REPUBLIC OF KENYA

MINISTRY OF ROADS, PUBLIC WORKS & HOUSING

PRELIMINARY DESIGN & FEASIBILITY STUDY FOR THE

REHABILITATION AND PERIODIC MAINTENANCE OR STRENGTHENING WORKS OF THE

MACHAKOS TURNOFF-ULU-SULTAN HAMUD NAIROBI-LIMURU-KAMANDURA AND THIKA-KAMAE-MAGUMU ROADS (A109/C62/C66)

FINAL

ENVIRONMENTAL IMPACT ASSESSMENT STUDY REPORT

April 2003

NORCONSULT INTERNATIONAL A.S
P.O. Box 48176
NAIROBI

PERMANENT SECRETARY
MINISTRY OF ROADS AND PUBLIC WORKS
P.O. Box 30260 NAIROBI

MACHAKOS TURNOFF – SULTAN HAMUD (A109), THIKA – KAMAE – MAGUMU ROADS (C66) AND NAIROBI – LIMURU – KAMANDURA (C62)

INITIAL ENVIRONMENTAL IMPACT ASSESSMENT STUDY

Table of Contents

Chapter	Description	Page
	EXECUTIVE SUMMARY	i
1	**INTRODUCTION**	
1.1	Background	1-1
1.2	Objective of the Study	1-1
1.3	Approach and Methodology	1-1
1.4	Presentation of the Report	1-2
2	**ENVIRONMENTAL LEGISLATION**	
2.1	Kenyan Legislation	2-1
2.2	Other Laws Related to Land and Natural Resources Management	2-1
2.3	Public Health	2-2
2.4	International Legislation	2-2
3	**ENVIRONMENTAL PROFILE**	
3.1	General	3-1
3.2	**Machakos Turnoff – Sultan Hamud (A109)**	
	3.2.1 Administrative Location of the project road	3-1
	3.2.2 Services	3-2
	3.2.3 Demographic Characteristics	3-2
	3.2.4 Climate and Rainfall	3-2
	3.2.5 Topography, Drainage, Geology and Soils	3-3
	3.2.6 Forests and Forest Resources	3-3
	3.2.7 Agro-ecological Zones	3-3
	3.2.8 Wetlands and Wildlife	3-4
	3.2.9 Current Land Use Activities	3-4
	3.2.10 Minerals and Materials	3-4
3.3	**Thika – Kamae – Magumu Road (C66)**	
	3.3.1 Administrative Location of the project road	3-4

Chapter	Description	Page
	3.3.2 Services	3-5
	3.3.3 Demographic Characteristics	3-5
	3.3.4 Climate and Rainfall	3-6
	3.3.5 Topography, Drainage, Geology and Soils	3-6
	3.3.6 Forests and Forest Resources	3-7
	3.3.7 Agro-ecological Zones	3-7
	3.3.8 Wetlands, Wildlife and Fisheries	3-7
	3.3.9 Current Land Use Activities	3-7
	3.3.10 Minerals and Materials	3-8
3.4	**Nairobi – Limuru – Kamandura Road (C62)**	
	3.4.1 Administrative Location of the project road	3-8
	3.4.2 Services	3-8
	3.4.3 Demographic Characteristics	3-8
	3.4.4 Climate and Rainfall	3-9
	3.4.5 Topography, Drainage, Geology and Soils	3-9
	3.4.6 Forests, Forest Resources and Vegetation	3-9
	3.4.7 Agro-ecological Zones	3-10
	3.4.8 Wetlands and Wildlife	3-10
	3.4.9 Current Land Use Activities	3-10
	3.4.10 Minerals and Materials	3-10
4	**KEY PROJECT COMPONENTS**	
4.1	Machakos Turn Off – Ulu – Sultan Hamud, Road (A109)	4-1
4.2	Thika – Kamae – Magumu Road (C66)	4-3
4.3	Nairobi – Limuru – Kamandura Road (C62)	4-5
5	**EXISTING IMPACTS AND OBSERVATIONS**	
5.1	General	5-1
5.2	Positive Impacts	5-1
	5.2.1 Economic Benefits	5-1
	5.2.2 Provision of Access	5-1
5.3	Negative Impacts	5-1
	5.3.1 Gravel Pits	5-1
	5.3.2 Hydrology and Drainage	5-2
	5.3.3 Erosion	5-2

Chapter	Description	Page
	5.3.4 Impact on Town Centres/Settlements	5-2
	5.3.5 Road Safety	5-3
	5.3.6 Road Reserve	5-3
6	**ANTICIPATED IMPACTS DUE TO THE REHABILITATION WORKS**	
6.1	General	6-1
6.2	Machakos Turnoff – Ulu – Sultan Hamud (A109)	6-2
6.3	Thika – Kamae – Magumu Road (C66)	6-4
6.4	Nairobi – Limuru – Kamandura (C62)	6-8
6.5	Summary of Main Issues	6-11
7	**MITIGATION OF IMPACTS**	
7.1	General	7-1
7.2	Hydrology	7-1
7.3	Soil Erosion	7-1
7.4	Pollution	7-1
7.5	Deviations	7-2
7.6	Compensation	7-2
7.7	Gravel Pits and Quarries	7-3
	7.7.1 Excavation of Gravel Pits and Hardstone Quarries	7-3
	7.7.2 Rehabilitation	7-3
7.8	Trading Centres and Settlements	7-3
7.9	Vegetation	7-4
7.10	Livestock	7-4
7.11	Workmen's Camps	7-4
	7.11.1 Local Resources	7-4
	7.11.2 Location of the Camps	7-4
7.12	Public Health and Occupational Safety	7-4
7.13	Road Safety	7-5
7.14	Visual Enhancement	7-5
7.15	Public Awareness	7-5
7.16	MORPW Environmental Requirements	7-5

Chapter	Description	Page
8	**ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN**	
8.1	General	8-1
8.2	Environmental Monitoring and Management	8-1
8.3	Institutional Responsibilities	8-19
9	**CONCLUSIONS AND RECOMMENDATIONS**	
9.1	Conclusions	9-1
9.2	Recommendations	9-1

LIST OF TABLES

Table		Page
Table 3.1	Projected Populations and Population densities by division along the A109 project road	3-2
Table 3.2	Projected Populations and Population densities by division along the C66 project road	3-5
Table 3.3	Populations and Population densities along the C62 project road.	3-9
Table 6.1	Anticipated Environmental Impacts on the A109	6-2
Table 6.2	Anticipated Environmental Impacts on the C66	6-4
Table 6.3	Anticipated Environmental Impacts on the C62	6-8
Table 6.4	Environmental Characteristics of Gravel Pits and Hardstone Quarries along the Machakos Turnoff – Ulu – Sultan Hamud Road	6-13
Table 6.5	Environmental Characteristics of Gravel Pits and Hardstone Quarries along the Thika-Kamae-Magumu Road	6-14
Table 6.6	Environmental Characteristics of Gravel Pits and Hardstone Quarries along the Nairobi-Limuru-Kamandura Road	6-15
Table 8.1	Monitoring and Management of Impacts and Mitigation Measures on the A109	8-3
Table 8.2	Monitoring and Management of Impacts and Mitigation Measures on the C62	8-9
Table 8.3	Monitoring and Management of Impacts and Mitigation Measures on the C66	8-15

APPENDICES

Appendix A LOCATION MAPS AND AGRO-ECOLOGICAL ZONE MAPS OF THE PROJECT ROADS

Map 1	Location of the A109 in Makueni District
Map 2	Location of the A109 in Machakos District
Map 3	Makueni District Agro-Ecological Zone Map
Map 4	Machakos District Agro-Ecological Zone Map
Map 5	Thika District Agro-Ecological Zone Map
Map 6	Kiambu District Agro-Ecological Zone Map

Appendix B REFERENCES AND TOPOGRAPHICAL MAPS

Appendix C MONITORING CHECKLIST

List of Abbreviations and Acronyms used in this report

AEZs	Agro-Ecological Zones
BoQ	Bill of Quantities
DWO	District Works Officer
EIA	Environmental Impact Assessment
EMMP	Environmental Management and Monitoring Plan
GCS	Gravel Crushed Stones
HGV	Heavy Goods Vehicles
Km	Kilometres
LH	Lower Highland
m	metres
mm	millimetres
MORPW	Ministry of Roads and Public Works
STDs	Sexually Transmitted Diseases
ToR	Terms of Reference
UM	Upper Midland
UNEP	United Nations Environmental Programme

EXECUTIVE SUMMARY

I. INTRODUCTION

Poor road conditions have been a major obstacle for development in Kenya. In view of this, the Ministry of Roads and Public Works, Government of Kenya (GoK) with funding from the World Bank, contracted Norconsult A.S. Kenya for the Preliminary Design, Feasibility Study, Detailed Engineering Design and Contract Documentation for the Rehabilitation and Periodic Maintenance and Strengthening of Works on three roads.

One of the objectives of the study was to identify the most appropriate economically justified rehabilitation and periodic maintenance or strengthening solutions for each of the study roads.

This environmental study is part of the preliminary feasibility study on three project roads: the Machakos Turnoff-Ulu-Sultan Hamud Road (A109), Nairobi-Limuru-Kamandura Road (C62), and the Thika-Kamae-Magumu Road (C66).

II. PROJECT SETTING

The locations of the three project roads are indicated in the 'Location Map of Project Roads' in Appendix A.

The three roads traverse areas of high to moderate population. The Machakos Turnoff-Ulu-Sultan Hamud Road is part of the international trunk highway and traverses two districts, Machakos and Makueni. The Thika-Kamae-Magumu Road traverses commercial sectors in Thika and Kiambu that are well developed. This is attributed to the high incomes generated from the growth of tea and coffee in agriculturally high potential areas.

III. DESIGN COMPONENTS

The project involves the feasibility and preliminary design for periodic maintenance, strengthening and reconstruction of the project roads. Only four realignments, less than 500 m each, are proposed for only one of the three project roads, the A109, necessary to smoothen curves along the project road.

IV. EXISTING IMPACTS

Economic benefits derived from the project roads are most obviously noticed along the A109 and C62. The A109 is part of the Nairobi – Mombasa international trunk road, and carries a substantial amount of traffic including heavyly loaded trucks. The C62 provides an alternative and quicker access route to Limuru town and other market centres along the road.

Better access to rural areas often leads to higher prices for land, as compared to the same sized plot in areas where access is difficult. Numerous schools and health centres located along the C66 are made accessible by the road.

Several open gravel pits were noticed along the Machakos Turnoff-Ulu- Sultan Hamud road, none of which have been rehabilitated. The land has little value in terms of crop production, so selling of material from the pit is of benefit to the owners. The accumulation of water in some of the pits poses a potential malaria risk. Erosion was also noticed at the edges of some pits.

Impeded drainage in culverts is a factor featured along all three of the project roads. Along the Thika-Kamae-Magumu road, a few drains are water logged, due to the inadequate gradient in the construction of the drains. On the Machakos Turnoff-Ulu- Sultan Hamud road, the armco culverts provided are inadequate to cater for the flow of water.

The Nairobi-Limuru-Kamandura road has no evident drainage problems but the structural design of the culverts and will need to be reviewed as part of the investigations.

Erosion was noticed on all the project roads, along the sides of the roads. This was more evident on the A109, attributed to road runoff and partially blocked or lack of drainage structures.

The provision of proper parking bays for long haul trucks and heavy goods vehicles in order to reduce congestion and increase safety on the A109 is necessary. There are no pathways for pedestrians and cyclists along any of the project roads, nor any signs to warn motorists of their presence.

V. ANTICIPATED IMPACTS

In general, the proposed improvement works to the three project roads will pose minor environmental problems because any changes to the hydrological regime, vegetation, etc., occurred when the alignments were originally cleared and the roads constructed.

Positive impacts will result from better flow of traffic, improved access to markets, schools, health centres and administrative centres. During construction, opportunities for temporary employment will arise for the local people.

A major negative impact during construction will be soil erosion due to earthworks (including deviations). More significant impacts will arise from the ecological damage from the clearance of areas for construction camps, storage of materials (fuel, lubricants and machinery) and road widening for the C66 and C62 roads. The acquisition of land for road widening and smoothening of curves will be necessary along the A109. Air, dust and noise pollution will also be a problem, though this is expected to revert to the present situation after construction.

The workforce may exert pressure on water and fuel wood sources, and may contribute to the spread of sexually transmitted diseases (STDs) in the towns/settlements. Sanitation and solid waste disposal at the construction camps are issues that could also impact negatively on the environment.

VI. MITIGATION

Mitigation is possible for all adverse impacts that may result from the proposed rehabilitation works.

Hydrological impacts can be minimised by allowing unimpeded flow of water, i.e. through installing adequate box or pipe culverts in the road design.

Impacts due to earthworks can be reduced by exercising care, and if possible, carrying out these activities during the dry season. Replanting areas cleared for deviations, and vegetating slopes and embankments would help to prevent soil loss and reduce visual intrusion.

The introduction of speed restrictions will reduce dust emissions along deviations. Asphalt and crushing plants should be located downwind of settlements to reduce disturbance caused by noise and dust pollution to nearby residents. Sensitising motorists and providing special parking areas with provision for carrying out maintenance works for trucks to control oil and noise pollution will be necessary at Makutano and Salama on the A109.

Deviations should remain within the road reserve as far as is practically possible. Land acquired for realignments and the extension of road reserves must be fairly and promptly compensated. Similarly, crops and existing structures on land outside the road reserve that is temporarily acquired for deviations should be compensated. During the detailed design stage a Compensation Plan should be prepared in order to address these issues.

Locating workmen's camps at the major centres will minimise some impacts. For cooking, camps should use gas or kerosene to preclude the need to buy charcoal, and a central canteen for

the workforce would reduce energy and water consumption and the amount of solid waste generated. STD awareness campaigns should be conducted in the camps as well as in the trading centres along the project roads.

Workmen should be provided with suitable protective working gear. Fully equipped first aid kits should be kept on site and the contractor must have workmen's compensation cover.

Road safety can be enhanced through installing clear and frequent road signs and markings.

Diligence on the part of the contractor is essential in mitigating negative impacts, and therefore mitigation measures should be specified in the tender documents and conditions of contract.

VII. MONITORING

Mitigation measures, design features, or actual impacts can be monitored to ensure environmental acceptability of the project during and after construction. In some cases, monitoring can be done as part of routine or periodic maintenance, while other parameters, especially socio-economic or ecological ones, can only be effectively assessed in the longer term. Parameters that can be monitored include:

- efficiency of drainage structures
- soil conservation interventions
- gravel pit rehabilitation
- sanitation at workmen's camps
- impact on public health (due to STDs, clean drinking water)
- air quality
- water quality
- noise quality
- impact on road safety

VIII. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The improvement works on the three project roads will no doubt contribute to promoting economic development in the study area. As a result, socio-economic benefits, such as improved standards of living, improved health and education levels are also expected.

As all three project roads already exist, the natural environment has already been considerably altered. Therefore any major impacts have already occurred and additional disturbances due to construction works will be relatively minor.

Recommendations

The recommendations made in this report are summarised as follows:

- cordon off or fence gravel pits during use, and rehabilitate them after;
- provide road shoulders for non-motorised traffic;
- plant shrubs and grasses along road embankments to prevent erosion;
- avoid unnecessary clearing of vegetation to preclude additional erosion;

- plant trees, especially at settlements/centres, to improve visual aesthetics and as filters for particulate matter;
- provide special parking areas at Makutano and Salama;
- inform local people of the details and progress of the project, particularly those who will be affected by the realignments and extension of the road reserve;
- compensate landowners who must relinquish their land/crops/structures for the project road;
- prepare a Compensation Plan;
- include mitigation measures in the tender and contract documents so that the contractor is bound to implement them.

CHAPTER 1 INTRODUCTION

1.1 Background

Norconsult A.S. Kenya was invited in September 1997 to submit a tender to the Ministry of Public Works and Housing (now Ministry of Roads and Public Works), for the Preliminary Design, Feasibility Study, Detailed Engineering Design and Contract Documentation for the Rehabilitation and Periodic Maintenance and Strengthening of Works of three roads. The roads are Machakos Turnoff-Ulu-Sultan Hamud Road (A109), Nairobi-Limuru-Kamandura Road (C62), and the Thika-Kamae-Magumu Road (C66). The World Bank provides funding for the three project roads. Investigations for the Preliminary Design and Feasibility Study began in January 2001.

The Machakos Turnoff-Ulu-Sultan Hamud Road forms part of the Nairobi – Mombasa international trunk road. This road is important in terms of economic activity and it is vital that the road remains in sound condition. The Nairobi-Limuru-Kamandura Road is the shortest of the study roads and traverses through high potential agricultural land, which is densely populated and intensely cultivated. The Thika-Kamae-Magumu Road is the longest of the study roads and traverses indigenous and plantation forests home to a number of wildlife species.

An initial environmental impact assessment, of the existing roads and proposed works was undertaken as part of the requirements of the contract. An environmental management, mitigation and monitoring plan has been prepared to provide details of mitigation measures to reduce existing impacts and minimise any additional adverse environmental impacts during and following construction. Schedules for effecting proposed measures, monitoring of impacts after rehabilitation are included where possible. In addition, the environmental mitigation plan will outline institutional requirements and responsibilities necessary for successful implementation of mitigation measures, and where possible, estimate costs for incorporating these measures.

1.2 Objectives Of The Study

The objectives of the study are:

i) To identify the most appropriate economically justified rehabilitation and periodic maintenance or strengthening solutions for each of the study roads.

ii) To produce detailed engineering designs and contract documents for each of the study roads. The designs will incorporate appropriate environmental mitigation and monitoring measures.

The objective of the initial environmental impact assessment (EIA) study is to document the present condition of the environment and assess the positive and negative impacts due to the rehabilitation of the three roads together with the necessary mitigation measures.

The requirements of the environmental study are indicated in the Terms of Reference.

1.3 Approach And Methodology

The approach and methodology for conducting this study is based on World Bank environmental guidelines, and the Kenyan draft National Environmental regulations and guidelines as provided for in the Environmental Management and Co-ordination Act, 1999.

At the time the project was conceived and put to tender the Environmental Management and Co-ordination Act was not in place. As a result no screening and scoping studies were carried out, and therefore this study has been conducted as an initial EIA study.

The EIA study is part of the road improvement works, and aims to highlight the environmental issues of concern that need to be considered during the planning, design, construction and operation phases of the study.

The methodology used for this assessment was based on the standard World Bank method and involved four basic tasks:

- A review of the existing environmental conditions;
- Identification of the anticipated impacts;
- Identification of appropriate mitigation measures and/or design changes to eliminate or reduce the identified impacts and
- The formulation of an environmental management, mitigation and monitoring plan.

Field work for the environmental study was conducted in the second week of February 2001. Data on topographical surveys, hydrology and drainage, traffic surveys and data, soils and materials investigations, and condition surveys of the existing project roads were collected in the field during the following weeks.

At the time the initial study was carried out, the National Environment Management Authority (NEMA) had not been established. NEMA requires that any report pertaining to an EIA, such as this done in accordance with the ToR, should first be submitted to the Permanent Secretary in the Ministry of Roads and Public Works (MoRPW), who then submits it to NEMA for review and approval.

