)	GM	PI	Average CBR (%)	DN (mm/blow)	GM	PI
Base	112 (23)	2.6	1.8	18	97 (57)	2.9	1.9	14
Sub-base	103 (84)	2.8	1.8	22	46 (59)	5.9	1.1	27
Subgrade	35 (4)	7.7	-	8	22 (4)	11.9	1.6	7

In situ moisture content and compaction density were determined using the nuclear density gauge. The results are shown in Table 14. Both sections show low relative compaction, but the good section shows significantly higher moisture contents.

Table 14 In-situ moisture content and density Mpataba Junction – Half Assini

Layer	Section 1 (3+500 – 3+800) Poor		Section 2 (6+200-6+600) Good	
	Moisture (%)	Relative Compaction (%)	Moisture (%)	Relative Compaction (%)
0-150	8.8-9.9	80-85	11.3-13.0	83-88
150-300	8.4-9.2	82-91	11.1-14.5	76-86

The geometric characteristics of the study sections are presented in Table 15. These show a good camber but very low crown heights.

Table 15 Geometric parameters of Mpataba Junction – Half Assini sections

Section	Maximum Gradient (%)	Mean Camber (%)	Mean Crown Height (m)
Section 1 (Poor) 3+500 – 3+800	1.6	2.5	0.2
Section 2 (Good) 6+200-6+600	0.5	2.6	0.2

2.3.3 Koforidua – Adukrom

On Koforidua – Adukrom road, two study sections, one highly deteriorated and another in a fair condition, were identified. On the highly deteriorated section, a lot of the traffic was being diverted to the unsealed shoulders. We were informed by the local engineers that the road is over 20 years old and has undergone only routine maintenance. The visual condition assessment of the sections (Table 16) shows a marked difference in performance. This is attributed to poor drainage. It should be noted that Section 1 is 100 m whereas Section 2 is 300 m and therefore the extent of defects is far greater in Section 1 than Section 2.

Table 16 Visual condition assessment summary of Koforidua – Adukrom sections

Section	Crack Index (Crack Intensity x Extent)	Potholed Area (m^2)	Patched Area (m^2)	Mean Rut Depth (mm)		VCI	Drainage Indication
				LHS	RHS		
Section 1 (Poor) (14+100 – 14+200)	25	15	4.2	8	19	35	Poor
Section 2 (Good) (17+300 – 17+550)	6	0	0	7	5	78	Good

The test pit logs (Table 17 and Table 18, and Figure 5 and Figure 6) show several layers, which could be indicative of a pavement built over an existing pavement.

Table 17 Test pit log of Section 1 Koforidua – Adukrom

TEST PIT LOGGING FORM					
Project Title:	ReCAP Back Analysis Project			**Survey Number:**	TP-2
Province:	Eastern		**Road Name:**	Koforidua - Adukrom	
Section:	Poor (14+100 - 14+200)		**Date:**	03/04/2019	
Length (m):	100		**Chainage:** 14+150	**Test Position:**	LHS OWT
Lane:	1 LHS (Koforidua bound)		**Surveyors:**	LM, EB, JM, EA	
Surface Condition at point of test:			Crocodile cracking of medium intensity		
Layer	**Depth Reading (mm)**		**Thickness (mm)**	**Layer/Material Description/Defect**	**Sampled for:**
Surfacing	Top	0	20	Bituminous surfacing	Binder extraction, aggregate testing
	Bottom	20			
Base	Top	20	195	Brown gravel	Full characterisation
	Bottom	215			
Sub-base	Top	215	200	Reddish brown gravel	Full characterisation
	Bottom	415			
Subgrade-1	Top	415	100	Reddish brown clayey gravel	Full characterisation
	Bottom	515			
Subgrade-2	Top	515		Reddish brown gravel with fragments of bitumen	Full characterisation
	Bottom	745	230		
Total Thickness			745		
Other Notes: Old bituminous pavement encountereed beneath the subgrade					

Figure 5 Test Pit on Section 1 Koforidua - Adukrom

Table 18 Test pit log of Section 2 Koforidua – Adukrom

TEST PIT LOGGING FORM					
Project Title:	ReCAP Back Analysis Project			**Survey Number:**	TP-1
Province:	Eastern		**Road Name:**	Koforidua - Adukrom	
Section:	Fair (17+300 - 17+550)		**Date:**	02/04/2019	
Length (m):	250		**Chainage**	17+350	**Test Position:** 6 (OWT)
Lane:	2 RHS (Adukrom bound)		**Surveyors:**	LM, EB, JM, EA	
Surface Condition at point of test:			Good		

Layer	Depth Reading (mm)		Thickness (mm)	Layer/Material Description/Defect	Sampled for:
Surfacing	Top	0	35		
	Bottom	35		Bituminous surfacing	Binder extraction, aggregate testing
Base	Top	35	200		
	Bottom	235		Brown gravel	Full characterisation
Sub-base	Top	235	250		
	Bottom	485		Reddish brown clayey gravel	Full characterisation
Subgrade-1	Top	485	150		
	Bottom	635		Brown silty gravel	Full characterisation
Subgrade-2	Top	635			
	Bottom	815	180	Brown silt	Full characterisation
Total Thickness			815		

Other Notes:
Old pavement exists at the bottom of the test pit as evidenced from the bituminous material encountered

Figure 6 Test Pit on Section 2 Koforidua - Adukrom

The in-situ DCP-CBR strengths (Table 19) show a considerable difference between the two sections. This could be due to the poor drainage observed in Section 1. The laboratory CBR characteristics show that the good-performing section has materials generally inferior to the poorer performing section. This can be attributed to the good drainage of the good-performing section as seen by the lower in-situ moisture content in Table 20 and the higher crown height in Table 21.

Table 19 Materials characteristics of Koforidua – Adukrom sections

Layer	Section 1 (Poor performance)				Section 2 (Good performance)			
	Average CBR (%)	DN (mm/blow)	GM	PI	Average CBR (%)	DN (mm/blow)	GM	PI
Base	62 (34)	4.5	1.9	12	91 (24)	3.1	1.8	14
Sub-base	63 (24)	4.4	1.8	12	87 (48)	3.2	1.9	15
Subgrade	31 (49)	8.6	1.5	NP	21 (65)	12.5	1.6	8

Table 20 In-situ moisture content Koforidua - Adukrom

Layer	Section 1 (Poor performance) Moisture Content (%)	Section 2 (Good performance) Moisture Content (%)
Base	10.1	6.0
Sub-base	11.3	9.1
Subgrade	5.7	9.5

The geometric characteristics of the sections are shown in Table 21. The crown height of Section 1 is very low and moreover observations on site showed that the section is located in a sag curve with poor drainage. Thus poor drainage is very likely to be a major contributor to its poor performance. However, this can only be confirmed after the laboratory testing is completed.

Table 21 Geometric characteristics of Koforidua – Adukrom sections

Section	Maximum Gradient (%)	Mean Camber (%)	Mean Crown Height (m)
Section 1 (Poor)	0.9	1.3	0.1
Section 2 (Good)	1.6	2.3	0.7

2.4 Mozambique

The Mozambique study component was negatively impacted by the recent cyclone. This meant that several resources (especially personnel from ANE) could not be involved in the fieldwork. Nevertheless, ANE is to be commended for making available some resources despite these difficult times.

The study roads in Mozambique are: Boane - Namaacha Road in Maputo Province, Boane – Moamba Road in Maputo Province, Macia – Chokwe in Gaza Province.

Rainfall data, the age of the roads, and traffic loading for the study roads is shown in Table 22. The traffic loading growth rate is based on the average GDP over the last 30 years.

Table 22 Key data for the Mozambique roads

Road Name	Age (Yrs)	Estimated Traffic Loading to date (MESA)	Growth Rate used for Traffic Load Computation (%)	Mean Annual Rainfall (mm)	Remarks
Boane – Namaacha Sections 1 & 2	>20	5.8-11.7	3.2	835	Cyclone events raise the annual rainfall to 1945 mm
Boane – Namaacha Sections 3	>20	3.1-6.1	3.2	835	Cyclone events raise the annual rainfall to 1945 mm
Boane – Moamba Section 1	>20	0.6-1.1	3.2	835	Cyclone events raise the annual rainfall to 1945 mm
Boane – Moamba Section 2	>20	0.8-1.6	3.2	835	Cyclone events raise the annual rainfall to 1945 mm
Macia - Chokwe	>20	0.5-1.1	3.2	593	Cyclone events raise the annual rainfall to 1304 mm

2.4.1 Boane - Namaacha Road

This is a national road by virtue of it connecting to the border with Eswatinibut it began its life as a low volume road. However, in terms of traffic and the pavement design structure it is a secondary road and can also be regarded as a low volume road with relatively high traffic loading. The ADT from traffic counts (traffic count post 106) is 2794 of which 650 are heavy vehicles. However, locally available materials were used in the construction of the bases (unstabilised) and surfacings. Average annual rainfall is 518 – 658 mm. Three sections are being studied on this road.

2.4.1.1 Section 1

Observations:

1. The first part of the section is situated within the flood plain and is probably occasionally flooded during rainy seasons. There are patches in this section which signify failures related to poor drainage.
2. The subgrade is black cotton soil and the normal treatment either by structural design (Treatment for Expansive Clays) or chemical treatment of the black cotton soil is not immediately evident.
3. Natural rhyolite was used for the construction of base course which could be crusher run or unprocessed but it appears as though it is unprocessed judging by the high content of fines.
4. The surfacing looks old and brittle and it has exceeded its service life.
5. The 2nd part of the section, which is outside the flood plain, appears to be very sound structurally but the surfacing is also old and brittle.

2.4.1.2 Section 2

Observations:

1. The middle of the section is located at the boundary of a river flood plain hence the high embankment (approx. 2 m).
2. Subgrade is black cotton soil.
3. Some periodic intervention has been carried out on the section that is within the flood plain and it involved repairs on the base and resealing.

4. Cracks are predominantly longitudinal but there are also crocodile cracks in some parts of the section.

2.4.1.3 Section 3

Observations:

1. Traffic is lower than that in Sections 1 and 2 because it is located after the quarry at 10+200.
2. Subgrade is silty-loam soil and non-expansive.
3. Gradient is steep.
4. Drainage is good. Though it has shallow drains, drainage is generally good due to the steep gradient.

The visual condition assessment (Table 23) shows that Section 3 with the better drainage condition is the best-performing with no potholes and minimal patching. Once again, the impact of good drainage on pavement performance is evident as one of the key performance factors on low volume roads. Rut depths remain low.

Table 23 Visual condition survey summary of sections on Boane - Namaacha

Section	Crack Index (Crack Intensity x Extent)	Pothole Area (m^2)	Patched Area (m^2)	Mean Rut Depth (mm)		VCI	Drainage Indication
				LHS	RHS		
1 Poor (1+800 – 2+100)	8	4	195	7	8	53	Fair
2 Fair (2+650 - 2+950)	5	0.3	34	4	4	75	Fair
3 Good (10+900-11+200)	4	0	3.5	4	6	83	Good

The following key observations were made:

- The cracking which had occurred had developed over very long periods (according to reports from provincial engineers) and was not as severe as was anticipated. There were some subsections which had minor cracks or no cracks. This shows that the surfacings had performed exceptionally well, which makes them suitable for research.
- Unexpectedly, there was very little spalling of the surfacing despite the intensity of cracking. This gives an indication that the binder had not aged as quickly as would normally be expected of thin surfacings in very hot climates (air temperatures exceeding 40°C for long periods in summer).
- Some of the surfacings were very thin i.e. 10 mm or less and nevertheless only minor cracks were observed after 20 years of trafficking.

Ravelling, stripping, bleeding

- None of these defects were observed. This indicates that the surfacings were constructed properly.

Drainage – Drainage is a determinant factor for good or poor performance of LVRs. It has been observed through research that, for LVRs, drainage is just as important as traffic loading in influencing in-service performance. However, it is not easy to quantify drainage factors and their impact on performance of LVRs. This is because drainage itself also has many factors influencing it, which include.

- External drainage characteristics such as precipitation, rainfall intensity, runoff, size and slope of channels, roughness of the channels, flow depth and velocities and size of catchment area.

- Internal drainage or subsurface drainage – this basically refers to drainage of the pavement layers and general ground water. Poor internal drainage is the major cause of pavement failures in LVRs. This drainage depends largely on the terrain and permeability of the materials, which influence seepage and filtration
- Sensitivity of the pavement materials to moisture – this is an important aspect in LVR pavement and drainage design. If the materials are less sensitive and/or well-drained then poor internal and external drainage would have minimal impact on performance.

The following observations were made regarding drainage:

i. The side drains were generally shallow and overgrown.

ii. Their capacity was generally low and most likely inadequate.

iii. Most of the drains are flat or gently sloping.

iv. There were no signs of erosion.

From the test pit excavated in Section 1 of Boane – Namaacha road (Table 24 and Table 25, and Figure 7 and Figure 8), the subgrade was observed to be black, fine and plastic which is typical of black cotton soil. This was of great interest to the study because no special treatment seems to have been used to improve the quality of the subgrade which at the time of excavation was assumed to be expansive. The road has been in existence for over 20 years and no significant failures related to high expansivity of subgrade were visible.

Conversely, a cobble layer (Figure 9) directly below the base course was observed in Section 3 of the same road.

Table 24 Test pit log of Section 1 on Boane – Namaacha

TEST PIT LOGGING FORM						
Project Title:	Regional Back Analysis			**Survey Number:**		
Province:	Maputo		**Road Name:**	N2: Boane-Namaacha		
Section:	1		**Date:**	04/04/2019		
Length (m):			**Chainage**	2+050	**Test Position:**	LHS
Lane:	LHS		**Surveyors:**	TRL		
Surface Condition at point of test:						
Layer	**Depth Reading (mm)**		**Thickness (mm)**	**Layer/Material Description/Defect**		**Sampled for:**
Surfacing	Top		30	Double surface dressing with 16 mm nominal maximum size of ryolite aggregate		Bitumen recovery and bitumen quality tests; binder content, penetration, softening point, viscosity and RTFOT. Tests on recovered aggregate, e.g. grading, ACV, 10%FACT, flackness, ALD, etc.
	Bottom					
Base	Top		140	Ryolite gravel, brown in clour with angular aggregate. Most likely extracted using hard excavation methods or it could be crusher-run.		Grading, Mod. Proctor (MDD, OMC), field moisture, field density, soaked CBR, swell, triaxial, etc.
	Bottom					
Subbase	Top		280	Ryolite gravel, brown in clour with angular aggregate. Most likely extracted using hard excavation methods or it could be crusher-run. There is high content of very coarse aggregate and boulders		Grading, Mod. Proctor (MDD, OMC), field moisture, field density, soaked CBR, swell, triaxial, etc. (some of these tests may not be possible due to the high content of boulders)
	Bottom					
Subgrade	Top			Fine black plastic soils, typical of black cotton soil. High in-situ moisture and it is untreated.		Grading, Mod. Proctor (MDD, OMC), field moisture, field density, CBR (soaked, at OMC and 0.75OMC), swell, triaxial, etc. (some of these tests may not be possible due to the high content of boulders)
	Bottom					
	Top					
	Bottom					
Total Thickness						
Other Notes: A total of depth of 600mm was excavated.						

Figure 7 Clayey subgrade (possibly black-cotton soil) observed on Boane – Namaacha Section 1

Table 25 Test pit log of Section 2 Boane – Namaacha

TEST PIT LOGGING FORM					
Project Title:	Regional Back Analysis			**Survey Number:**	
Province:	Maputo		**Road Name:**	N2: Boane-Namaacha	
Section:	2		**Date:**	05/04/2019	
Length (m):			**Chainage**	2+700	**Test Position:** RHS
Lane:	RHS		**Surveyors:**	TRL	
Surface Condition at point of test:					

Layer	Depth Reading (mm)		Thickness (mm)	Layer/Material Description/Defect	Sampled for:
Surfacing	Top		20-50	Think asphalt with nominal maximum aggregate (ryolite) size of 13 mm.	Bitumen recovery and bitumen quality tests; binder content, penetration, softening point, viscosity and RTFOT. Tests on recovered aggregate, e.g. grading, ACV, 10%FACT, flackness, ALD, etc.
	Bottom				
Base	Top		130	Ryolite gravel, brown in clour with angular aggregate. Most likely extracted using hard excavation methods or it could be crusher-run. The base seemed to have been cement stabilised because DCP failed to penetrate the base on all except 1 point.	Grading, Mod. Proctor (MDD, OMC), field moisture, field density, soaked CBR, swell, triaxial, etc.
	Bottom				
Subbase	Top		100	Ryolite gravel, brown in clour with angular aggregate. Most likely extracted using hard excavation methods or it could be crusher-run. There is high content of very coarse aggregate and boulders. The subbase is part of the fill.	Grading, Mod. Proctor (MDD, OMC), field moisture, field density, soaked CBR, swell, triaxial, etc. (some of these tests may not be possible due to the high content of boulders)
	Bottom				
Subgrade	Top			The subgrade could not be reached due to the high embankment > 2 m) but it is black cotton soil	
	Bottom				
	Top				
	Bottom				
Total Thickness					

Other Notes: Fill section with boulders used for fill. Fill could not be penetrated.

Figure 8 Test pit Section 2 Boane - Namaacha

Table 26 Test pit log of Section 3 Boane – Namaacha

TEST PIT LOGGING FORM						
Project Title:	Regional Back Analysis			**Survey Number:**		
Province:	Maputo		**Road Name:**	N2: Boane-Namaacha		
Section:	3		**Date:**	09/04/2019		
Length (m):			**Chainage**	10+950	**Test Position:**	RHS
Lane:	RHS		**Surveyors:**	TRL		
Surface Condition at point of test:						
Layer	**Depth Reading (mm)**		**Thickness (mm)**	**Layer/Material Description/Defect**	**Sampled for:**	
Surfacing	Top Bottom		25-30	Double surface dressing with 16 mm nominal maximum size of ryolite aggregate	Bitumen recovery and bitumen quality tests; binder content, penetration, softening point, viscosity and RTFOT. Tests on recovered aggregate, e.g. grading, ACV, 10%FACT, flackness, ALD, etc.	
Base	Top Bottom		140	Ryolite gravel, brown in clour with angular aggregate. Most likely extracted using hard excavation methods or it could be crusher-run.	Grading, Mod. Proctor (MDD, OMC), field moisture, field density, soaked CBR, swell, triaxial, etc.	
Subbase 1	Top Bottom		170	Ryolite gravel, greenish orange brown in clour with angular aggregate. Most likely extracted using hard excavation methods or it could be crusher-run. There is high content of very coarse aggregate and boulders	Grading, Mod. Proctor (MDD, OMC), field moisture, field density, soaked CBR, swell, triaxial, etc. (some of these tests may not be possible due to the high content of boulders)	
Subbase 2	Top Bottom		200	Reddish brown poorly graded material with big boulders	Grading, Mod. Proctor (MDD, OMC), field moisture, field density, soaked CBR, swell, triaxial, etc. (some of these tests may not be possible due to the high content of boulders)	
Subgrade	Top Bottom			Dark brown and poorly graded materials with a high content of boulders	Grading, Mod. Proctor (MDD, OMC), field moisture, field density, soaked CBR, swell, triaxial, etc. (some of these tests may not be possible due to the high content of boulders)	
Total Thickness						
Other Notes: Section has 5 pavement layers.						

Figure 9 Base course material and cobbles for sub-base observed on Section 3 of Boane – Namaacha road

The in situ DCP strengths (Table 27) of the pavement layers are quite different and show a marked variation between Section 1 and the other 2 sections. The laboratory tests show high base strengths but high plasticity indices for Sections 1 and 2. Some test could not be done due to very large cobbles used in the sub-base.

Table 27 Materials characteristics for Boane - Namaacha

Layer	Section											
	1 (1+800 – 2+100)				2 (2+650 - 2+950)				3 (10+900-11+200)			
	Average CBR (%)	DN (mm/ blow)	GM	PI	Average CBR (%)	DN (mm/ blow)	GM	PI	Average CBR (%)	DN (mm/ blow)	GM	PI
Base	317 (87)	1.0	2.5	13	174 (151)	1.7	1.9	11	229 (151)	1.4	2.5	6
Sub-base	129 (21)	2.3	2.5	3	100	2.8	2.2	5	91 (55)	3.2	1.6	4
Subgrade	22 (10)	8.9	1.0	31	44	6.2	-	-	40 (3)	8.4	-	-

The geometric characteristics of the sections on Boane – Namaacha are presented in Table 28. The sections show good camber but varied crown-heights. The low crown height does not seem to be adversely affecting the performance of Section 1.

Table 28 Geometric characteristics of Boane – Namaacha sections

Section	Maximum Gradient (%)	Mean Camber (%)	Mean Crown Height (m)
Section 1 (1+800 – 2+100)	0	2.7	0.2
Section 2 (2+650 - 2+950)	0	2.5	1.0
Section 3 (10+900-11+200)	0	2.5	0.7

Traffic data for Section 1 and Section 2 of Boane – Namaacha are presented in Table 29 and Table 30 respectively. For safety reasons, counts could only be conducted for 12-hr periods and then factored to obtain 24-hr flows. ANE have committed to providing a 24-hr factor based on previous longer duration counts. These were used to revise the current 12-hr data. Axle load data provided by ANE was used to estimate the traffic loading carried to date.

Table 29 ADT for both directions on Section 1 Boane - Namaacha

Vehicle Type	Total ADT
Class A Cars, Pickups, S/wagons	656
Class B Light Trucks	206
Class C Small Bus	244
Class D Large Bus	40
Class E Medium Truck (2 Axles)	224
Class F Heavy Truck (3 or 4 Axles)	118
Class G Heavy Truck (5 or more Axles)	99
Class H Tractors and Farm Equipment	4
Total	**1591**

Table 30 ADT for both directions on Section 2 Boane - Namaacha

Vehicle Type	Total ADT
Class A Cars, Pickups, S/wagons	682
Class B Light Trucks	160
Class C Small Bus	216
Class D Large Bus	29
Class E Medium Truck (2 Axles)	135
Class F Heavy Truck (3 or 4 Axles)	10
Class G Heavy Truck (5 or more Axles)	74
Class H Tractors and Farm Equipment	6
Total	**1312**

2.4.2 Boane – Moamba Road

This is an old road with a very old surfacing. The road was targeted due to its unique design and exceptional performance. This is not a typical LVR but there are good engineering and scientific aspects which will contribute significantly to the research results.

The base course is a layer of very coarse natural gravel with nominal maximum size of 75 mm. The majority of the road has failed as expected but there are sections which are still performing well with very little rutting (< 10 mm) and no localised subgrade deformation. Only routine maintenance has ever been carried out on this road and these sections have performed well under such extreme traffic loading (axle loads of up to 21 tonne).

The ADT obtained from traffic counts (station 116) is 505 of which 436 are heavy vehicles (trucks and tippers carrying mainly wet sand and other construction materials). The average annual rainfall is 518 – 658 mm. Two sections were studied on this road.

2.4.2.1 Section 1

Observations:

1. Subgrade consists of very coarse gravel which is gap graded.
2. There is one base layer of very coarse and gap graded natural gravel.
3. Double surface dressing is still intact in some isolated sections.
4. Drainage is good in some parts and very poor in other parts.

2.4.2.2 Section 2

Observations:

1. Subgrade is expansive black cotton soil.
2. Drainage of the area is generally poor and flooding occurs occasionally.
3. Traffic is slightly lower because this is after the main quarries in the area.

A visual condition survey summary is presented in Table 31. The results show that, despite the varied conditions of the sections in terms of both cracking and potholing, the mean rut depths are the same and low. This can be interpreted as the pavements behaving in a structurally similar manner.

Table 31 Visual condition survey summary of sections on Boane – Moamba

Section	Crack Index (Crack Intensity x Extent)	Pothole Area (m^2)	Patched Area (m^2)	Mean Rut Depth (mm)		VCI	Drainage Indication
				LHS	RHS		
1 Poor (22+100 – 22+400)	5	290	0	7	7	61	Fair
2 Fair (29+700 - 30+000)	12	92	0	7	7	62	Fair

The test pit excavation yielded very coarse pavement layers (Table 32, Table 33, and Figure 10 and Figure 11). The surfacing appeared well-bonded to the coarse base course materials.

Table 32 Test pit log of Section 1 Boane - Moamba

TEST PIT LOGGING FORM						
Project Title:	Regional Back Analysis			**Survey Number:**		
Province:	Maputo		**Road Name:**	Boane-Moamba		
Section:	2		**Date:**	10/04/2019		
Length (m):			**Chainage**	22+100	**Test Position:**	RHS
Lane:	RHS		**Surveyors:**	TRL		
Surface Condition at point of test:						
Layer	**Depth Reading (mm)**		**Thickness (mm)**	**Layer/Material Description/Defect**		**Sampled for:**
Surfacing	Top		10	Single surface dressing with nominal maximum aggregate size of 13 mm.		Bitumen recovery and bitumen quality tests; binder content, penetration, softening point, viscosity and RTFOT. Tests on recovered aggregate, e.g. grading, ACV, 10%FACT, flackness, ALD, etc.
	Bottom					
Base	Top		250	Ryolite gravel, brown in clour with angular aggregate. Most likely extracted using hard excavation methods or it could be crusher-run. The base seemed to have been cement stabilised because DCP failed to penetrate the base on all except 1 point.		Grading, Mod. Proctor (MDD, OMC), field moisture, field density, soaked CBR, swell, triaxial, etc.
	Bottom					
Subbase	Top		>200	The subbase was made up of a layer of boulders which could not be excavated using hand tools.		No sample was collected
	Bottom					
Subgrade	Top			Surround subgrade material is poorly graded ryolite with boulders but the subgrade below the pavement could not be reached for sampling because the subbase was too hard to excavate.		No sample was collected
	Bottom					
	Top					
	Bottom					
Total Thickness						
Other Notes:						

Figure 10 Base Course Boane – Moamba Section 1

Table 33 Test pit log of Section 2 Boane - Moamba

TEST PIT LOGGING FORM					
Project Title:	Regional Back Analysis		**Survey Number:**		
Province:	Maputo	**Road Name:**	Boane-Moamba		
Section:	2	**Date:**	10/04/2019		
Length (m):		**Chainage**	29+750	**Test Position:**	RHS
Lane:	RHS	**Surveyors:**	TRL		
Surface Condition at point of test:					

Layer	Depth Reading (mm)		Thickness (mm)	Layer/Material Description/Defect	Sampled for:
Surfacing	Top		10	Single surface dressing with nominal maximum aggregate size of 13 mm.	Bitumen recovery and bitumen quality tests; binder content, penetration, softening point, viscosity and RTFOT. Tests on recovered aggregate, e.g. grading, ACV, 10%FACT, flackness, ALD, etc.
	Bottom				
Base	Top		250	Macadam base of very coarse greyish basaltic aggregate mixed with medium sizes grey sand.	Grading, specific gravity, bulk density, ACV, 10%FACT.
	Bottom				
Subbase	Top		>200	Orange brown ryolite aggregate with a high content of boulders.	Grading, Mod. Proctor (MDD, OMC), field moisture, field density, soaked CBR, swell, triaxial, etc.
	Bottom				
Subbase/Fill	Top			Brown grevel with high content of boulders	Grading, Mod. Proctor (MDD, OMC), field moisture, field density, soaked CBR, swell, triaxial, etc.
	Bottom				
Subgrade	Top			Surround subgrade material is black cotton soil but could not be reached. The Subgrade below the pavement could not be reached for sampling due to the high fill	No sample was collected
	Bottom				
Total Thickness					

Other Notes:

Figure 11 Coarse base materials and a well-bonded surfacing on Section 2 Boane - Moamba

The geometric characteristics (Table 34) of the sections are very similar and as such cannot be the differentiating feature in the relative performance of the two sections.

Table 34 Geometric characteristics of sections on Boane - Moamba

Section	Maximum Gradient (%)	Mean Camber (%)	Mean Crown Height (m)
Section 1 Poor (22+100 – 22+400)	0	2.4	0.8
Section 2 Fair (29+700 - 30+000)	0	0.8	0.8

Traffic data for Section 1 and Section 2 of Boane –Moamba are presented in Table 35 and Table 36 respectively. For safety reasons, counts could only be conducted for 12-hr periods and then factored to obtain 24-hr flows. ANE have committed to providing a 24-hr factor based on previous longer duration counts. These will be used to revise the current 12-hr data. ANE have also committed to providing axle load data.

Table 35 ADT for both directions on Section 1 Boane - Moamba

Vehicle Type	Total ADT
Class A Cars, Pickups, S/wagons	12
Class B Light Trucks	6
Class C Small Bus	0
Class D Large Bus	0
Class E Medium Truck (2 Axles)	2
Class F Heavy Truck (3 or 4 Axles)	20
Class G Heavy Truck (5 or more Axles)	7
Class H Tractors and Farm Equipment	2
Total	**49**

Table 36 ADT for both directions on Section 2 Boane - Moamba

Vehicle Type	Total ADT
Class A Cars, Pickups, S/wagons	11
Class B Light Trucks	7
Class C Small Bus	0
Class D Large Bus	0
Class E Medium Truck (2 Axles)	7
Class F Heavy Truck (3 or 4 Axles)	11
Class G Heavy Truck (5 or more Axles)	17

Class H Tractors and Farm Equipment	2
Total	**55**

2.4.3 Macia – Chokwe

This road connects the national road N1 in Gaza Province to the border with Zimbabwe at Chicualacuala Border Post. The road was chosen in order to investigate the impact of timely maintenance on the performance of LVRs. Five years ago routine maintenance involving crack sealing was carried out on the section from 0+000 for 24-25km along the road. No crack sealing was carried out on the remaining sections. The section which received crack sealing is still in fair to good condition whereas the remaining sections are either in poor condition or have completely failed thus requiring heavy maintenance or rehabilitation. All sections have double surface dressing. The surfacing is old and no reseal has ever been applied.