1.4 Presentation of the Report

This report presents the findings of the initial environmental study for all the three project roads, and recommends mitigation measures that should be incorporated in order to minimise adverse impacts that may arise from the rehabilitation works.

Chapter 1 gives background information relevant to the study, describing the objectives and requirements of the study.

Chapter 2 outlines the legislative and regulatory framework of the study.

Chapter 3 presents the environmental profile and describes the administrative, physical, natural and social environments of the project areas.

Chapter 4 briefly outlines the anticipated project components that are relevant to the environmental study.

Chapter 5 describes the impacts and observations from the existing roads.

Chapter 6 addresses impacts anticipated as a result of the improvement works.

Chapter 7 provides a summary of the mitigation measures.

Chapter 8 provides an environmental management and monitoring plan for each of the three roads.

Chapter 9 presents conclusions and recommendations.

CHAPTER 2 ENVIRONMENTAL LEGISLATION

2.1 Kenyan Legislation

An Environmental Impact Assessment study (EIA) is a legal requirement in Kenya for all development projects. The Environmental Management and Co-ordination Act 1999, is the legislation that governs EIA studies. This EIA falls under the Second Schedule of the Act, which lists the projects to undergo EIA studies in accordance with section 58 (1-4) of the Act. These projects are considered to pose potentially negative environmental impacts. Part 3 of this Schedule, refers to transportation projects and these include *inter alia*, all major roads and all roads in scenic, wooded or mountainous areas and wetlands.

The law has made provisions for the establishment of the National Environment Management Authority (NEMA), which has the statutory mandate to supervise and co-ordinate all environmental activities. This report upon completion will be submitted to NEMA who will determine if the intended rehabilitation works of the project may or is likely to have or will have a significant impact on the environment.

Reference has also been made to the draft **National Environmental Guidelines** specifically related to the roads sector.

2.2 Other Laws Related to Land and Natural Resources Management

Policies and legislation highlighting the legal and administrative requirements pertinent to this study and relating to land and natural resources, water management, forests and public health are briefly summarised below.

The Local Government Act Chapter 265 Laws of Kenya: provides for making by-laws and institutions by the Local County Councils. By-laws can be made on the governance of a project under the provisions of this Act.

The Registered Land Act Chapter 300 Laws of Kenya: provides for the absolute proprietorship over land (exclusive rights). Such land can be acquired by the state under the Land Acquisition Act Land in the project area.

The Land Adjudication Act Chapter 95 Laws of Kenya: provides for ascertainment of interests prior to land registrations under the Registered Land Act.

The Wayleaves Act Chapter 292 Laws of Kenya: provides for certain undertakings to be constructed e.g. pipelines, canals, pathways etc., through or under any lands. The project is under the provision of the Act.

The Water Act Chapter 372 Laws of Kenya: The Act vests the water in the State and gives the provisions for the water management, including irrigation water, pollution, drainage, flood control and abstraction. It is the main legislation governing the use of water especially through water permit system.

The Lakes and River Act Chapter 409 Laws of Kenya: This Act provides for protection of river, lakes and associated floral and fauna. The provisions of this Act may be applied in the management of the project.

Forests Act, Chapter 385. This Act provides for the establishment, control and regulation of Central Forests, forests and forest areas in the Nairobi Area and on unalienated Government land.

2.3 Public Health

The MoRPW has guidelines on environmental protection and mitigation. In the Ministry's Standard Specification for Road and Bridge Construction a number of clauses address protection from water, health safety and accidents, water supply, maintenance of the engineers staff houses, offices, laboratories, and attendance upon the engineer and his staff. (Standard Specification Clauses 116, 117, 125, 135, 137).

The Public Health Act Laws of Kenya: Provides for the securing of public health and recognises the important role of water. It provides for prevention of water pollution by stakeholders, among them Local Authorities (county councils).

2.4 International Legislation

This EIA is also based on internationally respected procedures recommended by the World Bank in the World Bank Operational Directives 4.01 and Environmental Assessment Source Book Volume II, which provides the relevant sectoral guidelines. As such, this EIA is intended to meet the expectations of international financiers and Kenyan adjudicators.

CHAPTER 3 ENVIRONMENTAL PROFILE

3.1 General

The study area for the Machakos Turnoff-Sultan Hamud Road (A109) traverses Machakos and Makueni Districts. The road is located within a rectangle between latitude 1° 31′ south and longitude 37° 07′ east and latitude 1° 57′ south and longitude 37° 19′ east at elevations between 600 and 700 m above sea level. The road forms part of the Nairobi – Mombasa highway. The road can be divided into two sections, the Machakos Turnoff to Ulu section and the Ulu to Sultan Hamud section. The Machakos Turnoff-Ulu section is approximately 30 km long and traverses the Athi and Kaputei Plains falling gently from Machakos to Ulu in a south-easterly direction. The Ulu-Sultan Hamud section is approximately 25 km long continuing in the same south-easterly direction ending 8 km before Sultan Hamud.

There are a few noted hill ranges along the A109 project road, such as Kalama Hill north of Konza (near Machakos Town) and Kilima Hills to the north of Sultan Hamud. There are no permanent rivers or streams crossing this section of the road but there are two notable river crossings, Isinya River (seasonal) which crosses the road at Ulu and Muoni River (seasonal) from the Kilima Hills towards the end of the project road. There are however numerous crossings of small perennial streams.

The Thika – Kamae – Magumu road (C66) is located primarily in Thika District starting at latitude 1° 02′ south and longitude 37° 03′ east and ends at latitude 0° 51′ south and longitude 36° 33′ east. The road connects the A2 (Nairobi – Thika Road) to the A104 (Nairobi – Nakuru Road). The C66 rises gently from Thika through Gatukuyu, Mangu, Kamwangi and Kanjuku before rising fairly steeply to the high tea growing areas of Gakoe, then meanders through the lower reaches of the Aberdare Ranges through Thunguri, Kieni and Kamae before emerging at Magumu joining the A104 at the escarpment. This road passes through the gazetted forests of Kamae and Kieni.

The Nairobi – Limuru – Kamandura road is the shortest of the three roads, at approximately 26 Km and runs in a north-westerly direction from Nairobi. It is located between latitudes 1° 15′ and 1° 07′ south and longitudes 36° 49′ and 36° 38′ east. The road stretches from the northern suburbs of Nairobi through Gigiri and onto a number of densely populated areas including Ruaka, Ndenderu, Ngecha and to the junction of the main Nairobi – Nakuru Road (A104) at Kamandura.

3.2 Machakos Turnoff – Sultan Hamud

3.2.1 Administrative Location of the project road

The road traverses two districts, Central Division of Machakos District, which covers the section from the Machakos Turnoff to the junction at Kwangati seasonal river and A109 at latitude 1° 45′ south and longitude 37° 12′ east. The other section is in Kasikeu Division of Makueni District and ends at 1° 57′ south and longitude 37° 19′ east. Kasikeu Division is situated in the north-western part of Makueni District. Maps 1 and 2 (Appendix A) show the location of the roads in the two districts.

3.2.2 Services

This road forms part of the A109 international trunk road. Most of the formal sector activities take place at market centres located along the Mombasa – Nairobi Highway such as Salama and Sultan Hamud.

Surface water is scarce in the district, and is mainly derived from rivers, some of which are seasonal, springs and dams. Due to the varying rock formations in the district, groundwater is not uniformly distributed. The boreholes in Kasikeu have good yields though the water is saline.

There is only one major power line along the Nairobi – Mombasa road serving a few urban and market centres including Salama. The major sources of energy in the district are wood fuel, charcoal and diesel driven generators. (*Makueni District Development Plan, 1997 – 2001*)

3.2.3 Demographic Characteristics

Population Structure and Distribution

According to the 1989 census based on figures from the Makueni and Machakos District Development Plans 1997 – 2001, the populations of Makueni and Machakos Districts are growing at a rate of 3.09%. This rapid increase in population is attributed to the immigration of people from neighbouring districts onto the settlement schemes in the districts. Table 3.1 tabulates the projected populations of the divisions along the project road.

Table 3.1 Projected Populations and Population densities by division along the A109 project road.

Division	Projected Population 1999	Projected Density in 1999 persons/sq km	Projected Population 2001	Projected Density in 2001 persons/sq km
Kasikeu	47,981	176	51,040	199
Kilome	90,360	139	96,120	157
Central	158,601	220	168,712	234

Source: District Planning Unit, Wote, 1996 and 1989 Kenya Population Census, District Planning Unit, Machakos.

The population density has been influenced over the years by rural trade and production centres such as Salama and Sultan Hamud. These towns offer the district industrial activities because they are better provided with infrastructure and other social facilities. The population in these towns is between 15,000 and 20,000 people. With connection to electricity, access to market outlets and services such as Kenya Posts and Telecommunications, makes these areas potential centres for industrial investment.

3.2.4 Climate and Rainfall

The project road falls under agro-climatic zone V, which is classified as semi-arid, with an average annual rainfall of 450 – 900 mm, falling in two seasons. Long rains occur in March/April continuing to the end of May, and the short rains in October/November continuing to the end of December. The stretch of road inches between the Machakos Turnoff to Konza and

Sultan Hamud crosses an area that receives most its rainfall between March – May and October – December.

Temperature slightly varies along the project road, getting progressively warmer towards the end of the project road. The districts are generally hot and dry experiencing high temperatures during the day and low temperatures during the night. Extreme heat is more pronounced, especially in the low-lying regions, during the dry season between March and October (*Machakos* and *Makueni District Development Plans 1997-2001* and *Agro-climatic Zone Map of Kenya, 1980*).

3.2.5 Topography, Drainage, Geology and Soils

The A109 traverses the Athi and Kaputei Plains. All catchments drain in a south-easterly direction towards the Indian Ocean on the Kenyan coast. The are no permanent rivers or streams crossing the A109, however, there are numerous crossings of small ephemeral streams.

The road traverses well drained soils of which there are three soil types evident:

- Acrisols – these soils are dominant near the start of the road
- Cambisols – these are present near the end of the road
- Vertisols – poorly drained black cotton soils are evident on the Kaputei plains.

From Kilima Kui at Km 43 to the end of the project road, the soils are mainly well drained, moderately deep to very deep, dark reddish brown to dark yellowish brown, friable to firm clays. These types of soils are developed on undifferentiated basement system rocks (predominantly of the gneisses type). North of the project road from Kilima Kui to the start of the project road at Machakos Turnoff, the soils are imperfectly drained moderately deep, dark greyish brown to black, very firm, gravelly, cracking clay. These types of soils are developed on quartz – feldspar gneisses. (*Exploratory Soil Map* and *Agro-climatic Zone Map of Kenya, 1980)*

3.2.6 Forests and Forest Resources

Forests in Machakos District are limited and are only found on the hilly masses in the high potential parts of the district (*Machakos and Makueni District Development Plans, 1997 – 2001*), though there are no significant forest reserves within the area of influence of the A109 project road.

The type of vegetation cover along the A109 is predominantly of the *Commiphora*-Acacia type. Acacia species are dominant where tree cover has been destroyed (by man, fire or animals), accompanied by *Commiphora* species such as *C. africana* and *C. baluensis*. There is also extensive grass cover along the road. Species tend to be *Tetrapogon bidentatus* and *Chrysopogon ancheri*. From around kilometre 39 there are smallholder cultivations of maize and bananas.

3.2.7 Agro-Ecological Zones

The Agro-Ecological Zones (AEZs) give an indication of the land potential, which is dependent on sound farming practices, improved seed and regimented planting programmes based on rainfall probabilities. Maps 3 and 4 (Appendix A), taken from the Makueni and Machakos District Development Plans 1997 – 2001 respectively show the AEZs for the project road.

The project road lies in the medium to lower potential AEZs. From the start of the project road at Machakos Turnoff, the road lies in the Upper Midland (UM) zone 6 and Lower Midland (LM) zones 5 and 6. A large portion of the project road lies in ranch land, other activities include, livestock rearing, and millet farming. The remainder of the project road, from the area around the Kwamakengi Hills, lies in UM zone 4 and LM zone 3. These used to be the main cotton zone before the collapse of the Wote Ginnery. They are now primarily cash crop zones.

3.2.8 Wetlands and Wildlife

There are no wetlands along the A109 project road. Wildlife can be found along ranches on the A109 project road, although Ol Donyo Sabuk National Park, in Matungulu Division, outside the project road zone of influence, is the only gazetted wildlife sanctuary in Machakos District. In Makueni District, there is no wildlife found along the project road environs.

3.2.9 Current Land Use Activities

Land use activities are very limited and vary along the project road, and is governed by factors such as climate (rainfall and temperature), soil conditions, altitude etc.

Any crop farming is mainly for subsistence purposes. Major food crops grown include maize, beans, pigeon peas and cowpeas. Cotton, sorghum and millet are grown in the lowland areas. Horticultural crops such as tomatoes, kales, onions, beans and okra are grown mainly for domestic consumption though the surplus can be exported. Coffee is the main cash crop grown in the highlands. The district produces only 75% of the potential yield in coffee production. This is attributed to the unreliable rains in the district and under utilisation of the irrigation potential.

Livestock reared include beef and dairy cattle, sheep, goats, rabbits, pigs and bees. Livestock is a major economic activity in the districts. Dairy and beef cattle populations have increased steadily over the years due to increased local demand.

3.2.10 Minerals and Materials

No commercial minerals have been discovered in Makueni District. However along the project road, there is plenty of sand, which is harvested along rivers and streams. The sand is used for building and construction industries in the district and in Nairobi (*Machakos* and *Makueni District Development Plans, 1997 – 2001*).

3.3 Thika – Kamae – Magumu Road

3.3.1 Administrative Location of the project road

The longest of the three roads at approximately 67 Km the Thika – Kamae – Magumu road is located primarily in Thika District and partly in Kiambu District, and a small section of the road lies in Nyandarua District to the west. The C66 road traverses three divisions, Thika and Gatundu Divisions in Thika District and Lari Division in Kiambu District.

The project road rises through hilly terrain from Thika to Magumu and passes through Kieni and Kamae Forests. The road starts at latitude 1° 02′ south and longitude 37° 03′ east in Thika District and ends at latitude 0° 51′ south and longitude 36° 33′ east at Magumu in Nyandarua District. The C66 crosses the Thika – Kiambu District at around latitude 0° 50′ south and longitude 36° 39′ east between the Kieni and Kamae Forests. The project road crosses into

Nyandarua District from Kiambu District at latitude 0° 51′ south and longitude 36° 35.6′ east approximately 4 Km from Kamae Forest Station.

3.3.2 Services

The commercial sectors in Thika and Kiambu Districts are well developed. This is attributed to the high incomes generated from the growth of tea and coffee in the agriculturally high potential areas.

The area covered by the project road passes through three major market centres. These include Kamwangi, Kanyoni, and Gakoe markets. The sources of energy in the districts are fuel wood, petroleum and electricity. There is an acute shortage of wood fuel in the district, due to encroachment into forests in a search for more farmland. Electricity is not adequate enough for the districts and in parts where it is used it is over utilised. Electricity utilisation rates in the rural areas, such as Kamwangi and Gakoe, are normal because it is mainly used for lighting purposes in homes.

Most of Kiambu District is well served with posts and telecommunication services, except for parts of Lari division. In Thika District these facilities are inadequate and as a result over utilised. Likewise the supply of water does not meet the demands for the communities. For example in Lari division, a number of water facilities have been vandalised in the past, coupled with the mismanagement of water projects has contributed to water shortages (*Kiambu* and *Thika District Development Plans 1997-2001*).

3.3.3 Demographic Characteristics

Population Structure and Distribution

Details obtained from the Thika District Development Plan 1997 – 2001 indicate that Thika's population is growing at a rate of 2.9% per year. This rapid rate of population increase has created a growing rate of imbalance between the supply of and demand for basic facilities such as schools, health facilities, water supply, and other services. Table 3.2 tabulates the projected populations of the divisions along the project road in Thika and Kiambu Districts.

Table 3.2 Projected Populations and Population densities by division along the C66 project road.

Division	Projected Population 1999	Projected Density in 1999 persons/sq km	Projected Population 2001	Projected Density in 2001 persons/sq km
Thika	101,948	386	101,035	401
Gatundu	135,372	750	143,455	778
Lari (Kiambu District)	116,499	206	123,391	219

Source: District Statistical Offices, Thika and Kiambu 1996

The high population growth has created pressure on the land, with the average farm size becoming progressively smaller due to sub-divisions.

3.3.4 Climate and Rainfall

The project road is located in the western part of Thika District and the upper highlands of Kiambu District. These areas are characterised by deeply dissected topography and drained by several rivers that flow from the Aberdare Ranges.

From the start of the project road to the area around Karuri Market at Km 28, the road falls under agro-climatic zone III. This area is classified as semi-humid with a mean annual temperature of between 18°C and 20°C. The majority of the project road from Karuri Market lies in the humid agro-climatic zone I. In this zone the mean annual temperatures are much cooler, averaging 12 – 16°C. The coldest months are June to August and the hottest are February to April. Towards the end of the project road at Magumu, the road lies in the sub-humid agro-climatic zone II.

The area of influence along the project road is relatively wet most of the year with a minimum average rainfall of 1000 – 2000 mm per annum. Rainfall figures for Thika (southern end of the road) average 650 mm – 1100 mm and for Magumu (northern end of the road) average 1200 mm – 1750 mm. In the forest areas rainfall figures are quite high, averaging in excess of 1350 mm to 2000 mm. The long rains occur from March to May and the short rains from October to December.

3.3.5 Topography, Drainage, Geology and Soils

As the road follows a ridge alignment, no major watercourses are encountered. The drainage pattern runs in a perfect radial and parallel pattern that has developed from the Aberdare and Kikuyu catchment forests.

Well-drained soils dominate this road section. Three soil types are evident along this project road

- Regosols – are dominant near the start of the road and are characterised by low moisture content
- Nitisols – these soils dominate the rest of the road section
- Andosols – these soils are porous.

From the start of the project road to Karuri Market the soils are generally classified as highly fertile well drained, deep, dusky red to dark reddish brown friable clays. Parts of the clays are over pisoferric or petroferric rock material. These types of soil are developed on tertiary basic igneous rocks.

Just after Gakoe Market Centre towards Kieni Market at Km 53 extending into Lari Division of Kiambu District, the soils are highly fertile consisting of well drained, very deep, dark reddish brown to dark brown, very friable and smeary clay loam to clay with a thick, acid humic topsoil. These soils are developed on olivine basalts and ashes of older volcanoes.

From the Kamae to the end of the project road the soils are predominantly well drained, very deep, dark reddish brown to dark brown silty clay loams. Some parts are friable and slightly smeary clay, with humic topsoil. These soils are developed from pyroclastic rocks and undifferentiated volcanic rocks. The last 4 kilometres of the project road lies on imperfectly drained, deep very dark greyish brown firm clay, underlying thick topsoil of friable silty clay loam (*Exploratory Soil Map of Kenya, 1980*).