The road is over 20 years old and the ADT from traffic counts is 1692 of which 120 are heavy vehicles. The average annual rainfall is 658 – 758 mm. Three sections for possible further study were identified on this road.

2.4.3.1 Section 1

Observations:

1. The base is cement-stabilised white sand and there is evidence of block cracking.
2. There is no evidence of structural failure, but longitudinal and transverse cracking is pronounced and could be a reflection of the block cracking in the base course.

2.4.3.2 Section 2

Observations:

1. There is a macadam or crushed stone base and there were no deformations observed.
2. Rutting is very minimal showing good performance of the pavement.

The visual condition assessment (Table 37) of the sections shows similar rut depths and yet the quantity of patching is very high for Section 2. This suggests that the defects are not caused by the low? pavement strength and that the defects themselves are not leading to a reduction of the overall pavement strength.

Table 37 Visual condition assessment summary of Macia – Chokwe sections

Section	Crack Index (Crack Intensity x Extent)	Pothole Area (m^2)	Patched Area (m^2)	Mean Rut Depth (mm)		VCI	Drainage Indication
				LHS	RHS		
1 Fair (19+100 – 19+400)	4	0.4	13.5	7	6	75	Good
2 Poor (32+300 – 32+600)	3	5.4	392	5	4	57	Good

The profile in Figure 12 and Table 38 show the possible presence of a neat sand sub-base for Section 1. The section will offer a great opportunity for the revision of overall pavement strength requirements for low-

volume roads and drainage requirements to ensure good performance. Section 2 also shows a neat sand base and highly clayey subgrade (Table 39 and Figure 13).

Table 38 Test pit log of Section 1 Macia - Chokwe

TEST PIT LOGGING FORM					
Project Title:	Regional Back Analysis			**Survey Number:**	
Province:	Gaza		**Road Name:**	Macia-Chokwe	
Section:	1		**Date:**	11/04/2019	
Length (m):			**Chainage**	19+150	**Test Position:** LHS
Lane:	LHS		**Surveyors:**		
Surface Condition at point of test:					

Layer	Depth Reading (mm)		Thickness (mm)	Layer/Material Description/Defect	Sampled for:
Surfacing	Top		20	Double surface dressing with 16 mm nominal maximum size of ryolite aggregate	Bitumen recovery and bitumen quality tests; binder content, penetration, softening point, viscosity and RTFOT. Tests on recovered aggregate, e.g. grading, ACV, 10%FACT, flackness, ALD, etc.
	Bottom				
Base	Top		150	Macadam base of very coarse grey basaltic aggregate mixed with medium sezed sand.	Grading, specific gravity and bulk density.
	Bottom				
Subbase	Top		200	Untreated red sand	Grading, Mod. Proctor (MDD, OMC), field moisture, field density, CBR (soaked, OMC and 0.75OMC), swell, etc.
	Bottom				
Subgrade	Top			Untreated grey sand	Grading, Mod. Proctor (MDD, OMC), field moisture, field density, CBR (soaked, OMC and 0.75OMC), swell, etc.
	Bottom				
	Top				
	Bottom				
Total Thickness					

Other Notes:

Figure 12 Test pit on Section 1 Macia – Chokwe with probable neat sand sub-base

Table 39 Test pit log Section 2 Macia - Chokwe

TEST PIT LOGGING FORM					
Project Title:	Regional Back Analysis			**Survey Number:**	
Province:	Gaza		**Road Name:**	Macia-Chokwe	
Section:	2		**Date:**	12/04/2019	
Length (m):			**Chainage**	32+350	**Test Position:** LHS
Lane:			**Surveyors:**		
Surface Condition at point of test:					

Layer	Depth Reading (mm)		Thickness (mm)	Layer/Material Description/Defect	Sampled for:
Surfacing	Top		20	Double surface dressing with 16 mm nominal maximum size of ryolite aggregate	Bitumen recovery and bitumen quality tests; binder content, penetration, softening point, viscosity and RTFOT. Tests on recovered aggregate, e.g. grading, ACV, 10%FACT, flackness, ALD, etc.
	Bottom				
Base	Top		180	Cement treated grey sand (most likely lightly treated because DCP penetrated relatively easely). The layer was slightly moist.	Cement content
	Bottom				
Subbase	Top		250	Untreated moist grey sand	Grading, Mod. Proctor (MDD, OMC), field moisture, field density, CBR (soaked, OMC and 0.75OMC), swell, etc.
	Bottom				
Subgrade	Top			Yellowish, orange grey clay. The clay had high moisture content	Grading, hydrometer test, Mod. Proctor (MDD, OMC), field moisture, field density, CBR (soaked, OMC and 0.75OMC), swell, etc.
	Bottom				
	Top				
	Bottom				
Total Thickness					

Other Notes:

Figure 13 Test Pit on Section 2 Macia - Chokwe

Figure 14 Subgrade on Section 2 Macia - Chokwe

The in-situ DCP-CBR strengths (Table 40) of the pavement layers of the two sections are significantly different. Section 1 had a cement-stabilised base whereas Section 2 had a Macadam base. Neither of these could be tested in the laboratory.

Table 40 Materials characteristics for Macia - Chokwe

Layer	Section 1 (19+100 – 19+400) Fair performance				Section 2 (32+300 – 32+600) Fair performance			
	Average CBR (%)	DN (mm/blow)	GM	PI	Average CBR (%)	DN (mm/blow)	GM	PI
Base	-	-	1.7	NP	-		-	-
Sub-base	40 (41)	6.8	1.0	2	96 (34)	3.0	-	NP
Subgrade	50 (14)	5.5	1.0	1	10 (1)	25.1	1.0	17

The geometric characteristics of the sections are as shown in Table 41. There are marked differences in crown height which may be enhancing the performance of Section 2 despite the DCP-CBR showing a very weak subgrade. However, Section 1 despite the low crown height is performing better than Section 2. This could be due to the fact that Section 2 crosses through a swamp.

Table 41 Geometric characteristics of Macia – Chokwe sections

Section	Maximum Gradient (%)	Mean Camber (%)	Mean Crown Height (m)
Section 1 (19+100 – 19+400)	0	3.5	0.2
Section 2 (32+300 – 32+600)	0	2.5	1.5

Traffic data for Macia – Chokwe road is presented in Table 42. For safety reasons, counts could only be conducted for 12-hr periods and then factored to obtain 24-hr flows. ANE have committed to provided 24-hr counts. These were used to revise the current 12-hr data.

Table 42 ADT for both directions on Macia – Chokwe road

Vehicle Type	Total ADT
Class A Cars, Pickups, S/wagons	258
Class B Light Trucks	303
Class C Small Bus	364
Class D Large Bus	4
Class E Medium Truck (2 Axles)	49
Class F Heavy Truck (3 or 4 Axles)	7
Class G Heavy Truck (5 or more Axles)	9
Class H Tractors and Farm Equipment	0
Total	**994**

2.5 Uganda

The study roads in Uganda were: Matugga – Semuto – Kapeeka Road in the Central Region, Kikorongo – Mpondwe Road in the Western Region, and Ishaka – Kasese Road also in the Western Region. A major advantage of the Uganda study roads was that traffic and axle load data was available through other studies; one of those studies is a sister ReCAP project (Long-term Pavement Performance (LTPP) monitoring project under AfCAP (GEN2132A)).

Rainfall data, the age of the roads, and traffic loading for the study roads is shown in Table 43.

The traffic loading growth rate is based on the average GDP over the age of the roads, except for Matugga – Semuto – Kapeeka Road where the historical growth rate was used. The characteristics of the surfacing materials used on the sections are as shown in Table 44. It is worth noting that the surfacing aggregates are of high quality with high TFV, low flakiness, and low dust quantities. Remarkably, the penetration values of the bitumen have remained good (more than the 50% of initial penetration of 80/100 pen) on all sections despite Uganda being in a region of high ultraviolet index (>14). In terms of penetration, the Inverted Double Surface Dressing has the highest penetrations – probably least affected by radiation.

Table 43 Key data for the study roads in Uganda

Road Name	Age (Yrs)	Estimated Traffic Loading to date (MESA)	Growth Rate used for Traffic Load Computation (%)	Mean Annual Rainfall (mm)
Matugga – Semuto – Kapeeka	8	2.6	12.6	1426
Kikorongo - Mpondwe	11	2.1	5.3	912
Ishaka - Katunguru	29	5.8	5.3	1209

Table 44 Surfacing characteristics for the study roads in Uganda

Road Section	Type of Surfacing	Aggregate Characteristics				Bitumen Characteristics		
		Flakiness Index (%)	TFV (kN)	TFV Ratio	Dust (< P0.075 mm)	Bit. Cont. (%)	Bit. Pen. (%)	Bit. Soft. Pt. (%)
Matugga 6A	Inverted Double Surface Dressing	8	258	88	2.7	7.2	91	42
Matugga 10	Single Otta Seal + Sand Seal	7	-	-	-	7.9	57	46
Ishaka – Katunguru 1	Inverted Double Surface Dressing	11	285	79	0.3	8.7	68	49
Ishaka – katunguru 2	Inverted Double Surface Dressing	17	293	82	1.1	8.7	57	47
Kikorongo – Mpondwe 2	Double Surface Dressing	10	246	83	0.51	5.6	53	59
Kikorongo – Mpondwe 3	Double Surface Dressing	16	271	85	0.17	5.7	57	58

2.5.1 Kikorongo – Mpondwe Road

Kikorongo – Mpondwe road, which according to local engineers was constructed 15 – 20 years ago, was found to be ideal for consideration in this study. The road has overgrown side drains and its base material was made of natural gravel which appeared to be modified. The pavement surfacing was Double Surface Dressing (DSD). Three study sections were selected from this road, two of which were performing well and one fairly well. The first "good" section had no cracking, few potholes and minimum rutting whereas the second one had no potholes, no rutting and low cracking intensity. On the "fair" section, the maximum rutting was estimated at 30 mm, the crack intensity was low and only a few potholes (mostly along the centreline) were observed. It was also observed that most of the previously existing potholes on this road had been patched. The visual condition assessment of these sections is presented in Table 45. The Test Pit logs for the sections are shown in Table 46, Table 47 and Table 48. Test pit photos are shown in Figure 15, Figure 16 and

Figure 17. The logs and test pits show that the pavement structure is thin in comparison to the traffic that the road is estimated to have carried.

Table 45 Visual condition summary of Kikorongo – Mpondwe sections

Section	Crack Index (Crack Intensity x Extent)	Pothole Area (m^2)	Patched Area (m^2)	Mean Rut Depth (mm)		Roughness (IRI)	VCI	Drainage Indication
				LHS	RHS			
1 (Good) (2+000 – 2+300)	0	0.2	20	8	6	3.0	89	Good
2 (Poor) (7+100 – 7+450)	0	0.5	59	6	3	4.5	83	Good
3 (Fair) (12+300 – 12+600)	0	0	0.2	3	6	3.5	97	Good

Table 46 Test Pit Log Section 1 Kikorongo - Mpondwe

TEST PIT LOGGING FORM						
Project Title:	AFCAP BACK ANALYSIS			**Survey Number:**	1	
Province:	KASESE		**Road Name:**	KIKORONGO - MPONDWE		
Section:	1		**Date:**	27/03/2019		
Length (m):			**Chainage**	0+016	**Test Position:**	OWP
Lane:	EB		**Surveyors:**	DOMINIC		
Surface Condition at point of test:			No visible defects			
Layer	**Depth Reading (mm)**		**Thickness (mm)**	**Layer/Material Description/Defect**		**Sampled for:**
Surfacing	Top	0	18	Bituminous surfacing dressing		Bitumen Recovery, PSD
	Bottom	18				
Base	Top	18	180	Slightly moist greyish light brown gravels. Probably CRS		Full Characterisation
	Bottom	198				
Subbase	Top	198	125	Moist reddish brown silty clay gravelly material with cobbles		Full Characterisation
	Bottom	323				
Subgrade	Top	323	150	Moist dark brown silty clay with occassional gravels of about 25 mm		Subgrade Characteristation
	Bottom	473				
	Top					
	Bottom					
Total Thickness						
Other Notes:						

Figure 15 Test Pit on Section 1 Kikorongo – Mpondwe road

Table 47 Test pit log of Section 2 Kikorongo – Mpondwe

TEST PIT LOGGING FORM						
Project Title:	AFCAP BACK ANALYSIS			**Survey Number:**	1	
Province:	KASESE		**Road Name:**	KIKORONGO - MPONDWE		
Section:	2		**Date:**	29/03/2019		
Length (m):	300		**Chainage**	0+000	**Test Position:**	OWP
Lane:	WB		**Surveyors:**	DOMINIC		
Surface Condition at point of test:			No visible defects			

Layer	Depth Reading (mm)		Thickness (mm)	Layer/Material Description/Defect	Sampled for:
Surfacing	Top	0	17	Bituminous surfacing dressing	Bitumen Recovery, PSD
	Bottom	17			
Base	Top	17	240	Slightly moist greyish light brown medium dense intact crushed aggregates CRS of maximum sinze ranging to 50mm) imported base material.	Full Characterisation
	Bottom	257			
Subbase	Top	257	100	slightly reddish grey moist medium dense intact crushed rocks, CRS imported sub base.	Full Characterisation
	Bottom	357			
Subgrade	Top	357	163	Slightly moist light brown medium dense intact silty clays with presence of cobbles in subgrade masterial	Subgrade Characteristation
	Bottom	520			
	Top				
	Bottom				
Total Thickness					

Other Notes:

Figure 16 Test pit on Section 2 Kikorongo – Mpondwe

Table 48 Test pit log of Section 3 Kikorongo – Mpondwe

TEST PIT LOGGING FORM						
Project Title:	AFCAP BACK ANALYSIS			**Survey Number:**	1	
Province:	KASESE		**Road Name:**	KIKORONGO - MPONDWE		
Section:	3		**Date:**	29/03/2019		
Length (m):			**Chainage**	0+200	**Test Position:**	OWP
Lane:	WB		**Surveyors:**	DOMINIC		
Surface Condition at point of test:			No visible defects			
Layer	**Depth Reading (mm)**		**Thickness (mm)**	**Layer/Material Description/Defect**		**Sampled for:**
Surfacing	Top	0	20	Bituminous surfacing dressing		Bitumen Recovery, PSD
	Bottom	20				
Base	Top	20	210	Slightly moist greyish brown dense intact cruched stone with cobbles imported base material		Full Characterisation
	Bottom	230				
Subbase	Top	230	100	Slightly moist reddish grey dense intact silty gravel with aggregates of average size, 20mm, and traces of cobbles imported sub-base material.		Full Characterisation
	Bottom	330				
Subgrade	Top	330	150	Slightly moist blackish dark brown medium dense silty clays existing sub-grade material, not imported		Subgrade Characteristation
	Bottom	480				
	Top					
	Bottom					
Total Thickness						
Other Notes:						

Figure 17 Test pit on Section 3 Kikorongo – Mpondwe

The results for the in-situ average DCP-CBR tests on the sections of this road (Table 49) shows a high base and sub-base strengths but low subgrade strength. The laboratory CBRs were used for comparison purposes since the previously cemented materials were broken down before laboratory testing. Plasticity indices are higher than the common "low volume roads manuals specification" values.

Table 49 Materials characteristics Kikorongo - Mpondwe

Layer	Section											
	1 (Good)				2 (Poor)				3 (Fair)			
	Average CBR (%)	DN (mm/blow)	GM	PI	Average CBR (%)	DN (mm/blow)	GM	PI	Average CBR (%)	DN (mm/blow)	GM	PI
Base	197 (69)	1.5	2.2	10	142 (42)	2.0	2.4	9	238 (61)	1.3	2.2	4
Sub-base	163 (48)	1.8	2.2	15	127 (24)	2.3	2.2	6	178 (29)	1.6	2.2	5
Subgrade	37 (25)	7.3	1.5	13	41 (24)	6.6	1.8	6	28 (7)	9.5	0.9	10

The central deflections measured by the FWD at a target load of 50 kN are shown in Table 50; there is very little difference in the deflection values between the sections. This indicates that the defects observed on Sections 2 and 3 are superficial.

Table 50 FWD Central Deflection of Kikorongo – Mpondwe sections

Section	Average Central Deflection (µm)	
	LHS OWP	RHS OWP
1 (Good)	878	711
2 (Poor)	770	712
3 (Fair)	833	865

The geometric characteristics of the sections are shown in Table 51. The camber is very similar, but the crown heights of the sections are dissimilar with the crown height of the best-performing section (Section 1) being unexpectedly the lowest.

Table 51 Geometric characteristics of Kikorongo – Mpondwe sections

Section	Maximum Gradient (%)	Mean Camber (%)	Mean Crown Height (m)
Section 1 (Good)	0	1.8	0.3
Section 2 (Poor)	0	1.9	0.8
Section 3 (Fair)	0	1.6	0.5

The vehicle ADT and VEF were obtained from previous axle load survey and are shown in Table 52. This will be used to estimate the traffic carried by the road to date.

Table 52 Vehicle ADT and VEF of Kikorongo – Mpondwe sections

Vehicle Type	Two Way ADT (2016)	VEF	ESA/Day (1 Direction)
Bicycles	7	0	0
Carts	0	0	0
Motorcycle	203	0	0
Saloon Cars and Taxis	165	0	0
Light Goods Vans, Pick-ups and 4WD	144	0	0
Small Bus: Minibuses and Matatus	175	0	0
Medium Bus:-Coasters	5	0	0

Buses	7	2.91	10
Light Single Unit Truck:- Dynas and Tractors	30	0.8	12
Medium:- Large Unit Trucks:- Lorries, Fusos, etc	72	8.1	292
Truck Trailer and Semi Trailer	77	10.7	412
Total	**885**		**726**

2.5.2 Ishaka – Katunguru Road

On Ishaka – Katunguru road, two sections were studied. Two study sections were identified on this road. One of the identified sections had a good surface condition with no cracks, no potholes and maximum rutting of 20 mm. The second section had low crack intensity, few potholes and estimated maximum rutting of 10 mm. Localised block cracking was also observed on this section. Sections of this road are currently undergoing rehabilitation. The visual condition assessment (Table 53) shows low mean rut depths and low roughness in both sections. Section 2 has not had a reseal since construction (30 years) and remains in good condition despite being in a cut.

The Test Pit logs (Table 54, Table 55, and Figure 18 and Figure 19) show a thin pavement structure in relation to the traffic that the road is estimated to have carried.

Table 53 Visual condition assessment summary of Ishaka – Katunguru sections

Section	Crack Index (Crack Intensity x Extent)	Pothole Area (m^2)	Patched Area (m^2)	Mean Rut Depth (mm)		Roughness (IRI)	VCI	Drainage Indication
				LHS	RHS			
1 (Fair) 28+000 – 28+300	10	3.3	5.0	6	4	4.5	64	Fair
2 (Good) 0+100 – 0+400	0	0.4	0	8	6	4.3	89	Good

Table 54 Test Pit Log Section 1 Ishaka – Katunguru

TEST PIT LOGGING FORM						
Project Title:	AFCAP BACK ANALYSIS			**Survey Number:**	1	
Province:	KASESE		**Road Name:**	KATUNGURU - ISHAKA		
Section:	1		**Date:**	26/03/2019		
Length (m):			**Chainage**	28+109	**Test Position:**	OWP
Lane:	SB		**Surveyors:**	DOMINIC		
Surface Condition at point of test:			No visible defects			
Layer	**Depth Reading (mm)**		**Thickness (mm)**	**Layer/Material Description/Defect**		**Sampled for:**
Surfacing	Top	0	15	Bituminous surfacing dressing		Bitumen Recovery, PSD
	Bottom	15				
Base	Top	15	200	Moist reddish brown silty clay gravelly material with cobbles		Full Characterisation
	Bottom	215				
Subbase	Top	215	150	Slightly moist yellowish brown silty clayey gravel with cobbles		Full Characterisation
	Bottom	365				
Subgrade	Top	365	150	Slightly moist dark brown clay material		Subgrade Characteristation
	Bottom	515				
	Top					
	Bottom					
Total Thickness						
Other Notes:						

Figure 18 Test Pit on Section 1 Ishaka – Katunguru road

Table 55 Test Pit Log Section 2 Ishaka – Katunguru

TEST PIT LOGGING FORM						
Project Title:	AFCAP BACK ANALYSIS			**Survey Number:**	1	
Province:	KASESE		**Road Name:**	KATUNGURU - ISHAKA		
Section:	2		**Date:**	27/03/2019		
Length (m):	200		**Chainage**	0+100	**Test Position:**	OWP
Lane:	NB		**Surveyors:**	DOMINIC		
Surface Condition at point of test:			No visible defects			
Layer	**Depth Reading (mm)**		**Thickness (mm)**	**Layer/Material Description/Defect**		**Sampled for:**
Surfacing	Top	0	18	Bituminous surfacing dressing		Bitumen Recovery, PSD
	Bottom	18				
Base	Top	18	200	Moist reddish brown silty clay gravelly material with cobbles		Full Characterisation
	Bottom	218				
Subbase	Top	218	150	Slightly moist yellowish brown silty clayey gravel with cobbles		Full Characterisation
	Bottom	368				
Subgrade	Top	368	150	Slightly moist dark brown clay material		Subgrade Characteristation
	Bottom	518				
	Top					
	Bottom					
Total Thickness						
Other Notes: Rut = 6 mm, vegetation in vicinity of the drainage						

Figure 19 Test Pit on Section 2 Ishaka – Katunguru

The in-situ average DCP-CBR test results for Section 1 (Table 56) show that the base is of lower strength compared to the sub-base – thus an inverted pavement structure. The laboratory characteristics show that the good-performing section has materials generally inferior to the fair-performing section.

Table 56 Materials characteristics for Ishaka – Katunguru

Layer	Section							
	1 (28+000-28+300) Fair				2 (0+100-0+400) Good			
	Average CBR (%)	DN (mm/blow)	GM	PI	Average CBR (%)	DN (mm/blow)	GM	PI
Base	72 (34)	3.9	1.7	16	52 (11)	5.3	2.0	14
Sub-base	138 (24)	2.1	1.3	13	28 (16)	9.5	2.0	13
Subgrade	50 (34)	5.5	1.0	16	11 (5)	23.0	2.2	13

The central deflections measured by the FWD at a target load of 50 kN are shown in Table 57. Unfortunately, no measurement was made for Section 2 because by the time the FWD got there, the section had already been scarified. No geometric characteristics were measured either.

Table 57 FWD central deflection of Ishaka – Katunguru sections

Section	Average Central Deflection (µm)	
	LHS OWP	RHS OWP
1 (28+000-28+300) Fair	Not measured	Not measured
2 (0+100-0+400) Good	591	501

The vehicle ADT and VEF for the study sections on this road are shown in Table 58. These will be used to estimate the traffic that the road will have carried to date.

Table 58 Vehicle ADT and VEF of Ishaka – Katunguru sections

Vehicle Type	Two Way ADT (2018)	VEF	ESA/Day (1 Direction)
Bicycles	87	0	0
Carts	5	0	0
Motorcycle	831	0	0
Saloon Cars and Taxis	240	0	0
Light Goods Vans, Pick-ups and 4WD	171	0	0

Small Bus: Minibuses and Matatus	189	0	0
Medium Bus:-Coasters	4	0	0
Buses	10	2.91	14
Light Single Unit Truck:- Dynas and Tractors	84	0.8	34
Medium:- Large Unit Trucks:- Lorries, Fusos, etc	108	8.1	439
Truck Trailer and Semi Trailer	111	10.7	595
Total	**1842**		**1082**

2.5.3 Matugga – Semuto – Kapeeka Road

Matugga – Semuto – Kapeeka road (opened around 2010) is made up of a number of trial sections with varying types of surfacing. This road is currently being studied in an ongoing Long-term Pavement Performance (LTPP) monitoring project under AfCAP (GEN2132A). The study sections selected along this road included four with "good" surface condition, one with "fair" surface condition and one highly deteriorated section. The sections that were performing well were those with single Otta seal + sand, double sand seal, SSD + sand seal, and inverted DSD in their surfacing layers. The surfacing layer of the "fair" section was made of double Otta seal, whereas that of the highly deteriorated section was made of single Otta seal. The sections identified on this road will enable the performance of unconventional surfacing in LVSRs under high rainfall and heavy traffic to be studied.

The visual condition assessment summary is shown in Table 59. All the sections have good drainage. The relative performance of these sections will provide crucial information for surfacings for low-volume sealed roads. It is interesting to note that Double Sand Seal has performed well despite being subjected to high traffic volumes.

The Test Pit logs (Table 60, Table 61, Table 62 and Figure 20) show a thin pavement structure in comparison to the traffic that the road is estimated to have carried.

Table 59 Visual condition assessment summary of Matugga – Semuto sections

Section	Crack Index (Crack Intensity x Extent)	Pothole Area (m^2)	Patched Area (m^2)	Mean Rut Depth (mm)		Roughness (IRI)	VCI	Drainage Indication
				LHS	RHS			
6 (Inverted DSD) (21+900 - 22+250)	0	0.5	0.6	4	5	4.5	89	Good
8a (SSD+ Quarry Sand) (22+600 - 22+850)	2	0.1	14.4	4	3	4.4	76	Good
8b (SSD+River Sand) (22+850 – 22+950)	11	0.0	26.9	4	5	4.0	52	Good
9a (DSS Quarry Sand) (22+950 – 23+200)	14	0	10.1	4	4	4.0	66	Good
9b (DSS River Sand) (23+200 – 23+300)	19	0	107	2	5	4.1	50	Good
10a (SOS) (23+300 – 23+475)	7	0	0.3	2	5	4.0	71	Very Good
11 (DOS) (23+650 – 24+00)	6	0	17.2	4	5	3.7	79	Good

Table 60 Test Pit Log Section 6 Matugga - Semuto

TEST PIT LOGGING FORM						
Project Title:	AFCAP BACK ANALYSIS			**Survey Number:**	1	
Province:	LUWERO		**Road Name:**	MATUGGA - SEMUTTO		
Section:	6		**Date:**	22/03/2019		
Length (m):			**Chainage**	22+225	**Test Position:**	OWP
Lane:	NB (RHS)		**Surveyors:**	DOMINIC		
Surface Condition at point of test:			No visible defects			
Layer	**Depth Reading (mm)**		**Thickness (mm)**	**Layer/Material Description/Defect**		**Sampled for:**
Surfacing	Top	0	16	Bituminous surfacing dressing		Bitumen Recovery, PSD
	Bottom	16				
Base	Top	16	120	Yellowish brown coase-grained quartzitic gravel		Full Characterisation
	Bottom	136				
Subbase	Top	136	120	Reddish brown fine-grained quartzitic gravel		Full Characterisation
	Bottom	256				
Subgrade	Top	256	120	Reddish brown fine-grained quartzitic loose gravel		Subgrade Characteristation
	Bottom	376				
	Top					
	Bottom					
Total Thickness						
Other Notes: Rut = 3 mm						

Table 61 Test Pit Log Section 9a Matugga - Semuto

TEST PIT LOGGING FORM						
Project Title:	AFCAP BACK ANALYSIS			**Survey Number:**	1	
Province:	LUWERO		**Road Name:**	MATUGGA - SEMUTTO		
Section:	9a		**Date:**	21/03/2019		
Length (m):			**Chainage**	23+075	**Test Position:**	OWP
Lane:	SB (RHS)		**Surveyors:**	DOMINIC		
Surface Condition at point of test:			No visible defects			
Layer	**Depth Reading (mm)**		**Thickness (mm)**	**Layer/Material Description/Defect**		**Sampled for:**
Surfacing	Top	0	9	Bituminous surfacing dressing		Bitumen Recovery, PSD
	Bottom	9				
Base	Top	9	200	Yellowish brown coase-grained quartzitic gravel		Full Characterisation
	Bottom	209				
Subbase	Top	209	160	Reddish brown fine-grained quartzitic gravel		Full Characterisation
	Bottom	369				
Subgrade	Top	369	200	Reddish brown fine-grained quartzitic loose gravel		Subgrade Characteristation
	Bottom	569				
	Top					
	Bottom					
Total Thickness						
Other Notes:						

Figure 20 Test Pit on Section 9a Matugga – Semuto road

Table 62 Test Pit Log Section 10a Matugga - Semuto

TEST PIT LOGGING FORM						
Project Title:	AFCAP BACK ANALYSIS			**Survey Number:**	1	
Province:	LUWERO		**Road Name:**	MATUGGA - SEMUTTO		
Section:	10a		**Date:**	22/03/2019		
Length (m):			**Chainage**	23+335	**Test Position:**	OWP
Lane:	SB		**Surveyors:**	DOMINIC		
Surface Condition at point of test:			Slight visible longitudinal crack			
Layer	**Depth Reading (mm)**		**Thickness (mm)**	**Layer/Material Description/Defect**		**Sampled for:**
Surfacing	Top	0	12	Bituminous surfacing dressing		Bitumen Recovery, PSD
	Bottom	12				
Base	Top	12	200	Yellowish brown coase-grained quartzitic gravel		Full Characterisation
	Bottom	212				
Subbase	Top	212	120	Reddish brown fine-grained quartzitic gravel		Full Characterisation
	Bottom	256				
Subgrade	Top	332	200	Reddish brown fine-grained quartzitic loose gravel		Subgrade Characteristation
	Bottom	532				
	Top					
	Bottom					
Total Thickness						
Other Notes: Rut = 11 mm lower end of superelevation						

The in-situ average DCP-CBR strengths on these sections (Table 63) are very high thus indicating a very high level of stabilisation. The laboratory CBRs were used only for comparison purposes since the previously cemented materials were broken down before laboratory testing (Table 63). DCP-DN values are shown Table 64. Plasticity indices are above common specification values (Table 65).

Table 63 Mean in-situ DCP-CBR and lab CBR for Matugga – Semuto sections

Layer	Section						
	6 CBR (%)	8a CBR (%)	8b CBR (%)	9a CBR (%)	9b CBR (%)	10a CBR (%)	11 CBR (%)
Base	266 (31)	178	237	193 (58)	256	179 (69)	173
Sub-base	169 (14)	101	254	47 (20)	79	128 (14)	92
Subgrade	21 (9)	12	12	14 (4)	14	28 (5)	30

Table 64 Mean in-situ DCP-DN values for Sections on Matugga – Semuto

Layer	Section						
	6 mm/blow	8a mm/blow	8b mm/blow	9a mm/blow	9b mm/blow	10a mm/blow	11 mm/blow
Base	1.1	1.6	1.3	1.5	1.2	1.6	1.7
Sub-base	1.7	2.8	1.2	5.8	3.6	2.3	3.1
Subgrade	12.5	21.1	21.1	18.3	18.3	9.5	8.9

Table 65 Grading Modulus and Plasticity Indices on Matugga – Semuto

Layer	Section					
	6		9a		10a	
	GM	PI	GM	PI	GM	PI
Base	1.8	14	2.1	14	2.4	13
Sub-base	1.8	18	1.8	16	1.7	20
Subgrade	1.5	20	1.3	19	1.4	18

The central deflections measured by the FWD at a target load of 50 kN are shown in Table 66. This shows significant differences between the section strengths, but rut depths and roughness values remain low.

Table 66 FWD central deflection of Matugga – Semuto sections

Section	Average Central Deflection (µm)	
	LHS OWP	RHS OWP
6	634	511
8a	748	925
8b	433	643
9a	415	568
9b	367	694
10a	415	666
11	304	766

The geometric characteristics of the sections are shown in Table 66**.** The sections all have high crown heights.

Table 67 Geometric characteristics of Matugga – Semuto sections

Section	Maximum Gradient (%)	Mean Camber (%)	Mean Crown Height (m)
6	0.0	1.9	1.0
8a	5.0	1.2	1.0
8b	1.0	1.8	1.3
9a	3.0	1.9	1.2
9b	1.0	1.7	1.3
10a	2.3	1.6	4.0
11	3.0	0.8	1.1

The vehicle ADT and VEF for the sections on this road are shown in Table 68. These will be used to estimate the traffic carried by the roads to date.

Table 68 Vehicle ADT and VEF of Matugga – Semuto sections

Vehicle Type	Average Daily Traffic (ADT) No.	VEF	ESA/Day (1 Direction)
Carts	4	0	0
Bicycle	98	0	0
Motorcycle	1169	0	0
Medium busses and Coaster	21	0	0
Saloon cars	413	0	0
Vans, Pick-up and 4WD	449	0	0
Minibus	311	0	0
Bus	1	0	1
Light Goods Vehicle	520	0.08	20.8
Medium Goods Vehicle	343	3.54	607.11
Heavy Goods Vehicle	77	21.04	810.04
Total	**3,405**		**1,439**

2.6 Zambia

The study roads in Zambia are: Samfya – Musaila Road, Mansa – Mwense (Bahati) Road, and Samfya – Mukuku Bridge Road all in Luapula Province in north-western Zambia. This is the highest rainfall region of Zambia receiving on average 1000 – 1500 mm/yr of rainfall.

Rainfall data, the age of the roads, and traffic loading for the study roads are shown in Table 69.

The traffic loading growth rate is based on the average GDP over the past 30 years. The characteristics of the surfacing aggregates used on the sections is as shown in Table 70. It is worth noting that the surfacing aggregates are of high quality with high TFV and low flakiness.

Table 69 Key data for the study roads in Zambia

Road Name	Age (Yrs)	Estimated Traffic Loading to date (MESA)	Growth Rate used for Traffic Load Computation (%)	Mean Annual Rainfall (mm)	Remarks
Samfya – Musaila	>40	3.1-3.4	4.4	1250	Received slurry seal reseal in the year 2012
Mansa – Mwense (Bahati)	>40	0.9-1.1	4.4	1250	Received single surface dressing reseal in the year 2012
Samfya – Mukuku Bridge	>40	1.3-1.4	4.4	1207	Received single surface dressing reseal in the year 2012

Table 70 Surfacing characteristics of the study roads in Zambia

Road Section	Type of Surfacing	Aggregate Characteristics			
		Flakiness Index (%)	Elongation Index (%)	ACV (%)	TFV (kN)
Samfya – Musaila 1	Slurry Seal (Cape Seal)	-	-	-	-
Samfya – Musaila 2	Cape Seal	19	25	29	114
Mansa – Bahati 1	Double Surface Dressing	13	13	22	195
Mansa – Bahaiti 2	Double Surface Dressing	11	21	24	170
Samfya – Mukuku 1	Triple Surface Dressing	12	16	24	175
Samfya – Mukuku 2	Triple Surface Dressing	14	21	26	155

2.6.1 Samfya – Musaila Road

On Samfya – Musaila road D94 (off the D235), two suitable sections were selected – one with a good surface condition, and another "fair". On both sections, the rut depth was low (Table 71). For the "good" section (Section 2), the estimated crack intensity was very low whereas that of the "fair" section (Section 1) was high. Both sections have low average rut depth and good drainage. The first section however has a high cracking confined to the wheelpaths. The test pit logs (Table 72, Table 73, and Figure 21 and Figure 22) show thin pavement layers although the in situ base and sub-base strengths are high (Table 74). The in-situ subgrade strength is also moderate.

Table 71 Visual condition assessment summary of Samfya – Musaila sections

Section	Crack Index (Crack Intensity x Extent)	Potholed Area (m^2)	Patched Area (m^2)	Mean Rut Depth (mm)		VCI	Drainage Indication
				LHS	RHS		
1 Fair (2+080 – 2+380)	20	1.5	0	7	4	71	Good
2 Good (7+380 - 7+580)	0	0	0	6	8	94	Good

Table 72 Test Pit Log Section 1 Samfya - Musaila

TEST PIT LOGGING FORM					
Project Title:	AFCAP BACK ANALYSIS			**Survey Number:**	1
Province:	LUAPULA		**Road Name:**	SAMFYA - MUSAILA D94	
Section:	1 (Poor)		**Date:**	22/03/2019	
Length (m):	300		**Chainage**	2+100	**Test Position:** OWP
Lane:	RHS		**Surveyors:**	Andrew (RDA)	
Surface Condition at point of test:			Interconnected cracks		
Layer	**Depth Reading (mm)**		**Thickness (mm)**	**Layer/Material Description/Defect**	**Sampled for:**
Surfacing	Top		10	Bituminous surfacing dressing seemingly a Cape Seal	Bitumen Recovery, PSD
	Bottom				
Base	Top		150	Tough lateritic gravelly layer (Probably stabilised)	Full Characterisation
	Bottom				
Subbase	Top		200	Lateritic gravel	Full Characterisation
	Bottom				
Subgrade	Top		-	Silty-Clay	Subgrade Characteristation
	Bottom				
	Top				
	Bottom				
Total Thickness					
Other Notes: Section is on an a shallow embankment. Crown height measurements to verify. Rut = 3 mm					

Figure 21 Test Pit on Section 1 Samfya - Musaila

Table 73 Test Pit Log Section 2 Samfya - Musaila

TEST PIT LOGGING FORM					
Project Title:	AFCAP BACK ANALYSIS		**Survey Number:**	1	
Province:	LUAPULA	**Road Name:**	SAMFYA - MUSAILA D94		
Section:	2 (Good)	**Date:**	22/03/2019		
Length (m):	200	**Chainage**	7+400	**Test Position:**	OWP
Lane:	RHS	**Surveyors:**	Andrew (RDA)		
Surface Condition at point of test:		No visible defects			

Layer	Depth Reading (mm)		Thickness (mm)	Layer/Material Description/Defect	Sampled for:
Surfacing	Top		10	Bituminous surfacing dressing seemingly a Cape Seal	Bitumen Recovery, PSD
	Bottom				
Base	Top		160	Tough lateritic gravelly layer (Probably stabilised)	Full Characterisation
	Bottom				
Fill	Top		140	Lateritic gravel	Full Characterisation
	Bottom				
	Top		-		
	Bottom				
	Top				
	Bottom				
Total Thickness					

Other Notes:
Section is on an a shallow embankment. Crown height measurements to verify. Rut = 13 mm

Figure 22 Test Pit on Section 2 Samfya – Musaila

Both sections on this road show high base and subgrade in-situ DCP-CBR values and similar in-situ subgrade strengths (Table 74). The laboratory CBRs were used only for comparison purposes since the previously cemented materials were broken down before laboratory testing. Plasticity indices are above common specification values.

Table 74 Materials characteristics for Samfya - Musaila

Layer	Section							
	1 (2+080 – 2+380) Poor				2 (7+380 - 7+580) Good			
	Average CBR (%)	DN (mm/blow)	GM	PI	AverageCBR (%)	DN (mm/blow)	GM	PI
Base	114 (17)	2.5	2.2	7	212 (40)	1.4	2.1	7
Sub-base	137 (18)	2.1	2.1	8	141 (28)	2.1	2.2	10
Subgrade	30 (2)	8.9	0.8	7	28 (2)	9.5	-	-

The FWD central deflection values measured at a target load of 40 kN are shown in Table 75. The values are similar for both sections, suggesting that the defects in Section 1 are superficial.

Table 75 FWD central deflection of Samfya – Musaila sections

Section	Average Central Deflection (µm)	
	LHS OWP	RHS OWP
1 Poor	384	365
2 Good	299	345

The geometric characteristics of the sections are also similar to one another as shown in Table 76.

Table 76 Geometric characteristics of Samfya – Musaila sections

Section	Maximum Gradient (%)	Mean Camber (%)	Mean Crown Height (m)
1 (2+080 – 2+380) Poor	0.9	1.6	0.5
2 (7+380 - 7+580) Good	0.8	2.0	0.6

The vehicle ADT and VEF of the sections on this road were obtained through counts and axle load surveys conducted during the fieldwork. These are shown in Table 77. They will be used in estimating the traffic load carried by the sections to date.

Table 77 Vehicle ADT and VEF of Samfya – Musaila sections

Vehicle Type	Total ADT	VEF	ESA/day (S-M)
Cars, Pickups, S/wagons	258	0	0
2-axle Trucks	37	0.32	5.92
3-Axle Trucks	86	3.00	129
4-Axle Trucks			
5-Axle Trucks	185	0.52	48.1
6-Axle Trucks			
7-Axle Trucks			
Total	**566**		**183**

2.6.2 Mansa – Bahati Road

On Mansa – Bahati Road D79, two sections were identified and are being studied. This is one of the major routes to the Democratic Republic of Congo and Zambia (through Mwense). The sections were judged, on the basis of their visual condition, to be in 'Poor' and 'Good' condition. On the 'Poor' section, the pavement had lost its camber, and water from the pavement could not make it to the verge.

Both sections have a high average rut depth. Section 1 (Poor) also has a large number of potholes (Table 78) compared to Section 2 (Good). The test pit logs (Table 79 and Table 80, and Figure 23 and Figure 24) show thin pavement layers.

Table 78 Visual condition assessment summary of Mansa - Bahati sections

Section	Crack Index (Crack Intensity x Extent)	Potholed Area (m^2)	Patched Area (m^2)	Mean Rut Depth (mm)		VCI	Drainage Indication
				LHS	RHS		
1 Poor (15+600 – 15+900)	0	113	6	14	18	61	Poor
2 Good (26+600 - 26+900)	0	0.3	0	13	18	83	Fair

Table 79 Test Pit Log Section 1 Mansa – Bahati road

TEST PIT LOGGING FORM							
Project Title:	AFCAP BACK ANALYSIS			**Survey Number:**	1		
Province:	LUAPULA		**Road Name:**	MANSA - MWENSE/BAHATI D79			
Section:	1 (Poor)		**Date:**	26/03/2019			
Length (m):	300		**Chainage**	15+839	**Test Position:**	OWP	
Lane:	RHS		**Surveyors:**	Andrew (RDA)			
Surface Condition at point of test:			No visible defects				
Layer	**Depth Reading (mm)**		**Thickness (mm)**	**Layer/Material Description/Defect**		**Sampled for:**	
Surfacing	Top		10	Bituminous surfacing dressing		Bitumen Recovery, PSD	
	Bottom						
Base	Top		150	Tough gravelly lateritic layer (Probably stabilised)		Full Characterisation	
	Bottom						
Subbase	Top		150	Lateritic gravel, highly weathered/plastic		Full Characterisation	
	Bottom						
Subgrade	Top		-	Brown clayey-gravelly highly plastic/weathered material		Subgrade Characterisation	
	Bottom						
	Top						
	Bottom						
Total Thickness							
Other Notes: No surface defects at test pit position. Rut = 17 mm							

Figure 23 Test Pit on Section 1 Mansa - Bahati

Table 80 Test Pit Log Section 2 Mansa – Bahati road

TEST PIT LOGGING FORM								
Project Title:	AFCAP BACK ANALYSIS			**Survey Number:**	1			
Province:	LUAPULA		**Road Name:**	MANSA - MWENSE/BAHATI D79				
Section:	2 (Good)		**Date:**	23/03/2019				
Length (m):	300		**Chainage**	26+700	**Test Position:**	OWP		
Lane:	RHS		**Surveyors:**	Andrew (RDA)				
Surface Condition at point of test:			No visible defects					
Layer	**Depth Reading (mm)**		**Thickness (mm)**	**Layer/Material Description/Defect**		**Sampled for:**		
Surfacing	Top		20	Bituminous surfacing dressing seemingly a Double Surface Dressing		Bitumen Recovery, PSD		
	Bottom							
Base	Top		150	Tough lumpy lateritic layer (Probably stabilised)		Full Characterisation		
	Bottom							
Subbase	Top		150	Lateritic gravel, highly weathered/plastic		Full Characterisation		
	Bottom							
Subgrade	Top		-	Brown clayey-sand		Subgrade Characterisation		
	Bottom							
	Top							
	Bottom							
Total Thickness								
Other Notes: Section is on part cut (LHS) and part fill (RHS). Rut = 13 mm								

Figure 24 Test Pit on Section 2 Mansa - Bahati road

The in-situ DCP-CBR values measured in Section 1 are significantly lower than those in Section 2 (Table 81). Observations on site showed poor surface drainage on Section 1. Moreover Section 1 is in a shallow cut and the water table appears to be high in the area (there is a domestic water dam nearby). The laboratory CBRs were used only for comparison purposes since the previously cemented materials were broken down before laboratory testing. Plasticity indices are above common specification values.

Table 81 In Situ DCP-CBR and lab CBR averages and Mansa – Bahati road

Layer	Section							
	1 (15+600 – 15+900) Poor				2 (26+600 - 26+900) Good			
	Average CBR (%)	DN (mm/blow)	GM	PI	Average CBR (%)	DN (mm/blow)	GM	PI
Base	84 (12)	3.4	1.8	9	257 (70)	1.2	2.3	6
Sub-base	26 (1)	10.2	1.4	16	73 (5)	3.8	1.0	8
Subgrade	66 (9)	4.2	1.2	9	178 (7)	1.6	1.0	5

The FWD central deflection values measured at a target load of 40 kN are shown in Table 82. The values for Section 1 are higher than those for Section 2 showing weaker in-situ strength of Section 1. This result is in agreement with the DCP-CBR results Table 81.

Table 82 FWD central deflection of Mansa – Bahati sections

Section	Average Central Deflection (µm)	
	LHS OWP	RHS OWP
1 Poor (15+600 – 15+900)	782	725
2 Good (26+600 - 26+900)	447	495

The geometric characteristics of the sections are similar to each other (Table 83) although Section 1 is in a shallow cut and Section 2 is in part cut and part fill.

Table 83 Geometric characteristics of Mansa – Bahati sections

Section	Maximum Gradient (%)	Mean Camber (%)	Mean Crown Height (m)
1 Poor (15+600 – 15+900)	1.0	2.1	0.4
2 Good (26+600 - 26+900)	0.9	1.8	0.6

The vehicle ADT and VEF of the sections on this road were obtained through counts and axle load surveys conducted during the fieldwork. These are shown in Table 84. They will be used in estimating the traffic load carried by the sections to date.

Table 84 Vehicle ADT and VEF of Mansa – Bahati sections

Vehicle Type	Total ADT	VEF	ESA/day (M to B)
Cars, Pickups, S/wagons	256	0	0
2-axle Trucks	52	0.66	19.14
3-Axle Trucks	44	1.06	25.44
4-Axle Trucks	11	2.13	10.65
5-Axle Trucks	5	1.18	2.36
6-Axle Trucks	18	4.82	48.2
7-Axle Trucks	6	1.48	4.44
Total	**392**		**110**

2.6.3 Samfya – Mukuku Bridge Road

The Samfya - Mukuku Bridge Road (D235) is located in a swampy/marshy area with a high water table (less than 1m below the surface of the road). Accordingly, the side drains had overgrown grass which impeded the water from flowing off the pavement in most of the sections. Two sections with surface condition of "good" and "poor" were selected from this road. The "good" section has no cracking, no potholes and minor rutting. The "poor" section has numerous potholes.

Both sections have moderate average rut depth. Section 2 (Poor) however has a high pothole area (Table 85) compared to Section 1 (Good). The test pit logs (Table 86 and Table 87, and Figure 25 and Figure 26) show that Section 2 has thicker pavement layers.

Table 85 Visual condition assessment summary of Samfya – Mukuku Bridge sections

Section	Crack Index (Crack Intensity x Extent)	Potholed Area (m^2)	Patched Area (m^2)	Mean Rut Depth (mm)		VCI	Drainage Indication
				LHS	RHS		
1 Good (101+800 – 102+100)	0	0	0	8	8	90	Good
2 Poor (102+600 - 102+900)	0	23	5	10	12	73	Fair

Table 86 Test Pit Log Section 1 Samfya – Mukuku Bridge

TEST PIT LOGGING FORM							
Project Title:	AFCAP BACK ANALYSIS			**Survey Number:**	1		
Province:	LUAPULA		**Road Name:**	SAMFYA - MUKUKU BRIDGE D235			
Section:	1 (Good)		**Date:**	23/03/2019			
Length (m):	300		**Chainage**	102+100	**Test Position:**	OWP	
Lane:	RHS		**Surveyors:**	Andrew (RDA)			
Surface Condition at point of test:			No visible defects				
Layer	**Depth Reading (mm)**		**Thickness (mm)**	**Layer/Material Description/Defect**		**Sampled for:**	
Surfacing	Top		25	Bituminous surfacing dressing seemingly a triple seal		Bitumen Recovery, PSD	
	Bottom						
Base	Top		150	Tough lumpy lateritic layer (Probably stabilised)		Full Characterisation	
	Bottom						
Subbase	Top		150	Lateritic gravel		Full Characterisation	
	Bottom						
Subgrade	Top		-	Grey to black clayey-sand (Probably a blend of clay and sand)		Subgrade Characterisation	
	Bottom						
	Top						
	Bottom						
Total Thickness							

Other Notes:
Section is on an embankment in a swamp. A drainage ditch excavated at the toe of the embankment shows black clay, while a berm (to keep water away from the embankment) further away 40 - 80 m away from the RHS of the embankment shows a grey sandy material. Rut = 5 mm

Figure 25 Test Pit on Section 1 Samfya – Mukuku Bridge

Table 87 Test Pit Log Section 2 Samfya – Mukuku Bridge

TEST PIT LOGGING FORM							
Project Title:	AFCAP BACK ANALYSIS			**Survey Number:**	1		
Province:	LUAPULA		**Road Name:**	SAMFYA - MUKUKU BRIDGE D235			
Section:	2 (Poor)		**Date:**	23/03/2019			
Length (m):	300		**Chainage**	102+621	**Test Position:**	OWP	
Lane:	LHS		**Surveyors:**	Andrew (RDA)			
Surface Condition at point of test:			No visible defects				
Layer	**Depth Reading (mm)**		**Thickness (mm)**	**Layer/Material Description/Defect**		**Sampled for:**	
Surfacing	Top		25	Bituminous surfacing dressing seemingly a triple seal		Bitumen Recovery, PSD	
	Bottom						
Base	Top		200	Tough lumpy lateritic layer (Probably stabilised)		Full Characterisation	
	Bottom						
Subbase	Top		200	Lateritic gravel		Full Characterisation	
	Bottom						
Subgrade	Top		-	Grey to black clayey-sand (Probably a blend of clay and sand)		Subgrade Characterisation	
	Bottom						
	Top						
	Bottom						
Total Thickness							

Other Notes:
Section is on an embankment in a swamp. A large body of seemingly deep water is standing on both sides of the embankment within 5-10 m of the edge of the seal. The top of the water seems to be within 1 m of the crown. No protective berm either side of the embankment. Rut = 5 mm

Figure 26 Test Pit on Section 2 Samfya – Mukuku Bridge road

The in-situ strengths of the base, sub-base and subgrade in Sections 1 and 2 are very similar to one another (Table 88). This means whatever defects are observed on Section 2 are superficial. The laboratory CBRs were used only for comparison purposes since the previously cemented materials were broken down before laboratory testing. Plasticity indices are in line with common specification values.

Table 88 In Situ DCP-CBR and lab CBR averages Samfya – Mukuku Bridge Road

Layer	Section							
	1 (101+800 – 102+100) Good				2 (102+600 - 102+900) Poor			
	Average CBR (%)	DN (mm/blow)	GM	PI	Average CBR (%)	DN (mm/blow)	GM	PI
Base	124 (25)	2.3	2.0	7	111 (80)	2.6	2.1	6
Sub-base	78 (28)	3.6	2.1	7	73 (11)	3.8	2.1	8
Subgrade	50 (2)	5.5	1.1	-	47 (1)	5.8	1.1	-

The FWD central deflection values measured at a target load of 40 kN are shown in Table 89. The values are similar for both sections, suggesting that the defects in Section 1 are superficial. These values are in agreement with the DCP-CBR values shown in Table 88.

Table 89 FWD central deflection of Samfya – Mukuku Bridge sections

Section	Average Central Deflection (µm)	
	LHS OWP	RHS OWP
1 Good (101+800 – 102+100)	506	460
2 Poor (102+600 - 102+900)	595	573

The geometric characteristics of the sections are shown in Table 90. The values for Section 2 are superior to that for Section 1.

Table 90 Geometric characteristics of Samfya – Mukuku Bridge sections

Section	Maximum Gradient (%)	Mean Camber (%)	Mean Crown Height (m)
1 Good (101+800 – 102+100)	0.4	1.2	0.4
2 Poor (102+600 - 102+900)	0.0	1.8	0.7

The vehicle ADT and VEF of the sections on this road were obtained through counts and axle load surveys conducted during the fieldwork. These are shown in Table 91. They will be used in estimating the traffic load carried by the sections to date.

Table 91 Vehicle ADT and VEF of Samfya – Mukuku Bridge sections

Vehicle Type	Total ADT	VEF	ESA/day (S-M)
Cars, Pickups, S/wagons	192	0	0
2-axle Trucks	19	0.32	3.04
3-Axle Trucks	65	3.00	97.5
4-Axle Trucks			
5-Axle Trucks	56	0.52	14.56
6-Axle Trucks			
7-Axle Trucks			
Total	**332**		**115**

3 Capacity Building

3.1 General

Capacity building activities started with site reconnaissance and continued through the fieldwork, laboratory testing and finally joint data analysis stages of this work. In order to enhance capacity and knowledge transfer, all these activities were undertaken jointly with counterparts from the participating road agencies. The overall capacity-building aim was to develop a culture of systematic research that leads to revision or development of standards and preservation of study data. This was facilitated through involvement of the counterparts in all activities being undertaken. The counterparts have been asked to write conference or journal papers on the findings in their countries during the Phase 3 activities. Writing papers helps to retain and consolidate the skills and knowledge gained. Possible tables of contents have been discussed with the counterparts.

Two-day Joint Analysis Workshops (JAWs) were held in Uganda (12th and 15th July 2019), Zambia (17th and 18th July 2019), Ghana (14th and 15th August 2019), and Mozambique (21st and 22nd August 2019) with teams from the research departments and the LTPP monitoring consultant.

The objectives of the workshops were to:

1. Empower the participants with the knowledge to query and revise existing catalogues and specifications.
2. Evaluate the implications of the study for the design, construction and maintenance of low volume roads.
3. Demonstrate the importance of accurate measurements both in the field and laboratory.

3.2 Workshop Schedule

The schedule followed for the JAWs is shown in Table 92 and Table 93. All together 37 people attended the JAWs. The list and roles of participants are as shown in Annex 4 – however some participants preferred not to register.

Table 92 Joint Analysis Workshop Schedule Day 1

Interval	Item	Description	Presenter
08:00-08:30	1	Registration of participants	All
08:30-08:40	2	Welcome remarks	Host
08:40-08:50	3	Introduction of participants	All
08:50-09:00	4	Background to the Back Analysis Project	TRL
09:00-10:00	5	Visual Condition Indices (Computations and Plotting)	All
10:00-10:30	Refreshment Break		
10:30-11:30	6	Completion of Item 5 and discussions	All
11:30-12:00	7	Rainfall analysis and discussion	TRL
12:30-12:30	8	Introduction to DCP Analysis	TRL
12:30-13:30	Lunch Break		
13:30-14:00	9	Item 8 Continued	TRL
14:00-15:00	10	DCP Analysis	All
15:00-15:10	11	Day 1 Closing Remarks	All
15:10-15:30	Refreshment Break		

Table 93 Joint Analysis Workshop Schedule Day 2

Interval	Item	Description	Presenter
08:00-08:30	1	Registration of participants	All
08:30-08:45	2	Recap of Day 1	TRL
08:45-10:00	3	Collation of Laboratory Data	All
10:00-10:30	Refreshment Break		
10:30-11:00	4	Completion of Item 5 and discussions	All
11:00-11:30	5	Rainfall analysis and discussion	TRL
11:30-12:00	6	Introduction to DCP Analysis	All
12:00-12:30	7	Comparisons and discussions	All
12:30-13:30	Lunch Break		
13:30-14:00	8	Item 7 Continued	All
14:00-14:30	9	Particle Size Distribution discussions	All

14:30-15:00	10	Summary and scope for revision of manuals and specifications for LVSRs	TRL
15:00-15:10	11	Closing remarks	Host
15:10-15:30	Refreshment Break		

3.3 Analysis Exercises

Samples of materials taken from the study sections were tested in laboratories in the respective countries. These test results provided the data used in the joint analysis required to develop cells in the design catalogues and specifications for the use of local materials. The data were collated, and various calculations were carried out to determine visual condition indices; structural numbers were used to make strength comparisons between the structures that existed in-situ and those that would be recommended in the pavement catalogue.

Various discussions on technical issues ensued between the team members during and following the analysis. The topics included the definition of terminal road failure conditions in terms of rutting and cracking, the potential benefits of sealing shoulders, benefits and problems of chemical stabilisation, the testing and properties of local materials and their use in the various road pavement layers, and problems with surfacing materials.

The issue of testing materials at various moisture contents to enable decisions on the exploitation of drier climatic conditions and pavement environment on material choice was also discussed. It was explained that laboratory testing of material strength in this way enables a strength/moisture relationship to be developed and provides improved options for the selection of materials that satisfy the strength requirements at the likely/required field in-situ moisture condition. This applies equally to California Bearing Ratio (CBR) and Dynamic Cone Penetrometer test methods.

Day 2 involved guiding the participants in the use of the field and laboratory data to produce the various parameters required to calculate the Structural Number of the pavement at the selected trial site; this is needed in order to calculate the strength values required to fill a cell in the design catalogue. Various technical issues arose during the exercise which included material properties and availability, discussions of Plasticity and Plastic Modulus, with some perception that the values of plasticity in the specifications tending to be rather restrictive, and the provision of sealed shoulders.

There was also considerable discussion on the subject of climate change, the impact of extreme climatic events on drainage structures, the cost of these impacts and of climate resilience measures.