3.3.6 Forests and Forest Resources

The two major gazetted forests the road passes through are Kieni and Kamae. These forests are made up of natural forest and plantations. The final portion of the project road lies in Kieni and Kamae forests, and traverses smaller portions of natural forest and open land in Lari Division. These forests form an important water catchment area for the districts. Kieni Forest, the larger of the two, has just over 10,000 hectares of natural forest and 3,708 hectares of plantations. The major tree species of economic importance in the natural forests are camphor, podo and bamboo There is no exploitation of these trees. The tree species in the plantations are cypress, pines and eucalyptus. Forestry plantations are managed on a sustainable basis (*Thika District Development Plan, 1997 – 2001*). The forests also play an important role for the provision of fuel wood and charcoal. The forests provide a wide range of products such as timber, fencing posts, poles, medicine, and wattle barks used in furniture making. Because they harbour a lot of indigenous species, any deviations or re-alignments will need to be carefully thought out so as to cause the least damage to these areas.

3.3.7 Agro-Ecological Zones

Maps 5 and 6 (Appendix A), taken from the 1997 – 2001 District Development Plans for Thika and Kiambu, show the AEZs for the project road. The road passes through Upper Midland zones (UM) 3, 2 and 1 in Thika and Gatundu Divisions and Lower Highland zone (LH) 1 of Gatundu Division. These zones are suitable for coffee and tea growing. This area is characterised by tea farming and dairy production.

3.3.8 Wetlands, Wildlife and Fisheries

No wetlands are found along the C66 project road, though Thika District is well endowed with many water bodies such as rivers and dams, making it a favourable environment for sport fishing, practised mainly along Thiririka and Ndarugu Rivers (*Thika District Development Plan, 1997 – 2001*). The rivers are restocked with trout from time to time by the Department of Fisheries, in order to allow continued fish harvesting from fish ponds (*Thika District Development Plan, 1997 – 2001*). There is no significant number of wildlife, except elephants, which are found in Kieni and Kamae Forests.

3.3.9 Current Land Use Activities

The favourable climatic conditions and soils make Thika and Gatundu Divisions suitable for agricultural activities. The major food crops grown include maize, beans and potatoes. Vegetables are grown mainly for the domestic and export markets, these include kales, cabbages, tomatoes, french beans, carrots and onions.

The main cash crops grown are coffee and tea in the upper midlands and lower highlands. Most of the large-scale coffee farms along the project road are in Gatundu and Lari Divisions. Small-scale farmers own 43% of the coffee while the rest is managed under large scale coffee estates.

Livestock reared include goats, beef and dairy cattle, sheep, pigs and poultry. Dairy and beef cattle, and goats are the predominant livestock along the project road especially in Gatundu Division.

3.3.10 Minerals and Materials

The only mineral resources of economic significance found in Thika District are natural stone and clay, which are important in the construction industry, as they provide building stones, ballast and bricks (*Thika District Development Plan, 1997 – 2001*). Natural stones are found in all six divisions of the district.

3.4 Nairobi – Limuru – Kamandura Road

3.4.1 Administrative Location of the project road

The Nairobi – Limuru – Kamandura road is the shortest of the three roads at 26 Km. The road lies in the Nairobi area in the east and traverses Kiambaa and Limuru Divisions of Kiambu District. Kilometre 0+000 at the Muthaiga roundabout is located at latitude 1° 14.9′ south and longitude 36° 49.2′ east and ends at Kamandura at latitude 1° 07.7′ south and longitude 36° 37.8′ east. The project road crosses the Nairobi – Kiambu District at latitude 1° 12.5′ south and longitude 36° 47.3′ just before the junction to Nairobi – Limuru road.

3.4.2 Services

The proximity of the road to Nairobi has continually encouraged and promoted a cash economy. Manufacturing, distribution, wholesale, and retail are the major commercial activities found in the districts along the project road. The demand for such activities is dictated by the purchasing power of the local people. The area along the project road is generally well served with both postal and telecommunication services. The major water facilities are bore holes and piped water schemes although they are over utilised because of over population and the decreasing size of the catchment area. But this has not been in any way an impediment on industrialisation. Most, if not all, of the market centres along the project road are connected to the electricity grid. Fuel wood and charcoal are the most widely used sources of energy especially in the rural areas at the continued detriment of the environment.

3.4.3 Demographic Characteristics

Population Structure and Distribution

The distribution of population along the project road is highly uneven. Within Kiambu District alone, Kiambaa Division has a larger population than Limuru Division (*Kiambu District Development Plan 1997 – 2001*).

The 1999 Population and Housing Census Report Volume I compiled by the Central Bureau of Statistics, indicate that Nairobi's population is growing at a rate of 4.8% per year. Kiambu's population is growing at a rate of 2.87% per year. Areas recognised to have higher populations have better infrastructure and job opportunities. Table 3.3 tabulates the populations by area along the project road in the districts/divisions.

Table 3.3 Populations and Population densities along the C62 project road.

District/ Division/Area	Population 1999	Density in 1999 persons/sq km	Projected Population 2001	Projected Density in 2001 persons/sq km
Nairobi	2,143,254	3,079	2,353,944	3,382
Muthaiga area	6,786	481	No data	No data
Kiambaa (Kiambu Dist.)	181,684	948	192,380	1004
Limuru (Kiambu Dist.)	120,174	414	127,273	438

Source: 1999 Population and Housing Census Volume I and District Statistical Office, Kiambu 1996

3.4.4 Climate and Rainfall

The altitude of the area traversed by the road lies between 1800 – 2100 m above sea level. The project road falls under agro-climatic zones II and III. Zone III covers the start of the project road to Ndenderu Market at Km 12. This area is classified as semi-humid with an average annual rainfall of between 750 – 1000 mm. Zone II is classified as sub-humid with an average annual rainfall of 1250 – 1500 mm. The rainfall regime is bimodial, with the long rains occurring between April and May and the short rains from October to November. Temperature in both zones is relatively cool to warm temperate. The mean annual temperature is between 16°C and 20°C. July and August are the coolest months, whereas January through March are the hottest (*Agro-climatic Zone Map of Kenya 1980* and *Kiambu District Development Plan 1997 – 2001*).

3.4.5 Topography, Drainage, Geology and Soils

The road follows a ridge alignment through undulating terrain often with steep slopes separated by gentle valleys.

The C62 lies within the Tana catchment and no major watercourses are encountered, except for the Gitathuru River at Km 0+735 in Nairobi at the start of the road and the Karura stream at Km 3+980.

Well drained nitisols and latosolic soils dominate this road section The soils from the start of the project road up to the junction around Ruaka at Km 7, are well drained, extremely deep, dusky red to dark reddish brown, friable clays. These soils have inclusions of well-drained, moderately deep, dark red to dark reddish brown, friable clay over rock, pisoferric or petroferric material. From the Chapore Lane junction to the end of the project road, he soils are layered with acid-humic topsoil. These soils are developed on tertiary basic igneous rocks (*Exploratory Soil Map of Kenya, 1980*).

3.4.6 Forests and Forest Resources and Vegetation

Karura Forest, a gazetted forest, is the only forest found at the start of the project road. According to the District Forest Office, there is no non-gazetted forest in Kiambu District (*Kiambu District Development Plan 1997 – 2001*). Most of the forests are man-made and are found in Kinale and Lari Divisions.

Smallholder farms of maize, kale, potatoes, bananas and napier grass for cattle dominate the vegetation types along this short project road.

3.4.7 Agro-Ecological Zones

Map 6 taken from the Kiambu District Development Plan 1997 – 2001 shows the AEZs for the project road. Just before the Limuru road junction in Kiambu District, the project road lies in Upper Midland (UM) zone 3 and Lower Highlands (LH) zone 2. The agricultural LH zone 2 is ideal for the growth of wheat, maize and pyrethrum, and UM zone 3 is primarily a marginal coffee zone (*District Agricultural Office, Kiambu, 1996*).

3.4.8 Wetlands and Wildlife

There are no wetlands along the project road nor within its zone of influence. There is no significant wildlife found along the project road or its zone of influence.

3.4.9 Current Land Use Activities

In Kiambu District, 97% of the land is arable, of which 90% is under small holder farming, that is intensively cultivated, while the remaining 10% are large scale commercial farms. The soils along the project road are highly fertile and well drained, especially in the UM zone 3 and LH zone 2, ideal for growth of the major cash crops such as coffee, horticultural crops and pyrethrum. Coupled with the ideal climate, the district has a high potential for agro-based industries. The main subsistence food crops grown by the small holders are maize, beans, potatoes and bananas.

3.4.10 Minerals and Materials

Stone quarries are scattered all over the divisions in Kiambu District. The quarries are used in the construction industry within and outside the district, very, few of which are found along the project road's zone of influence (*Kiambu District Development Plan 1997 – 2001*).

CHAPTER 4 KEY PROJECT COMPONENTS

The design of the project roads will be described in more detail in the preliminary design report.

For the purposes of the EIA study, it is necessary to understand features that are to be included in the road design in order to identify significant impacts that may arise from the project.

A brief history and the pertinent features are listed below:

4.1 Machakos Turn Off – Ulu – Sultan Hamud, Road (A109)

The road section between Machakos Turn Off – Ulu – Sultan Hamud can broadly be divided into two sections. This division is based on when the last major repairs were undertaken on the road. The sections are:

a) Km 0+000 to Km 30+000

This section of the road was improved between 1991 to 1993. The soils along this section are predominantly poor and/or weak foundation soils and comprises of black silty clays (black cotton soils). The existing pavement consists of very thick bituminous layers. As a result the predominant mode of failure is huge plastic deformations or rutting of the bituminous layer.

This section predominantly has 600 mm diameter culverts with a few 900 mm diameter pipe culverts. The designs of the culvert intakes and outlets are very similar. Grouted stone pitching for culverts has provided useful protection against scouring and erosion. In a few cases (less than 10% of the total), silting and uncontrolled vegetative growth around the inlet or outlet of the culverts has taken place. It is evident that there has not been adequate maintenance at least in removing unwanted vegetation from the culvert openings and little or no effort has been made to de-silt the affected culverts.

The soils along the entire stretch of the project road have high sodium content, and as a result tend to be highly erodible with the exception of approximately an 8 Km stretch along Salama, where soils are not as erosive due to silica.

The Ministry guidelines state that only 900 mm and 1200 mm diameter culverts are to be used on major trunk roads. If the improvement of this section of road is to be undertaken under the guidelines of the most recent road and bridges specifications, all 600 mm diameter pipe culverts will have to be replaced with 900 mm or 1200 mm diameter pipe culverts.

There are ten bridges along this section, which also serve as cattle underpasses. All were found in good structural condition. The only aspects requiring attention are:

- guard rails on most of the structures have been damaged and will require replacement;
- protection works such as grouted stone pitching and gabion works on the inlets and outlets of the bridges is required – this becomes important during the rainy seasons;
- some minor repair work to be carried out on the damaged wingwalls of the bridges.

b) Km 30+000 to Km 55+262

This section has been re-done several times (road works/ re-surfacing) between 1989 to 1996. The soils along this section are substantially stronger than the section from Km 0 to Km 30. The soils comprise residual red silty sands, which are highly erosive. The predominant mode of pavement failure is fatigue cracking due to traffic loading.

This section of the road is well served by 600 mm diameter culverts and very few 900 mm culverts. All culverts on this section of the road have sunken inverts and are provided with drop inlets and outlets. About 75% of the culverts are in good working order while the remaining exhibit defects, which require replacement or repair.

In view of the varying degree of siltation seen on about 25% of the culverts and the difficulty of de-silting the 600 mm diameter culverts (small diameter imposes limitations on the clearing methods available), replacement with 900 mm or 1200 mm diameter may be the most viable option. 25% or fewer, of the 900 mm diameter culverts should be de-silted using normal available means, while heavily silted culverts be replaced with 1200 mm diameter culverts wherever the road profile allows.

There were eleven locations where Corrugated Steel Culverts (ARMCO) are used in single or double combination. All ARMCO's were clear (not blocked in any way) and free of any siltation. However, the ARMCO culvert locations will require gabion works and grouted stone pitching to adequately protect the inlets and outlets.

In summary, the key components of the project road are as follows:

- The proposed rehabilitation options are:

  Periodic maintenance of 14.8 km of the road.

  This will be undertaken for sections of the roads that do not exhibit substantial deterioration of riding surface. The proposed form is a maintenance overlay (30 mm thin layer of asphalt) to improve riding surface, seal cracks and improve the life of the road. New material in the form of hardstone for asphaltic concrete will be required.

  Strengthening of 22.8 km of the road.

  This is proposed to cover sections of the road which exhibit inadequate strength (in foundation soils and existing pavement). The proposed form of strengthening is a bituminous overlay. New materials required will be crushed stones and gravel.

  Reconstruction of 17.66 km of the road.

  This is proposed for sections with tattered pavement. The proposed reconstruction is heavy-duty pavement construction mainly comprising a thick bituminous layer overlying treated granular material. New material required will be crushed stone and gravel. Not all the existing material will be recycled. It is estimated that 50% may be recycled depending on the final pavement configuration. The recyclable materials are bitumen bound layers, granular and treated layers.

- The existing alignment will be followed with the exception of approximately 780 m of realignment for smoothening of curves.

  4 new shifts of the existing alignment are proposed as follows:

  - From Km 40+550 to Km 40+680 approx. 130m, 2.5m shift to the left.
  - From Km 41+150 to Km 41+320 approx. 170m, 3.0m shift to the right.
  - From Km 41+800 to Km 42+000 approx. 200m, 5.0m shift to the right.
  - From Km 42+200 to Km 42+480 approx. 280m, 9.0m shift to the left.

  All the realignments lie within the existing road reserve.

- Proposed climbing lane at Km 42+500.
- The last 5 Km of the road will be raised to approximately 0.5 – 1.0m.
- Guard rails on most of the structures have been damaged and will require replacement;
- Protection works such as grouted stone pitching and gabion works on the inlets and outlets of the bridges is required – this becomes important during the rainy seasons;
- Some minor repair work to be carried out on the damaged wingwalls of the bridges.

- Between Km 49+990 and Km 50+020, there are 9 small sized culverts in total. These are susceptible to blockages when serious rains occur. The construction of a bridge (three span with a clear 10m mid-span or a single span pre-stressed beams) is recommended.
- Need to arrest serious gully erosion at the outfall of the existing ARMCO pipe at Km 52+300.
- The ARMCO culvert locations will require gabion works and grouted stone pitching to adequately protect the inlets and outlets.
- A bus and truck park will be introduced at Makutano (Km 0+000) on the right hand side (towards Mombasa).
- The bus and truck park at Salama will be improved with tarmac.
- The width of the bitumen carriageway will be 7.0m.
- The width of each shoulder will be 2.0m.
- The total width of the road will therefore be 11.0m.

Other Considerations:

- The road reserve for Class A roads is 60m.
- There is adequate room within the road reserve necessary for deviations to enable uninterrupted traffic flow
- Material sites (1 hardstone and 4 gravel) for the various improvement and rehabilitation options have been identified
- Workmen's camps will have to be located along the road during construction
- As part of the feasibility study, contract and tender documents are to be prepared to include environmental considerations.

4.2 Thika – Kamae – Magumu Road (C66)

The road was first constructed to bitumen standards in the very early 1980's and has since undergone a number of reseals over various sections of its 66 Km length. The road section between Thika – Kamae – Magumu of C66 can broadly be divided into three sections. This division is based on the pavement and drainage characteristics. The sections are:

a) Km 0+000 to Km 23+000

The Thika to Kamwangi section was initially constructed as a low volume road in terms of pavement strength and geometric capacity. The existing pavement has undergone major periodic maintenance by way of overlays. There are no shoulders. There are intermittent potholes over the length of the road attributed to artificial drainage problems resulting from blockage of mitre drains and culverts. There is also intermittent cracking attributable to inherent weakness in pavement layers. The road has also deteriorated from the edges due to its' narrowness.

Drainage facilities on this section of the road from Thika to Mangu are generally silted and obsolete. Land adjudication has also resulted in many of the drainage facilities on the road being blocked to stem the discharge of storm water to various smallholdings during the wet seasons.

Overall, the road alignment has been designed such that it hugs the hilly terrain as it meanders its way through the intense small coffee settlements. The overall intensity of farming activity along the road will ultimately call for well thought out drainage strategies

for the road, due to the very high land use for this section of road. The hilly terrain and intensive land use will limit the location of culvert outlets.

From Mangu to Mataara Tea Factory Turnoff, the road tightly hugs the hilly terrain as it meanders its way towards the Mataara Tea Factory. The main activities along this stretch are coffee growing up to Mangu, pineapple growing at Kanjuku and tea growing up towards Mataara Tea Factory Turnoff. Nearly all drainage facilities are not functioning due to blockages brought about by silt, vegetation growth in the inlets/outlets and lack of maintenance.

b) Km 23+000 to Km 43+000

The section from Kamwangi to Kamae Forest is in fairly good state. The construction of this section up to Gatundu road was done in 1978. The pavement is a bit wider. The sub-grade soils are good quality red coffee soils. The terrain on this section of the road is similar to that found in most tea growing areas at altitudes over 2100m.

There are a few culverts, which are serviceable and in relatively good condition despite their age. This area is lightly trafficked with tea trucks providing the bulk of vehicles on the road at this section.

c) Km 43+000 to Km 66+000

The section from the beginning of the forest area to Magumu is in fairly bad state. The *in situ* soils are lighter dark grey volcanic silts, which are highly erosive. There seems to have been a modification of pavement design at the construction stage reflected by inadequate thickness of the pavement. This section of the road is seriously pot-holed and cracked and in some places the road is non-existent. A few sections have apparent drainage problems. The section between Km 63 to Magumu is characterised by flat topography hence the need for wide side/retention ditches to work as water storage.

The area around Kieni and Kamae has only recently been cleared of the forest. It is understood that the area remains a legislated forest plantation area and that the present farming activities are temporary. The area is high ground and generally slopes in a south-westerly direction towards the eastern escarpment of the rift valley.

The road itself assumes a gentle alignment with gentle curves and gradients. There are a number of small streams crossing the road, which emanate from the Aberdare Forest. The drainage facilities comprise culverts, which were constructed in the early 1980's and have since become blocked or partially blocked over the years due to lack of adequate maintenance.

In this predominantly forest area, the emergence of new settlements (temporary and permanent) has compounded the natural drainage patterns. This together with the destruction of forest cover will call for the re-designing of the drainage for the road through this forest.

In summary, the key components of the project road are as follows:

- The proposed rehabilitation options are as follows:

  Periodic maintenance and later strengthening overlay of 28 km of the road.

  The proposal involves patchwork and resealing of sections of the road with gravel crushed stones (GCS) and bitumen. Strengthening overlay will comprise one layer of GCS and a double seal.

  Reconstruction of 39 km of various sections of the road.

  For the section between Km 0 to Km 23, the proposed reconstruction involves a substantial amount of earthworks. This may involve land acquisition. Ripping of the existing base and

re-processing the GCS as sub-base on sections between Km 23 to Km 48 would be required. On sections between Km 23 to Km 48, the existing sub-base with additional material will be used as earthworks. The existing base and sub-base can be recycled on a very limited scale due to contamination by sub-base during removal. A new base of GCS plus surface dressing will be required.

- The existing alignment will be followed along the entire length of the road.
- All 600mm culverts need to be replaced by 900mm culverts.
- New culverts are proposed for the section between Thunguri to Kamae (15 Km). The predominant feature in this section of the road is the establishment of trading centres and new settlements. This would necessitate the re-siting of drainage crossing points along the road.
- On sections of the road between Kamae and Magumu where the road is at level with surrounding ground, new culverts are proposed.
- The width of the bitumen carriageway will be 6.5m.
- The width of each shoulder will be 1.25m.
- The total width of the road will therefore be 9.0m.

Other Considerations:

- The road reserve for Class C roads is 30m.
- Deviations to enable uninterrupted traffic flow may not be possible on this road.
- Material sites (3 gravel, and 2 hardstone) for the various improvement and rehabilitation options have been identified.
- Contractor's work site will have to be located along the road (near the trading centres) during construction.
- As part of the study, contract and tender documents are to be prepared to include environmental considerations.

4.3 Nairobi – Limuru – Kamandura Road (C62)

The C62 was put up in sections from 1960 to 1970. Subsequently the road has undergone numerous repairs and resurfacing. Due to its proximity to the City, numerous developments have taken place adjacent to its environs and various developments have had to be undertaken to accommodate the new ventures such as siting of UNEP. The road can be split into two sections as follows:

a) Km 0+000 to Km 7+000

This section of the road from Muthaiga round about to Ruaka lies within the city limits of Nairobi. The section is built to Nairobi City Council standards. There have been various rehabilitation works by way of patchwork, overlays and reconstruction by city authorities. The bitumen bound layers on this section are substantially thicker than the section after Km 7. This section exhibits serious cracking, which has contributed to pavement weakening, necessitating pavement re-construction. There is currently a proposal that this section should be designed as a dual carriageway.

The soils along the entire stretch of the road are uniform red silty clays with a resistance to erosion.

The section from Muthaiga roundabout to Gigiri has nine drainage structures that require attention:

- Two structures at Muthaiga roundabout were silted with one end of a culvert structures not being visible;
- One bridge (approximately km 0+735) which was found to be in acceptable condition (requiring only minor repairs), provided the road width is not changed;
- One drainage culvert approximately (km 1+090) which was silted;
- Five access culverts, which were silted.

b) Km 7+000 to Km 26+000

This section of road is within Kiambu District. It has maintained the initial construction with one maintenance overlay. More recently, major rehabilitation works have been undertaken, involving patchwork, resealing, re-carpeting and re-construction. The rehabilitation works were at an advanced stage by the time the study was undertaken.

There are five bridges on this section, all in appropriate condition but requiring some work to be undertaken principally on the guard-rails, clearing of the drainage path and general maintenance of the structures.

In summary, the key components of the project road are as follows:

- The proposed rehabilitation options are as follows:

  Periodic maintenance and later strengthening overlay of 20.2 km of the road.

  This is proposed to cover sections of the road, which exhibit inadequate strength. The proposed form of strengthening is a bituminous overlay. New materials required will be crushed stones and gravel.

  Reconstruction of 6.8 km of the road.

  This will require new construction materials – stone and gravel. There is no option for recycling. The proposed construction methodology is half-width construction since there is no room for deviations.

- The existing alignment will be followed along the entire length of the road.
- The width of the bitumen carriageway will be 7.0m.
- The width of each shoulder will be 1.5m.
- The total width of the road will therefore be 10.0m.
- All 600mm culverts will be by 900mm culverts

Other Considerations

- The road reserve for Class C roads is 30m.
- Deviations may be necessary to enable uninterrupted traffic flow but these will be limited due to the densely populated settlements along the project roads.
- Material sites (1 hardstone and 1 gravel pit) for the various improvement and rehabilitation options have been identified.
- Contractor's work site will have to be located along the road during construction
- As part of the feasibility study, contract and tender documents are to be prepared to include environmental considerations.

CHAPTER 5 EXISTING IMPACTS AND OBSERVATIONS

5.1 General

A study of existing environmental impacts due to the three project roads was carried out. From observations in the field and discussions held with various people in the field and in Nairobi, a number of aspects affecting the natural, physical and social environment were noted. These observations are also intended as useful pointers during the design stage of this project.

5.2 Positive Impacts

5.2.1 Economic Benefits

Economic benefits derived from the project roads are most obviously noticed along the A109 and the C62. The A109 is part of the Nairobi – Mombasa international trunk road, and carries a substantial amount of traffic including heavy loaded trucks. The C62 will provide an alternative quicker access route to Limuru town and other market centres along the project road. Traffic flow is therefore expected to increase from the current condition. The C66 was a favoured route for commercial, and transport vehicles, especially those making long distance journeys from places such as Garissa, Meru, Embu, Thika to Naivasha and Nakuru. Improvement of the route will greatly enhance traffic flow and in addition contribute to the national economy, and on a smaller scale stimulate trade along the road and in the market centres.

Detailed economic benefits will be determined during the economic feasibility assessment when the internal rates of return for each road proposed for improvement will be calculated.

5.2.2 Provision of Access

There are numerous sociological and socio-economic benefits, resulting from improved access to schools, health facilities and market centres associated with road projects. This in turn contributes to increased productivity and thus an ultimate improvement in standards of living.

A number of schools and health centres are located along the Thika – Kamae – Magumu (C66) road. Improved access to these facilities implies that they are better staffed and equipped. Businesses along the project road, including along the trading centres, such as garages, shops and restaurants are flourishing. Better access to rural areas often leads to higher prices for land, as compared to the same sized plot in areas where access is difficult.

5.3 Negative Impacts

5.3.1 Gravel Pits

Three open gravel pits were identified along the Machakos Turnoff – Ulu – Sultan Hamud project road. Only two of these will be used for the rehabilitation purposes. Two open gravel pits at Km 9+300 and 24+900, used for previous maintenance purposes, were never reinstated or landscaped.

This land has little value in terms of crop production although selling of material from the pits is of benefit to the owners. When gravel pits are left open after use, the entire quarry area is rendered useless for cultivation. In addition, their steep sides can be dangerous for young children and animals. Soil erosion was also noticed at the edges of the pits leading to further loss of productivity. During the rainy seasons water can accumulate in the pits, posing a potential health risk by creating stagnant and providing a breeding habitat for mosquitoes, which spread malaria. Children are also put at risk of drowning if they play in the water.

5.3.2 Hydrology and Drainage

Drainage problems are a factor featured in all three of the project roads. From Km 50+800 on the A109 Machakos Turnoff-Ulu- Sultan Hamud road to practically the end of the project road the drainage problems become more evident. At Km 51+200 the armco culvert provided is inadequate to cater for the flow of water, and as a result has become heavily silted, resulting in the formation of a deep ravine at the opposite side of the road as a consequence of erosion. Erosion and siltation has occurred, attributed to high velocity run-off from the bottom of a steep hill at Km 54+750. The flow is from an upper catchment watercourse way. The fallow land and patchy vegetation in the area cannot intercept this heavy water flow. As a result, the run-off flows over the road leading to the deterioration of the road and siltation on both sides. In order to determine the size, type and location of culverts, a detailed hydrological survey will be necessary. This section of the road may need to be raised. There is a culvert at Km 55, but there is also a ponding and drainage problem. The culvert design and location needs to be reviewed.

Between Km 62 and 67 along the C66 Thika-Kamae-Magumu road, the few drains that are present are water logged, due to the inadequate gradient in the construction of the drains, thereby inhibiting storm water flow by gravity. This section of the road up to Kamae Forest is on a plateau and black cotton soil is predominant, resulting in a number of stagnant pools along this section creating a potential health risk. The solution, upon consultation with the respective land owners, is the construction of retention ditches by the side drains.

Kamwangi Market at Km 30+300 has steep side drains that overflow on to the sides of the road. A possible corrective measure is to create artificial waterways and trenches, to not allow the flow of water. One draw back of this measure is that the waterways would lead onto the farms at the bottom of the hill. Prior consultation with land owners is needed prior to any works. Alternatively a corridor of land could be purchased along the road

The C62 Nairobi-Limuru-Kamandura road has no evident drainage problems but the structural design of the culverts and will need to be reviewed as part of the investigations. A detailed hydrological survey will be able to determine any sensitive areas along the project road.

5.3.3 Erosion

Erosion was noticed on all the three project roads, along the sides of the roads, more evident on the A109 Machakos Turnoff-Ulu- Sultan Hamud road. This was attributed to road runoff and partially blocked or lack of drainage structures. Erosion was also seen along the sides of embankments on the Nairobi-Limuru-Kamandura project road.

5.3.4 Impact on Town Centres/Settlements

Trailers park along the highway on the approach to Salama at Km 40 on the A109 road. There is a need to consider the provision of proper parking bays for the long haul trucks and heavy goods vehicles in order to reduce congestion and increase safety. Minor servicing of vehicles is done on the road reserve and as a result the oil is washed on to the roadside vegetation due to of lack of proper storm water drains.

Shops and tea kiosks have been set up along all the project roads, and they virtually lie on the road reserve. The junction at Makutano (Km 00) on the A109 is heavily congested due to the parking of lorries and trucks on the road side. At Magumo (Km 67) on the C66, there are temporary and permanent business structures close to the road. Commuter vehicles also use this as a drop off and pick up point for passengers resulting in congestion and creating a safety hazard to other road users. This problem is also evident at the junction of Gigiri on the C62. Consequently there is a substantial amount of solid and liquid waste accumulating at the road junctions and no proper waste disposal measures are in place.

5.3.5 Road Safety

Trading centres along the road such as Salama on the A109 road, have become established truck stops and pose a significant hazard to both vehicles and people. These heavy goods vehicles, as well as commercial vehicles, are parked on the side of the road and as a result impede visibility for on coming traffic on the main road and traffic entering the main road.

There is a high number of non-motorised traffic, including pedestrians and cyclists on the C66. There are no hard shoulder provided for this category of road users who at present are forced to share the road with vehicles. There are also no signs to warn motorists of their presence.

Approaches to market centres have no or an inadequate number of speed bumps. On a few places along the C62 there are speed control measures. For example, there are rubble strips at Ruaka and Ndenderu, and speed bumps on the approach to the Village Market in Gigiri. There is a general lack of warning or directional signs, especially near hospitals and schools along the C66. In addition, there are no warning signs of wildlife crossings along the C66 on the approach to the Kieni and Kamae Forests on the C66. There will be no speed bumps along the A109.

5.3.6 Road Reserve

On all project roads, encroachment of vegetation, and crops in particular, onto the road reserve is very substantial. Although the presence of such vegetation is beneficial for the road edges, in that it reduces the risk of erosion of soil from the road embankment, this may cause social problems during routine and future clearing activities, as farmers would expect compensation for lost crops. People residing alongside the project roads, even within the proposed road reserve extension, must be made aware, through Chiefs and local councillors, that by law they are not allowed to build structures or grow crops in the road reserves, and if they do, they are not entitled to compensation of any sort.

CHAPTER 6 ANTICIPATED IMPACTS DUE TO THE REHABILITATION WORKS

6.1 General

This chapter focuses on the impacts likely to occur as a result of the proposed rehabilitation works on the three project roads. Each road has been dealt with separately for the actual assessment of impacts, while issues considered as being significant for the purposes of the overall assessment are described in more detail in Section 6.5. Monitoring measures for the various impacts highlighted are described in Chapter 8.

In general, environmental issues likely to be of concern during the periodic maintenance, rehabilitation and reconstruction phase of all the three project roads include:

- Ecological damage resulting from route deviations and clearance;
- Limited nuisance from noise and air (dust) pollution;
- Ecological damage from the clearance of areas for construction camps, storage of materials (fuel, lubricants and machinery) and road widening for the C66 and C62 roads;
- Water supply for the upgrading works; and
- Social disturbance caused by the teams undertaking the periodic maintenance, rehabilitation and reconstruction.

Impacts can be positive or negative, direct or indirect. The magnitude of each impact is described in terms of being significant, minor or negligible, temporary or permanent, long-term or short-term, specific (localised) or widespread, reversible or irreversible. The impacts due to or affecting certain elements during construction and operation are presented below in tabular form for ease of reference.

These qualities are indicated in the assessment tables as follows:

Key	Type of Impact	Key	Type of Impact
++	major positive impact	+	minor positive impact
--	major negative impact	-	minor negative impact
0	negligible/ zero impact	NC	no change
sp	specific/localised	w	widespread
r	reversible	ir	irreversible
sh	short term	L	long term
t	temporary	p	permanent
Y	mitigation of negative impacts/ enhancement of positive ones IS possible	N	mitigation of negative impacts/ enhancement of positive ones is NOT possible

Generally, temporary impacts having no obvious long term consequences are regarded as being minor. But those with long term repercussions are classified as significant. Significant positive impacts are usually associated with improved access, which is the prime objective of the rehabilitation project.

6.2 Machakos Turnoff – Ulu – Sultan Hamud (A109)

Rehabilitation works will be confined to upgrading the existing road. The existing alignment will be followed with the exception of approximately 780m of realignment (smoothening of curves).

The proposed sections where new shifts of the existing alignment are as follows:
- From Km 40+550 to Km 40+680 approx. 130m, 2.5m shift to the left.
- From Km 41+150 to Km 41+320 approx. 170m, 3.0m shift to the right.
- From Km 41+800 to Km 42+000 approx. 200m, 5.0m shift to the right.
- From Km 42+200 to Km 42+480 approx. 280m, 9.0m shift to the left.

The number of realignments and their exact location will be finalised during the detailed design stage.

Table 6.1: Anticipated Environmental Impacts on the A109

Impacts on or due to	Construction	Mit	Operation	Mit	Remarks
Changes in hydrology/ drainage	- ir t	Y	+	Y	The flow of runoff will be altered during the rehabilitation process due to blocked drains and culverts. This will be a temporary problem occurring during only the construction works.
Soil erosion	-- L sp	Y	-	Y	Caused by earthworks will have a major impact on soil erosion. Incorporating appropriate soil conservation measures and proper drainage facilities during construction would mitigate impacts during operation.
Pollution: Air, dust, noise oil wastes sediment loads	 -- t ir -- t ir -- t ir -- L ir - t ir	 Y Y Y Y Y	 -- p ir -- p ir -- p ir -- L ir	 Y Y Y Y	During operation, air, noise, dust and oil waste pollution will affect settlements/households along the road. Mitigation is possible through consideration on the part of the contractor and motorists, or legal enforcement.
Loss of land	- - p ir - t r	Y Y	0		Some land may have to be acquired for the proposed realignments and mitigation will be in the form of compensation. Deviations would necessitate temporary loss of land in some places if it goes beyond the road reserve.
Loss of crops	- p sp	Y	0		Loss of crops will have to be compensated for provided they lie on private property.
Hardstone quarries and gravel pits	- p r	Y	- p r	Y	Negative impacts such as soil erosion, loss of crop productivity, hazards to children and livestock may result from quarries that are not reinstated/ landscaped or fenced.

Impacts on or due to	Construction	Mit	Operation	Mit	Remarks
Sand sources	0		- ir	Y	Sand should be taken from authorised sand sources or bigger rivers and not from small rivers as this may alter the hydrological regime of the river
Wetlands	0		0		No wetlands of significance will be affected by the road works or during the operation of the road.
Forests	0		0		No forests will be affected by the road works or during the operation of the road.
Water resources	-- sh	Y	0		There are a number of seasonal rivers/streams found along the road, pressure will be put on the local communities. During operation, it will revert to the present situation.
Wildlife	- r	Y	-	Y	Wildlife is found along the road and sometimes crosses the road. The wildlife will be disturbed by on-going construction works. Mitigation includes the placement of warning signs and raising awareness among construction workers.
Vegetation/ Flora	- p ir	Y	0		Clearing of vegetation will be necessary within the road reserve, deviations and minor realignments. However, clearing activities could encourage soil erosion.
Fauna	- p ir	N	0		Clearing activities may disturb small animals and birds and their homes/nesting sites. Any clearing will be done with the utmost consideration for the animal species.
Livestock movement	-	Y	-	Y	Warning signs should be erected at intervals along the road to indicate the crossing points.
Settlements / Induced settlements	- t	Y	+		During operation, people in the settlements along the road should benefit from improved access.
			- p	Y	There could be an increase in unplanned settlements along the road on approaches to the market centres.
Employment opportunities	++ t		0		The local people will benefit from temporary employment during road improvement activities.
Workmen's camps	+ sh		0		Some benefits are expected from increased business at centres such as Makutano or Salama.
	-- L r	Y	-	Y	However the presence of the camp is likely to lead to an increase in water usage and wood fuel putting a strain on the local community.
Public health	-- p ir sp	Y	-- p ir sp	Y	Immigrant workers on road projects, and truck drivers are associated with the spread of sexually transmitted diseases. Awareness campaigns in towns and market centres would help to mitigate this problem.

Impacts on or due to	Construction	Mit	Operation	Mit	Remarks
			++		Better access to health facilities can be regarded as a major positive impact.
Road safety	t sp r	Y	-	Y	During construction there will be some danger to pedestrians and cyclists along the existing and realignment routes.
			++	Y	The rehabilitation works will be designed to improve road safety during operation. Road safety can be enhanced, by awareness and educational campaigns.
Visual intrusion	- t/p	Y			During construction visual intrusion will be due to road works (including quarries) and traffic.
			--	Y	These conditions will create a greater impact during operation and will include nocturnal glare. Mitigation will be achieved through controlling traffic, sensitising motorists and clearing of construction debris.

6.3 Thika-Kamae-Magumu (C66)

Road rehabilitation works along the Thika-Kamae-Magumu road may merely warrant periodic maintenance for most of the road. Realignments along this road are unlikely to be recommended. In some sections, the road reserve has been cultivated with napier grass and cypress trees. These will have to be cleared in order increase the road reserve and improve site distance. Minimal deviations from the centreline are expected, though in some sections deviations may be difficult because of topography and forest areas.

Table 6.2: Anticipated Environmental Impacts on the C66

Impacts on or due to	Construction	Mit	Operation	Mit	Remarks
Changes in hydrology/ drainage	- ir L	Y	+		There will be alterations to the hydrological regime, especially around Kamae and Kieni forests. During rehabilitation works, the flow of runoff will alter, especially towards the end of the project road, near Magumu, were water does not drain because of the flat terrain and clay soils. During operation, drainage will substantially improve from the current situation.
Changes in hydrology/ drainage cont/	- ir L	Y	- ir L	Y	Most rivers and streams run parallel to the existing road, which is designed on a ridge. In Kamwangi waterways and/or trenches will have to be created or alternatively a corridor may have to be purchased in order to drain roadside runoff.