3.4 Feedback

Feedback from the participants was sought by means of anonymous questionnaire from participants of the Joint Analysis Workshop. The following key points were captured:

1. All participants were of the view that their knowledge of low volume road materials was greatly improved by their participation in the workshops; they rated their knowledge of low volume road materials between 1 and 3 (on a scale of 5) before the workshop and at 4 or 5 after the workshops.
2. Participants in the workshops stated that all parts of the analysis were useful especially structural number analysis.
3. Other topics that they felt should have been included in the analysis were high volume roads, sealing shoulders and traffic analysis. Traffic analysis was however addressed in all the analysis sessions.

Detailed feedback on the workshops is given in Annex 5.

4 Summary and way forward

The following activities were carried out on the study sections on the selected roads:

- Deflection measurements.
- Roughness measurements.
- Visual condition assessment (rutting, cracking, potholing and patching).
- Determination of cross-section levels.
- Dynamic Cone Penetrometer (DCP) tests.
- Field density test.
- Test pits/ layer thicknesses/ sampling.
- Traffic counts.
- Axle load surveys.

The tests varied according to the data already available on some of the sections and the intensity of testing also varied depending on the extent of deterioration observed on the sections. Deflection and roughness measurements were subject to the availability of equipment in the countries. In Zambia and Uganda deflection tests were undertaken. No roughness measurement equipment exists in the Zambia; and in Ghana the equipment is faulty. In Mozambique, no functional deflection measurement equipment was available and the roughness measurement equipment is also faulty. Traffic and axle load data for the study roads in Uganda and Ghana were provided from previous studies.

All other tests were carried out on the sections in all countries. Although the availability of deflection and roughness measurements in all countries would be beneficial, the lack of these data sets is not critical since other parameters like DCP strengths, test pit logs, visual condition surveys and laboratory characterisation were used to compare the performance of the different sections.

Samples collected from test pits of the study roads were tested in the laboratories of the RRCs. The samples were subjected to the following laboratory tests:

- Soils related tests
  - CBR.
  - Maximum Dry Density (MDD) / Optimum Moisture Content (OMC).
  - Moisture contents.
  - Atterberg Limits.
  - Particle Size Distribution (PSD).
  - Unconfined Compressive Strength.
- Aggregate related tests
  - PSD.
  - Aggregate Crushing Value (ACV) / Ten per cent Fines Value (TFV) / Aggregate Impact Value (AIV).
  - Los Angeles Abrasion (LAA).
  - Average Least Dimension (ALD).
  - Flakiness Index (FI).
  - Specific gravity and water absorption.
- Bitumen tests (on recovered binders)
  - Penetration.
  - Softening point.

Summary data tables are contained in Annex 2 and Annex 3. These sets of data will also be entered into the Back Analysis Database for future use.

The road agencies and a number of consultants in the various countries participated in the joint analysis of the performance of the different sections. The data analysis will be reported in the Final Report and in the Scientific Paper.

Annex 1 Road network, soil and climatic maps for Ghana, Malawi, Mozambique, Tanzania, Uganda and Zambia

Figures A.1 – A.17 show the climatic, road network and soil maps of Ghana, Malawi, Mozambique, Tanzania, Uganda and Zambia in the order below:

Figure numbers	Country
A.1 – A.3	Ghana
A.4 – A.5	Mozambique
A.6 – A.8	Uganda
A.9 – A.11	Zambia

Figure A.1 Climatic map of Ghana

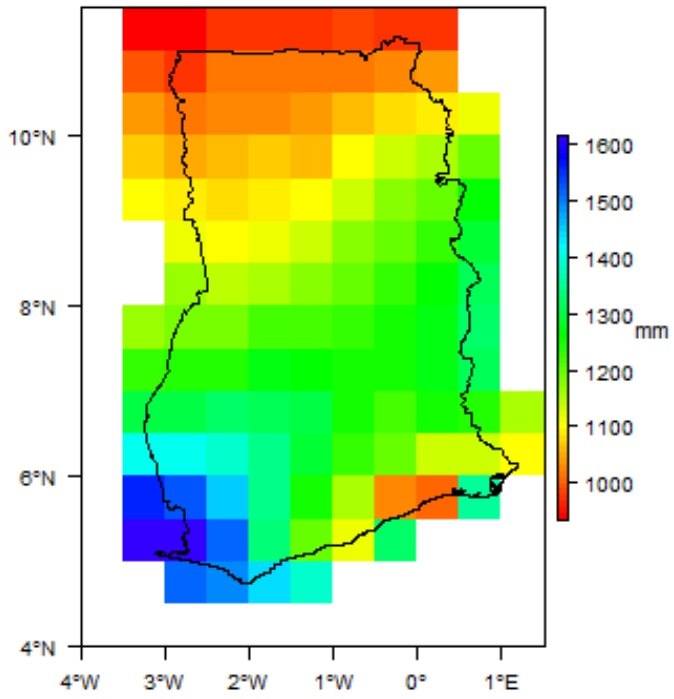


Figure A.2 Road network map of Ghana

Figure A.3 Soil map of Ghana

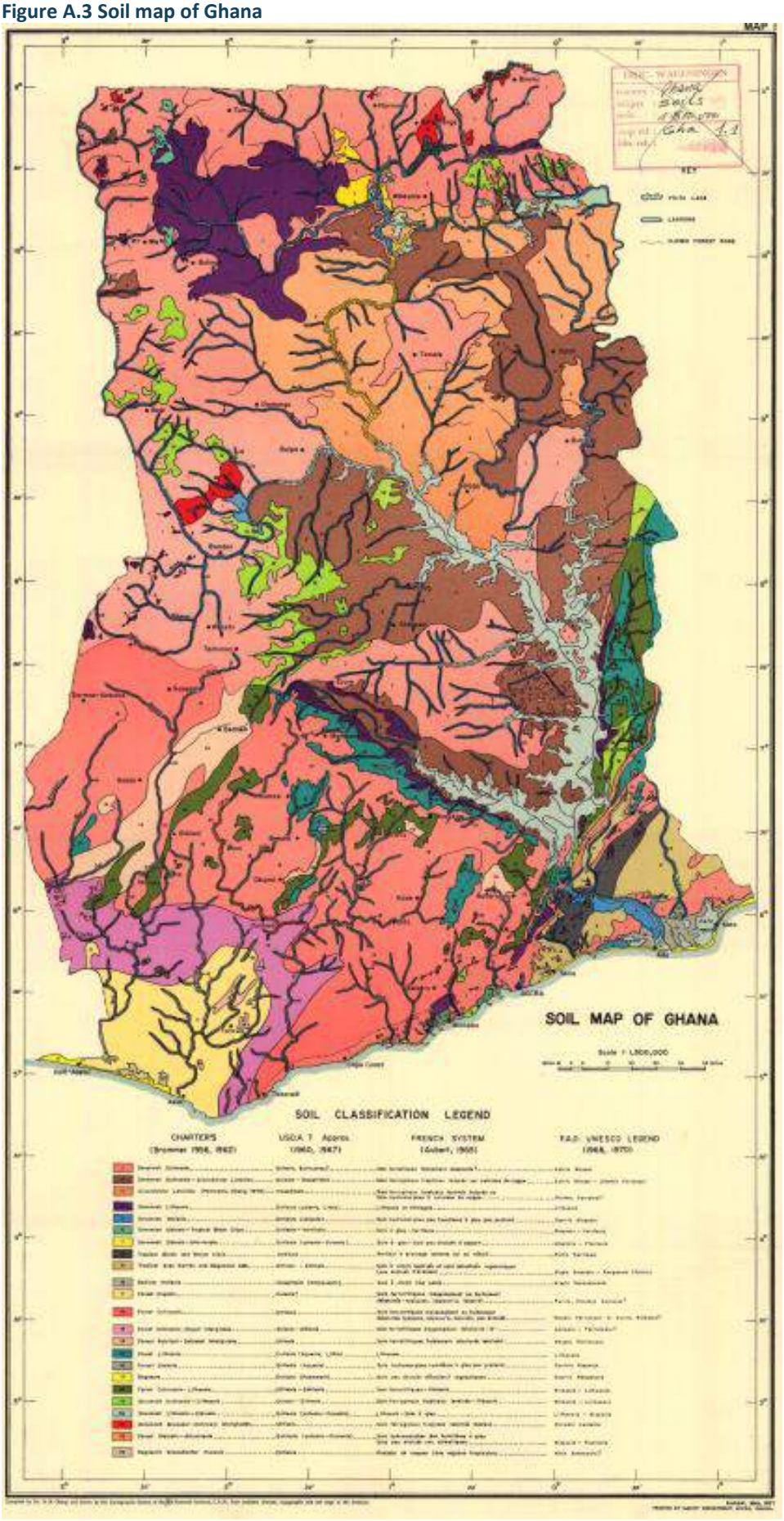


Figure A.4 Climate map of Mozambique

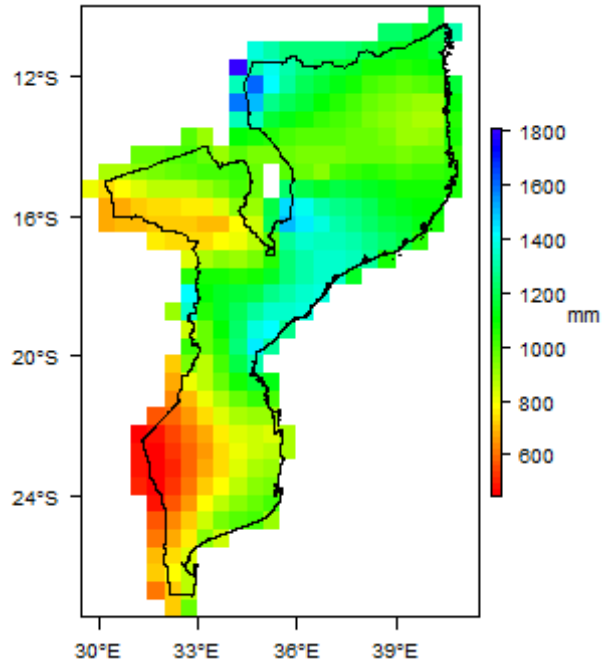


Figure A.5 Soil map with super-imposed road network of Mozambique

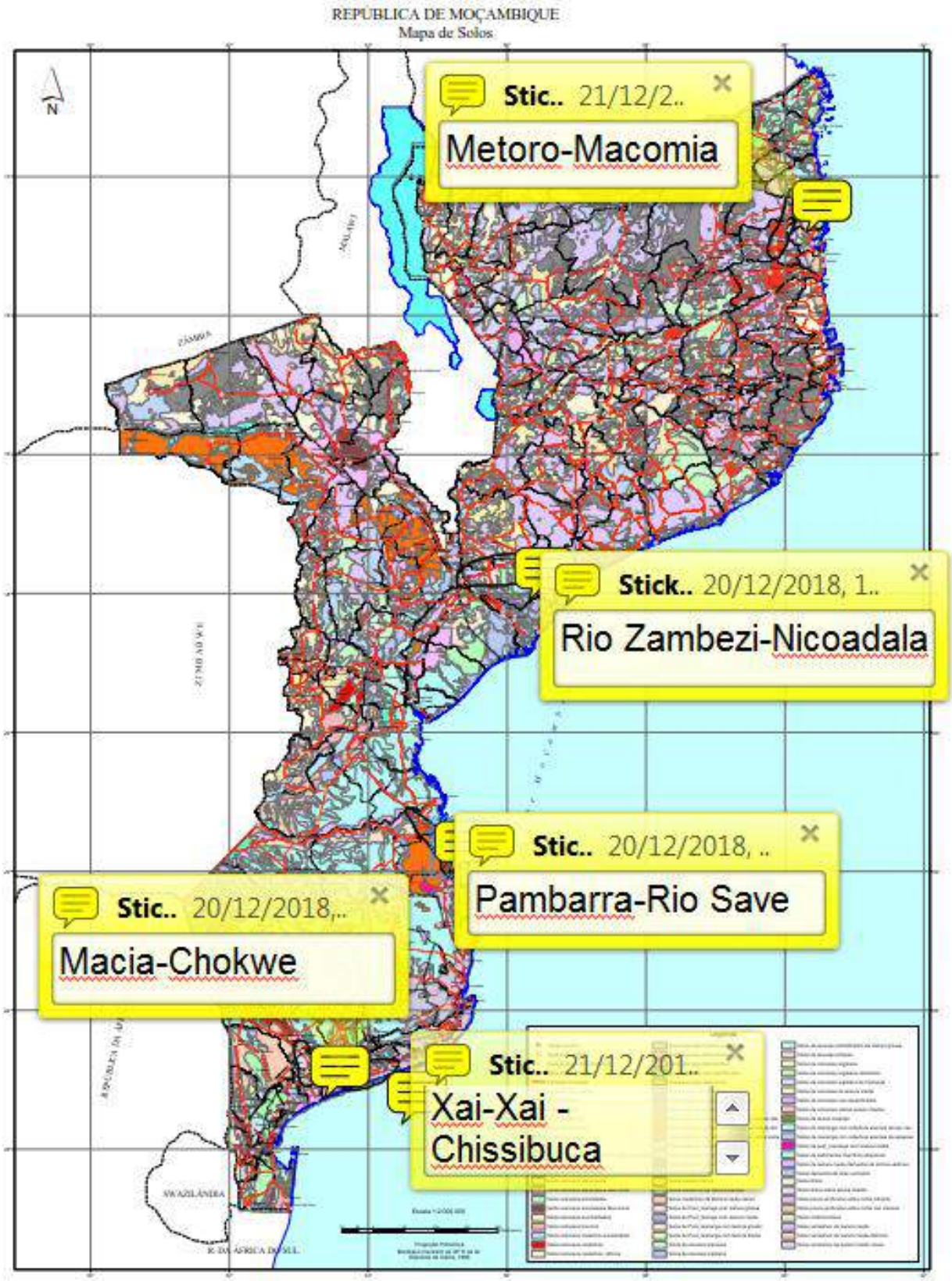


Figure A.6 Climate map of Uganda

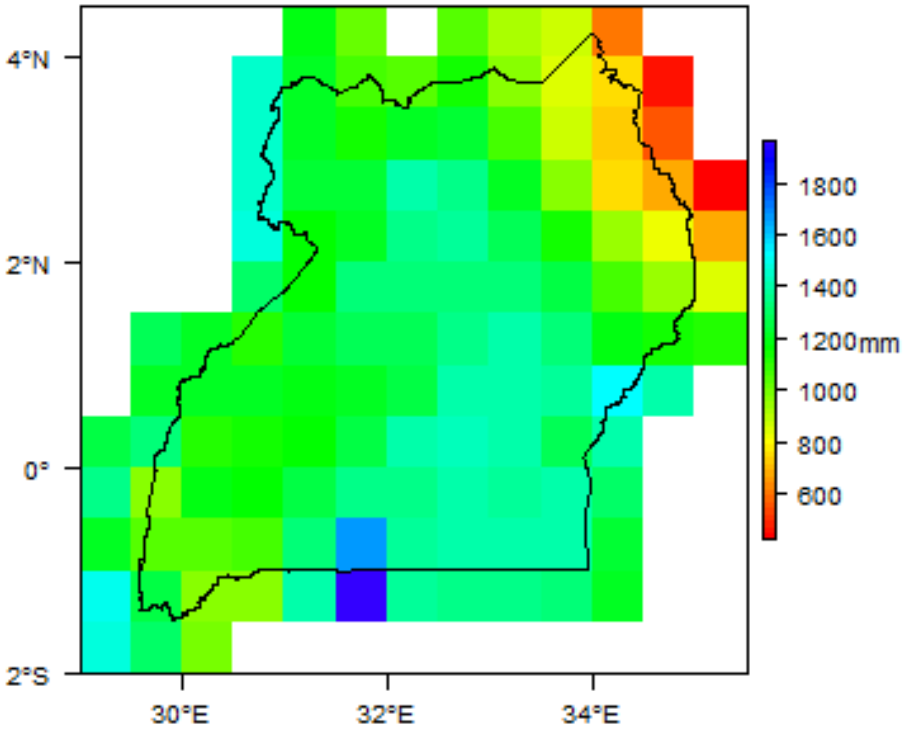


Figure A.7 Road network map of Uganda

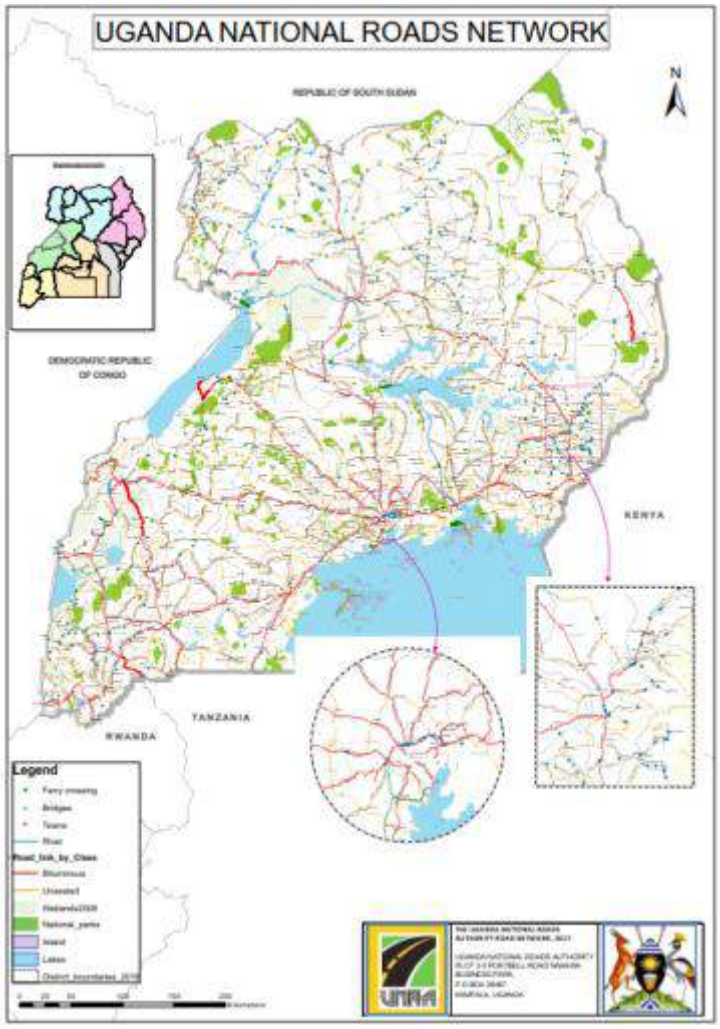


Figure A.8 Soil Map of Uganda

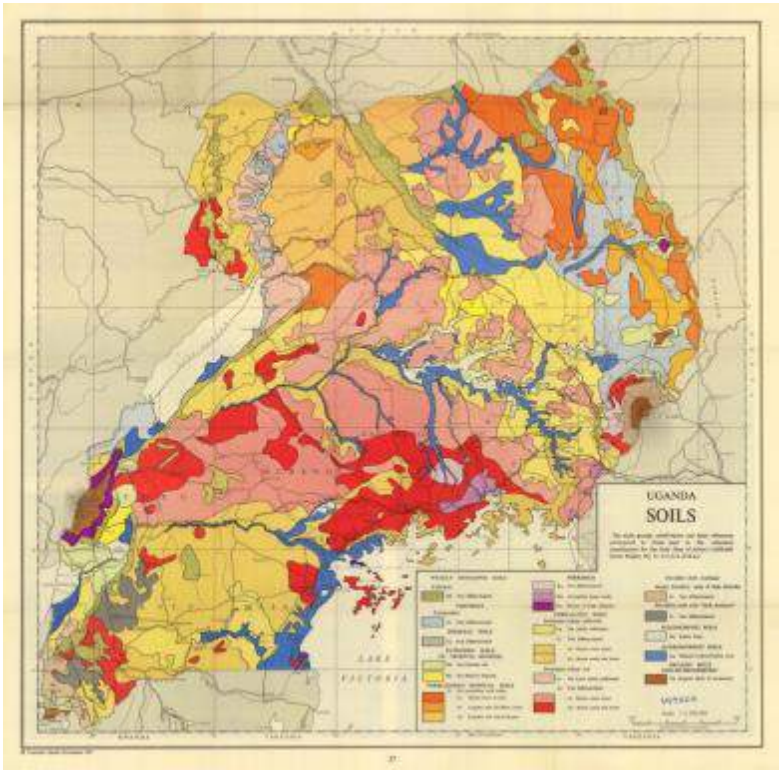


Figure A.9 Climate map of Zambia

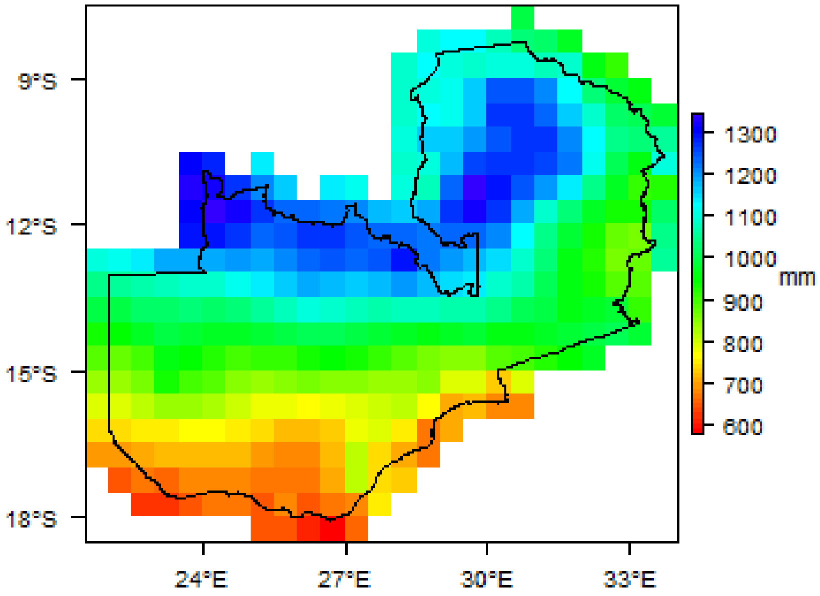
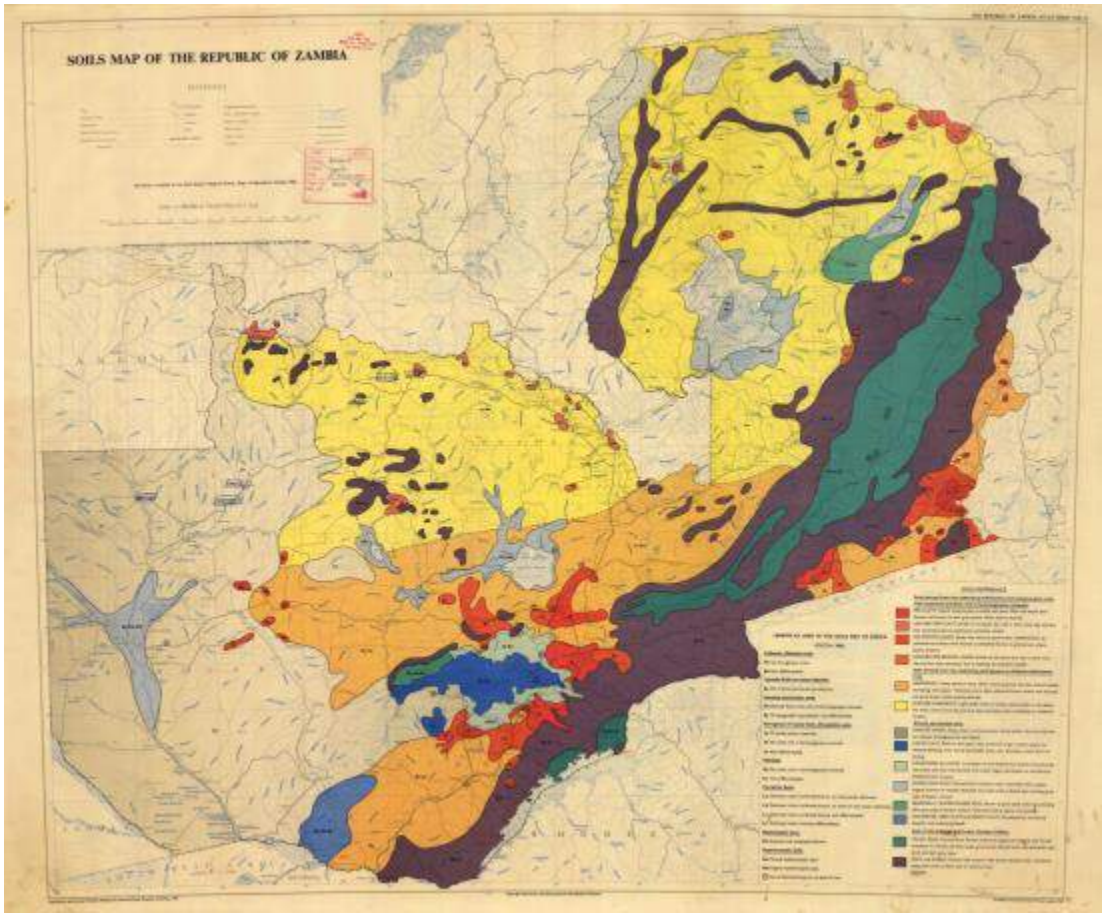


Figure A.10 Road network map of Zambia

Figure A.11 Soil Map of Zambia



Annex 2 Visual Condition Survey Forms

Ghana

DETAILED VISUAL CONDITION SURVEY

Road Name:	Mpataba Junction - Half Assini Road			**Route No:**	
Road Section:	Section 1 (3+500	**To:**	3+800	**Location:**	Western Region (Ghana)
Date:	21/03/2019			**Inspector:**	Leah Musenero

CHAINAGE			TEST POINT	TOTAL	X-section	Road Width*	Surface type	Cracking					Potholes		Patching		Rutting - depth exactly at chainage point		Deformation		Slips			Patching Quantities		Crown Height		Camber		Drainage		Remarks
Km	Block			km	0,1,2,3	(m)	S/U	Type	Width	Intensity	Extent	Posn	Area	Extent	Area	Extent	Depth left	Depth right	Type	Depth	Ext	Posn	Sever	Shallow	Inlay	LHS	RHS	LHS	RHS	0,1,2,3,4,5	Position	
	Start	to	End					Ln, Tr,Cr	1,2,3,4	0,1,2,3,4,5	0,1,2,3,4,5	L,C,R,A	(m2)	0,1,2,3,4,5	(m2)	0,1,2,3,4,5	(mm)	(mm)	S or G	(mm)	0,1,2,3,4,5	L,C,R,A	0,1,2,3	(m2)	(m2)	(mm)	(mm)	(%)	(%)			
3.000	0.500	to		3.500																											Drainage features are inadequate
	0.500	to	0.550	3.550	1	7.2	S	Cr	2	4	3	L, R (OWT)	0.92	2	55.5	3	35	25	S	20	0								4	3+525 on RHS	Mitre drain
	0.550	to	0.600	3.600	1	6.8	S	Cr	3	3	3	L, R (OWT)	0.34	1	23.0	2	15	20	S	35	0								0		Edge break on RHS starting 3+550; stone loss and pothole in patch 3+800
	0.600	to	0.650	3.650	1	6.9	S	Cr	3	3	3	L, R (OWT)	9.6	2	44.8	4	18	22	S	20											
	0.650	to	0.700	3.700	1	6.8	S	Cr	4	4	4	L, R (OWT)	0.24	1	23.5	3	10	28	S	11											
	0.700	to	0.750	3.750	1	6.9	S	Cr	4	3	3	L, R (OWT)	1.25	3	65.0	3	10	2	S	42											
	0.750	to	0.800	3.800	1	7.1	S	Cr	4	3	4	L, R (OWT)	0	0	12.0	1	1	3	S	18									2	3+800	Culvert

DETAILED VISUAL CONDITION SURVEY

Road Name:	Mpataba Junction - Half Assini Road			**Route No:**	
Road Section:	Section 2 (6+200	**To:**	6+600	**Location:**	Western Region (Ghana)
Date:	21/03/2019			**Inspector:**	Leah Musenero

CHAINAGE			TEST POINT	TOTAL	X-section	Road Width*	Surface type	Cracking					Potholes		Patching		Rutting - depth exactly at chainage point		Deformation		Slips			Patching Quantities		Crown Height		Camber		Drainage		Remarks
Km	Block			km	0,1,2,3	(m)	S/U	Type	Width	Intensity	Extent	Posn	Area	Extent	Area	Extent	Depth left	Depth right	Type	Depth	Ext	Posn	Sever	Shallow	Inlay	LHS	RHS	LHS	RHS	0,1,2,3,4,5	Position	
	Start	to	End					Ln, Tr,Cr	1,2,3,4	0,1,2,3,4,5	0,1,2,3,4,5	L,C,R,A	(m2)	0,1,2,3,4,5	(m2)	0,1,2,3,4,5	(mm)	(mm)	S or G	(mm)	0,1,2,3,4,5	L,C,R,A	0,1,2,3	(m2)	(m2)	(mm)	(mm)	(%)	(%)			
6.000	0.200	to		6.200																											Ravelling on entire section
	0.200	to	0.250	6.250	0	7.3	S	0	0	0	0	0	0	0	0.4	1	18	10	S	25									1	6+200 RHS	Mitre drain
	0.250	to	0.300	6.300	0	7.2	S	0	0	0	0	0	0.2552	1	0.0	0	6	5		0									1	6+250 LHS	Mitre drain
	0.300	to	0.350	6.350	0	6.9	S	0	0	0	0	0	0	0	0.0	0	6	0		0									1	6+300 RHS	Mitre drain; Bleeding at 6+320
	0.350	to	0.400	6.400	0	7.1	S	0	0	0	0	0	0	0	0.0	0	0	0		0									1	6+350, 6+370	Cross culvert ~ 1.8m (arc) at 6+350; Mitre drain at 6+370 RHS
	0.400	to	0.450	6.450	0	6.8	S	0	0	0	0	0	0	0	0.0	0	0	0	S	20									1	6+400, 6+440	Culvert at 6+400; Mitre drain on RHS at 6+440 and 6+450
	0.450	to	0.500	6.500	0	7.1	S	0	0	0	0	0	0	0	0.0	0	6	3	0	0									1	6+450	Mitre drain
	0.500	to	0.550	6.550	0	7.2	S	0	0	0	0	0	0	0	0.0	0	7	15	0	0											
	0.550	to	0.600	6.600	0	7.2	S	0	0	0	0	0	0	0	0.0	0	0	0	0	0									1	6+550 RHS	Mitre drain

DETAILED VISUAL CONDITION SURVEY

Road Name: Cape Coast - Twifo Praso Road | **Route No:**

Road Section: 33+500 | **To:** 33+850 | **Location:** Central Region (Ghana)

Date: 26/03/2019 | **Inspector:** Leah Musenero, Edmond Balika, Joseph Mawusi, Emmanuel Aboagye

CHAINAGE				TEST POINT	TOTAL	X-section	Road Width*	Surface type	Cracking					Potholes		Patching		Rutting - depth exactly at chainage point		Deformation		Slips			Patching Quantities		Crown Height		Camber		Drainage		Remarks
Km	Block				km	0,1,2,3	(m)	S/U	Type	Width	Intensity	Extent	Posn	Area	Extent	Area	Extent	Depth left	Depth right	Type	Depth	Ext	Posn	Sever	Shallow	Inlay	LHS	RHS	LHS	RHS	0,1,2,3,4,5	Position	
	Start	to	End						Ln, Tr,Cr	1,2,3,4	0,1,2,3, 4,5	0,1,2,3, 4,5	L,C,R, A	(m2)	0,1,2,3 ,4,5	(m2)	0,1,2,3, 4,5	(mm)	(mm)	S or G	(mm)	0,1,2,3, 4,5	L,C,R,A	0,1,2,3	(m2)	(m2)	(mm)	(mm)	(%)	(%)			
33.000	0.500	to	0.500		33.500	1	7.45	S																								Ravelling all through
	0.500	to	0.525		33.525	1	7.30	S	-	0	0	0	-	0	0	0.00	0	11	0	0	0											
	0.525	to	0.550		33.550	1	7.50	S	Cr	3	4	4	L (OWT)	0	0	0.05	1	33	0	0	0									3	LHS	Mitre drain grassed with evidence of water stagnation
	0.550	to	0.575		33.575	1	7.70	S	Cr	3	4	4	A	0	0	0.00	0	23	0	0	0											Cracking is more on the LHS
	0.575	to	0.600		33.600	1	7.60	S	Cr	2	2	3	C	0	0	0.00	0	28	9	S	8									4	RHS	Mitre drain
	0.600	to	0.625		33.625	1	7.50	S	-	0	0	0	-	0	0	0.00	0	0	0	0	0											
	0.625	to	0.650		33.650	2	7.20	S	Cr	2	1	3	L	0	0	0.00	0	7	0	0	0											
	0.650	to	0.675		33.675	2	7.30	S	Cr	3	1	1	L	0.52	1	0.00	0	0	0	0	0									1	33.662	Cross culvert
	0.675	to	0.700		33.700	2	7.55	S	Cr	4	4	4	L, R	0	0	0.00	0	0	9	0	0											Cracking is more on the LHS
	0.700	to	0.725		33.725	2	7.10	S	Cr	2	2	1	L, R	0	0	0.00	0	9	0	0	0											
	0.725	to	0.750		33.750	2	7.22	S	Cr	2	2	1	L	0	0	0.00	0	18	0	0	0											Edge break on the RHS
	0.750	to	0.775		33.775	2	7.44	S	Cr, Ln	4	4	3	L	0	0	0.00	0	7	0	0	0											Longitudinal crack from mechanical damage
	0.775	to	0.800		33.800	2	7.30	S	Cr	3	3	3	L, R	0	0	0.00	0	0	0	0	0											
	0.800	to	0.825		33.825	2	7.50	S	Cr	2	2	3	L, R	0	0	0.00	0	24	7	0	0											Intense cracking on the LHS
	0.825	to	0.850		33.850	2	6.80	S	Cr	4	4	4	L	0	0	0.00	0	33	0	0	0											Edge break

DETAILED VISUAL CONDITION SURVEY

Road Name: Cape Coast - Twifo Praso Road | **Route No:**

Road Section: 36+300 | **To:** 36+475 | **Location:** Central Region (Ghana)

Date: 26/03/2019 | **Inspector:** Leah Musenero, Edmond Balika, Joseph Mawusi, Emmanuel Aboagye

CHAINAGE				TEST POINT	TOTAL	X-section	Road Width*	Surface type	Cracking					Potholes		Patching		Rutting - depth exactly at chainage point		Deformation		Slips			Patching Quantities		Crown Height		Camber		Drainage		Remarks
Km	Block				km	0,1,2,3	(m)	S/U	Type	Width	Intensity	Extent	Posn	Area	Extent	Area	Extent	Depth left	Depth right	Type	Depth	Ext	Posn	Sever	Shallow	Inlay	LHS	RHS	LHS	RHS	0,1,2,3,4,5	Position	
	Start	to	End						Ln, Tr,Cr	1,2,3,4	0,1,2,3, 4,5	0,1,2,3, 4,5	L,C,R, A	(m2)	0,1,2,3 ,4,5	(m2)	0,1,2,3, 4,5	(mm)	(mm)	S or G	(mm)	0,1,2,3, 4,5	L,C,R,A	0,1,2,3	(m2)	(m2)	(mm)	(mm)	(%)	(%)			
36.000	0.300	to	0.300		36.300	1	8.95	S										18	0	S	10											0.72 m sealed shoulders on the LHS
	0.300	to	0.325		36.325	2	8.20	S	Cr	3	2	2	A	0	0	0.0	0	10	0	0	0									2	36.325 RHS	Culvert
	0.325	to	0.350		36.350	2	8.00	S	Cr	3	4	4	C, L	0	0	0.0	0	15	0	0	0											
	0.350	to	0.375		36.375	2	7.90	S	Cr	3	3	3	A	0	0	0.0	0	20	0	0	0											Bleeding
	0.375	to	0.400		36.400	2	7.50	S	Cr	3	3	3	A	0	0	0.0	0	18	0	0	0											Adjoining land is marshy
	0.400	to	0.425		36.425	2	7.80	S	Cr	3	3	4	A	0	0	0.0	0	13	0	S	7											
	0.425	to	0.450		36.450	2	8.00	S	Cr	3	3	3	A	0	0	0.0	0	11	0	0	0											Cracking is more on the LHS
	0.450	to	0.475		36.475	2	8.13	S	Cr	3	3	3	A	0	0	0.0	0	11	0	0	0											

DETAILED VISUAL CONDITION SURVEY

Road Name: Koforidua - Adukrom Road — **Route No:**

Road Section: 14+100 **To:** 14+200 — **Location:** Eastern Region (Ghana)

Date: 02/04/2019 — **Inspector:** Leah Musenero, Edmond Balika, Joseph Mawusi, Emmanuel Aboagye

CHAINAGE				TEST POINT	TOTAL	X-section	Road Width*	Surface type	Cracking					Potholes		Patching		Rutting - depth exactly at chainage point		Deformation		Slips			Patching Quantities		Crown Height		Camber		Drainage		Remarks
Km	Block				km	0,1,2,3	(m)	S/U	Type	Width	Intensity	Extent	Posn	Area	Extent	Area	Extent	Depth left	Depth right	Type	Depth	Ext	Posn	Sever	Shallow	Inlay	LHS	RHS	LHS	RHS	0,1,2,3,4,5	Position	
	Start	to	End						Ln, Tr,Cr	1,2,3,4	0,1,2,3, 4,5	0,1,2,3, 4,5	L,C,R, A	(m2)	0,1,2,3 ,4,5	(m2)	0,1,2,3, 4,5	(mm)	(mm)	S or G	(mm)	0,1,2,3, 4,5	L,C,R,A	0,1,2,3	(m2)	(m2)	(mm)	(mm)	(%)	(%)			
14.000	0.100	to	0.100		14.100	3	5.61	S	Cr									0	10													
	0.100	to	0.125		14.125	3	6.60	S	Cr	4	5	5	A	0.2496	2	4.19	2	19	10	S	70											Scouring on RHS of road
	0.125	to	0.150		14.150	3	6.46	S	Cr	4	5	5	A	3.6552	5	0.00	0	9	45													
	0.150	to	0.175		14.175	3	4.14	S	Cr	4	5	5	A	9.6122	5	0.00	0	not measured														
	0.175	to	0.200		14.200	3	5.10	S	Cr	4	5	5	A	1.6867	4	0.00	0	2	11													

DETAILED VISUAL CONDITION SURVEY

Road Name: Koforidua - Adukrom Road — **Route No:**

Road Section: 17+300 **To:** 17+550 — **Location:** Eastern Region (Ghana)

Date: 02/04/2019 — **Inspector:** Leah Musenero, Edmond Balika, Joseph Mawusi, Emmanuel Aboagye

CHAINAGE				TEST POINT	TOTAL	X-section	Road Width*	Surface type	Cracking					Potholes		Patching		Rutting - depth exactly at chainage point		Deformation		Slips			Patching Quantities		Crown Height		Camber		Drainage		Remarks
Km	Block				km	0,1,2,3	(m)	S/U	Type	Width	Intensity	Extent	Posn	Area	Extent	Area	Extent	Depth left	Depth right	Type	Depth	Ext	Posn	Sever	Shallow	Inlay	LHS	RHS	LHS	RHS	0,1,2,3,4,5	Position	
	Start	to	End						Ln, Tr,Cr	1,2,3,4	0,1,2,3, 4,5	0,1,2,3, 4,5	L,C,R, A	(m2)	0,1,2,3 ,4,5	(m2)	0,1,2,3, 4,5	(mm)	(mm)	S or G	(mm)	0,1,2,3, 4,5	L,C,R,A	0,1,2,3	(m2)	(m2)	(mm)	(mm)	(%)	(%)			
17.000	0.300	to	0.300		17.300	2	6.50	S	Cr									20	10													
	0.300	to	0.325		17.325	2	6.56	S	Cr, Tr	4	3	2	L, R (OWT)	0	0	0.00	0	12	0	S	19											
	0.325	to	0.350		17.350	2	6.30	S	Cr, Tr	4	3	3	L, R (OWT)	0	0	0.00	0	10	0													Edge break
	0.350	to	0.375		17.375	2	6.60	S	Ln, Tr,Cr	2	2	2	L, R (OWT)	0	0	0.00	0	0	0													
	0.375	to	0.400		17.400	2	6.20	S	Tr, Ln	4	3	2	L, R (OWT)	0	0	0.00	0	0	8													Edge break close to km 17+375 on the LHS (road width reduced to 5.2 m) causing the centreline to be used as a shared wheel track. The depression in the shared wheel track is about 7 mm
	0.400	to	0.425		17.425	2	6.62	S	Tr	4	3	2	L, R (OWT)	0	0	22.86	0	0	7													
	0.425	to	0.450		17.450	2	6.63	S	Tr, Ln	3	3	3	L, R (OWT)	0	0	3.73	0	0	7													
	0.450	to	0.475		17.475	2	6.57	S	Cr, Tr	3	3	3	L, R (OWT)	0	0	0.00	0	0	7													Rutting on the RHS is 13 mm in the middle section
	0.475	to	0.500		17.500	2	6.47	S	Ln, Tr	1	1	1	L, R (OWT)	0	0	0.00	0	22	9													
	0.500	to	0.525		17.525	2	6.40	S	Ln, Tr	1	2	2	L, R	0	0	0.00	0	0	5													
	0.525	to	0.550		17.550	2	6.56	S	Ln, Tr,Cr	3	3	3	L, R (OWT)	0	0	0.00	0	7	0													Diagonal crack on the LHS

Mozambique

DETAILED CONDITION SURVEY

Road Name: Boane-Namaacha **Route No:**

Road Section: km 1+800 **To:** km 2+100 **Location:**

Date: 22/03/2019 **Inspector:** TRL

CHAINAGE				TEST POINT	TOTAL	X-section	Road Width*	Surface type	Cracking					Potholes		Patching		Rutting - depth exactly at chainage point				Deformation			Slips		Patching Quantities		Crown Height		Camber		Drainage		Remarks
Km		Block			km	0,1,2,3	(m)	S/U	Type	Width	Intensity	Extent	Posn	Area	Extent	Area	Extent	OWT (LHS)	IWT (LHS)	IWT (RHS)	OWT (RHS)	Type	Depth	Ext	Posn	Sever	Shallow	Inlay	LHS	RHS	LHS	RHS	0,1,2,3,4,5	Position	
									Ln, Tr,Cr	1,2,3,4	0,1,2,3,4,5	0,1,2,3,4,5	L,C,R,A	(m2)	0,1,2,3,4,5	(m2)	0,1,2,3,4,5	(mm)	(mm)	(mm)	(mm)	S or G	(mm)	0,1,2,3,4,5	L,C,R,A	0,1,2,3	(m2)	(m2)	(mm)	(mm)	(%)	(%)			
1.000	+	to	0.800	1.800																														Sealed shoulders, SD
	0.800	to	0.850	1.850	1	6.8(10)	SD	L	4	4	4	All	0	-	131.0	4							0	-	0	-	-					1	All	Section fair but bushy
	0.850	to	0.900	1.900	1	6.8(10)	SD	L, C	4	2	2	L, R	0	-	44.6	2							0	-	0	-	-					1	All	Section in good condn
	0.900	to	0.950	1.950	1	6.8(10)	SD	L, C	3	3	2	All	0.4	1	4.0	1							0	-	0	-	-					1	All	Section in good condn
	0.950	to	1.000	2.000	1	6.8(10)	SD	L, C	3	3	2	All	1.2	1	3.8	1							0	-	0	-	-					1	All	Section in good condn
	1.000	to	1.050	2.050	1	6.8(10)	SD	L, T	3	3	2	L, R	1.84	2	2.4	1							0	-	0							1	All	Fair section
	1.050	to	1.100	2.100	1	6.8(10)	SD	L, C	3	3	3	All	0.5	1	9.4	2							0	-	0							2	All	Fair section

DETAILED CONDITION SURVEY

Road Name: Boane-Namaacha **Route No:**

Road Section: km 2+650 **To:** km 2+950 **Location:**

Date: 26/03/2019 **Inspector:** TRL

CHAINAGE				TEST POINT	TOTAL	X-section	Road Width*	Surface type	Cracking					Potholes		Patching		Rutting - depth exactly at chainage point				Deformation			Slips		Patching Quantities		Crown Height		Camber		Drainage		Remarks
Km		Block			km	0,1,2,3	(m)	S/U	Type	Width	Intensity	Extent	Posn	Area	Extent	Area	Extent	OWT (LHS)	IWT (LHS)	IWT (RHS)	OWT (RHS)	Type	Depth	Ext	Posn	Sever	Shallow	Inlay	LHS	RHS	LHS	RHS	0,1,2,3,4,5	Position	
									Ln, Tr,Cr	1,2,3,4	0,1,2,3,4,5	0,1,2,3,4,5	L,C,R,A	(m2)	0,1,2,3,4,5	(m2)	0,1,2,3,4,5	(mm)	(mm)	(mm)	(mm)	S or G	(mm)	0,1,2,3,4,5	L,C,R,A	0,1,2,3	(m2)	(m2)	(mm)	(mm)	(%)	(%)			
2.000	+	to	0.650	2.650																														Sealed shoulders, SD
	0.650	to	0.700	2.700	1	6.8(10)	SD	L, C	3	3	3	L, C	0.1	0	4.9	3							0	-	0	-	-					2	All	Fill area, darins bushy
	0.700	to	0.750	2.750	1	6.8(10)	SD	L	3	3	3	L, C	0.035	1	0.6	1							0	-	0	-	-					2	All	Fair section condn
	0.750	to	0.800	2.800	1	6.8(10)	SD	L, C	3	2	2	L, C	0.12	2	29.2	3							0	-	0	-	-					2	All	Fair secion condn
	0.800	to	0.850	2.850	1	6.8(10)	SD	L, C	3	2	3	L, C	0	-	0.0	-							0	-	0	-	-					2	All	Section condn good
	0.850	to	0.900	2.900	1	6.8(10)	SD	L, T	2	1	1	C	0	-	0.0	-							0	-	0							2	All	Section condn good
	0.900	to	0.950	2.950	1	6.8(10)	SD	-	-	-	-	-	-	-	-	-							0	-	0							2	All	Section condn very good

DETAILED CONDITION SURVEY

Road Name: Boane-Namaacha **Route No:**

Road Section: km 10+900 **To:** km 11+200 **Location:**

Date: 26/03/2019 **Inspector:** TRL

CHAINAGE				TEST POINT	TOTAL	X-section	Road Width*	Surface type	Cracking					Potholes		Patching		Rutting - depth exactly at chainage point				Deformation			Slips		Patching Quantities		Crown Height		Camber		Drainage		Remarks
Km		Block			km	0,1,2,3	(m)	S/U	Type	Width	Intensity	Extent	Posn	Area	Extent	Area	Extent	OWT (LHS)	IWT (LHS)	IWT (RHS)	OWT (RHS)	Type	Depth	Ext	Posn	Sever	Shallow	Inlay	LHS	RHS	LHS	RHS	0,1,2,3,4,5	Position	
									Ln, Tr,Cr	1,2,3,4	0,1,2,3,4,5	0,1,2,3,4,5	L,C,R,A	(m2)	0,1,2,3,4,5	(m2)	0,1,2,3,4,5	(mm)	(mm)	(mm)	(mm)	S or G	(mm)	0,1,2,3,4,5	L,C,R,A	0,1,2,3	(m2)	(m2)	(mm)	(mm)	(%)	(%)			
10.000	+	to	0.900		10.900																													Sealed shoulders, SD
	0.900	to	0.950		10.950	1	6.8(10)	SD	L	3	2	3	L, R	-	0	-	0							0	-	0	-	-					1	All	Section in good condn
	0.950	to	1.000		11.000	1	6.8(10)	SD	L	3	2	2	All	-	0	-	0							0	-	0	-	-					1	All	Section in good condn
	1.000	to	1.050		11.050	1	6.8(10)	SD	L	4	2	2	L	-	0	1.0	1							0	-	0	-	-					1	All	Section in good condn
	1.050	to	1.100		11.100	1	6.8(10)	SD	L	3	2	2	L	-	0	2.5	1							0	-	0	-	-					1	All	Cracks mai defect
	1.100	to	1.150		11.150	1	6.8(10)	SD	L	-	-	-	-	-	0	-	0							0	-	0							1	All	Section in good condn
	1.150	to	1.200		11.200	1	6.8(10)	SD	L	2	2	2	R	-	0	-	0							0	-	0							1	All	All sections good

DETAILED CONDITION SURVEY

Road Name: Boane-Moamba **Route No:**

Road Section: km 22+100 **To:** km 22+400 **Location:**

Date: 21/03/2019 **Inspector:** TRL

CHAINAGE				TEST POINT	TOTAL	X-section	Road Width*	Surface type	Cracking					Potholes		Patching		Rutting - depth exactly at chainage point				Deformation			Slips		Patching Quantities		Crown Height		Camber		Drainage		Remarks
Km		Block			km	0,1,2,3	(m)	S/U	Type	Width	Intensity	Extent	Posn	Area	Extent	Area	Extent	OWT (LHS)	IWT (LHS)	IWT (RHS)	OWT (RHS)	Type	Depth	Ext	Posn	Sever	Shallow	Inlay	LHS	RHS	LHS	RHS	0,1,2,3,4,5	Position	
									Ln, Tr,Cr	1,2,3,4	0,1,2,3,4,5	0,1,2,3,4,5	L,C,R,A	(m2)	0,1,2,3,4,5	(m2)	0,1,2,3,4,5	(mm)	(mm)	(mm)	(mm)	S or G	(mm)	0,1,2,3,4,5	L,C,R,A	0,1,2,3	(m2)	(m2)	(mm)	(mm)	(%)	(%)			
22.000	+	to	0.100		22.100													11	7	4	9													Unsealed shoulders,
	0.100	to	0.150		22.150	1	5.4(9.4)	SD	T, L	3	2	4	L, R	55.25	3	-	0	3	4	6	9			0	-	0	-	-					3	All	Fair section
	0.150	to	0.200		22.200	1	5(8.0)	SD	All	3	2	2	L, R	24.5	3	-	0	2	5	2	8			0	-	0	-	-					1	All	Fill section, fair condn.
	0.200	to	0.250		22.250	1	4.3(6.7)	SD	All	3	2	3	L, R	62	3	-	0	-	-	4	8			0	-	0	-	-					1	All	Fill section, fair condn.
	0.250	to	0.300		22.300	1	5(8.4)	SD	L, C	2	2	2	R	46	3	-	0	7	9	-	6			0	-	0	-	-					1	All	Fill section, fair condn.
	0.300	to	0.350		22.350	1	4(8.7)	SD	L, C	3	2	2	R	42.4	3	-	0	9	7	7	11			0	-	0							1	All	Fill section, fair condn.
	0.350	to	0.400		22.400	1	5.4(8)	SD	L, C	2	2	2	C, R	59.5	3	-	0	7	7	9	6			0	-	0							2	All	Fill section, fair condn.
																																		Whole section has edge b

DETAILED CONDITION SURVEY

Road Name: Boane-Moamba **Route No:**

Road Section: km 29+700 **To:** km 30+000 **Location:**

Date: 21/03/2019 **Inspector:** TRL

CHAINAGE					TEST POINT	TOTAL	X-section	Road Width*	Surface type	Cracking					Potholes		Patching		Rutting - depth exactly at chainage point				Deformation			Slips		Patching Quantities		Crown Height		Camber		Drainage		Remarks
Km		Block				km	0,1,2,3	(m)	S/U	Type	Width	Intensity	Extent	Posn	Area	Extent	Area	Extent	OWT (LHS)	IWT (LHS)	IWT (RHS)	OWT (RHS)	Type	Depth	Ext	Posn	Sever	Shallow	Inlay	LHS	RHS	LHS	RHS	0,1,2,3,4,5	Position	
										Ln, Tr,Cr	1,2,3,4	0,1,2,3,4,5	0,1,2,3,4,5	L,C,R,A	(m2)	0,1,2,3,4,5	(m2)	0,1,2,3,4,5	(mm)	(mm)	(mm)	(mm)	S or G	(mm)	0,1,2,3,4,5	L,C,R,A	0,1,2,3	(m2)	(m2)	(mm)	(mm)	(%)	(%)			
29.000	+	to	0.700	29.700															4	8	8	4													Unsealed shoulders,
	0.700	to	0.750	29.750	2	6(8)	SD	C	4	5	5	All	0.7	1	-	0	12	7	3	4			0	-	0	-	-					1	All	Water ponding on shoulde
	0.750	to	0.800	29.800	2	6.1(8)	SD	All	4	4	4	All	4.2	3	-	0	5	11	2	7			0	-	0	-	-					1	All	Fill section, no Maintenanc
	0.800	to	0.850	29.850	2	6(9)	SD	T, L	4	3	3	All	20	3	-	0	10	3	17	9			0	-	0	-	-					1	All	Fill section.
	0.850	to	0.900	29.900	2	6(9.8)	SD	All	4	3	3	All	39.75	4	-	0	6	-	-	-			0	-	0	-	-					1	All	Poor section. Water pondi
	0.900	to	0.950	29.950	2	6(9.7)	SD	C, T	4	2	3	All	1.7	1	-	0	4	4	4	6			0	-	0							1	All	Fir section with edgebreak
	0.950	to	1.000	30.000	2	6(10)	SD	All	4	2	3	All	26	4	-	0	7	4	12	7			0	-	0							1	All	Fair section

DETAILED CONDITION SURVEY

Road Name: Macia-Chokwe **Route No:**

Road Section: km 19+100 **To:** km 19+400 **Location:**

Date: 06/04/2019 **Inspector:** TRL

CHAINAGE					TEST POINT	TOTAL	X-section	Road Width*	Surface type	Cracking					Potholes		Patching		Rutting - depth exactly at chainage point				Deformation			Slips		Patching Quantities		Crown Height		Camber		Drainage		Remarks
Km		Block				km	0,1,2,3	(m)	S/U	Type	Width	Intensity	Extent	Posn	Area	Extent	Area	Extent	OWT (LHS)	IWT (LHS)	IWT (RHS)	OWT (RHS)	Type	Depth	Ext	Posn	Sever	Shallow	Inlay	LHS	RHS	LHS	RHS	0,1,2,3,4,5	Position	
										Ln, Tr,Cr	1,2,3,4	0,1,2,3,4,5	0,1,2,3,4,5	L,C,R,A	(m2)	0,1,2,3,4,5	(m2)	0,1,2,3,4,5	(mm)	(mm)	(mm)	(mm)	S or G	(mm)	0,1,2,3,4,5	L,C,R,A	0,1,2,3	(m2)	(m2)	(mm)	(mm)	(%)	(%)			
19.000	+	to	0.100	19.100		5.6	SD												7	7	7	2													
	0.100	to	0.150	19.150	0	5.8	SD	L,C,T	3	2	2	C, R	0.4	1	7.8	3	10	6	4	13	-	-	0	-	0							1	Both sides	Area has no drains, in goo
	0.150	to	0.200	19.200	1	6.0	SD	T	2	1	2	R	-	0	2.2	1	5	2	7	4	-	-	0	-	0							1	Both sides	Stripping in some sections
	0.200	to	0.250	19.250	1	6.0	SD	T,L	3	3	2	L, R	-	0	-	0	8	4	6	4	-	-	0	-	0							1	Both sides	Small edge breaks in sme
	0.250	to	0.300	19.300	1	5.8	SD	L, C	3	2	2	A	-	0	0.9	1	12	6	4	7	-	-	0	-	0							1	Both sides	Flat section
	0.300	to	0.350	19.350	1	5.9	SD	T,L	3	3	2	A	-	0	2.7	1	7	4	0	4	-	-	0	-	0							1	Both sides	Whole section generally in
	0.350	to	0.400	19.400	1	6.0	SD	T,L	3	2	2	L, R	-	0	-	0	20	0	10	6	-	-	0	-	0							1	Both sides	

DETAILED CONDITION SURVEY

Road Name:	Macia-Chokwe			**Route No:**	
Road Section:	km 32+300	**To:**	km 32+600	**Location:**	
Date:	06/04/2019			**Inspector:**	TRL

CHAINAGE					TEST POINT	TOTAL	X-section	Road Width*	Surface type	Cracking					Potholes		Patching		Rutting - depth exactly at chainage point				Deformation			Slips		Patching Quantities		Crown Height		Camber		Drainage		Remarks
Km		Block				km	0,1,2,3	(m)	S/U	Type	Width	Intensity	Extent	Posn	Area	Extent	Area	Extent	OWT (LHS)	IWT (LHS)	IWT (RHS)	OWT (RHS)	Type	Depth	Ext	Posn	Sever	Shallow	Inlay	LHS	RHS	LHS	RHS	0,1,2,3,4,5	Position	
										Ln, Tr,Cr	1,2,3,4	0,1,2,3,4,5	0,1,2,3,4,5	L,C,R,A	(m2)	0,1,2,3,4,5	(m2)	0,1,2,3,4,5	(mm)	(mm)	(mm)	(mm)	S or G	(mm)	0,1,2,3,4,5	L,C,R,A	0,1,2,3	(m2)	(m2)	(mm)	(mm)	(%)	(%)			
32.000	+	to	0.300	32.300		5.8													4	2	3	0														
	0.300	to	0.350	32.350	1	6	SD	L. C	3	3	3	A	0.5	1	30.87	3	3	8	4	7	-	-	0	-	0							1	Both sides	Fill section. Embankment t
	0.350	to	0.400	32.400	2	6.2	SD	C	3	2	2	R	0.9	1	77.18	4	15	3	3	3	-	-	0	-	0							1	Both sides	
	0.400	to	0.450	32.450	2	5.9	SD	C	3	2	2	R	0	-	61.74	4	0	2	6	3	-	-	0	-	0							1	Both sides	Many edge breaks and patches. Contractor yet to seal trimmed patches. Refer to photos from Kenneth for appreciation
	0.450	to	0.500	32.500	3	5.5	SD	-	-	0	0	-	1.2	1	58.65	4	9	9	4	3	-	-	0	-	0							1	Both sides	
	0.500	to	0.550	32.550	3	6.8	SD	-	-	0	0	-	1.5	-	80.26	4	5	5	4	Pothole	-	-	0	-	0							1	Both sides	
	0.550	to	0.600	32.600	3	6.2	SD	-	-	0	0	-	1.3	-	83.35	4	0	3	4	2	-	-	0	-	0							1	Both sides	