Impacts on or due to	Construction	Mit	Operation	Mit	Remarks
Soil erosion	-- L sp	Y	-	Y	During and after construction, earthworks (for road construction) will have a major impact on soil erosion. Erosion is also caused by improper drainage, and therefore appropriate soil conservation measures and drainage facilities would mitigate impacts during operation.
Pollution: air dust noise oil wastes sediment loads	 -- t ir -- t ir -- t ir -- L ir - t ir	 Y Y Y Y Y	 -- p ir -- p ir -- p ir -- L ir	 Y Y Y Y	Air, dust and noise pollution will be present during construction, but only temporarily. Oil wastes entering the rivers and streams pose a bigger and long term threat. Sediment loads (building debris) will temporarily increase in water courses due to the construction of culverts, side drains and retention ditches. During operation, air, noise, dust and oil waste pollution may affect settlements/households along the road. Pollution due to sediment loads (apart from soil - see above) is not likely to be a problem during operation. Mitigation is possible through consideration on the part of the contractor and motorists, or legal enforcement.
Loss of land	-- t r	Y	0		There will be temporary loss of land if deviations occur outside the road reserve. In some sections this may be the case. Compensation will have to be paid to owners of the land through which the deviations pass.
Loss of crops	- p sp	Y	0		Some sections of the road reserve are cultivated. These crops will be cleared during road improvement works, but cannot be compensated for. Crops lost due to the extension of the road reserve will have to be compensated for if they lie outside the existing road reserve and on private property.
Hardstone quarries and gravel pits	+		+ L		Quarry/pit owners can benefit from the sale of material, during and after construction.
Sand sources	0		 - ir	 Y	There are no sand sources of significance that will be affected by the road works and during the operation of the road. Although sand should be taken from authorised sand sources or bigger rivers and not from small rivers as this may alter the hydrological regime of the river
Wetlands	0		0		No wetlands of significance will be affected by the road works and during

Impacts on or due to	Construction	Mit	Operation	Mit	Remarks
					the operation of the road.
Forests	- sh		0		Because no realignments are planned for the project road Kieni and Kamae Forests will not be significantly affected by the road works or during the operation of the road.
Water resources	-- sh	Y	0		A number of seasonal rivers/stream are found along the road, pressure will be put on the local communities. During operation, it will revert to the present situation.
Vegetation / Flora	-- p ir	Y	0		Any vegetation within the road reserve and for any deviations will be cleared. Forest vegetation will be cleared, if necessary, in a manner that invokes as little damage to the forest. Clearing activities could encourage soil erosion.
Fauna	- p ir	N	0		Clearing activities, especially in the forest area, may disturb small animals and birds and their homes/nesting sites. Any clearing will be done with the utmost consideration for the animal species.
Wildlife	-	Y	-	Y	Elephants cross the road around the forests. Mitigation includes the placement of warning signs.
Settlements / Induced settlements	- t	Y	- p	Y	During operation, people in the settlements along the road should benefit from improved access. There could be an increase in unplanned settlements along the road on approaches to the market centres. Chiefs and local councillors should monitor the development of settlements along the road through awareness campaigns and proper planning.
Employment opportunities	++ t		0		There will be temporary employment opportunities for many of the local people.
Agricultural activities	NC		++ p w		During construction, little or no change is expected with regard to agricultural activities. However during operation, the improved road should slightly encourage agricultural activity along the project road and in its area of influence.
Workmen's camps	0/-		0		Assuming the camps will be located at existing centres, there will be negligible impact if workmen's camps are located at Magumu, Kamwangi and Thika.
Public health	- t ir w	Y	- p w ir	Y	During construction and operation, increased dust, noise and air pollution levels could impact on public health.

Impacts on or due to	Construction	Mit	Operation	Mit	Remarks
	-- p ir sp	Y	-- p ir sp	Y	But very few people will be affected. Workmen brought in for road works and truck drivers may increase the incidence of socially contracted diseases. Mitigation would be through awareness campaigns.
			++		Better access to health facilities can be regarded as a major positive impact.
Road safety	t sp r	Y	-	Y	There will be some danger to pedestrians and cyclists during rehabilitation works. This can be mitigated with awareness campaigns and road signs, and by providing shoulders for non-motorised traffic.
			++	Y	The rehabilitation works aim to improve road safety during operation. Appropriate road furniture should include warning and directional signs, particularly near schools, hospitals and trading centres.
			--	Y	The improved road will encourage speeding that could be a hazard.
Visual intrusion	- t/p	Y			During construction visual intrusion will be evident due to road works and traffic.
			--	Y	These conditions will create a greater impact during operation and will include nocturnal glare. Mitigation will be achieved through controlling traffic, sensitising motorists, and clearing of construction debris.
Agricultural activities	NC				During construction, little or no change is expected with regard to agricultural activities.
			++ p w		However during operation, the improved road should slightly encourage agricultural activity along the project road and in its area of influence.
Workmen's camps	0/-		0		Assuming the camps will be located at existing centres, there will be negligible impact if workmen's camps are located at Magumu, Kamwangi and Thika.
Public health	- t ir w	Y	- p w ir	Y	During construction and operation, increased dust, noise and air pollution levels could impact on public health.
	-- p ir sp	Y	-- p ir sp	Y	But very few people will be affected. Workmen brought in for road works and truck drivers may increase the incidence of socially contracted diseases. Mitigation would be through awareness campaigns.
			++		Better access to health facilities can be regarded as a major positive impact.

Impacts on or due to	Construction	Mit	Operation	Mit	Remarks
Road safety	t sp r	Y	-	Y	There will be some danger to pedestrians and cyclists during rehabilitation works. This can be mitigated with awareness campaigns and road signs, and by providing shoulders for non-motorised traffic.
			++	Y	The rehabilitation works aim to improve road safety during operation. Appropriate road furniture should include warning and directional signs, particularly near schools, hospitals and trading centres.
			--	Y	The improved road will encourage speeding that could be a hazard.
Visual intrusion	- t/p	Y			During construction visual intrusion will be due to road works and traffic.
			--		These conditions will create a greater impact during operation and will include nocturnal glare.
				Y	Mitigation will be achieved through controlling traffic, sensitising motorists, and clearing of construction debris.

6.4 Nairobi – Limuru - Kamandura (C62)

The Nairobi-Limuru-Kamandura road will mainly involve re-carpeting the existing road, construction and design of drainage structures and road furniture refurbishment. No realignments have been recommended in the design for this road. In some sections, site distance improvement will be a factor, involving minor clearing of vegetation that has encroached on to the road reserve. Minimal deviations are expected.

Table 6.3: Anticipated Environmental Impacts on the C62

Impacts on or due to	Construction	Mit	Operation	Mit	Remarks
Changes in hydrology/ drainage	- ir L	Y	- ir L	Y	There will be slight alterations to the hydrological regime during the rehabilitation phase but these are not considered serious. Although water will have to be drained from the road reserve on to farms located along the project road. These drains will have to be constructed to pass through these farms.
Soil erosion	-- L sp	Y	-	Y	Caused by earthworks will have a major impact on soil. Incorporating appropriate soil conservation measures and proper drainage facilities during construction would mitigate impacts during operation.

Impacts on or due to	Construction	Mit	Operation	Mit	Remarks
Pollution: air dust noise oil wastes sediment loads	 -- t ir -- t ir -- t ir - L ir - t ir	 Y Y Y Y Y	 -- p ir -- p ir -- p ir -- L ir	 Y Y Y Y	During operation, air, noise, dust and oil waste pollution will affect settlements/households along the road. Mitigation is possible through consideration on the part of the contractor and motorists, or legal enforcement.
Loss of land	- t r sp	Y	0		Deviations would necessitate temporary loss of land in some places, and can be used again for cultivation afterwards. If deviations go beyond the road reserve owners will have to be compensated.
Loss of crops	- t sp	Y	0		Crops to be cleared during road improvement works lying in the road reserve will not be compensated for.
Hardstone quarries and gravel pits	- p r	Y	- p r	Y	Negative impacts such as soil erosion, loss of crop productivity, hazards to children and livestock, water accumulating in the quarry/pit providing a breeding ground for mosquitoes may result from quarries that are not reinstated/ landscaped or fenced.
Sand sources	0		- ir	Y	Sand should be taken from authorised sand sources or bigger rivers and not from small rivers as this may alter the hydrological regime of the river.
Wetlands	0		0		No wetlands of significance will be affected by the road works or during the operation of the road.
Forests	0		0		The Karura Forest will not be significantly affected by the road works or during the operation of the road.
Water resources	- sh	Y	0		A few seasonal rivers and streams are found along the road. As a result of construction activities, pressure will be put on the local communities.
Wildlife	0		0		No wildlife of significance is found along the project road.
Vegetation/Flora	- p ir	Y	0		Clearing of vegetation will be necessary within the road reserve and for deviations, and in some cases for improving sight distance. However, clearing activities could encourage soil erosion.
Fauna	- p ir	N	0		As an established road traversing densely populated areas there is not expected to be a major issue with fauna.
Livestock movement	-	Y	-	Y	Livestock movement is not so extensive, although mitigation would include erecting warning signs at intervals along the road.

Impacts on or due to	Construction	Mit	Operation	Mit	Remarks
Settlements/ Induced settlements	- t	Y	- p	Y	During operation, people in the settlements along the road should benefit from improved access. There could be an increase in unplanned settlements along the road on approaches to the market centres.
Employment opportunities	++ t		0		The local people will benefit from temporary employment during road improvement activities. This will benefit their families and the local economy
Agricultural activities	NC		+ p w		Agricultural activities are unlikely to be affected during construction. During operation, agricultural activity will be slightly enhanced by the improved road.
Workmen's camps	-/0		0		Workmen's camps are not expected to be set up for the project road. But is set up they are likely to have minimal impact.
Public health	- t ir w -- p ir sp	Y Y	- p w ir -- p ir sp ++	Y Y	During construction and operation, increased dust, noise and air pollution levels could impact on public health. Immigrant workers on road projects, and truck drivers are associated with the spread of sexually transmitted diseases. Awareness campaigns in towns and market centres would help to mitigate this problem. Better access to health facilities can be regarded as a major positive impact.
Road safety	t sp	Y	- ++	Y Y	During construction pedestrians and cyclists will be exposed to some danger along the existing and route. Mitigation is through sensitisation campaigns and road signs, and by providing shoulders that can be used by non-motorised traffic. During operation, road safety will improve.
Visual intrusion	- t/p	Y	--	Y	During construction visual intrusion will be evident due to road works and traffic. These conditions will create a greater impact during operation and will include nocturnal glare. Mitigation will be achieved through controlling traffic, sensitising motorists, and clearing construction debris.

6.5 Summary of Main Issues

Soil Erosion

Soil erosion will be a major issue during the rehabilitation works, and will result from earthworks, quarrying and deviations. Improper drainage of runoff from the road to lower catchments can also cause erosion. Incorporating soil conservation measures during construction would help to mitigate damage caused by erosion.

Clearing of vegetation from road reserves and for new shifts in alignments, and excavating murram from gravel pits with slopes exceeding 4% could result in an increase in runoff along the slopes and thus encourage erosion. Hardstone quarries tend to have soils with more stable structures, so erosion may not be such a problem.

Pollution

Exhaust and engine emissions from vehicles cause air pollution, which can have an impact on public health, soils, crops and water supplies.

Where culverts, drains and retention ditches are required, sediment loads in the rivers and streams will increase as a result of construction debris and excavation works along the banks. In addition, the Resident Engineer should ensure that the contractor disposes of all construction debris in a sensible manner, and does not throw it into rivers/streams. Air, noise and dust pollution and disposal of oil wastes is already occurring to a certain extent (whether significant or not) along the project roads. The situation will be exacerbated temporarily during construction, but will also occur during operation as a result of anticipated increased traffic along the roads.

Realignments

The realignment proposed for the A109 is essentially to reduce the curves along the existing alignment and for the extension of the road reserve. No realignments are proposed for the C62 and C66. Most of the realignments will lie within the existing road reserve, however some parts may go beyond the road reserve, but for very short lengths. Any structures lying within the proposed realignment road reserve will have to be removed or relocated. But the relocation of any households is not envisaged.

Deviations

During improvement works, it will be necessary to have deviations in order to allow uninterrupted traffic flow. Although deviations should ideally remain within the road reserve, this is not always practical or possible, so traffic may have to be diverted temporarily across private land. In such cases, landowners will have to be compensated for loss of crops/grazing land, nuisance, fencing, etc.

For instance along A109, from the traffic census, the flows on Nairobi bound are higher and heavily loaded than the Mombasa bound traffic. It is therefore suggested that the deviations be provided on the left side of the existing Mombasa – Nairobi carriageway. The deviations will need to be constructed in 20 km sections and the contractor should be barred from using long deviations and haul routes. Sections where re-alignment is considered, the existing carriageway will be used as the deviation. Deviations along C66 will be unlikely whereas along C62, the existing deviations can be used.

The proposed rehabilitation works can be undertaken in most cases without deviations. Periodic maintenance does not require deviations. Hot mixes can be done with traffic flowing on the road. The construction methodology can be half-width construction over short stretches (300 – 400

m). The contractor needs to institute traffic control measures. Strengthening overlays ideally require deviations. If constrained by space, half-width construction can be adopted. Reconstruction requires deviations for safety reasons and to reduce construction costs but is subject to availability of space.

If deviations are made, then they should be demolished and allowed to re-vegetate. In some of the trading centres or settlements along the roads, shops, kiosks and houses have been set up within the road reserve. These may have to be removed, but from a legal standpoint the owners are not eligible for compensation.

Extension of Road Reserves

The road reserves will have to be extended at various places for a number of reasons. Where realignments are proposed for smoothening curves or bends along the roads, there will be a slight change in the alignment of road reserve, and where temporary structures have been built and crops planted along the road reserve. According to the MoRPW Road Design Manual, the width of the road reserve will be 40 m for a class C road and 60 m for a class A road.

Gravel Pits and Quarries

The number of gravel pits and hardstone quarry sites identified during the preliminary materials investigation conducted in February and March 2001 are as follows:

A109: 4 gravel pits, 1 hardstone quarry

C66: 3 gravel pits, 2 hardstone quarries

C62: 1 gravel pit, 1 hardstone quarry

Tables 6.4 to 6.6 below summarise quarry characteristics of relevance to this assessment for each of the project roads.

Major concerns relating to quarries include vegetation clearance, landscape scars, dust and general disturbance during excavation, and the need to reinstate or landscape the quarries when the contractors have completed quarrying.

Most of the gravel sites are privately owned *shambas* with homesteads on them or located fairly close by. Most of these homesteads will therefore be, affected by dust and noise during excavation and quarrying. The Engineer will need to establish the general wind directions on project roads and advice the contractor accordingly.

Traffic to the gravel sites and quarries will also pose a nuisance to people living around them. Haulage routes will need to be identified and maintained by watering to minimise the impact of dust.

The tables indicate the depth of overburden at each gravel pit. Most of the gravel pits have overburden layers between 0.20 m and 0.3 m (i.e. 20 to 30 cm) in depth. Only two pits have an overburden layer over 0.5 m. This would mean that reinstatement might be difficult because there is little topsoil to be used to reinstate.

Erodibility depends largely on soil type and to some extent on the gradient of the site (slope). Gravel pits are more susceptible to erosion than hardstone quarries. In general the soil types along the project roads and gravel pit locations are fairly stable. Erosion was mainly noticed along the Machakos Turnoff – Sultan Hamud Road.

6.4: Environmental Characteristics of Gravel Pits and Hardstone Quarries along the Machakos Turnoff – Ulu – Sultan Hamud Road

Source Type	Approximate Chainage or Location (km+m)	Extent of Ground Cover Good (G) Moderate (M) Poor (P)	Approximate Gradient of Site (%)	Depth of Overburden (m)	Soil Type	Susceptibility to Erosion Yes (Y) No (N)	Proximity to Homesteads, Schools, Shops or Churches (m)	Remarks
gravel	Km 9+300	G	2%	0.6	Overburden: black cotton Gravel – grey clayey	Y	> 500 m	Pit on ranchland not open. Grass and shrubs to be cleared. Existing borrow pit adjacent to site was not reinstated.
gravel	Km 24+900	G	2%	0.9	Overburden: black cotton Gravel – white-brown silty calcerite	Y	> 500 m	Pit on ranchland not open. Grass and shrubs to be cleared. Existing borrow pit adjacent to site was not reinstated.
gravel	Km 34+600	M	4%	0.3	Overburden: red silty sands. Gravel	Y	50 m	Pit not open. Grass, a few trees and shrubs to be cleared.
gravel	Km 58+260	G	4%	0.2	Overburden: red silty sands. Gravel	Y	100 m	Pit not open. Grass, a few trees and shrubs to be cleared.
hardstone	Sultan Hamud	G	N/A	N/A	Fractured bedrock	N/A	100 m	Small portion of quarry is open. Crushed ballast can be seen at entrance to quarry.

6.5: Environmental Characteristics of Gravel Pits and Hardstone Quarries along the Thika – Kamae – Magumu Road

Source Type	Approximate Chainage or Location (km+m)	Extent of Ground Cover Good (G) Moderate (M) Poor (P)	Approximate Gradient of Site (%)	Depth of Overburden (m)	Soil Type	Susceptibility to Erosion Yes (Y) No (N)	Proximity to Homesteads, Schools, Shops or Churches (m)	Remarks
gravel	Km 6+100	G	1%	0.3	Overburden: red coffee soil Gravel – brown lateritic gravel	N	< 100 m	Pit not open. Land not arable.
gravel	Km 6+100	G	1%	0.2	Overburden: red coffee soil Gravel – brown lateritic gravel	N	< 100 m	Pit not open. Land not arable.
gravel	Km 7+200	G	1%	0.3	Overburden: red coffee soil Gravel – brown lateritic gravel	N	< 100m	Pit not open. Land not arable. Existing quarry adjacent to site.
hardstone	Kamwangi quarry	P	steep access	N/A	Soft stone for crusher run.	N	50 m	Quarry exploited. Located in steep river valley.
hardstone on Kedong ranch	Naivasha, 1.2 km from Moi South Road, 8 km to Homegrown (Flamingo farm)	G	N/A	N/A		N/A	50 m	Sections of the quarry already exploited and reinstated.

6.6: Environmental Characteristics of Gravel Pits and Hardstone Quarries along the Nairobi – Limuru – Kamandura Road

Source Type	Approximate Chainage or Location (km+m)	Extent of Ground Cover Good (G) Moderate (M) Poor (P)	Approximate Gradient of Site (%)	Depth of Overburden (m)	Soil Type	Susceptibility to Erosion Yes (Y) No (N)	Proximity to Homesteads, Schools, Shops or Churches (m)	Remarks
gravel	Off Kamiti road	G	2%	Not known	Brown gravel clayey	Y	100 m	Commercial quarry for gravel and hardcore. Pit open and stockpiles on site. Too much dust on site.
hardstone	Kayole, 1.5 km off Kangundo road	G	N/A	N/A	Bedrock	N	100 m	Commercial quarry for hardstones. Quarry temporarily closed but stockpiles on site.

Workmen's Camps

During rehabilitation, there will be some direct employment opportunities for both skilled and unskilled labour with the construction teams along the project roads. Furthermore, indirect employment opportunities are bound to arise from the provision of services to the construction teams. Camps for these roads would generally require approximately 2 to 5 acres of land. In addition, an area will have to be allocated to plant and equipment, and for crushing hardstone.

In setting up workmen's camp, consideration must be given to water availability and fuel supplies. It is likely that the workforce will put an additional demand, albeit temporarily, on fuelwood for cooking. This demand may affect local fuel wood supplies and may also compromise its availability to the local people.

Water is generally plentiful along the C66 and C62 project roads; but water supplies are not extensive. On the A109 water sources are limited. The demand for water may put temporary pressure on local supplies. Water in the camps is important in terms of maintaining hygiene and sanitary conditions.

The settlements/towns along the project road are not served by sewage systems or waste collection services. Sanitation and solid waste disposal will be a significant issue due to the workmen's camps.

The actual location of the camps will determine the extent of the impacts due to the camps. Along A109, the ideal locations are 1 km on the left (towards Mombasa), before Machakos Turnoff. A contractor for the Machakos Turnoff Ulu section previously used the location in 1989 and 1993. The other probable location of the workmen's camp is at the end of the project road, near the hardstone quarry source, plot no. LR 9730. There will be intermediate temporary camps along the project roads all depending on the rate of progress of the works.

For C66, possible locations for the camps are Thika and Kamwangi; the third location would be ideal towards the end of the project road near Magumu. This would also make it easier for the contractor to collect the hardstone from the Naivasha quarry.

For C62 the proposed works are not very extensive. It would be preferable to use a Nairobi based contractor with workmen coming from their homes. However, lay down areas for machinery and equipment storage will need to be identified.

Construction teams have the potential to cause natural resource degradation in terms of accelerating tree felling, hunting and vegetation clearance at the location. Sewage, solid and petroleum wastes are also usually produced at the camps.

Public Health

Improvement works and traffic during operation will create dust, air and noise pollution, which can have an impact on public health. Oil wastes from vehicles can also impact on public health if they find their way into water sources.

Sanitation and hygiene in the workmen's camps are also issues of concern, and if not properly addressed may lead to outbreaks of illnesses such as hepatitis, typhoid, intestinal worms, etc.

Road projects are associated with an increase in sexually transmitted diseases such as STDs and, HIV/AIDS due to the influx of workmen interacting with the local people. Construction teams can also cause social upheaval among communities along the project roads as well as the greater number of drivers who are expected to pass through the centres and settlements along the roads as a result of the improved road conditions.

Road Safety

The project roads have been designed for maximum speeds of 110 km/h on flat sections and rolling terrain and 80 km/h in mountainous/hilly areas. It is likely that the residents in the areas will not be used to fast traffic, and there may therefore be an increase in the number of accidents, at least in the initial months of operation.

On all three roads there is a considerable amount of non-motorised traffic, specifically pedestrians and cyclists. Increased vehicular traffic travelling at high speeds as a result of the improved road condition will pose a hazard to pedestrians and cyclists.

CHAPTER 7 MITIGATION OF IMPACTS

7.1 General

This chapter focuses on measures that have been incorporated into the design, improvement works and operation stages of the project in order to mitigate the negative environmental impacts and enhance the positive ones described in Chapter 5.

7.2 Hydrology

Changes to the hydrological regime have been taken into account in the road design through the construction of box and pipe culverts so that the flow in the rivers and streams is unimpeded, and by having side drains and mitre drains to direct road runoff away from the road.

These features must be properly designed and regularly maintained to prevent runoff from accumulating by the side of the road, and to ensure that water that is drained off the road does not create gullies, and that siltation of the structures does not occur. Safe final disposal and self-cleaning are essential elements in designing drainage structures. In some cases, the construction of artificial waterways is necessary to facilitate the safe discharge of runoff to the final recipient body, i.e. a river or stream.

7.3 Soil Erosion

The speed of road runoff is one of the major contributing factors to erosion and scouring in the side drains along steep sections of a road. In order to reduce the impact of runoff; check dams or scour checks have been introduced in the side drains at specified intervals, depending on the gradient of the slope. Grouted stone pitching and rock fill gabion works are necessary to protect culvert inlets and outlets.

Earthworks should be controlled during construction, so that land that is not required for deviations, realignments or gravel sites are not disturbed. The contract documents should stipulate that, wherever possible, earthworks should be carried out during the dry season to prevent soil from being washed away by the rain.

The specified cut and fill gradients (1:1.5) must be adhered to, and the embankments should be planted with shrubs and grasses to reduce erosion of road embankments.

Areas that have been cleared of vegetation, e.g. for improving sight distance or for deviations, must be planted. Acacia trees or shrubs for example can be planted on the A109, and shrubs and grasses on the C66. The vegetation will reduce the risk of erosion and stability problems. Sloped road embankments and gravel sites can also be terraced, and trash lines along terraces will stop soil from being washed away. Gravel sites must be landscaped and re-vegetated. This is discussed further in Section 7.7.2.

In order to ensure that environmental protection is taken into account during construction, these issues must be specified in the contract documents.

7.4 Pollution

Dust emissions can be reduced during construction by dampening the gravel pit area, deviations or earth along the road section. Off-road driving can be prevented if the road is always in motorable condition, and through creating awareness among drivers. In the case of deviations, slowing the speed of traffic by using bumps and/or clearly marked road signs may contribute to reducing dust levels.

Poorly maintained vehicles often emit noxious fumes (carbon dioxide, carbon monoxide, and nitrogen and sulphur oxides). There is also much documentation on lead concentrations in the blood of people residing beside roads. Such issues need to be addressed at a national level, through encouraging the use of lead free petrol, and introducing "road worthiness tests" which must be passed before road licenses are issued.

Noise abatement can be done through sensitising motorists/truck drivers, particularly in towns and market centres, by using signboards and conducting awareness campaigns. Regulations should be introduced that restrict the movement of heavy vehicles through settlements after certain hours.

The asphalt and crushing plants will create dust, air and noise pollution. Ensuring that the plant is located downwind of settlements can reduce this impact. The plants should not operate during the night. Plant and equipment should also be well maintained to reduce the amount of pollution emitted.

Oil is often drained from trucks and lorries by the side of the road, usually in the settlements/centres. Such maintenance activities should be carried out in specially designated trucking stops or at petrol stations. This can only be assured through legal means. Contamination of soil and/or water sources resulting from oil in stormwater drains can be controlled through installing oil sumps at truck parking bays (e.g. at Salama), and at the point where stormwater drains meet rivers or streams.

Installing culverts during the dry season, wherever possible can reduce sediment loads in the rivers and streams. In addition, the Resident Engineer should ensure that the contractor disposes of all construction debris, including oil and oil wastes, in a sensible manner. Disposal of waste into any water bodies (rivers/streams) should be prohibited.

7.5 Deviations

Deviations should, wherever practical, adhere to the road reserve. All deviations must be planned and their routes specified in the contract documents.

As a condition of contract, any trees removed for the purposes of the deviation, must be replanted when the road works are complete and the deviation ceases to be of use.

7.6 Compensation

Loss of land, crops and housing should be mitigated through compensation. The Commissioner for Lands in the Ministry of Lands and Settlement determines the amount of compensation to be paid for private land. When the road design is complete, the MoRPW must instruct or notify the Commissioner for Lands of its intention to rehabilitate the road. All technical details of the road design and quarries (including drawings and plans, details of location, volume of materials required, etc.) must be submitted along with the letter of notification.

The Consultant has indicated the amount of land required for realignments, gravel sites, extended road reserves and deviations, and the number of households that will have to be compensated. The Commissioner for Lands will then assesses the amount of land required and determine the market value of the land itself, value of crops lost, value of buildings on the land that may be affected, environmental and social implications, etc. The Ministry of Lands and Settlement then acquires the land for the MoRPW. No relocation of families is expected.

7.7 Gravel Pits and Quarries

7.7.1 Excavation of Gravel Pits and Hardstone Quarries

Mitigation measures for soil erosion and dust emissions from gravel pits and hardstone quarries have been discussed under Sections 7.3 and 7.4.

Normally landowners sign contracts with the MoRPW before excavation begins which include terms and conditions for payment, the amount of land to be excavated and rehabilitation measures to be carried out.

The area to be excavated should be cordoned off, particularly for hardstone quarries, which tend to be very deep and pose a danger to livestock and children. The contract documents should instruct the contractor to maintain fences and "make good" afterwards.

All access routes to gravel pits/quarries and crossings over pipelines should be planned ahead of construction and described in the contract documents.

Blasting for hardstone should be done only during the day, and residents in the vicinity of the quarry should be suitably warned of blasting activities. This must be specified in the conditions of contract if the quarry in question is selected for exploitation.

7.7.2 Rehabilitation

When gravel pits are being excavated the owner cannot use the land. Excavation also sometimes leaves an uneven land surface, which makes it difficult to cultivate.

Gravel pits must be landscaped then reinstated or backfilled with overburden, if the depth of the overburden is sufficient to allow for this. If excavation is properly planned, organised and executed, it would be possible to rehabilitate most of the gravel pits. It is therefore important to have separate stockpiles for overburden, gravel, etc.

Terracing and replacement of fencing is part of the rehabilitation process. Contract documents should instruct contractors to plant trees to replace those that have been removed during excavation.

Sometimes landowners wish to leave the gravel pits as they are so that they can be used as temporary water sources (pans) for livestock. Apart from encouraging the breeding of mosquitoes (the vectors for malaria), the pans will encourage localised erosion caused by trampling.

Landowners must be informed of the environmental implications of the excavation works at the time of identification of the gravel pits. They should be told at the earliest whether testing has revealed that material from their plot was acceptable or not for use on the project road. They must also be told of the options available to them after excavation, i.e. rehabilitation/landscaping, or construction of water pans. It is very important that they understand the conditions on the contract form before they sign it, and must ensure that these conditions include their requirements such as back filling, fencing, terracing, etc.

7.8 Trading Centres and Settlements

Activities in the trading centres and settlements along the project roads must not be disturbed as far as is possible. People should be informed of intended roadwork activities, including likely dates for commencement and completion of works. Warning signs should also be introduced on the approach to settlement areas.

In some of the settlements/centres along the road, shops and kiosks are located within the road reserve. These will probably have to be removed during improvement works, but the owners are not eligible for compensation. Nevertheless, they should be informed in advance, through the

chiefs and local councillors, if their structures are to be removed so that they can make arrangements to relocate their premises if necessary, and for future planning prevent the construction of the same on the road reserve.

7.9 Vegetation

Vegetation should not be cleared unnecessarily during the improvement works, whether for the existing alignment, any proposed realignment or the excavation of gravel pits. This should be specified in the contractor's contract.

In towns, trading centres and settlements through which the project roads pass, trees should be planted along the edge of the road reserve after completion of the roadwork. The contractor should be instructed to do this by the Resident Engineer, but the town councils or chiefs should care for the trees. This would augment the aesthetics of the settlements/towns, and would also help to prevent soil erosion along the roadside. Trees also filter dust and particulate matter from the air.

Planting of trees and grassing must be specified in the Standard Specification, and as an item in the Bills of Quantities.

7.10 Livestock

Livestock movement is more extensive on the A109 than on the C66 and C62. Mitigation would include erecting warning signs at intervals along the road. In addition, the provision of shoulders along the road would allow livestock to use these instead of the road, and warning signs should be erected at intervals along the roads, particularly at frequently used crossings.

7.11 Workmen's Camps

7.11.1 Local Resources

The impact on water sources will be influenced by the location of the workmen's camps. Care should be taken not to stress the local supply at the expense of the local population. The contractor should consult with the local authorities on where they source their water from and see if this provides for a viable option.

The workforce should be discouraged from buying charcoal. Each camp should have a central canteen to serve the entire workforce, and gas, kerosene or electric cookers should be used.

7.11.2 Location of the Camps

Camps should preferably be located at urban centres along the project roads. For example, camps for the A109 can be set up at Makutano or Salama, for the C66 at Magumu, Kamwangi and Thika. These centres would be able to temporarily absorb the workforce in terms of provision of food, water, fuel, etc, without greatly impacting on local demand. Camps should not be located at isolated points along the road where they will attract periphery businesses, and provide a nucleus for the growth of unplanned settlements. On the C62, because of the length of the road and its proximity to Nairobi workmen's camps are likely to have a minimal impact.

7.12 Public Health and Occupational Safety

A central canteen for the workforce at each camp, as recommended in Section 7.11.1, would contribute towards the general health in the camp as kitchen wastes can be disposed of in an organised manner, while hygiene can be monitored.

The location of pit latrines in the camps should preferably be downhill of potable water sources, or 200 m to 500 m from any water body. Communal bathrooms/lavatories with soakaway pits are a less polluting option, but would be a slightly more expensive option.

STD awareness campaigns should be conducted in the camps as well as in the settlements/trading centres.

Workmen should be provided with suitable protective gear (such as nose masks, ear muffs, helmets, overalls, industrial boots, etc), particularly during quarrying, blasting, drilling, and while working on the asphalt and crushing plant, and handling tar. There must be a fully equipped first aid kit on site and a Safety Officer who has first aid training and knowledge of safety regulations. In addition, the contractor must have workmen's compensation cover.

These issues are included in the Standard Specification.

7.13 Road Safety

The danger posed to pedestrians, cyclists and livestock due to increased traffic volumes and installing clear and frequent road signs and markings (both directional and warning) can mitigate higher speeds. Signs are also necessary near health centres and schools.

The provision of shoulders that can be used as foot and cycle paths will also contribute to making the roads safer.

7.14 Visual Enhancement

Once road works are complete, the contractor must ensure that the landscape is restored as much as possible to its original form. Landscaping/reinstating and replanting gravel pits and deviations would reduce the visual intrusion caused by the excavation and clearing works. Planting trees along the project road, particularly at settlements would greatly improve aesthetics.

Creating awareness among drivers to dim their lights for on-coming traffic can reduce nocturnal glare.

7.15 Public Awareness

It is most important that people along the project roads and in their area of influence are aware of the proposed road improvements. This is particularly important if land is to be requisitioned for realignments or the extension of the road reserve. People must be told well in advance that they may need to relinquish their land so that they can prepare and plan for any changes to their lifestyles. The mental and social impact of the project on the communities is consequently diminished.

The District Works Officer (DWO) represents the MoRPW on the ground. The DWO follows progress of the project from planning through construction, implementation and operation. Through the District Development Committee he must inform the district administration (i.e. District Commissioner, District Officers, Chiefs, etc.) of progress on the project. The district administration, in turn, should keep the local population posted on the progress of the project, and of any relevant developments relating to the road project. Other effective channels for dissemination of information are churches, women's groups and self-help groups.

7.16 MoRPW Environmental Requirements

The Ministry of Roads and Public Works has recently set up an environmental unit under its Planning Branch whose responsibility is to oversee environmental compliance in all road related

activities. Many MoRPW documents give guidelines on environmental protection and mitigation. For example, the Road Design Manual acknowledges that all road projects will have both positive and negative effects on the environment. It also states that the "location and design of a road should aim at maximising the favourable effects of the project, such as providing or removing undesirable traffic from environmentally vulnerable areas, while at the same time minimising the adverse effects of the project as much as possible".

Construction activities, protection from water, removal of camps, safety and public health requirements, site clearance and removal of topsoil and overburden, and maintenance of deviations are addressed in the Ministry's Standard Specification for Road and Bridge Construction.

Road safety, security and protection of the environment with regard to quarries and borrow pits, soil erosion, diversions, haulage routes, workmen's camps, asphalt plant and machinery units, rock blasting, spillage of oil/fuel etc, and liaison with authorities in charge of wildlife and natural resources are stipulated in the general conditions of the contract.

The conditions of contract to a large extent dictate the level of mitigation that can be achieved. Hence it is essential that all mitigation measures are stipulated in detail in the contract documents. In this way, the contractor and the Resident Engineer are forced to implement the recommended mitigation measures.

In addition, the contractor must, in his tender documents, cost all remedial measures as unit prices. These measures are included in the tender documents as follows:

- drainage structures (Standard Specification Section 8);
- replacement of fencing, and cordons for quarries/gravel pits during exploitation (Standard Specification Clauses 118, 605);
- trees, shrubs and grass for replanting quarry sites, embankments, road sides, deviations (Standard Specification Clauses 401, 404, 514 and Bills of Quantities);
- erosion control (Standard Specification Clauses 115, 116)
- landscaping of quarries (Standard Specification Clause 607);
- maintenance of plant and equipment (Standard Specification Clause 135);
- workmen's camps (Standard Specification Clauses 101,117, 136);
- special parking areas for HGVs (Engineering Drawings and Bills of Quantities);
- provision for fuel and water supply (water supply Special Specification Clause 125);
- public health and occupational safety including pollution, protective clothing, insurance, provision of Safety Officer, first aid kits (Standard Specification Clauses 115, 116, 117, 134);
- blasting/use of explosives (Special Specification Clause 119);
- road signs (Standard Specification Clauses 131, 907).

CHAPTER 8 ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

8.1 General

Monitoring is a long-term process, which should begin at the start of construction and should continue throughout the life of the road project. Its purpose is to establish benchmarks so that the nature and magnitude of anticipated environmental and social impacts can be continually assessed. So monitoring involves the continuous or periodic review of construction and maintenance activities to determine the effectiveness of recommended mitigation measures. Consequently, trends in environmental degradation or improvement can be established, and previously unforeseen impacts can be identified or pre-empted.

Environmental audits are carried out one year after completion of the project. These audits assess the relevance, efficiency and impact of any mitigation measures that have been employed.

8.2 Environmental Monitoring and Management

The responsibility for the incorporation of mitigation measures for the rehabilitation of the roads lies with the Supervising Engineer, who must ensure that the Contractor implements all specified mitigation measures. In order for the Contractor to carry out environmental management activities during construction he should draw up an environmental management plan of his own to show how he will address the mitigation measures during the construction period. The Supervising Engineer is responsible for assessing the Contractor's environmental management plan.

The MoRPW Maintenance Unit will have to oversee the Supervising Engineer to confirm that mitigation is being implemented in the correct manner.

Environmental monitoring allows measures to be implemented in order to prevent or avert negative impacts. Simple monitoring systems should be set up during construction by the Supervising Engineer and Contractor, and during operation by the MoRPW Maintenance Unit, so that potentially environmentally problematic areas can be detected well in advance and the appropriate remedial action taken. This could simply be a checklist of items that need to be inspected as a matter of routine, or periodically, depending on the nature of the aspect. An example of such a checklist can be found in Appendix C.

The types of parameters that can be monitored may include mitigation measures or design features, or actual impacts. In some cases, such as drainage structures and soil conservation interventions, monitoring is fairly straightforward and can be done as part of routine or periodic maintenance. However, other parameters, particularly those related to socio-economic and ecological issues can only be effectively assessed over a more prolonged period of say 3 to 5 years.

Tables 8.1 – 8.3 below summarise the environmental management plans for the three roads. It describes parameters that can be monitored, and suggests how monitoring should be done, how frequently, and who should be responsible for monitoring and action. Measures that can be incorporated into the tender documents and BoQs are *italicised.*

ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN MACHAKOS TURNOFF – SULTAN HAMUD (A109)

Table 8.1 below summarises the environmental management plan. It describes parameters that can be monitored, and suggests how monitoring should be done, how frequently, and who should be responsible for monitoring and action. Measures that can be incorporated into the tender documents and BoQs are italicised.