Uganda

DETAILED VISUAL CONDITION SURVEY

Road Name:	**Matuga-Semuto-Kapeeka Rd**			**Route No:**	LHS - Semuto Bound (NW), RHS - Matugga Bound (SE)
Road Section:	Section 6: Inverted DBST	**To:**	Matugga Bound-Semuto	**Location:**	Luweero Region
Date:	19/03/2019			**Inspector:**	Dominic Leal

Weather: Sunny/Dry

CHAINAGE				TEST POINT	TOTAL	X-section	Road Width*	Surface type	Cracking					Potholes		Patching		Rutting - depth exactly at chainage point		Deformation		Slips			Patching Quantities		Crown Height		Camber		Drainage		Remarks
Km	Block				km	0,1,2,3	(m)	S/U	Type	Width	Intensity	Extent	Posn	Area	Extent	Area	Extent	Depth left	Depth right	Type	Depth	Ext	Posn	Sever	Shallow	Inlay	LHS	RHS	LHS	RHS	0,1,2,3,4,5	Position	
	Start	to	End						Ln, Tr,Cr	1,2,3,4	0,1,2,3, 4,5	0,1,2,3, 4,5	L,C,R, A	(m2)	0,1,2,3 ,4,5	(m2)	0,1,2,3, 4,5	(mm)	(mm)	S or G	(mm)	0,1,2,3, 4,5	L,C,R,A	0,1,2,3	(m2)	(m2)	(mm)	(mm)	(%)	(%)			
21	900	to	900	0.000	-	6.20	IDBST	0	0	0	0	0	0	0	0.0	0	9	7	0	0	0	0	0	0	0			1.80	0.00	4	LHS & RHS	Inverted double surfact dressing, Starting Point 0m, Pavement in sound condition, no visual defects, good drianage both sides and wide shoulders, clear path for run off water. Sealed hard shoulder in good condition.Bottom of drain 0.81m (LHS) & 0.95m (RHS) below road surface. Grass bank and natural drainage. 20mm granite aggregates used, fair degree of polishing throughout site. Site starts straight (with regular straight line camber) then bends towards the LHS for first 200m (superelevation on RHS edge) then shallow uphill for the last 150m before reaching town. Road markings 50% visible, fairly worn out (especially yellow CL)
21	900	to	950	0.050	-	6.00	IDBST	0	0	0	0	0	0	0	0.0	0	0	7	0	0	0	0	0	0	0			1.50	2.00	4	LHS & RHS	First 50m in sound condition, no defects, good drainage. Surface slightly polsihed. No pathces, potholes. Shoulder in good condition both sides. Super elevation on RHS so camber falls from RHS to LHS. Surrounding area grassy but dry ground. No surface aggregates found loose on shoulder.
22	950	to	1000	0.100	-	6.20	IDBST	0	0	0	0	0	0	0	0	0	2	9	0	0	0	0	0	0	0			2.14	4.84	4	LHS & RHS	50-100m, pavement still in very good condition, no visible defects or cracking. Minor fatting across site (mostly in LHS nearside wheelpath). LHS has good drainage, although grass/dirt build up at edge is forming a barrier a few cm higher than the road surface. No surface aggregates found loose on shoulder.
22	0	to	50	0.150	-	6.00	IDBST	0	0	0	0	0	0	0	0.05	1	6	0	0	0	0	0	0	0.05	0			1.67	1.67	3	LHS	100-150m in very good condition, no visible surface defects. 2 minor patches look like reinstated 150mm core holes, patches in good condition (at LHS offside wheelpath 22km+003m; at LHS nearside wheelpath 22km+038m). Fatting in LHS nearside still continues. RHS verge mostly level ground now, with a driveway @ 22km+ 008m. LHS drainage still good, bottom of grass drain 1.16m below road surface. Camber falls towards LHS still. No surface aggregates found loose on shoulder.
22	50	to	100	0.200	-	6.20	IDBST	0	0	0	0	0	0	0	0.0	0	5	4	0	0	0	0	0	0	0			1.90	2.74	3	LHS	150-200m in very good condition, no visible surface defects. Minor fatting continues from previous section and ends at 22km+075m. Fatting in Both wheelpaths on LHS only. Good drainage both sides, 1m deep grass drains. Camber falls towards LHS still. No surface aggregates found loose on shoulder.
22	100	to	150	0.250	-	6.60	IDBST	0	0	0	0	0	0	0	0.03	1	0	0	0	0	0	0	0	0.025	0			1.82	1.94	4	LHS & RHS	200-250m in very good condition, no visible defects. Possible reinstated 150mm core hole @ RHS ofside wheelpath 22km+105m. LHS drainage is good, 1.16m below road sruface, RHS draniage flat verge. Camber regular, no super elevation, road creeps slightly uphill towards village. No surface aggregates found loose on shoulder.
22	150	to	200	0.300	-	6.10	IDBST	0	0	0	0	0	0	0	0.0	0	7	10	0	0	0	0	0	0	0			3.33	0.81	4	LHS & RHS	Both lanes in very good condition, no visible defects, good drainage on both sides, approx 0.95m deep from road surface, grassy banks on both sides, dry. Bank/fill builts deeper from flat verge on RHS as site progresses towards end. No surface aggregates found loose on shoulder. Speed bumps (shallow set of 4) acorss both lanes @ 22km+133m to 22km+135m. Shoulder still sealed on both sides.
22	200	to	250	0.350	-	6.40	IDBST	Ln, Tr	2	3	1	A	0.5	1	0.5	1	5	3	S	40	0	0	0	0.5	0			1.21	0.28	4	LHS & RHS	Section in very good condition apart from last 10m (both sides). Large speed bump at 22km+240m across both lanes, afterwehich there is a drepression on the LHS nearside filled with water, and water pooling around. Immediatley after speedbump are longitudine and L cracks in both wheelpaths. Less severe depression on the RHS nearside but developing (traffic is moving around the speed bump driving on the shoulder). Speed bump in good condition, apart from deterioration and wide blocks forming at CL/offside wheelpath on RHS portion and a pothole forming on the nearside LHS at end of speedbump. At end of senction LHS offside wheelpath there is a 0.8mx0.6m AC patch in good condition but with fine 1mm transverse cracks formings from the patches edge travelling towards the nearside. Patch on joint with section 7 concrete block paving. Wide cracks 2-3mm around joint with section 7 and depressions with wide cracks.

DETAILED VISUAL CONDITION SURVEY

Road Name:	**Matuga-Semuto-Kapeeka Rd**			**Route No:**	LHS - Semuto Bound (NW), RHS - Matugga Bound (SE)
Road Section:	Section 8a: Single Surface Dressing + Crushed Dust Sand Seal	**To:**	Matugga Bound-Semuto	**Location:**	Luweero Region
Date:	19/03/2019			**Inspector:**	Dominic Leal

Weather: Sunny/Dry

CHAINAGE				TEST POINT	TOTAL	X-section	Road Width*	Surface type	Cracking					Potholes		Patching		Rutting - depth exactly at chainage point		Deformation		Slips			Patching Quantities		Crown Height		Camber		Drainage		Remarks
Km	Block			km	0,1,2,3	(m)	S/U	Type	Width	Intensity	Extent	Posn	Area	Extent	Area	Extent	Depth left	Depth right	Type	Depth	Ext	Posn	Sever	Shallow	Inlay	LHS	RHS	LHS	RHS	0,1,2,3,4,5	Position	
	Start	to	End					Ln, Tr,Cr	1,2,3,4	0,1,2,3, 4,5	0,1,2,3, 4,5	L,C,R, A	(m2)	0,1,2,3 ,4,5	(m2)	0,1,2,3, 4,5	(mm)	(mm)	S or G	(mm)	0,1,2,3, 4,5	L,C,R,A	0,1,2,3	(m2)	(m2)	(mm)	(mm)	(%)	(%)			
22	600	to	600	0.00		6.60	SSD	0	0	0	0	0	0	0	2.8	1	5	7	0	0	0	0	0	2.8	0			1.18	1.72	4	LHS & RHS	Start of site, 0m, transition from sectyion 7 block paving to section 8 large patch running across both lanes (7mx0.4m). Slight gentle downhillDrainage good on both sides, however grass/dirt level at edge is 3-4cm higher than the road surface. RHS deeper bank (1.13m) than LHS (0.4m deep). Pothole at start of site,, 25mm deep 0.15mx0.15m. Single surface dressing (14mm) with sand seal. Speed bump @ 22km+ 607m (in good condition). Surfacing genreally polished but in very good condition. Fairly even camber both lanes
22	600	to	650	0.05		6.10	SSD	0	0	0	0	0	0.1	1	4.5	1	3	0	0	0	0	0	0	4.5	0			1.13	2.27	4	LHS & RHS	0-50m generally in very good condition, no visible surface defects, sealed shoulder in good condition, minor deterioation at the edge, edge markings visible and in good condition. 2 AC patches (possible test pits) 1) RHS @ 22km+605m offside wheelpath 1x1m = good condition; 2) LHS @ 22km+637m nearside wheelpath 1.5x1.5m = good condition. very little rutting throughout frist 50m. LHS drainage = okay but fairly shallow and blocked by vegetation; RHS drainage- good, grassy bank 1.25m below road surface. No loose surface aggregates at side of road.
22	650	to	700	0.10		6.00	SSD	Tr	2	1	1	L	0	0	0.0	0	4	2	0	0	0	0	0	0	0			0.33	0.94	3	LHS & RHS	Generally very good condition,1 2mm crack transverse, but in total no other cracks or defects. Drainage good both sides (LHS depth increasing, now 0.75m below surface level; RHS = 1m below surface). No loose surfacing material on the edge of the road.
22	700	to	750	0.15		6.10	SSD	Ln	3	1	1	L	0	0	1.1	1	3	2	S	30	0	0	0	1.1	0			1.50	0.83	3	LHS & RHS	Generally in very good condition with good drainage both sides. 2 pathces, both on the RHS from 22km+740m-750m. 1 patch in shoulder, patch 2 in nearside wheel path, minor longitudinal cracks extending from patch towards end of site. Minor depression adjacent to patch 2 in shoulder. minor rutting. surface generally very smooth.
22	750	to	800	0.20		6.10	SSD	Ln	3	1	1	L	0	0	0.0	0	5	1	G	30	1	L	1	0	0			0.65	0.65	3	LHS & RHS	Generally in very good condition with few defects throughout. Minor depression on RHS @ 22km+755m between should and nearside edge, 30mm deep with minor longitudinal cracking around - looks geotechnical as it is so close to the edge and bank. Wide 4mm crack (0.6m long) LHS nearside wheelpath @22km+782m with finer longitudinal cracks in the adjacent shoulder - looks like geotechnical failure. Otherwise good drainage and only minor/none rutting across site. No loose surface aggregates on the verge.
22	800	to	850	0.25		6.05	SSD	Cr	3	5	2	A	0.045	1	6.0	3	4	6	S	0	0	0	0	6.045	0			1.00	1.67	3	LHS & RHS	Generally in good condition, isolated defects. From 22km+815m to 825m LHS nearside large failed patch with wide transverse cracks throughout. Extending out of patch diagonally towards CL is failed patch from mechanical damage, looks like concrete/hbm patch. Wide block/crocodile cracking fored throughout this diagonal patch, with loss of surface material. From 22km+820-825m RHS nearside wheelpath wide 4mm longitudinal/crocodile cracking. Possible reinstated test pit or just a patch (1mx1m) in RHS nearside wheelpath @ 22km+824m <- good condition. Patch followed by a shallow pothole 25mm deep, 0.15mx0.15m. No loose surface material at the verge side. Reinstated core LHS @ 22km+830m nearside wheelpath 150mm core hole patched with concrete.

DETAILED VISUAL CONDITION SURVEY

Road Name:	**Matuga-Semuto-Kapeeka Rd**			**Route No:**	LHS - Semuto Bound (NW), RHS - Matugga Bound (SE)
Road Section:	Section 8b: Single Surface Dressing + Natural Sand Seal	**To:**	Matugga Bound-Semuto	**Location:**	Luweero Region
Date:	19/03/2019			**Inspector:**	Dominic Leal

Weather: Sunny/Dry

CHAINAGE				TEST POINT	TOTAL	X-section	Road Width*	Surface type	Cracking					Potholes		Patching		Rutting - depth exactly at chainage point		Deformation		Slips			Patching Quantities		Crown Height		Camber		Drainage		Remarks
Km	Block			km	0,1,2,3	(m)	S/U	Type	Width	Intensity	Extent	Posn	Area	Extent	Area	Extent	Depth left	Depth right	Type	Depth	Ext	Posn	Sever	Shallow	Inlay	LHS	RHS	LHS	RHS	0,1,2,3,4,5	Position	
	Start	to	End					Ln, Tr,Cr	1,2,3,4	0,1,2,3, 4,5	0,1,2,3, 4,5	L,C,R, A	(m2)	0,1,2,3 ,4,5	(m2)	0,1,2,3, 4,5	(mm)	(mm)	S or G	(mm)	0,1,2,3, 4,5	L,C,R,A	0,1,2,3	(m2)	(m2)	(mm)	(mm)	(%)	(%)			
22	850	to	850	0.00	-	6.05	SSD	0	0	0	0	0	0	0	0.0	0	4	6	0	0	0	0	0	0	0			1.00	1.67	4	LHS & RHS	Section in worse condition than 8a, RHS is generally in better condition than LHS however there are defects throughout in both lanes (cracking, failed patches, joint cracking, block cracking. Good drainage either side, LHS = 1.5m below road surface, RHS 1.3m below road surface, grassy banks, dry. Grassy slightly overgrown and dirt build up on shoulders
22	850	to	900	0.05	-	6.05	SSD	Ln, Tr	2	4	4	C	0	0	7.5	4	3	3	0	0	0	0	0	7.515	0			0.33	1.29	4	LHS & RHS	0-50m in good condition but many defects. 2 small patches on LHS offside wheelpath from 0-10m + reinstated core in RHS offside @4m. 6.5mx0.14m AC longitudinal patch between wheelpaths = in good condition. AT the start of thuis patch there is a 1-2mm wide transverse crack extending from the patch to the LHS verge. From 25m-50m LHS longitudinal patch (0.15m wide) in nearside wheelpath. From 20m-end of site LHS between offside wheelpath and CL is a longitudinal crack 1-2mm wide which extends for the rest of the site, it has short 1m transverse cracks branching from it both towards the CL and LHS verge. Generally good drainage, deeper banks 1.7m deep LHS, 1.25m deep RHS. On RHS from 40-50m nearside wheelpath is an narrow AC patch in good condition (this continues for the rest of the site).
22	900	to	950	0.10	-	6.04	SSD	Ln, Tr, Cr, Block	4	4	4	L, C	0	0	19.4	5	5	6	0	0	0	0	0	19.4	0			3.00	3.67	4	LHS & RHS	LHS fine longitudinal and transverse cracking in both wheelpaths (and between WPs) from 22km+900-920m, getting progressivley more severe 2-3mm wide. At 22km+920m-950m block cracking occurs in LHS offside wheelpath and gets more severe as it progresses toward the end of the site, large 3mm wide blocks 20x30cm. Parallel to the block cracking is the narrow longitudinal AC patch which runs for whole of section. From 22km+940-950 LHS narrow AC patch is also inbetween wheelpaths. At 22km+937-941 is a failed AC patch in the CL, with wide block cracking forming. RHS is in better condition, only 50m AC narrow longitudinal patch runs in nearside wheelpath. Generally good drainage on both sides. RHS is superelevation as road starts to bend towards the left. Road generally 1.5m above lowest point of verge slope.

DETAILED VISUAL CONDITION SURVEY

Road Name:	**Matuga-Semuto-Kapeeka Rd**			**Route No:**	LHS - Semuto Bound (NW), RHS - Matugga Bound (SE)
Road Section:	Section 9a: Double Sand Seal + Crushed Dust	**To:**	Matugga Bound-Semuto	**Location:**	Luweero Region
Date:	20/03/2019			**Inspector:**	Dominic Leal

Weather: Sunny/Dry

CHAINAGE				TEST POINT	TOTAL	X-section	Road Width*	Surface type	Cracking					Potholes		Patching		Rutting - depth exactly at chainage point		Deformation		Slips			Patching Quantities		Crown Height		Camber		Drainage		Remarks
Km	Block				km	0,1,2,3	(m)	S/U	Type	Width	Intensity	Extent	Posn	Area	Extent	Area	Extent	Depth left	Depth right	Type	Depth	Ext	Posn	Sever	Shallow	Inlay	LHS	RHS	LHS	RHS	0,1,2,3,4,5	Position	
	Start	to	End						Ln, Tr,Cr	1,2,3,4	0,1,2,3, 4,5	0,1,2,3, 4,5	L,C,R, A	(m2)	0,1,2,3 ,4,5	(m2)	0,1,2,3, 4,5	(mm)	(mm)	S or G	(mm)	0,1,2,3, 4,5	L,C,R,A	0,1,2,3	(m2)	(m2)	(mm)	(mm)	(%)	(%)			
22	950	to	950	0.00		6.04	DSS	0	0	0	0	0	0	0	0.0	0	5	6	0	0	0	0	0	0	0			3.00	3.67	4	LHS & RHS	
22	950	to	1000	0.05		6.17	DSS	Ln, Tr, Cr	2	3	5	A	0	0	1.9	3	5	3	0	0	0	0	0	1.85	0			1.99	0.72	4	LHS & RHS	Many defects, from 22km+950-970m 1-2mm longitudinal/transverse cracking spread across both lanes (not interconnected). From 22km+960-980m LHS narrow longitudinal AC patches in nswp & bwps, alongside narrow transverse AC patches from 22km+965,972,978m in shoulder with longitudinal crack running between them. No potholes throughout section. From 22km+980-1000m (23km+000m) wide 2-3mm cracks running longitudinally in the LHS shoulder, parallel to wide longitudinal/transverse cracks in LHS nswp. From 22km=970-1000m RHS generally better but still minor areas of isolated transverse and longitudinal cracking. Drainage generally very good, steep grassy banks with clear route for run-off. LHS verge base is 1.6m below roadsurface. RRHS = 1.26m below road surface. No loose surfacing material accumulated at the roadside. Surrounding ground dry and sandy. Reinstated core @ LHS oswp 22km+980m.
23	0	to	50	0.10		6.25	DSS	Ln, Tr, Cr	2	4	5	A	0	0	2.2	2	4	6	0	0	0	0	0	2.2	0			0.53	2.13	4	LHS & RHS	Many defects, from 23km+000-050m LHS has extensive 1-3mm cracking (longitudinal, transverse, crocodile) in the shoulder and nswp, and longitudinal crack running the length of the oswp. From 23km+000-040m RHS is free from defects largely, isolated very fine 1mm cracks in places but generally in good condition. 23km+040-050m RHS minor longitudinal cracking in both wheelpaths.. LHS has three patches 1) @ 23km+012m (0.4x0.3m), 2) 23km+040-050m shoulder (0.15x10m), 3)23km+047-060m nswp (0.15x13m). Patches in good condition but surrounded by cracking, some cracks extenting from patches. Good drainage bothsides, steep banks, LHS = 0.84m below road surface, RHS = 1.39m below road surface. RHS on superelevation as road bends towards the left. Grassy verges with sandy soil, dry.
23	50	to	100	0.15		6.28	DSS	Ln, Tr, Cr, Block	2	2	4	L,C	0	0	1.0	2	3	2	0	0	0	0	0	1	0			1.14	2.73	4	LHS & RHS	LHS severe longitudinal/travsverse/block cracking in both wheelpaths (mostly concentrated in the nswp) extensive but not crack only 1-2mm wide, minor long/tran cracking on shoulder.AC patch continued from previous panel on LHS nswp ends at 23km+060m. 23km+080-110m small AC patches in CL 1-2m long each, some have minor 1-2mm transverse cracks extending from them. 150mm reinstated core hole at 23km+098m. RHS cracking is much less intensive, minor isolated longitudinal cracks 1mm. Fatting in offside wheelpath in both lanes. Minor transverse cracking in RHS shoulder. Good drainage both sides.
23	100	to	150	2.00		6.16	DSS	Ln, Tr, Cr, Block	3	4	5	L,C	0.025	1	5.0	3	3	1	0	0	0	0	0	5	0			1.17	1.82	4	LHS & RHS	LHS intensive cracking- all types, 2-3mm wide. Block cracking LHS nswp from 23km+105m-end of section 9a. LHS oswp more unconnected longitudinal cracking which progresses to crocodile cracking further up the site. Fatting in both lanes oswp's. Failed AC patch with cracks in LHS nswp @23km+105m which leads into block cracking. narrow CL patch, still in good condition @ 23km+105-110m. From CL 23km+112-117m mechanical damage exposing base layer.CL narrow patch from 23km+125-150m with wide 2-3mm transverse cracks extending into both lanes . LHS minor transverse/L cracking throughout. LHS drainage good throughout. RHS generally in much better condition throughout, minor isolated fine longitudinal cracks and fatting throughout, no potholes. surface polished and very fine. RHS drainage good/deep, 1.5m+ below road surface. Reinstated 150mm core holes at 23km+120m LHS oswp, 23km+145m LHS nswp. no signs of slope failure.
23	150	to	200	2.50		6.10	DSS	Ln, Tr, Cr, Block	2	4	5	L, C	0	0	0.0	0	2	35	0	0	0	0	0	0	0			2.62	0.72	4	LHS & RHS	2-3mm wide block cracking throughout LHS both wheelpaths and CL, from 23km+180-200 blocks get more intensive and smaller in the CL. RHS relativley free from cracks, minor longitudinal crack, but at 23km+191-1200m RHS nswp deep rut 5m long 35mm deep, surrounded by closley spaced block cracking 1-3mm wide, continuing onto verge, pumpng around isolated rut - this is the lowest poiont on the entire section, seems to be geotechnical failure but no immediatley obvious, road transitions to bend right towards section 10-11 with super elevation on LHS. Good drainage both sides, road typically 1-1.8m below road surface down grassy bank with clear run off pathways. Reinstated core 150mm wide @ 23km+170m, +215m LHS nswp.

DETAILED VISUAL CONDITION SURVEY

Road Name:	**Matuga-Semuto-Kapeeka Rd**	**Route No:**	LHS - Semuto Bound (NW), RHS - Matugga Bound (SE)
Road Section:	Section 9b: Double Sand Seal + natural sand seal	**Location:**	Luweero Region
To:	Matugga Bound-Semuto		
Date:	20/03/2019	**Inspector:**	Dominic Leal

Weather: Sunny/Dry

CHAINAGE				TEST POINT	TOTAL	X-section	Road Width*	Surface type	Cracking					Potholes		Patching		Rutting - depth exactly at chainage point		Deformation		Slips			Patching Quantities		Crown Height		Camber		Drainage		Remarks
Km	Block				km	0,1,2,3	(m)	S/U	Type	Width	Intensity	Extent	Posn	Area	Extent	Area	Extent	Depth left	Depth right	Type	Depth	Ext	Posn	Sever	Shallow	Inlay	LHS	RHS	LHS	RHS	0,1,2,3,4,5	Position	
	Start	to	End						Ln, Tr,Cr	1,2,3,4	0,1,2,3,4,5	0,1,2,3,4,5	L,C,R,A	(m2)	0,1,2,3,4,5	(m2)	0,1,2,3,4,5	(mm)	(mm)	S or G	(mm)	0,1,2,3,4,5	L,C,R,A	0,1,2,3	(m2)	(m2)	(mm)	(mm)	(%)	(%)			
23	200	to	200	0.00		6.10	DSS	Ln, Tr,Cr, Block	3	4	5	A	0	0	0.0	0	2	35	0	0	0	0	0	0	0			2.62	0.72	4	LHS + RHS	This is the worst site on the Matugga Rd, large areas of AC patching, mostly failed, wide cracks throughout 2-4mm wide, large blocks forming mostly concentrated on LHS and CL. RHS still subject to freuent longitudinal cracking and failed nswp AC patches. start of section levels out before road bends right with super elevation on LHS.
23	200	to	250	0.05		6.10	DSS	Ln, Tr,Cr, Block	3	4	4	A	0	0	34.0	5	3	2	0	0	0	0	0	33.5	0			2.13	1.27	4	LHS + RHS	0-50m wide cracking in LHS nswp and oswp-CL. Frequent LHS oswp/nswp narrow AC patches, mostly failed with wide cracking running through and connecting to the next patch. RHS has less but still freuent nswp longitudinal cracking that runs through failed nswp narrow but long AC patches. LHS nswp and RHS nswp have continuous narrow patches 0.15-0.2m wide running across entire site. Good drainage, bottom of ditch 1-1.5m below road surface. No loose aggregates at roadside edge. AReas of fatting on both lanes throughout. Reinstated 150mm core @ 23km+205m CL. @ 23km+40m series of large CL ac patches start 2.2m widest and continue for rest of section.
23	250	to	300	0.10		6.14	DSS	Ln, Tr,Cr, Block	4	4	5	A	0	0	73.0	5	0	7	0	0	0	0	0	73	0			1.64	1.66	4	LHS + RHS	Continuous narrow AC patch in both lanes nswp with transverse cracks coming out of both into the lanes and into the shoulders. Large patches across Cl until end of section vast majority of these have failed with loss of material and wide cracking throughout. LHS and CL have wide block cracking for last 50m, RHS has oswp blocking from the patches with only wide longitudinal cracking throughout. Good drainage both sides, pavement super elevation on LHS. Very poor condition section.

DETAILED VISUAL CONDITION SURVEY

Road Name:	**Matuga-Semuto-Kapeeka Rd**	**Route No:**	LHS - Semuto Bound (NW), RHS - Matugga Bound (SE)
Road Section:	Section 10a: Single Otta Seal	**Location:**	Luweero Region
To:	Matugga Bound-Semuto		
Date:	21/03/2019	**Inspector:**	Dominic Leal

Weather: Sunny/Dry

CHAINAGE				TEST POINT	TOTAL	X-section	Road Width*	Surface type	Cracking					Potholes		Patching		Rutting - depth exactly at chainage point		Deformation		Slips			Patching Quantities		Crown Height		Camber		Drainage		Remarks
Km	Block				km	0,1,2,3	(m)	S/U	Type	Width	Intensity	Extent	Posn	Area	Extent	Area	Extent	Depth left	Depth right	Type	Depth	Ext	Posn	Sever	Shallow	Inlay	LHS	RHS	LHS	RHS	0,1,2,3,4,5	Position	
	Start	to	End						Ln, Tr,Cr	1,2,3,4	0,1,2,3,4,5	0,1,2,3,4,5	L,C,R,A	(m2)	0,1,2,3,4,5	(m2)	0,1,2,3,4,5	(mm)	(mm)	S or G	(mm)	0,1,2,3,4,5	L,C,R,A	0,1,2,3	(m2)	(m2)	(mm)	(mm)	(%)	(%)			
23	300	to	300	0.00		6.1	SOS	0	0	0	0	0	0	0	0.025	0	0	7	0	0	0	0	0	0.025	0			1.64	1.66	5	LHS & RHS	Site located on a bend towards the RHS, with super elevation on the LHS, good drainage throughout. Reinsatted core 150mm @ 23km+300m. Very polished surfacing throughout, aggregates rounded and smooth to the touch; alongside minor fatting in both lanes throughout.
23	300	to	350	0.05		6.15	SOS	In, Tr, Cr, Block	2	4	3	A	0	0	0.2	2	6	7	0	0	0	0	0	0.21	0			1.45	2.58	5	LHS & RHS	0-50m, LHS medium-wide longitudinal cracking in nswp rom 23km+300-320m, reinstated core hole in LHS nswp @ 23km+315m at which point longitudinal cracking brances into transverse cracking. From start of site to 23km+325mmedium block cracking in CL. 150mm reinstated core hole RHS nswp, good condition. 23km+305m small AC patch (0.4x0.4m). Possible reinstated 150mm core hole @ 23km+324m CL, surrounded by fine-medium crocodile cracking. RHS minor nswp L cracking at start of site but rest of 50m panel in good condition. LHS 23km+320m onwards for rest of 50m panel in good condition, minor cracking in wheelpaths and along CL. Good drainage both sides with clear run-off pathways. Grassy banks, dry sandy ground.
23	350	to	400	0.10		6.2	SOS	Ln, Tr, Cr	1	2	2	L	0	0	0.05	1	2	3	0	0	0	0	0	0.05	0			0.86	1.44	5	LHS & RHS	LHS 23km+350m-400m minor fine crocodile cracking in nswp, isolated transverse cracking fine-wide (1-3mm) in oswp. RHS 23km-350-400m good condition, minor rutting in nswp at start of panel, but apart from this rest of panel in good condition, no visible defects. Possible reinstated 150mm coreholes @ LHS shoulder 23km+376m, and CL 23km+370m. 23km+400m Deep culvert centre. LHS super elevation, good drainage on both sides, 3-4.5m below road surface.
23	400	to	450	0.15		6.17	SOS	In, Tr, Cr, Block	2	3	3	C,R	0	0	0.03	1	2	3	0	0	0	0	0	0.025	0			3.33	0.77	5	LHS & RHS	LHS patches of isolated defects; isolated fine-wide longitudinal/transverse/L cracking mostly in nswp. LHS fatting at the start of panel, 23km+400-410m. 23km+450 centre of deep culvert. RHS in worse condition than LHS, from 23km+400-450m longitudinal/transverse cracking in nswp (mostly fine 1mm cracking branching into oswp). From 23km+430m-450m CL block cracking (small blocks connected by fine cracks). Possible reinstated 150mm core hole @ 23km+442m CL. Super elevation on the LHS, good drainage both sides, deep grassy banks.
23	450	to	478	0.175		6.1	SOS	Block	2	4	3	C	0.01	1			0	6	0	0	0	0	0					1.82	0.77	5	LHS & RHS	From 23km+450-455m RHS fine longitudinal crack RHS, and fine/medium 1-2mm blocking in CL for first 5m, leading to a wide CL patch 7m long (in good condition). LHS from 23km+455-462m medium crack in nswp. Culvert centre at start of panel. From 23km+462-473m fine-medium 1-2mm block cracking in CL snapping both lanes. Minor fine isolated tranvsere cracks on RHS. Pothole forming at 23km+474m LHS between wheelpaths. Minor fatting in both lanes throughout. Polished surface both lanes throughout. entire section on bend to the RHS before straigteningout and heading uphill. Good drainage both sides, high fill, grassy banks. Cracks are generally fine and surfascing in good condition. Site is actually 3m longer, clear construction joint ending 10a, moving onto 10b.