Table 8.1: Monitoring and Management of Impacts and Mitigation Measures on the A109

Environmental/ Social Impact	Proposed Mitigation and Aspects for Monitoring	Responsibility for intervention and monitoring during design, construction and defects liability period	Responsibility for mitigation, monitoring and/or maintenance after defects liability period	Monitoring means (c) = construction (o) = operation	Recommended frequency of monitoring
Changes in hydrology /impeded drainage	- *Install drainage structures properly* - Efficiency of drainage structures	Design Engineer Supervising Engineer and Contractor Supervising Engineer	 MoRPW Maintenance Unit	(c) inspection (o) routine maintenance and road condition survey	(c) during construction and on completion of each structure (o) once a year
Soil erosion	- *Control earthworks* - *Install drainage structures properly* - *Install erosion control measures* - *grouted stone pitching and rock fill gabion works will be necessary to protect culvert inlets and outlets* - *Landscape embankments and re-vegetate gravel sites with grass (e.g. Tetrapogon bidentatus or Chrysopogon ancheri)* - *For drainage ditches along the road scour checks will be necessary in steep sections.* - *Management of excavation activities* - *On sections with high filling and deep cutting, slopes should be covered by stone walls and planted with grass, etc. If existing drainage systems are damaged, they should be rebuilt or rehabilitated by suitable methods.* - Impact on erosion (on road, off road, embankments, riverbanks, etc.) - Efficiency of erosion control measures	Supervising Engineer and Contractor Supervising Engineer	 MoRPW Maintenance Unit	(c) inspection (o) routine maintenance and road condition survey c) inspection (o) routine maintenance and road condition survey	(c) daily; erosion control measures: during construction and on completion of each measure (o) once a year (c) once a month (o) once in 6 months to account for seasonal variations over 3-5 years
Air pollution	- *Control speed of construction vehicles* - *Prohibit idling of vehicles* - *Sensitise workforce* - *Residences should be 500 m from downward wind of asphalt mixing sites.* - *Water should be sprayed during construction phase on deviations, temporary roads leading to quarry*	Design Engineer, Supervising Engineer and Contractor		(c) inspection / observation	(c) daily/random

	sites, borrow pits, and asphalt mixing sites. - *In filling sub-grade water spraying is needed to solidify the material and to assist in compaction. After compaction, water spraying should be regular to prevent dust.* - *Plant trees around settlements (e.g. Acacia sp. and Commiphora sp.)* - *Regular maintenance of plant and equipment* - Impose speed limits for all vehicles, especially at towns and villages - Sensitise motorists/road users		Traffic Police	(o) observation	(o) random
Noise pollution	- *Sensitise workforce* - *Supervise construction traffic* - *Sensitise drivers of construction vehicles* - *Maintain plant and equipment* - *Workers in the vicinity of high level noise to wear safety & protective gear.* - Impose speed limits for all vehicles, especially at towns and villages - Sensitise motorists/road users	Supervising Engineer and Contractor	Contractor Traffic Police	(c) inspection / observation (o) observation	(c) daily/random (o) random
Water pollution	- *Incorporate erosion control measures* - *Works on culverts to be done in the dry season* - *Proper disposal of construction debris and solid wastes from impeding water bodies and drainage systems* - *Proper handling, storage and disposal of oil and oil wastes* - *Proper disposal of wastewater / sewage at Contractor's/ workmen's camps*	Supervising Engineer and Contractor	n/a	(c) inspection / tests	(c) daily (o) to be monitored the first year after completion of project, then every 2-3 years
Oil pollution	- *Construct parking bays at terminal towns for heavy vehicles, with oil interceptors in drains* - *Proper storage, handling and disposal of oil and oil wastes* - *Maintain plant and equipment* - Maintenance of construction vehicles should be carried out in the Contractor's camp.	Design Engineer Supervising Engineer and Contractor Supervising Engineer and Contractor	District Engineer	(c) inspection (o) routine maintenance	(c) during construction and on completion (o) once in 6 months (c) daily

Environmental/ Social Impact	Proposed Mitigation and Aspects for Monitoring	Responsibility for intervention and monitoring during design, construction and defects liability period	Responsibility for mitigation, monitoring and/or maintenance after defects liability period	Monitoring means (c) = construction (o) = operation	Recommended frequency of monitoring
Gravel sites	- Inform people living at/near the sites that the pits have been selected for exploitation. - Arable lands should not be used as borrow pits whenever possible. For new borrow pits the topsoil (30cm) should be kept and refilled after construction is over to minimise the impact on ecosystem and agriculture	Supervising Engineer and Contractor		(c) meeting	(c) once, immediately after selection of sites
	- *Plan access to gravel sites* - *Control and restrict access to gravel sites (e.g. by fencing)* - *Control earthworks* - *Proper management of excavation activities* - *Landscape, terrace if necessary, and grass sites. Replace trees that were removed during excavation* - Discourage pans being made into water pans after construction - *Rehabilitate old unused gravel pits*	Supervising Engineer and Contractor		(c) inspection	(c) daily
	- Compensate owners as required	Design Engineer and Min. Lands and Settlement		(c) payment records	(c) once, before excavation begins
	- Progress of rehabilitated gravel sites (use of site, established vegetation)	Supervising Engineer	MoRPW Maintenance Unit	(o) inspection	(c) once in 2 months (o) once in 6 months
Water Sources	- *Management of water usage* - *Plan for harvesting and storage of water during rains for use later* - *Plan works schedule according to water availability* - *Abstraction not to be done during low flow.*	Supervising Engineer and Contractor	n/a	(c) meetings, inspection check plans and schedule,	(c) during rains, during abstraction at sources, and at random
Fuel	- Energy sources should be identified so as not to put a strain on the local resources - Discourage use of firewood/charcoal by providing alternatives such as kerosene and gas.	Contractor	Contractor	(c) inspection	(c) daily

Environmental/ Social Impact	Proposed Mitigation and Aspects for Monitoring	Responsibility for intervention and monitoring during design, construction and defects liability period	Responsibility for mitigation, monitoring and/or maintenance after defects liability period	Monitoring means (c) = construction (o) = operation	Recommended frequency of monitoring
Construction Camp	- *Sufficient measures will be taken in the construction camps i.e., provision of garbage bins and sanitation facilities. If septic tanks are installed, waste will be cleared periodically.* - *Special attention shall be paid to the sanitary condition of camps.* - *Garbage will be disposed of periodically* - *Sensitisation campaign on STDs will be mandatory at the camps and in the community*	Contractor, Supervising Engineer		(c) Inspection	(c) daily
Deviations	- *Plan deviations* - *Adhere to road reserve if possible* - *Obtain permission from inhabitants if deviation goes beyond ROW* - *Reinstate deviations (and old tracks) to original condition* - Management of traffic along deviation	Supervising Engineer and Contractor		(c) check plans; inspections	(o) daily when deviations are in use
	- Pay compensation for crops/property removed/destroyed by deviations on inhabited land	Design Engineer and Min. Lands and Settlement		(o) payment records	(c) once before constructing deviations
	- Monitor rehabilitation of deviations		Maintenance Branch		(o) once in 6 months
Vegetation	- *Control clearing* - *Avoid clearing using herbicides* - *Replant areas where vegetation is unnecessarily removed.* - *Landscaping and planting all disturbed areas (pits, deviations, embankments, camp sites)* - *Plant trees at main towns along road.* - Planting and grassing should be done just before the rains	Supervising Engineer and Contractor		(c) inspection	(c) daily
	- *Care for trees/plants.*	Contractor	MoRPW	(c) observation (o) observation	(c) weekly (o) random

Environmental/ Social Impact	Proposed Mitigation and Aspects for Monitoring	Responsibility for intervention and monitoring during design, construction and defects liability period	Responsibility for mitigation, monitoring and/or maintenance after defects liability period	Monitoring means (c) = construction (o) = operation	Recommended frequency of monitoring
Livestock	- Provide shoulders along the road to allow livestock to use these instead of the road	Design Engineer, Supervising Engineer and Contractor			
	- *Install warning signs*	Supervising Engineer and Contractor	District Roads Engineer	(c) inspection (o) routine maintenance	(c) when erecting (o) once in 6 months
	- *Enforce speed limits*	Contractor	Traffic Police	(c) observation	(c) daily (o) random
	- Monitor livestock kills		District Livestock Production Officer	(o) observation/reports	(o) once a year

ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN THIKA – KAMAE – MAGUMU ROAD (C66)

Table 8.2 below summarises the environmental management plan. It describes parameters that can be monitored, and suggests how monitoring should be done, how frequently, and who should be responsible for monitoring and action. Measures that can be incorporated into the tender documents and BoQs are italicised.

Table 8.2: Monitoring and Management of Impacts and Mitigation Measures on the C66

Environmental/ Social Impact	Proposed Mitigation and Aspects for Monitoring	Responsibility for intervention and monitoring during design, construction and defects liability period	Responsibility for mitigation, monitoring and/or maintenance after defects liability period	Monitoring means (c) = construction (o) = operation	Recommended frequency of monitoring
Changes in hydrology /impeded drainage	- *Install drainage structures properly* - *Rehabilitate and/or replace damaged culverts* - *Install wide side/retention ditches to act as water storage and new 900mm culverts to minimise siltation and improve drainage*	Design Engineer Supervising Engineer and Contractor		(c) inspection	(c) during construction and on completion of each structure
	- Efficiency of drainage structures	Supervising Engineer	MoRPW Maintenance Unit	(o) routine maintenance and road condition survey	(o) once a year
Soil erosion	- *Control earthworks* - *Install drainage structures properly* - *Install erosion control measures* - *grouted stone pitching and rock fill gabion works will be necessary to protect culvert inlets and outlets* - *For drainage ditches along the road scouring checks will be necessary* - *Management of excavation activities* - *In slopes and other suitable places along the roadside, shrubs should be planted along the first 15 Km.*	Supervising Engineer and Contractor		(c) inspection (o) routine maintenance and road condition survey	(c) daily; erosion control measures: during construction and on completion of each measure (o) once a year
	- Impact on erosion (on road, off road, embankments, riverbanks, etc.) - Efficiency of erosion control measures	Supervising Engineer	MoRPW Maintenance Unit	(c) inspection (o) routine maintenance and road condition survey	(c) once a month (o) once in 6 months to account for seasonal variations over 3-5 years

Environmental/ Social Impact	Proposed Mitigation and Aspects for Monitoring	Responsibility for intervention and monitoring during design, construction and defects liability period	Responsibility for mitigation, monitoring and/or maintenance after defects liability period	Monitoring means (c) = construction (o) = operation	Recommended frequency of monitoring
Air pollution	- *Control speed of construction vehicles* - *Prohibit idling of vehicles* - *Sensitise workforce* - The asphalt mixing could be done in Nairobi and transported to site *Residences should be 500 m from downward wind of asphalt mixing sites.* - *Water should be sprayed during construction phase on deviations, temporary roads leading to quarry sites, borrow pits, and asphalt mixing sites.* - *In filling sub-grade water spraying is needed to solidify the material and to assist in compaction. After compaction, water spraying should be regular to prevent dust.* - *Regular maintenance of plant and equipment* - Impose speed limits for all vehicles, especially at towns and villages - Sensitise motorists/road users	Design Engineer, Supervising Engineer and Contractor	Traffic Police	(c) inspection / observation (o) observation	(c) daily/random (o) random
Noise pollution	- *Sensitise workforce* - *Supervise construction traffic* - *Sensitise drivers of construction vehicles* - *Maintain plant and equipment* - *Workers in the vicinity of high level noise to wear safety & protective gear.* - Impose speed limits for all vehicles, especially at towns and villages - Sensitise motorists/road users	Supervising Engineer and Contractor	Contractor Traffic Police	(c) inspection / observation (o) observation	(c) daily/random (o) random

Environmental/ Social Impact	Proposed Mitigation and Aspects for Monitoring	Responsibility for intervention and monitoring during design, construction and defects liability period	Responsibility for mitigation, monitoring and/or maintenance after defects liability period	Monitoring means (c) = construction (o) = operation	Recommended frequency of monitoring
Water pollution	- *Incorporate erosion control measures* - *Works on culverts to be done in the dry season* - *Solid waste at workmen's camps should not be dumped in rivers, streams or any open water bodies along the project road resulting in any adverse impact on water quality.* - *Proper handling, storage and disposal of oil and oil wastes* - *Proper disposal of wastewater / sewage at Contractor's/ workmen's camps*	Supervising Engineer and Contractor	n/a	(c) inspection / tests	(c) daily (o) to be monitored the first year after completion of project, then every 2-3 years
Oil pollution	- *Proper storage, handling and disposal of oil and oil wastes* - *Maintain plant and equipment* - Maintenance of construction vehicles should be carried out in the Contractor's camp.	Supervising Engineer and Contractor		(o) routine maintenance	(c) daily
Gravel sites	- *Plan access to gravel sites* - *Control earthworks* - *Proper management of excavation activities*	Supervising Engineer and Contractor		(c) inspection	(c) daily
Water Sources	- *Management of water usage* - *Plan for harvesting and storage of water during rains for use later* - *Plan works schedule according to water availability* - *Abstraction not to be done during low flow.*	Supervising Engineer and Contractor	n/a	(c) meetings, inspection check plans and schedule,	(c) during rains, during abstraction at sources, and at random
Fuel	- Energy sources should be identified so as not to put a strain on the local resources - Discourage use of firewood/charcoal by providing alternatives such as kerosene and gas.	Contractor	Contractor	(c) inspection	(c) daily

Environmental/ Social Impact	Proposed Mitigation and Aspects for Monitoring	Responsibility for intervention and monitoring during design, construction and defects liability period	Responsibility for mitigation, monitoring and/or maintenance after defects liability period	Monitoring means (c) = construction (o) = operation	Recommended frequency of monitoring
Construction Camp	- *Sufficient measures will be taken in the construction camps i.e., provision of garbage bins and sanitation facilities. If septic tanks are installed, waste will be cleared periodically.* - *Special attention shall be paid to the sanitary condition of camps.* - *Garbage will be disposed of periodically* - *Sensitisation campaign on STDs will be mandatory at the camps and in the community*	Contractor, Supervising Engineer		(c) Inspection	(c) daily
Deviations	- *Plan deviations* - *Adhere to road reserve if possible* - *Obtain permission from inhabitants if deviation goes beyond ROW* - *Reinstate deviations (and old tracks) to original condition* - Management of traffic along deviation	Supervising Engineer and Contractor		(c) check plans; inspections	(o) daily when deviations are in use
	- Pay compensation for crops/property removed/destroyed by deviations on inhabited land	Design Engineer and Min. Lands and Settlement		(o) payment records	(c) once before constructing deviations
	- Monitor rehabilitation of deviations		District Engineer		(o) once in 6 months
Vegetation	- *Control clearing* - *Avoid clearing using herbicides* - *Replant areas where vegetation is unnecessarily removed.* - *Landscaping and planting all disturbed areas (deviations, embankments, camp sites)* - *Plant trees at main towns along road.* - Planting and grassing should be done just before the rains.	Supervising Engineer and Contractor		(c) inspection	(c) daily
	- *Care for trees/plants.*	Contractor	town councils and MoRPW	(c) observation (o) observation	(c) weekly (o) random

Environmental/ Social Impact	Proposed Mitigation and Aspects for Monitoring	Responsibility for intervention and monitoring during design, construction and defects liability period	Responsibility for mitigation, monitoring and/or maintenance after defects liability period	Monitoring means (c) = construction (o) = operation	Recommended frequency of monitoring
Wildlife	- *Control clearing of vegetation* - *Plant trees/shrubs to provide new habitats where vegetation has been destroyed* - Prohibit hunting by project staff	Supervising Engineer and Contractor Contractor			
	- *Install warning signs*	Supervising Engineer and Contractor	District Roads Engineer	(c) inspection (o) routine maintenance	(c) when erecting (o) once in 6 months
	- *Enforce speed limits*	Contractor	Traffic Police	(c) observation (o) observation	(c) daily (o) random
	- Monitor wildlife kills		Kenya Wildlife Service	(o) reports	(o) once a year

ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN NAIROBI – LIMURU – KAMANDURA ROAD (C62)

Table 8.3 below summarises the environmental management plan. It describes parameters that can be monitored, and suggests how monitoring should be done, how frequently, and who should be responsible for monitoring and action. Measures that can be incorporated into the tender documents and BoQs are italicised.

Table 8.3: Monitoring and Management of Impacts and Mitigation Measures on the C62

Environmental/ Social Impact	Proposed Mitigation and Aspects for Monitoring	Responsibility for intervention and monitoring during design, construction and defects liability period	Responsibility for mitigation, monitoring and/or maintenance after defects liability period	Monitoring means (c) = construction (o) = operation	Recommended frequency of monitoring
Changes in hydrology /impeded drainage	- *Install drainage structures properly*	Design Engineer Supervising Engineer and Contractor		(c) inspection	(c) during construction and on completion of each structure
	- Efficiency of drainage structures	Supervising Engineer	MoRPW Maintenance Unit	(o) routine maintenance and road condition survey	(o) once a year
Soil erosion	- *Control earthworks* - *Install drainage structures properly* - *Install erosion control measures* - *grouted stone pitching and rock fill gabion works will be necessary to protect inlets and outlets* - *Landscape and grass road embankments* - *Management of excavation activities* - *On sections with high filling and deep cutting, slopes should be covered by stone walls and planted with grass, etc.* - *Damaged drainage systems should be rebuilt or rehabilitated by suitable methods.*	Supervising Engineer and Contractor		(c) inspection (o) routine maintenance and road condition survey	(c) daily; erosion control measures: during construction and on completion of each measure (o) once a year
	- Impact on erosion (on road, off road, embankments, etc.) - Efficiency of erosion control measures	Supervising Engineer	MoRPW Maintenance Unit	c) inspection (o) routine maintenance and road condition survey	(c) once a month (o) once in 6 months to account for seasonal variations over 3-5 years

Environmental/ Social Impact	Proposed Mitigation and Aspects for Monitoring	Responsibility for intervention and monitoring during design, construction and defects liability period	Responsibility for mitigation, monitoring and/or maintenance after defects liability period	Monitoring means (c) = construction (o) = operation	Recommended frequency of monitoring
Soil erosion	- *Control earthworks* - *Install drainage structures properly* - *Install erosion control measures* - *Landscape and grass road embankments* - *For drainage ditches along the road scouring checks will be necessary* - *Outlets at out fall channels located along farmlands need to be concrete lined to allow for the flow of runoff* - *Management of excavation activities* - *On sections with high filling and deep cutting, slopes should be covered by stone walls and planted with grass, etc. If existing drainage systems are damaged, they should be rebuilt or rehabilitated by suitable methods.*	Supervising Engineer and Contractor		(c) inspection (o) routine maintenance and road condition survey	(c) daily; erosion control measures: during construction and on completion of each measure (o) once a year
	- Impact on erosion (on road, off road, embankments, riverbanks, etc) - Efficiency of erosion control measures	Supervising Engineer	MoRPW Maintenance Unit	(c) inspection (o) routine maintenance and road condition survey	(c) once a month (o) once in 6 months to account for seasonal variations over 3-5 years
Air pollution	- *Control speed of construction vehicles* - *Prohibit idling of vehicles* - *Sensitise workforce* - *Residences should be 500 m from downward wind direction of asphalt mixing sites.* - *Water should be sprayed during construction phase on temporary roads leading to asphalt mixing sites.* - *In filling sub-grade water spraying is needed to solidify the material and to assist in compaction. After compaction, water spraying should be regular to prevent dust.* - *Regular maintenance of plant and equipment*	Design Engineer, Supervising Engineer and Contractor		(c) inspection / observation	(c) daily/random