DETAILED VISUAL CONDITION SURVEY

Road Name:	**Matuga-Semuto-Kapeeka Rd**			**Route No:**	LHS - Semuto Bound (NW), RHS - Matugga Bound (SE)
Road Section:	Section 11: Double Otta Seal	**To:**	Matugga Bound-Semuto	**Location:**	Luweero Region
Date:	31/03/2019			**Inspector:**	Dominic Leal

Weather: Sunny/Dry

CHAINAGE				TEST POINT	TOTAL	X-section	Road Width*	Surface type	Cracking					Potholes		Patching		Rutting - depth exactly at chainage point		Deformation		Slips			Patching Quantities		Crown Height		Camber		Drainage		Remarks
Km	Block			km	0,1,2,3	(m)	S/U	Type	Width	Intensity	Extent	Posn	Area	Extent	Area	Extent	Depth left	Depth right	Type	Depth	Ext	Posn	Sever	Shallow	Inlay	LHS	RHS	LHS	RHS	0,1,2,3,4,5	Position	
	Start	to	End					Ln, Tr,Cr	1,2,3,4	0,1,2,3,4,5	0,1,2,3,4,5	L,C,R,A	(m2)	0,1,2,3,4,5	(m2)	0,1,2,3,4,5	(mm)	(mm)	S or G	(mm)	0,1,2,3,4,5	L,C,R,A	0,1,2,3	(m2)	(m2)	(mm)	(mm)	(%)	(%)			
23	650	to	650	0.00		6.11	DOS	Ln, Tr	0	0	0	0	0	0	0.0	0	4	3	0	0	0	0	0	0	0			0.56	0.82	4	LHS & RHS	Minor longitudinal/transverse cracking in wheelpaths for majority of site, fairly fine (1-2mm) for the most part but isolated sections of wider cracking (3-5mm) across site, with early block cracking formations in isolated sections. Longitdudinal cracking mostly in the LHS, but small sections of cracking on RHS as well. Last 30m of site medium sized patches throughout. Site runs uphill with an even camber and good drainage both sides, although interupted on the LHS because of driveways/small T junctions. Fatting in both lanes and wheelpaths across entire site. verge ground is dry and there are no loose chippings at the side of the road. Surface very polished throughout, smooth rounded aggregates across the site.
23	650	to	700	0.05		6.15	DOS	Ln, Tr	2	3	4	A	0	0	0.0	0	4	6	0	0	0	0	0	0	0			1.20	1.79	4	LHS & RHS	Fine (1-2mm) L cracks (sometimes joining) in LHS nswp, and constant fine 1-2mm longitudinal cracking in oswp (mostly 2mm). Fine transverse cracks in LHS mostly isolated. Small section of wide L cracking on RHS, with minor short sectionsd of longitudinal cracking in RHS. RHS mostly free from defects and in good condition. Junction @ 23km+365m. Good drainage both sides, RHS much deeper than LHS.
23	700	to	750	0.10		6.11	DOS	Ln, Tr	2	2	3	A	0	0	1.03	1	4	6	0	0	0	0	0	1	0			1.12	0.65	4	LHS & RHS	First 20m of panel free from defects, medium-wide (2-4mm) L cracking in LHS between wheelpaths and CL longitudinal crack from 23km+720-740m. Rest of panel has 2mm longitudinal cracking in both wheelpaths of both lanes. Still good drainage. Possible reinstated test pit @ 23km+ 757m LHS nswp.
23	750	to	800	0.15		6.12	DOS	Ln, Tr	1	2	3	L	0.01	1	0.15	1	5	3	0	0	0	0	0	0.15	0			1.57	0.65	4	LHS & RHS	Longitudinal cracking in wheelpaths continues in the LHS until 23km+750-800m. RHS minor isolated fine (1mm) longitudinal cracking in the nswp. Minor pothole 0.1x0.1m, 40mm deep @ RHS between wheelpaths 23km+787m. RHS mostly in very good condition. Good drainage both sides.
23	800	to	850	0.20		6.17	DOS	Ln, Tr	1	2	2	L	0	0	0.0	0	4	8	0	0	0	0	0	0	0			0.69	0.50	4	LHS & RHS	Longitudinal cracking in LHS wheelpaths continues to 23km+820m but generally fine (1mm). RHS free from cracking and defects, good condition. Last 30m of LHS also free from cracking and in good condition. Good drainage either side
23	850	to	900	0.25		6.14	DOS	Ln, Tr	3	3	4	L,R	0	0	0.0	0	5	5	0	0	0	0	0	0	0			0.52	0.52	4	LHS & RHS	First 10m of panel RHS is a series of closely spaced longitudinal cracks around a visible rut in the nswp, cracks 2-3mm wide. LHS 23km+860m-930 cnostant 2-4mm longitudina/transverse/L cracking in both wheel paths and in the shoulder, no signs of geotechnical failure. Very fine block crack patch 1x5m longitudinally in RHS oswp @ 23km+885m. Good drainage both sides.
23	900	to	950	0.30		6.17	DOS	Ln, Tr	2	2	3	L	0	0	1.0	1	3	4	0	0	0	0	0	1	0			0.81	0.65	4	LHS & RHS	LHS cracking continues but lessens throughout the panel. More short fine-medium transverse cracks on LHS toqwards top of panel. Medium-wide (2-5mm) longitudinal and transverse cracking in RHS nswp and shoulder from 23km+900-910m. Possible reinstated test pit in RHS nswp @ 23km+945m 1x1m, sealed in good condition, (B) painted on shoulder in LHS at this location. Panel generally in good condition. No loose surfacing material at the side of the road. Good drainage both sides.
23	950	to	1000	0.35		6.2	DOS	Ln, Tr	1	2	2	L	0	0	15.0	3	0	4	0	0	0	0	0	15	0			0.67	0.39	4	LHS & RHS	Fine (1mm) cracking in LHS wheelpaths continues to end of site. First 20m RHS in good condition, minor cracking. Medium sized AC patches (generally between 0.5x1m-2x2m in area) @ 23km+980m (LHS nswp & CL),990m (RHS nswp) 995-1003m (24km+003m). Patches crude but mostly in godo condition and sealed edges. Some patches have minor cracking. Speed bump at 23km+980m. COnstruction joint 3m ahead, site actually ends @ 24km+003m (clearly visible construction joint). End of site arrives at the peak of the climb and transitions to level ground throughout the village.

DETAILED VISUAL CONDITION SURVEY

Road Name: Kikorongo-Mpondwe Rd | **Route No:** EB (LHS) to Kakeses (QENP), WB (RHS) to Mpondwe (Congo Border)

Road Section: Mpondwe 1: Inverted Double Surface | **To:** Kikorongo | **Location:** Queen Elizibeth National Park

Date: 25/03/2019 | **Inspector:** Dominic Leal | **Weather:** Sunny/Dry

CHAINAGE				TEST POINT	TOTAL	X-section	Road Width*	Surface type	Cracking					Potholes		Patching		Rutting - depth exactly at chainage point		Deformation		Slips			Patching Quantities		Crown Height		Camber		Drainage		Remarks
Km	Block				km	0,1,2,3	(m)	S/U	Type	Width	Intensity	Extent	Posn	Area	Extent	Area	Extent	Depth left	Depth right	Type	Depth	Ext	Posn	Sever	Shallow	Inlay	LHS	RHS	LHS	RHS	0,1,2,3,4,5	Position	
	Start	to	End						Ln, Tr,Cr	1,2,3,4	0,1,2,3,4,5	0,1,2,3,4,5	L,C,R,A	(m2)	0,1,2,3,4,5	(m2)	0,1,2,3,4,5	(mm)	(mm)	S or G	(mm)	0,1,2,3,4,5	L,C,R,A	0,1,2,3	(m2)	(m2)	(mm)	(mm)	(%)	(%)			
0	0	to	0	0.000	-	6.30	IDBST	0	0	0	0	0	0	0	0.0	0	6	5	0	0	0	0	0	0	0			1.61	1.88	4	LHS & RHS	Straight site, good drainage eitherside, very few defects, minor fatting, fretting, and rutting, patches but no cracks, minor potholes (infrequent). Site generally in very good condition.
0	0	to	50	0.050	-	6.17	IDBST	0	0	0	0	0	0	0	7.7	3	8	6	0	0	0	0	0	7.72	0			2.03	1.67	4	LHS & RHS	Surfacing in excellent condition, no cracks. A series of small patches fomr 0m-20m in LHS (mostly in oswp). Larger patch (3x2m) at 47.5m in nswp RHS. Patches in good condition. Fatting across site, and discolouration of aggregates. Good drainage both sides, grassy bank, natural drainage, wide sealed shoulders, clear run-off path. Shoulders in good condition. Even camber on both sides, site relatively flat. Loose surface aggregates accumulating on shoulders and verge in both directions. Minor fretting in both wheelpaths in both directions.
0	50	to	100	0.100	-	6.09	IDBST	Tr	1	1	1	L	0.025	1	1	2	11	16	0	0	0	0	0	1	0			1.39	1.80	4	LHS & RHS	3 Ac patches, 2 in the LHS oswp, and one in the RHS nswp. One patch @83m LHS oswp has fine transverse cracking. Fatting, fretting throughout, but no cracking and 50m panel in very good condition. Good drainage, wide shoulders, clear run-off pathway. All patches sealed. Loose surface aggregates accumulating on shoulders and verge in both directions
0	100	to	150	0.150	-	6.14	IDBST	0	0	0	0	0	0	0	0.00	0	2	10	0	0	0	0	0		0			2.44	1.63	4	LHS & RHS	Fatting and fretting across panel in both lanes. No patches, good drainage, grassy babnks either side. Loose surface aggregates accumulating on shoulders and verge in both directions. Panel in excellent condition, no cracks or defects.
0	150	to	200	0.200	-	6.17	IDBST	0	0	0	0	0	0	0	0.0	0	5	5	0	0	0	0	0		0			2.23	0.96	4	LHS & RHS	Fatting and fretting across panel in both lanes. No patches, good drainage, grassy babnks either side. Loose surface aggregates accumulating on shoulders and verge in both directions. Panel in excellent condition, no cracks or defects.
0	200	to	250	0.250	-	6.18	IDBST	0	0	0	0	0	0	0	1.90	2	5	3	0	0	0	0	0	1.9	0			1.76	1.64	4	LHS & RHS	3 Ac patches, all in the LHS shoulder. patches in good condition. Fatting, fretting throughout, but no cracking and 50m panel in very good condition. Good drainage, wide shoulders, clear run-off pathway. All patches sealed. Loose surface aggregates accumulating on shoulders and verge in both directions. LHS minor edge deterioration.
0	250	to	300	0.300	-	6.17	IDBST	0	0	0	0	0	0	0	0.0	0	10	4	0	0	0	0	0	0	0			1.94	2.28	4	LHS & RHS	Fatting and fretting across panel in both lanes. No patches, good drainage, grassy babnks either side. Loose surface aggregates accumulating on shoulders and verge in both directions. Panel in excellent condition, no cracks or defects.
0	300	to	350	0.350	-	6.11	IDBST	0	0	0	0	0	0	0	0.0	0	6	3	0	0	0	0	0	0	0			1.45	3.01	4	LHS & RHS	Fatting and fretting across panel in both lanes. No patches, good drainage, grassy babnks either side. Loose surface aggregates accumulating on shoulders and verge in both directions. Panel in excellent condition, no cracks or defects.
0	350	to	400	0.400	-	6.11	IDBST	0	0	0	0	0	0.143	1	15.5	3	16	0	0	0	0	0	0	15.5	0			0.98	1.70	4	LHS & RHS	Frequent patches at end of site in LHS edge/nswp, and RHS edge/nswp. Patches in good condition, some LHS edge deterioration. @362m/370m potholes (0.15x0.15m; 03x0.4m) 25-40mm deep. Outside of fatting and fretting carriageway and shoulders in excellent condition. Drianage eitherside good. Loose surface aggregates accumulating on shoulders and verge in both directions.

DETAILED VISUAL CONDITION SURVEY

Road Name: Kikorongo-Mpondwe Rd | **Route No:** EB (LHS) to Kakeses (QENP), WB (RHS) to Mpondwe (Congo Border)

Road Section: Mpondwe 2 | **To:** Kikorongo | **Location:** Queen Elizibeth National Park

Date: 26/03/2019 | **Inspector:** Dominic Leal | **Weather:** Sunny/Dry

CHAINAGE				TEST POINT	TOTAL	X-section	Road Width*	Surface type	Cracking					Potholes		Patching		Rutting - depth exactly at chainage point		Deformation		Slips			Patching Quantities		Crown Height		Camber		Drainage		Remarks
Km	Block				km	0,1,2,3	(m)	S/U	Type	Width	Intensity	Extent	Posn	Area	Extent	Area	Extent	Depth left	Depth right	Type	Depth	Ext	Posn	Sever	Shallow	Inlay	LHS	RHS	LHS	RHS	0,1,2,3,4,5	Position	
	Start	to	End						Ln, Tr,Cr	1,2,3,4	0,1,2,3,4,5	0,1,2,3,4,5	L,C,R,A	(m2)	0,1,2,3,4,5	(m2)	0,1,2,3,4,5	(mm)	(mm)	S or G	(mm)	0,1,2,3,4,5	L,C,R,A	0,1,2,3	(m2)	(m2)	(mm)	(mm)	(%)	(%)			
0	0	to	0	0.000	-	6.12	IDBST	0	0	0	0	0	0	0	0.0	0	5	2	0	0	0	0	0	0	0			2.06	1.83	4	LHS & RHS	Level site, even camber both sides with good drainage. Inverted double surface dressing in good condition, although frequent AC patching towards the second half of the section, crude but generally all patches intact. Fatting in wheelpaths in both directions throughout thye site. Grassy banks. majority of patches in the LHS/Shoulder (EB) or CL. Edge deterioration throughout site. Loose surfacing material at the side of the road. Shoulder worn, sealed but loss of material.
0	0	to	50	0.050	-	6.20	IDBST	0	0	0	0	0	0.1	1	0.8	2	10	3	0	0	0	0	0	0.75	0			1.38	2.50	4	LHS & RHS	Minor rutting in LHS nswp between 0-20m. 25mm deep pothole (0.3x0.3m) in LHS between wheelpaths (base layer exposed and damaged). 2 small patches @ ch. 39.5m in LHS nswp and RHS oswp. Fatting and surface loss, material accumlated at the side of the road. No cracking, wide shoulder (partially deteriorated but still in good condition) with clear drainage paths.
0	50	to	100	0.100	-	6.09	IDBST	0	0	0	0	0	0	0	0	0	6	2	0	0	0	0	0	0	0			1.82	2.44	4	LHS & RHS	Free from dects or patches, minor rutting. Fatting and fretting throughout in both directions and wheelpaths. Loose surface material accumulating at the side of the road. Good drainage, wide shoulders clear ruhn off pathways. Grassy bank
0	100	to	150	0.150	-	6.10	IDBST	0	0	0	0	0	0.2	2	2	3	5	5	0	0	0	0	0	0.2	0			2.66	2.10	4	LHS & RHS	From ch. 105-125m LHS small AC patches (good condition) with small potholes (25mm deep) in oswp and CL. Fatting and fretting throughout in both lanes and directions. Surface material acculating at the side of the road. Surface aggregates fairly polished rounded and smooth but still coarse/cobbly. Good drainage both sides, grassy banks, clear run-off pathways.
0	150	to	200	0.200	-	6.11	IDBST	0	0	0	0	0	0.12	1	4.2	2	2	2	0	0	0	0	0	0.12	0			1.57	1.79	4	LHS & RHS	Large AC patch RHS nswp/edge (3.5x1m) in good condition @ ch. 150m. LHS mostly in good condition. Minor patches around ch. 180-200m and a 45mm deep pothole (0.4x0.3m). RHS in good condition. Both sides fatting and fretting, surface material acculating at side of the road. Granite surface aggregates smooth with few corners. Good drainage both sides, grassy banks wide shoulders.
0	200	to	250	0.250	-	6.10	IDBST	0	0	0	0	0	0.12	1	25.00	4	4	2	0	0	0	0	0	0.12	0			1.75	1.67	4	LHS & RHS	Series of medium AC patches between ch. 200-250m in both lanes across all points (lhs edge/nswp/oswp/CL). Fatting throughout both lanes. Aggregates accumalting at the side of the road. No cracks, but small isolated potholes. Small culvert @ ch. 250m. Good drainage both sides.
0	250	to	300	0.300	-	6.07	IDBST	0	0	0	0	0	0	0	27.3	4	10	4	0	0	0	0	0	0	0			1.32	1.46	4	LHS & RHS	Series of large patches in the CL for rest of panel and large patch on LHS @ ch. 273m edge. Patch by culvert @ ch. 250m. Patches in good condition. Fatting in both lanes with polished stones. Surface material accumlating at the shoulder. Good drainage both sides. Free from cracking, although patchy wheelpaths in fairly good condition, minor isolated potholes across the whole site, but generally good.

DETAILED VISUAL CONDITION SURVEY

Road Name: Kikorongo-Mpondwe Rd | **Route No:** EB (LHS) to Kakeses (QENP), WB (RHS) to Mpondwe (Congo Border)

Road Section: Mpondwe 3: Inverted Double Surface | **To:** Kikorongo | **Location:** Queen Elizibeth National Park

Date: 27/03/2019 | **Inspector:** Dominic Leal

Weather: Sunny/Dry

CHAINAGE				TEST POINT	TOTAL	X-section	Road Width*	Surface type	Cracking					Potholes		Patching		Rutting - depth exactly at chainage point		Deformation		Slips			Patching Quantities		Crown Height		Camber		Drainage		Remarks
Km	Block				km	0,1,2,3	(m)	S/U	Type	Width	Intensity	Extent	Posn	Area	Extent	Area	Extent	Depth left	Depth right	Type	Depth	Ext	Posn	Sever	Shallow	Inlay	LHS	RHS	LHS	RHS	0,1,2,3,4,5	Position	
	Start	to	End						Ln, Tr,Cr	1,2,3,4	0,1,2,3,4,5	0,1,2,3,4,5	L,C,R,A	(m2)	0,1,2,3,4,5	(m2)	0,1,2,3,4,5	(mm)	(mm)	S or G	(mm)	0,1,2,3,4,5	L,C,R,A	0,1,2,3	(m2)	(m2)	(mm)	(mm)	(%)	(%)			
0	0	to	0	0.000	-	6.11	IDBST	0	0	0	0	0	0	0	0.0	0	5	10	0	0	0	0	0	0	0			2.62	1.63	4	LHS & RHS	Site in very good condition, one small patch and a series of cracks/deterioration/potholes in the LHS shoulder over the first 80m of the site. Otherwise in excellent condition. Good drainage both sides, RHS swampy/damp; LHS damp.
0	0	to	50	0.050	-	6.10	IDBST	0	0	0	0	0	0	0	0.0	0	4	3	0	0	0	0	0	0	0			1.44	1.94	4	LHS & RHS	wide cracks in shoulder only and potholes all in shoulders 25mm deep LHS only. RHS in good condition, no cracks or visible defects. Loose aggregates on road surface and on verge side. LHS should deteriorated but adjactent pavement in very good condition. Aggregates dull but angular with scattered sharp broken pieces. cement stabilised base exposed at edge. Good drainage, but damp ground, RHS marshy/bush. very thin inverted double surface dressing 10-15mm thick.
0	50	to	100	0.100	-	6.19	IDBST	0	0	0	0	0	0	0	0.2	1	1	10	0	0	0	0	0	0.2	0			1.46	1.97	4	LHS & RHS	Small patch @60m otherwise carriageway in very good condition, same characteristics as previous panel. LHS shoulder has series of small-medium potholes in which end @ ch. 80m. Good drainage both sides. Loose surface aggregates on road and at verge side. Wide shoulders shallow grassy banks 0.5-0.7m deep below road surface. Good drainage with clear run off paths to grass drains.Flat site, even camber both sides.
0	100	to	150	0.150	-	6.10	IDBST	0	0	0	0	0	0	0	0.00	0	5	3	0	0	0	0	0		0			1.55	1.06	4	LHS & RHS	Excellent condition, good drainage. No defects and shoulder in good condition. Loose surface aggregates on road and at verge side.
0	150	to	200	0.200	-	6.08	IDBST	0	0	0	0	0	0	0	0.0	0	2	5	0	0	0	0	0		0			1.15	0.72	4	LHS & RHS	Excellent condition, good drainage. No defects and shoulder in good condition. Loose surface aggregates on road and at verge side.

DETAILED VISUAL CONDITION SURVEY

Road Name: ishaka-Kasese | **Route No:** Kasese

Road Section: Ishaka 1 | **To:** | **Location:** Ishaka

Date: ##### | **Inspector:** Dominic Leal

CHAINAGE				TEST POINT	TOTAL	X-section	Road Width*	Surface type	Cracking					Potholes		Patching		Rutting - depth exactly at chainage point		Deformation		Slips			Patching Quantities		Crown Height		Camber		Drainage		Remarks
Km	Block				km	0,1,2,3	(m)	S/U	Type	Width	Intensity	Extent	Posn	Area	Extent	Area	Extent	Depth left	Depth right	Type	Depth	Ext	Posn	Sever	Shallow	Inlay	LHS	RHS	LHS	RHS	0,1,2,3,4,5	Position	
	Start	to	End						Ln, Tr,Cr	1,2,3,4	0,1,2,3,4,5	0,1,2,3,4,5	L,C,R,A	(m2)	0,1,2,3,4,5	(m2)	0,1,2,3,4,5	(mm)	(mm)	S or G	(mm)	0,1,2,3,4,5	L,C,R,A	0,1,2,3	(m2)	(m2)	(mm)	(mm)	(%)	(%)			
27	900	to	900	0.000		6.5	DBST	0	0	0	0	0	0	0	0.0	0	3	2	0	0	0	0	0	0	0			1.91	1.77	4	LHS & RHS	Site in mixed condition. RHS in very good condition, isolated deep potholes/surface loss alongside minor rutting and fatting in nswp but generally in good condition. LHS has deep potholes, areas of crazing and block cracking (sometimes severe), depressions, and a mixturte of fine-wide longitudinal and transver cracking. Block cracking and crazing (spread across both wheelpaths and sometimes the CL) towards the end of the site and it goes downhill and gets close to water level of the adjacent lake. Again minor fatting and rutting in LHS nswp. Stonee/concrete drains on LHS in good condition across site clear running water and run-off pathways from carriageway.
27	900	to	950	0.050		6.6	DBST	0	0	0	0	0	0	2.1	2	0.0	0	5	1	0	0	0	0	0	0	0			1.82	1.97	4	LHS & RHS	Both lanes in good condition, one large pothole in RHS nswp @ 32m and smaller pothole in LHS nswp @ 40m. Good drainage both sides. Minor fatting and rutting in both directions.
27	950	to	1000	0.100		6.8	DBST	Cr	2	1	1	L	0.15	2	2.0	1	3	3	0	0	0	0	0	2	0			1.18	1.76	4	LHS & RHS	Minoe crocodile cracking in LHS nswp @ 60m, next to area of mechanical damae. Possible test pit reinstated but unsealed in @ 51m CL followed by a small pothole. Small shallow pothole in RHS nswp @ 53m. Minor fatting and rutting in nswp of both lanes, but generally in good condition in both lanes.
28	0	to	50	0.150		6.65	DBST	Ln, Tr, Cr, Block	1	4	3	L	0.5	0	0.0	0	4	4	G	50	1	L	2	0	0			1.27	1.14	4	LHS & RHS	RHS in good condition no defects. LHS has fine longtudinal cracks in nswp from 120-150m. LHS crazing/block cracking in nswp from 100-115m, with a deep depressioon and large pothole.
28	50	to	100	0.200		6.6	DBST	Ln, Tr, Cr, Block	3	5	3	L,C	0.15	1	0.0	0	5	6	G	50	1	L	2	0	0			2.15	1.49	4	LHS & RHS	LHS from 150-180m medium block cracking across the lane, with severe block cracking in CL. Blocking surrounded by rutting and deep pothole 45mm deep. Dpression on LHS in same location deep, looks geotechnical or from poor construction, no edge support. RHS in good condition, minor fine tranvsverse cracking in nswp from 180-200m.
28	100	to	**150**	0.250		6.7	DBST	Ln, Tr, Cr, Block	2	4	5	L,C	0.2	1	1.0	1	10	4	0	0	0	0	0	1	0			1.09	1.71	4	LHS & RHS	Fine-medium block cracking throughout LHS from 200-250m across the lane with visible rut in nswp and longitudinal 3mm cracking. LHS failed patch @ 240m nswp.. Between CL and oswp of RHS deep 60mm pothole surrounded by fine cracks @ 240m. Possible test pit reinstated but sealed @ RHS 249m. Good drainage nio both sides.
28	150	to	**200**	0.300		6.55	DBST	Ln, Tr, Cr, Block	2	4	5	L	0.2	1	2.0	1	11	7	0	0	0	0	0	2	0			1.85	1.67	4	LHS & RHS	fine-medium crazing and block cracking, crocodile cracking, longitudinal cracking across both wheelpaths from 250-300m LHS. LHS failed AC patch @ 264m with wide cracks and a small 60mm deep pothole in centre of patch nswp. Possible second test pit (or surface has been removed, signs of mechanical damage) on RHS @ 250m nswp. Good drainage both sides.

DETAILED VISUAL CONDITION SURVEY

Road Name:	**Ishaka - Kasese Rd**			**Route No:**	Kasese
Road Section:	Ishaka 2	**To:**		**Location:**	
Date:	#####			**Inspector:**	Dominic Leal

CHAINAGE			**TEST POINT**	**TOTAL**	**X-section**	**Road Width***	**Surface type**	**Cracking**					**Potholes**		**Patching**		**Rutting - depth exactly at chainage point**		**Deformation**		**Slips**			**Patching Quantities**		**Crown Height**		**Camber**		**Drainage**		**Remarks**
Km	**Block**			**km**	0,1,2,3	(m)	S/U	Type	Width	Intensity	Extent	Posn	Area	Extent	Area	Extent	Depth left	Depth right	Type	Depth	Ext	Posn	Sever	Shallow	Inlay	LHS	RHS	LHS	RHS	0,1,2,3,4,5	Position	
	Start	**to**	**End**					Ln, Tr,Cr	1,2,3,4	0,1,2,3,4,5	0,1,2,3,4,5	L,C,R,A	(m2)	0,1,2,3,4,5	(m2)	0,1,2,3,4,5	(mm)	(mm)	S or G	(mm)	0,1,2,3,4,5	L,C,R,A	0,1,2,3	(m2)	(m2)	(mm)	(mm)	(%)	(%)			
0.000	0.000	to	0.000	0.000		6.39		0	0	0	0	0	0	0	0.0	0	8	3	0	0	0	0	0	0	0			0.639	1.38	3	LHS & RHS	Level site, with even camber both sides, very few defects overall, minor potholes and surface loss (exposed base) and minor rutting and fatting throughout in both directions. No cracks, depressions, or other obvious failures. Good drainage both sides but water unable to make it from the shoulder to the drainage easily (as grass level is higher than surface level), so water pools on the surface during rain, expescially in the ruts. Surfacing in excellent condition. Fatting mostly in SB lane. Swampy verge with tall grass. Minor edge deterioration
0.000	0.000	to	50.000	0.050		6.42		0	0	0	0	0	0	0	0.0	0	2	4	0	0	0	0	0	0	0			1.166	0.649	3	LHS & RHS	Rutting in nswp. LHS @ 40m small pothole exposing base material. Rutting in nswp RHS throughout and fatting in LHS nswp from 0-50m. Good drainage but run-off unable to make it to drains
0.000	50.000	to	100.000	0.100		6.31		0	0	0	0	0	0.25	1	0.0	0	10	6	0	0	0	0	0	0.25	0			0.817	0.615	3	LHS & RHS	Surfacing in good condition both directions. Drainage better but water still pooling on the edge of the carriageway. Fatting in RHS nswp continues from 50-100m. Minor edge deterioration in LHS nswp edge.
0.000	100	to	150.000	0.150		6.48		0	0	0	0	0	0	0	0.0	0	6	6	0	0	0	0	0	0	0			1.898	0.755	3	LHS & RHS	Possible reinstated (unsealed test pit @ 120m RHS nswp. Rutting in both directions nswp.
0.000	150	to	200.000	0.200		6.56		0	0	0	0	0	0	0	0.0	0	12	8	0	0	0	0	0	0	0			0.602	0.617	3	LHS & RHS	Rutting in RHS nswp from 160-180m. Generally site in excellent condition

Zambia

DETAILED VISUAL CONDITION SURVEY

Road Name:	**Samfya - Musaila**	**Route No:**	D94
Road Section:	Section 1 and Section 2 **To:**	**Location:**	Samfya
Date:	22/03/2019	**Inspector:**	Andrew (TRL)

CHAINAGE				**TEST POINT**	**TOTAL**	**X-section**	**Road Width***	**Surface type**	**Cracking**					**Potholes**		**Patching**		**Rutting - depth exactly at chainage point**		**Deformation**		**Slips**			**Patching Quantities**		**Crown Height**		**Camber**		**Drainage**		**Remarks**
Km	**Block**				**km**	0,1,2,3	(m)	S/U	Type	Width	Intensity	Extent	Posn	Area	Extent	Area	Extent	Depth left	Depth right	Type	Depth	Ext	Posn	Sever	Shallow	Inlay	LHS	RHS	LHS	RHS	0,1,2,3,4,5	Position	
	Start	**to**	**End**						Ln, Tr,Cr	1,2,3,4	0,1,2,3,4,5	0,1,2,3,4,5	L,C,R,A	(m2)	0,1,2,3,4,5	(m2)	0,1,2,3,4,5	(mm)	(mm)	S or G	(mm)	0,1,2,3,4,5	L,C,R,A	0,1,2,3	(m2)	(m2)	(mm)	(mm)	(%)	(%)			
						Section 1 (Poor Condition)																												
2.000	0.080	to	0.130	2.130	0	6.2	CS	Cr	1	2	5	L,R	0.0	0	0.0	0	12	3													0	L,R	Cracks on both Inner and Outer W/Ps
	0.130	to	0.180	2.180	0	6.2	CS	Cr	1	2	5	L,R	0.0	0	0.0	0	12	3													0	L,R	Cracks on both Inner and Outer W/Ps
	0.180	to	0.230	2.230	0	6.2	CS	Cr	1	2	5	L,R	0.0	0	0.0	0	3	3													0	L,R	Cracks on both Inner and Outer W/Ps
	0.230	to	0.280	2.280	0	6.2	CS	Cr	1	2	5	L,R	1.5	1	0.0	0	4	2													0	L,R	Cracks on both Inner and Outer W/Ps
	0.280	to	0.330	2.330	0	6.2	CS	Cr	1	2	5	L,R	0.5	1	0.0	0	10	6													0	L,R	Cracks on both Inner and Outer W/Ps
	0.330	to	0.380	2.380	0	6.2	CS	Cr	1	2	5	L,R	0.0	0	0.0	0	2	4													0	L,R	Cracks on both Inner and Outer W/Ps
Notes		Surfacing is Cape Seal 10 mm. Potholes a result of a vehicle accident scratching the surface, cracks confined to both outer and inner wheel paths on both lanes. Start Coordinates: WP479 S11;21;00 E29;30;16. End Coordinates:WP478 S11;20;59 E29;30;01.																														
		to				**Section 2 (Good Condition)**																												
7.000	0.380	to	0.430	7.430	0	6.2	CS	-	-	0	0	-	0.0	0	0.0	0	3	5													0	L,R	Cracks on both Inner and Outer W/Ps
	0.430	to	0.480	7.480	0	6.2	CS	-	-	0	0	-	0.0	0	0.0	0	0	16													0	L,R	Cracks on both Inner and Outer W/Ps
	0.480	to	0.530	7.530	0	6.2	CS	-	-	0	0	-	0.0	0	0.0	0	5	5													0	L,R	Cracks on both Inner and Outer W/Ps
	0.530	to	0.580	7.580	0	6.2	CS	-	-	0	0	-	0.0	0	0.0	0	3	6													0	L,R	Cracks on both Inner and Outer W/Ps

DETAILED VISUAL CONDITION SURVEY

Road Name:	**Mansa - Mwense**	**Route No:**	D79
Road Section:	Section 1 and Section 2 **To:**	**Location:**	Bahati
Date:	25/03/2019	**Inspector:**	Andrew (TRL)

CHAINAGE				TEST POINT	TOTAL	X-section	Road Width*	Surface type	Cracking					Potholes		Patching		Rutting - depth exactly at chainage point		Deformation		Slips			Patching Quantities		Crown Height		Camber		Drainage		Remarks
Km	Block				km	0,1,2,3	(m)	S/U	Type	Width	Intensity	Extent	Posn	Area	Extent	Area	Extent	Depth left	Depth right	Type	Depth	Ext	Posn	Sever	Shallow	Inlay	LHS	RHS	LHS	RHS	0,1,2,3,4,5	Position	
	Start	to	End						Ln, Tr,Cr	1,2,3,4	0,1,2,3,4,5	0,1,2,3,4,5	L,C,R,A	(m2)	0,1,2,3,4,5	(m2)	0,1,2,3,4,5	(mm)	(mm)	S or G	(mm)	0,1,2,3,4,5	L,C,R,A	0,1,2,3	(m2)	(m2)	(mm)	(mm)	(%)	(%)			
							Section 1 (Good Condition)																									
26.000	0.600	to	0.650	26.650	0	6.2	DSD	-	-	-	-	-	0.0	0	0.0	0	10	30												1	L	overgrown grass drains
	0.650	to	0.700	26.700	0	6.2	DSD	-	-	-	-	-	0.0	0	0.0	0	4	13												1	L	overgrown grass drains
	0.700	to	0.750	26.750	0	6.2	DSD	-	-	-	-	-	0.3	1	0.0	0	7	20												2	L,R	overgrown grass drains
	0.750	to	0.800	26.800	0	6.2	DSD	-	-	-	-	-	0.0	0	0.0	0	10	20												2	L,R	overgrown grass drains
	0.800	to	0.850	26.850	1	6.2	DSD	-	-	-	-	-	0.0	0	0.0	0	22	25												2	L,R	overgrown grass drains
	0.850	to	0.900	26.900	1	6.2	DSD	Ln	1	1	0	L	0.0	0	0.0	0	20	10												2	L,R	overgrown grass drains
Notes		Surfacing is Double Surface Dressing 20 mm. Section in cut on LHS and fill on RHS. Start Coordinates: WP491 S10;58;27.6 E28;49;39.3; End Coordinates:WP490 S10;58;18.0 E28;49;36.5																														
		to					Section 2 (Poor Condition)																									
15.000	0.600	to	0.650	15.650	2	6.2	DSD	-	-	0	0	-	25.0	3	0.0	0	14	23												4	L,R	Shoulder camber flat
	0.650	to	0.700	15.700	2	6.2	DSD	-	-	0	0	-	24.0	5	0.0	0	7	10												4	L,R	Shoulder camber flat
	0.700	to	0.750	15.750	2	6.2	DSD	-	-	0	0	-	27.0	4	0.0	0	11	16												3	L,R	Shoulder camber flat
	0.750		0.800	15.800	1	6.2	DSD	-	-	0	0	-	9.0	2	0.0	0	12	15												3	L,R	Gradient begins to increase
	0.800		0.850	15.850	2	6.2	DSD	Ln	1	1	4	C,R	20.0	3	6.0	1	25	17												2	L,R	Substantial gradient
	0.850	to	0.900	15.900	1	6.2	DSD	-	-	0	0	-	8.0	2	0.0	0	17	12												1	L,R	Substantial gradient
Notes		Surfacing is Double Surface Dressing . Section in shallow cut on LHS and on RHS. Start Coordinates: WP487 S11;04;09.3 E28;51;30.9; End Coordinates:WP492 S11;03;47.9 E28;50;59.7																														
		In Block 1, Shoulders have potholes and water ponds on them. Only 4m2 of potholes on RHS , 21 m2 is on LHS (Deeper cut)																														
		In Block 2, Shoulders have potholes and water ponds on them. Potholes spread throughout both lanes																														
		In Block 3, Potholes mostly on LHS lane																														

DETAILED VISUAL CONDITION SURVEY

Road Name:	**Samfya - Mukuku Bridge**	**Route No:**	D235
Road Section:	Section 1 and Section 2 **To:**	**Location:**	Samfya
Date:	23/03/2019	**Inspector:**	Andrew (TRL)

CHAINAGE					TEST POINT	TOTAL	X-section	Road Width*	Surface type	Cracking					Potholes		Patching		Rutting - depth exactly at chainage point		Deformation		Slips			Patching Quantities		Crown Height		Camber		Drainage		Remarks
Km	Block			km						Type	Width	Intensity	Extent	Posn	Area	Extent	Area	Extent	Depth left	Depth right	Type	Depth	Ext	Posn	Sever	Shallow	Inlay	LHS	RHS	LHS	RHS	0,1,2,3,4,5	Position	
	Start	to	End				0,1,2,3	(m)	S/U	Ln, Tr,Cr	1,2,3,4	0,1,2,3,4,5	0,1,2,3,4,5	L,C,R,A	(m2)	0,1,2,3,4,5	(m2)	0,1,2,3,4,5	(mm)	(mm)	S or G	(mm)	0,1,2,3,4,5	L,C,R,A	0,1,2,3	(m2)	(m2)	(mm)	(mm)	(%)	(%)			
						Section 1 (Good Condition)																												
101.000	0.800	to	0.850	101.850	0	6.2	TSD	-	-	0	0	-	0.0	0	0.0	0	4	12														0	L,R	Embankment in swamp
	0.850	to	0.900	101.900	0	6.2	TSD	-	-	0	0	-	0.0	0	0.0	0	10	10														0	L,R	Embankment in swamp
	0.900	to	0.950	101.950	0	6.2	TSD	-	-	0	0	-	0.0	0	0.0	0	11	15														0	L,R	Embankment in swamp
	0.950	to	0.000	102.000	0	6.2	TSD	-	-	0	0	-	0.0	0	0.0	0	3	4														0	L,R	Embankment in swamp
102.000	0.000	to	0.050	102.050	0	6.2	TSD	-	-	0	0	-	0.0	0	0.0	0	4	6														0	L,R	Embankment in swamp
	0.050	to	0.100	102.100	0	6.2	TSD	-	-	0	0	-	0.0	0	0.0	0	10	5														0	L,R	Embankment in swamp
Notes		Surfacing is Triple Surface Dressing 25 mm. Start Coordinates: WP483 S12;02;48 E29;39;03. End Coordinate:WP482 S12;02;53 E29;39;12. Shallow water flood RHS within 5-10 m.																															
		to				Section 2 (Poor Condition)																												
102.000	0.600	to	0.650	102.650	0	6.2	TSD	-	-	0	0	-	2.0	2	4.0	1	-	5														0	L,R	Embankment in swamp
	0.650	to	0.700	102.700	0	6.2	TSD	-	-	0	0	-	4.5	1	0.0	0	20	15														0	L,R	Embankment in swamp
	0.700	to	0.750	102.750	0	6.2	TSD	-	-	0	0	-	4.0	2	0.0	0	8	15														0	L,R	Embankment in swamp
	0.750	to	0.800	102.800	0	6.2	TSD	-	-	0	0	-	4.5	3	1.0	1	8	20														0	L,R	Embankment in swamp
	0.800	to	0.850	102.850	0	6.2	TSD	-	-	0	0	-	4.5	4	0.0	0	11	7														0	L,R	Embankment in swamp
	0.850	to	0.900	102.900	0	6.2	TSD	-	-	0	0	-	3.5	1	0.0	0	5	10														0	L,R	Embankment in swamp
Notes		Surfacing is Triple Surface Dressing 25 mm. Start Coordinates: WP480 S12;03;04. E29;39;31. End Coordinates: WP481 S12;03;09 E29;39;40. Water flooding on both sides within 5-10 m of edge, 1 m to crown																															

Annex 3 Summary of Laboratory and Field Data

Ghana Sections															
Section	Layer	Relative Compaction (%)	FMC (%)	OMC (%)	FMC/OMC	CBR Insitu (%)	CBR soaked @ Field density Base ≥ 80; Sub-base ≥ 40	CBR soaked @ design density	PI Base ≤ 10; Sub-base ≤ 14	PM Base ≤ 200; Sub-base ≤ 250	Test Pit Thickness (mm)	Subgrade Class	MESA	SN Actual	SN Chart
Mpataba Junction - Half Assini 1 (Poor)	Base	92	6.9	7.1	1.0	74	23	85	18	648	300		**0.6 - 1.2**	0.71	0.77
	Sub-base	101	9.2	8.1	1.1	38	84	57	22	814	280			1.21	1.28
	Subgrade		8.7	-	-	22	-	4	18	-		SC2			
														1.92	**2.05**
Mpataba Junction - Half Assini 2 (Good)	Base	95	11.1	12.0	0.9	97	57	75	14	490	400		**0.6 - 1.2**	1.73	0.77
	Sub-base	100	10.7	11.0	1.0	150	59	30	27	1755	520			2.25	1.28
	Subgrade		7.6	-	-	28	-	4	19	817		SC2			
														3.99	**2.05**
Koforidua - Adukrom 1 (Poor)	Base	87	10.1	7.4	1.4	111	34	52	11	441	195		**3.5 - 6.9**	0.35	
	Sub-base	89	11.3	9.3	1.2	63	24	114	11	455	200			0.71	
	Capping		5.7	6.4	0.9	50	-	33	0	0	100			0.39	
	Subgrade		7.1	6.8	1.0		-	49	9	408		SC4			
														1.46	**2.3-3.2**
Koforidua - Adukrom 2 (Fair)	Base	88	6.0	7.6	0.8	65	24	41	12	499	200		**3.5 - 6.9**	0.47	
	Sub-base	91	9.1	8.7	1.0	137	48	62	13	466	250			1.07	
	Capping		9.5	6.9	1.4	52	-	39	8	408	150			0.62	
	Subgrade		6.0	8.0	0.8		-	65	7	598		SC4			
														2.17	**2.5-3.0**
Cape Coast - Twifo Praso 1 (Good)	Base					114		85	23	805	130		**0.6**	0.46	
	Sub-base		2.6	9.5	0.3	99			-	-	110				
	Subgrade					154						-			
Cape Coast - Twifo Praso 2 (Fair)	Base		2.6	9.8	0.3	67		87	22	774	100		**0.6**	0.35	
	Sub-base					145					360				
	Subgrade					123						-			

Mozambique Sections																
Section	Layer	Relative Compaction (%)	FMC (%)	OMC (%)	FMC/OMC	CBR Insitu (%)	CBR soaked @ Field density	CBR at design density	PI	PM	Test Pit Thickness (mm)	Subgrade Class	MESA	SN of Existing Structure	SN from Chart if Traffic was 1 MESA	SN from Chart at Actual MESA
Boane - Namaacha 1 (Cracked, Potholed and Patched)	Base	98	7.0	12.2	0.6	119	87	87	13	179	140	S4	5.8-11.7	0.74	1.05	1.3
	Sub-base	96	9.4	9.7	1.0	45	21	21	3	49	280			1.00	0.83	1.0
	Subgrade	95	36.8	20.0	1.8	13	10	10	31	2130	-					
														1.7	**1.9**	**2.3**
Boane - Namaacha 2 (Fair)	Base	-	-	9.5	-	137	-	151	11	416	130		5.8-11.7	0.74	1.05	1.3
	Sub-base	-	-	-	-	101	-	-	5	141	100				0.83	1.0
	Subgrade	-	-	-	-	38	-	-	-	-	-					
															1.9	**2.3**
Boane - Namaacha 3 (Good)	Base	99	4.5	10.2	0.4	231	151	151	6	80	140	S2	3.1-6.1	0.79	1.05	1.1
	Sub-base	95	12.9	16	0.8	91	55	55	4	187	370			1.62	0.72	1.9
	Subgrade	-	15.4	13.2	1.2	49	-	3			-				0.62	
														2.4	**2.4**	**3.0**
Boane - Moamba 1 (Potholed)	Base	-	-	-	-	-	-	-	-	-	250		0.6-1.1			
	Sub-base	-	-	-	-	-	-	-	-	-	200					
	Subgrade	-	-	-	-	-	-	-	-	-	-					
						-	-	-	-	-						
Boane - Moamba 2 (Cracked)	Base	-	-	-	-	-	-	-	-	-	250		0.8-1.6			
	Sub-base	-	-	-	-	-	-	-	-	-	200					
	Subgrade	-	-	-	-	-	-	-	-	-	-					
Macia - Chokwe 1 (Good)	Base	-	-	-	-	-	-	-	0	0	150	S4	0.5-1.1	0.83	0.90	
	Sub-base	106	8.2	9.1	0.9	40	57	41	2	182	200			0.87	0.72	
	Subgrade	137	7.9	5	1.6	50	14	14	1	98	-					
														1.7	**1.6**	
Macia - Chokwe 2 (Patched)	Base	-	-	-	-	-	-	-	-	-	180	S1	0.5-1.1	0.92	0.90	
	Sub-base	129	15.3	22.0	0.7	96	34	34	0	0	250			1.07	1.79	
	Subgrade	82	30.3	10.5	2.9	10	1	1	17	1647	-					
														2.0	**3.3**	

Uganda Sections															
Section	Layer	Relative Compaction (%)	FMC (%)	OMC (%)	CBR Insitu (%)	CBR soaked @ Field density	CBR soaked @ Design density	PI	PM	Test Pit Thickness (mm)	Subgrade Class	MESA	SN Actual	SN Chart (1 MESA)	SN Chart (3 MESA)
Matugga - Semuto - Kapeeka															
Section 4 TP1	Base	96	9.6	8.8	61	24		16	480	175	S3	2.6	0.90	0.90	1.02
	Sub-base	96	13.1	12.4	28	10		16	886	180			0.46	1.06	0.69
	Subgrade	94	11.1	9.0	18	5		22	1962				**1.36**	**1.96**	**2.11**
Section 1 6a Inverted DSD (Good)	Base	95	4.3	10.4	78	17	31	14	499	120	S4	2.6	0.61	0.90	1.02
	Sub-base	84	4.6	8.2	42	25	14	18	678	120			0.47	0.79	0.39
	Subgrade		9.1	9.8	21		9	20	1018				**1.09**	**1.68**	**1.73**
Section 4: 9a Double Sand Seal (CD) Fair	Base	95	9.1	9.2	81	32	58	14	378	200	S2	2.6	1.02	0.90	1.02
	Sub-base	99	6.8	10.6	23	28	20	16	605	160			0.63	0.79	0.69
	Subgrade		5.5	10.3	33		4	19	1124				**1.65**	**1.68**	**2.42**
Section 6: 10a Single Otta Seal + Sand Seal (CD) Good	Base	104	3.2	10.4	115	141	69	13	246	200	S3	2.6	1.02	0.90	1.02
	Sub-base	93	11.2	8.2	63	4	14	20	880	120			0.47	1.06	0.69
	Subgrade		10.1	9.8	32		5	18	912				**1.50**	**1.96**	**2.11**
Ishaka - Katunguru															
Section 2 (Good)	Base	101	11.8	11.7	52	34	22	16	703	200	S6	5.8	1.02	0.90	1.15
	Sub-base	98	8.7	9.0	28	14	31	13	716	150			0.59		
	Subgrade		12.1	10.8	11	-	34	16	1040				**1.62**	**0.90**	**1.55**
Section 1 (Fair)	Base	95	10.3	13.9	72	11	35	14	459	200	S3	5.8	1.02	0.90	1.02
	Sub-base	92	7.4	7.7	138	16	8	13	434	150			0.59	0.59	0.79
	Subgrade		4.4	8.2	50	-	5	13	377				**1.62**	**1.96**	**2.21**
Kikorongo - Mpondwe															
Section 1 (Fair)	Base	103	3.1	8.6	197	96	69	9.8	235	180	S5	2.1	0.92	0.90	0.90
	Sub-base	104	3.4	5.2	163	174	48	15.1	378	125			0.49	0.59	0.59
	Subgrade		4.9	10.3	37	-	25	13.4	657				**1.41**	**1.49**	**1.49**
Section 2 (Poor)	Base	100	4.3	8.9	142	42	39	9.4	169	240	S5	2.1	1.23	0.90	0.90
	Sub-base	97	2.9	5.8	127	24	21	17.8	409	100			0.39	0.59	0.59
	Subgrade		4.1	6.2	41	-	24	12.3	480				**1.62**	**1.49**	**1.49**
Section 3 (Good)	Base	100	3.8	8.5	238	61	54	8	184	210	S3	2.1	1.08	0.90	1.02
	Sub-base	93	3.2	5.8	178	29	29	10.1	253	100			0.39	0.59	0.69
	Subgrade		9.4	11.6	28	-	7	18.5	1314				**1.47**	**1.96**	**2.11**

Zambia Sections															ORN 31	
Section	Layer	Relative Compaction (%)	FMC (%)	OMC (%)	FMC/OM	CBR Insitu (%)	CBR soaked @ Field density	CBR at design density	PI	PM	Test Pit Thicknes s (mm)	Subgrade Class	MESA	SN Actual	SN Chart (0.7-1.5 MESA) T3	SN Chart (3-6 MESA) T5
Samfya - Musaila 1 (Cracked)	Base	100	8.4	8.6	1.0	106	17	10	7	180	150			0.77		1.02
	Sub-base	80	9.0	8.0	1.1	55	2	18	8	263	200			0.71		0.99
	Subgrade		8.7	7.8	1.1	28		2	7	531		S1	3.1 - 3.4	**1.48**		**3.11**
Samfya - Musaila 2 (Good)	Base	78	6.2	7.5	0.8	197	1	40	7	205	160			0.82		1.02
	Sub-base	75	7.5	7.3	1.0	125	1	28	10	267	140			0.55		0.99
	Subgrade			7.0	0.0	24		2				S1	3.1 - 3.4	**1.37**		**3.11**
Samfya - Mukuku 1 (Good)	Base	92	12.1	7.5	1.6	73	11	25	7	229	150			0.77	0.90	
	Sub-base	82	11.1	5.6	2.0	121	3	28	7	201	150			0.59	0.69	
	Subgrade		7.9	8.4	0.9	64		2	NP	NP		S1	1.3 - 1.4	**1.36**	**2.69**	
Samfya - Mukuku 2 (Potholed)	Base	85	12.2	7.5	1.6	291	4	80	6	182	200			1.02	0.90	
	Sub-base	83	12.8	5.5	2.3	53	3	11	8	259	200			0.51	0.69	
	Subgrade		9.3	7.6	1.2	50		1	NP	NP		S1	1.3 - 1.4	**1.54**	**2.69**	
Mansa - Bahati 1 (Potholed)	Base	86	14.9	7.5	2.0	95	1	12	9	371	150			0.77	0.90	
	Sub-base	83	25.3	8.6	2.9	23	1	1	16	847	150			0.47	0.69	
	Subgrade		17.1	9.0	1.9	14			9	541	200		0.9 - 1.1	0.51		
			17.1	9.6	1.8			2	11	788		S1		**1.75**	**2.69**	
Mansa - Bahati 2 (Fair/Good)	Base	85	8.8	7.0	1.3	145	3	70	6	146	150			0.77	0.90	
	Sub-base	85	11.0	7.0	1.6	53	1	5	8	500	150			0.18	0.59	
	Subgrade		6.3	6.3	1.0	100		7	5	369		S3	0.9 - 1.1	**0.95**	**1.88**	

Annex 4 List of Participants in Joint Analysis Workshops

Name	Organisation	Job Title
UGANDA		
Steven Musumba	UNRA	Laboratory Manager
Andrew Otto	TRL	BA Team Leader
Kenneth Mukura	TRL	BA LVR Expert
Robert Obetia	KOM Consult	Database Manager
Isaac F A	KOM Consult	Field Supervisor
Peter Muhanguzi	KOM Consult	Highway Engineer
Lorna M Nibyagaba	GFS Engineering Services	Laboratory Manager
Denis Onapa Miaduch	GFS Engineering Services	Senior Laboratory Technician
Rodgers Mugume	UNRA	Research Fellow
ZAMBIA		
Presley Chilonda	RDA	Principal Engineer
Geoffrey Siwanzi	RDA	Engineer Quality
Peter Gumbo	RDA	Principal Engineer
Dominic Pamu	RDA	Materials Engineer
Kenneth Mukura	TRL	BA LVR Expert

Tony Greening	-	Consultant Advisor to BA Project
Musonda C Mwale	RDA	Principal Engineer – Urban and Rural Roads
Sundie Silwimba	RDA	Engineer – Planning and Design
Andrew Otto	TRL	BA Team Leader
Christopher Ngwira	RDA	Engineer - Research
Andrew Mwale	RDA	Laboratory Manager
GHANA		
Andrew Otto	TRL	BA Team Leader
Olivia Soli	GHA	Research Manager
Balika Edmond	MRH	Engineer
Jerry M Kittoe	DFR	Engineer
Emmanuel Aboagye	DFR	Engineer
Joseph Mausi	DFR	Engineer
E A Gobadayo	MRH	Principal Engineer
Raymond O Nuamah	GHA	Engineer
Patrick Bekoe	DFR	Principal Engineer
Tony Greening	-	Consultant Advisor to BA Project
Isaac Tackie-Nyadeh	GHA	Materials Engineer

Leah Musenero	TRL	BA Field Engineer
MOZAMBIQUE		
Sultane Badrui	ANE - Gaza	Laboratory Technician
Fernando Dabo	ANE	Civil Engineer
Rubina Normahomed	ANE	Head – Maintenance Department
Osorio Antonio Muianga	ANE - Maputo	Head – Technical Department
Valter Sereso Jose Dos Santos	ANE - Maputo	Tecnico – Seguranca Rodoviaria
Belmiro Rodolfo	ANE - Gaza	Head – Technical Department Gaza
Cedrik Edson Namburete	ANE - Inhambane	Civil Engineer
Jeremiah A.P. Cumbane	LEM	Tecnico Especializado

Annex 5 Detailed Questionnaire Feedback

No.	Feedback Questions	Individual Responses : Scale 1 minimum (worst) and 5 maximum (best)														
		R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	**Average**
1	How would you rate your knowledge of low volume roads materials Before the Back Analysis Project or this workshop?	1	3	5	3	3	3	3	2	3	3	3	3	2	1	**3**
2	How would you rate your knowledge of low volume roads materials After the activities and trainings carried out in the Back Analysis Project or this workshop?	4	5	5	3	4	4	4	4	4	2	3	4	3	3	**4**
3	How much have you learned from this training?	5	4	5	4	4	5	4	5	5	5	3	3	4	4	**4**
7	Are there any subjects you feel should have been omitted (left out)?	None	None	N/A	None	-	No		None	None	-	-	-	None	-	
8	How do you rate this workshop overall?	5	5	5	4	4	5	3	5	5	5	8	4	5	5	**5**
9	How do you rate the facilities of the training?	4	4	4	4	4	4	3	5	5	5	4	3	5	4	**4**

Other questions and feedback

Q3. How much have you learned from this training? If your answer was 4 or 5, why do you think this?

- The details and insight revealed by the analysis process shed those light on the thinking process in low volume roads design.
- I have learned new things and further understood those I was previously familiar with.
- At least I have got knowledge of choice of materials use for LVR and how its performs
- It brought out empirical evidence about the performance of roads in Ghana
- Low volume roads at the minimum specifications are performing better even at those specifications so our high standards for these roads should be looked at again
- I appreciate too much all the issues
- Got a lot of new knowledge, some of my understanding and doubts were clarified
- I think this because I got knowledge about design of pavements, and this is the first thing to analyse and understand the performing of the roads and help choose the best solutions.
- I came with little knowledge and with this training I got more knowledge

Q4. What part/s of this workshop did you find most useful?

- Presentations and discussions
- The practical data entry and analysis of field data
- Everything
- All aspects of the training is very useful
- All parts
- The calculation of the structural Number and the software of DCP calculation
- Structural Number calculation, practical exercises after theoretical explanations
- The part that talked about structural number
- All training was most useful

Q5. What part/s of this workshop did you find least useful?

- The hands-on approach in explaining how to carry out data analysis

Q6. Are there any subjects you feel should have been included (added)?

- Not one I can think of at the moment
- High volume and high performing roads (Trunk Roads)
- At least sealing of shoulders of roads
- Traffic Analysis (Axle Calculations)
- More details about traffic, know how to classify traffic, calculations of ESA, etc.

Q10. Please add any other comments below.

- More exposure to trunk roads using the same back analysis
- It was a very useful training; the Ministry should embark on a long-term data collection and analysis to be used for the modification of its current standards
- Overall workshop is very useful and more such programme should be organised
- More time for exercises and discussions would be useful
- This training very good

- Many points I had no opportunity to see because I only participated in the second day