	- Impose speed limits for all vehicles, especially at towns and villages - Sensitise motorists/road users		Traffic Police	(o) observation	(o) random
Noise pollution	- *Sensitise workforce* - *Supervise construction traffic* - *Sensitise drivers of construction vehicles* - *Maintain plant and equipment* - *Workers in the vicinity of high level noise to wear safety & protective gear.* - Impose speed limits for all vehicles, especially at towns and market centres - Sensitise motorists/road users	Supervising Engineer and Contractor	Contractor Traffic Police	(c) inspection / observation (o) observation	(c) daily/random (o) random
Water pollution	- *Incorporate erosion control measures* - *Proper disposal of construction debris and solid wastes from impeding water bodies and drainage systems* - *Proper handling, storage and disposal of oil and oil wastes* - *Proper disposal of wastewater / sewage at Contractor's/ workmen's camps*	Supervising Engineer and Contractor	n/a	(c) inspection / tests	(c) daily (o) to be monitored the first year after completion of project, then every 2-3 years
Oil pollution	- *Proper storage, handling and disposal of oil and oil wastes* - *Maintain plant and equipment* - Maintenance of construction vehicles should be carried out in the Contractor's camp.	Supervising Engineer and Contractor	Contractor	(c) inspection (o) routine maintenance	(c) daily (o) once in 6 months
Gravel sites	- *Plan access to gravel sites* - *Control earthworks* - *Proper management of excavation activities*	Supervising Engineer and Contractor		(c) inspection	(c) daily
Water Sources	- *Management of water usage* - *Plan for harvesting and storage of water during rains for use later* - *Plan works schedule according to water availability* - *Abstraction not to be done during low flow.*	Supervising Engineer and Contractor	n/a	(c) meetings, inspection check plans and schedule,	(c) during rains, during abstraction at sources, and at random

Environmental/ Social Impact	Proposed Mitigation and Aspects for Monitoring	Responsibility for intervention and monitoring during design, construction and defects liability period	Responsibility for mitigation, monitoring and/or maintenance after defects liability period	Monitoring means (c) = construction (o) = operation	Recommended frequency of monitoring
Fuel	- Energy sources should be identified so as not to put a strain on the local resources - Discourage use of firewood/charcoal by providing alternatives such as kerosene and gas.	Contractor	Contractor	(c) inspection	(c) daily
Construction Camp	- *Sufficient measures will be taken in the construction camps i.e., provision of garbage bins and sanitation facilities. If septic tanks are installed, waste will be cleared periodically.* - *Special attention shall be paid to the sanitary condition of camps.*	Contractor / Supervising Engineer		(c) Inspection	(c) daily
Deviations	- *Plan deviations* - *Adhere to road reserve if possible* - *Obtain permission from inhabitants if deviation goes beyond ROW* - *Reinstate deviations (and old tracks) to original condition* - Management of traffic along deviation - Pay compensation for crops/property removed/destroyed by deviations on inhabited land - Monitor rehabilitation of deviations	Supervising Engineer and Contractor Design Min. Lands and Settlement	 District Engineer	(c) check plans; inspections (o) payment records	(o) daily when deviations are in use (c) once before constructing deviations (o) once in 6 months
Vegetation	- *Control clearing* - *Replant areas where vegetation is unnecessarily removed.* - - Planting and grassing should be done just before the rains. - *Care for trees/plants.*	Supervising Engineer and Contractor Contractor	 MoRPW	(c) inspection (c) observation (o) observation	(c) daily (c) weekly (o) random

8.3 Institutional Responsibilities

Institutional responsibilities for incorporating mitigation measures and for monitoring various environmental/socio-economic aspects have been indicated in Tables 8.1 – 8.3 above.

During the defects liability period the contractor must make sure that the road is completely serviceable, which entails ensuring optimal performance of all structures.

During construction, the Supervising Engineer and Contractor will be responsible for implementing all the proposed mitigation measures. However, the overall task of ensuring that mitigation is in fact implemented lies with the MoRPW Maintenance Unit.

After the defect liability period, responsibility for the maintenance of the project road will lie with the Maintenance Units of the Roads Department in the MoRPW. Therefore certain parameters, such as efficiency of drainage structures and borrow pit rehabilitation can be monitored by the District Roads Engineer during routine or periodic maintenance, or when carrying out annual maintenance needs assessments.

The Environmental Unit in the Roads Department of the MoRPW will be responsible for ensuring that monitoring does take place. It will also be responsible for analysis of data collected during monitoring, so that overall performance in terms of environmental degradation or improvement can be assessed and, if need be, the performance targets changed in order to achieve the objectives of mitigation interventions. The Environmental Unit can then instruct the relevant divisions within the Roads Department as to what (further) measures should be implemented, or whether changes or modifications are necessary to interventions or monitoring methodologies.

CHAPTER 9 CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

The primary objective of the study on the Machakos Turnoff-Ulu-Sultan Hamud (A109), Thika-Kamae-Magumu (C66) and Nairobi-Limuru-Kamandura (C62) roads is to identify the most appropriate economically justified rehabilitation and periodic maintenance or strengthening solutions for each of the roads. It is anticipated that in the long term there will be considerable economic benefit accruing to the areas of influence of the project roads due to stimulated agricultural activities and improved traffic flow.

All the three project roads are existing, thus the environment along the roads has been considerably altered and any major impacts will have already occurred. Additional disturbances due to construction will therefore be relatively minor.

At this preliminary stage, no adverse environmental impacts of significant magnitude are foreseen that would hinder the proposed rehabilitation of the project roads. The project roads will not harm any sites that are historically or environmentally sensitive.

The most important negative impact will result from soil erosion during earth works and construction of structures, e.g. between Km 0 and 23 on the C66. Soil erosion is also likely to occur, particularly as a result of excavation of gravel pits; but this can be mitigated. Pollution due to air, dust, noise, and sediments will occur during construction and continue during operation.

Workmen's camps should preferably be located at the major centres along the roads. In addition, the camps must not stress local fuelwood and water supplies at the expense of the local population.

The project roads are to be designed for higher speeds, which pose a danger to non-motorised traffic. The provision of shoulders and installation of road signs will help to mitigate this impact.

9.2 Recommendations

Recommendations for the prevention and mitigation of adverse impacts are as follows:

- new gravel pits must be cordoned off or fenced during use, and rehabilitated after use as per the requirements of the landowners;
- shrubs and grasses should be planted along road embankments to prevent erosion;
- unnecessary clearing of vegetation should be avoided to preclude additional erosion;
- trees should be planted, especially at settlements/centres, to improve visual aesthetics and as filters for particulate matter;
- provide road shoulders for non-motorised traffic;
- special parking areas should be provided for trucks at Makutano and Salama on the A109;
- the local people must be informed of the details and progress of the project, particularly those who will be affected by the proposed realignment and extension of the road reserve (A109), so that they can plan for the future accordingly;
- compensation to landowners who must relinquish their land for the project road must be fair and paid promptly. It should cover crops, all structures (permanent and mud-and-wattle structures, pens, sheds, fences, etc) and land;
- a Compensation Plan needs to be prepared to address issues such as amount of payment, methods of payment, etc;

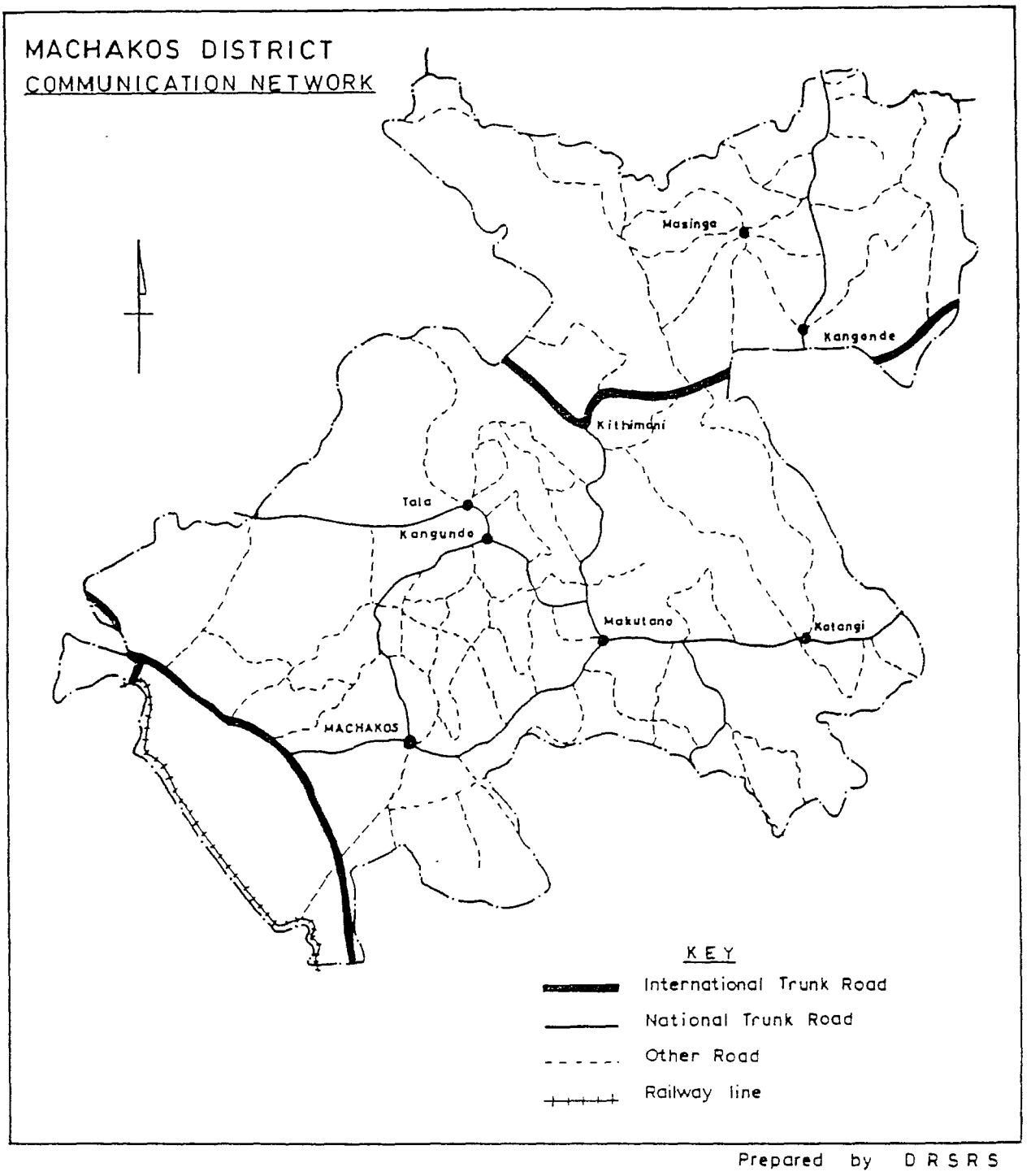
Diligence on the part of the contractor and proper supervision by the Supervising Engineer during construction and the initial operation period is crucial for mitigating impacts. However all mitigation measures need to be specified in tender and contract documents, and must be included in the Engineering Drawings, Specifications and Bills of Quantities.

During operation, maintenance of the road is a key factor in protecting the environment. For example, if the project roads are always in motorable condition, vehicles would not have to drive off-road, thereby destroying vegetation, road structures, and posing a danger to pedestrians, cyclists and livestock.

Environmental monitoring allows measures to be implemented in order to prevent or avert negative impacts.

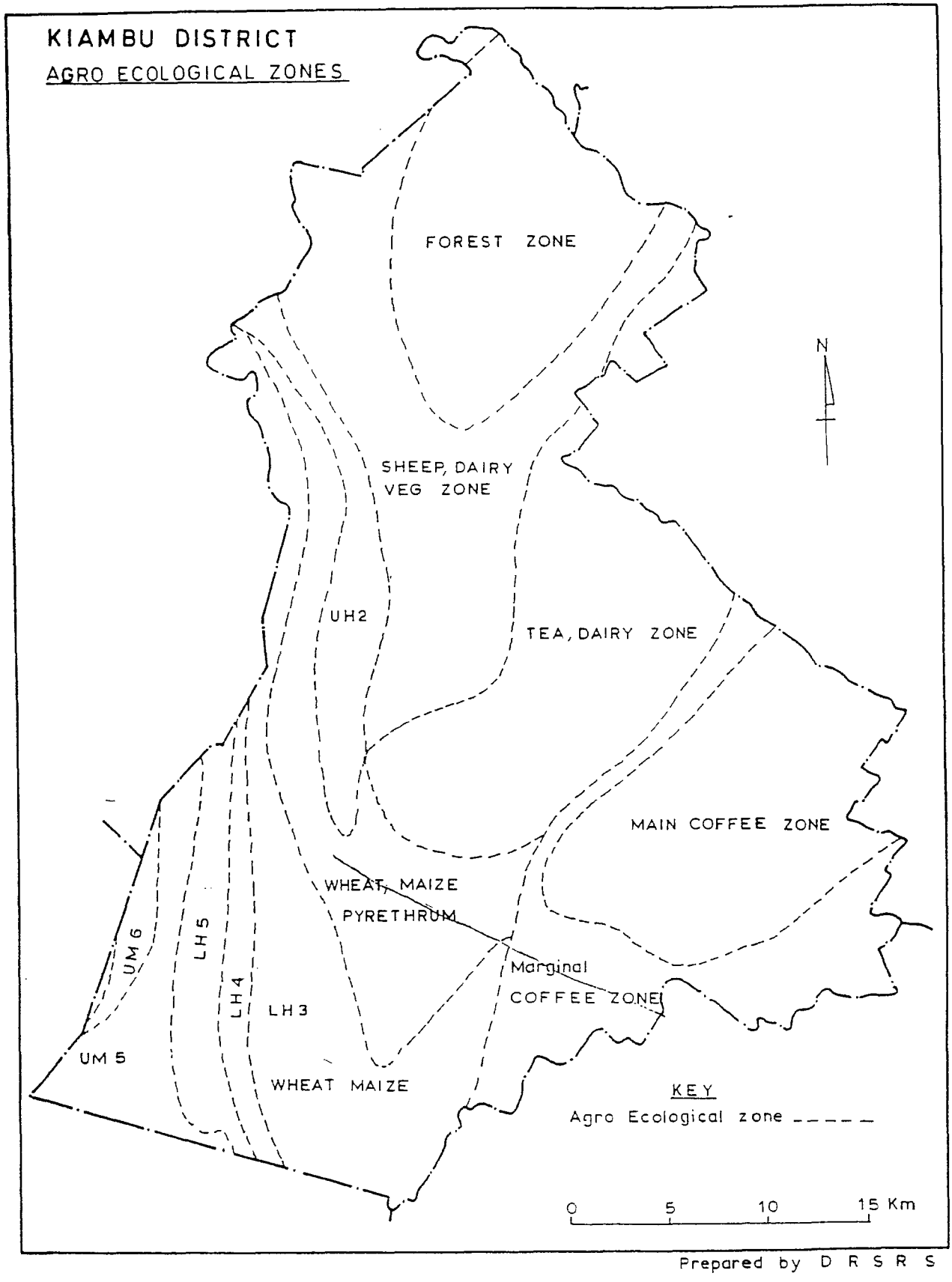
APPENDIX A

AGRO-ECOLOGICAL ZONE MAPS OF THE PROJECT ROADS



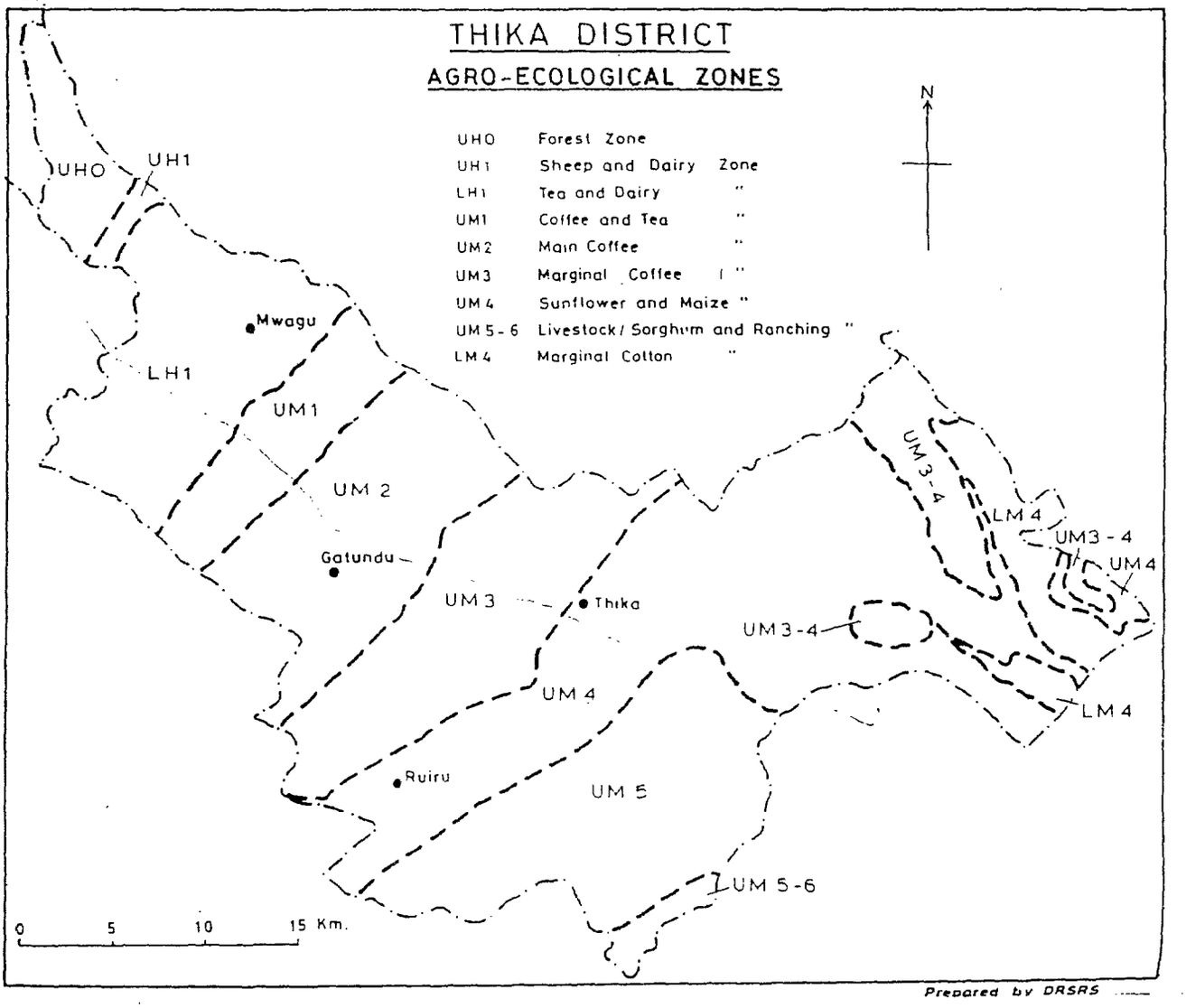
MAP 2: Location of the A109 in Machakos District

APPENDICES

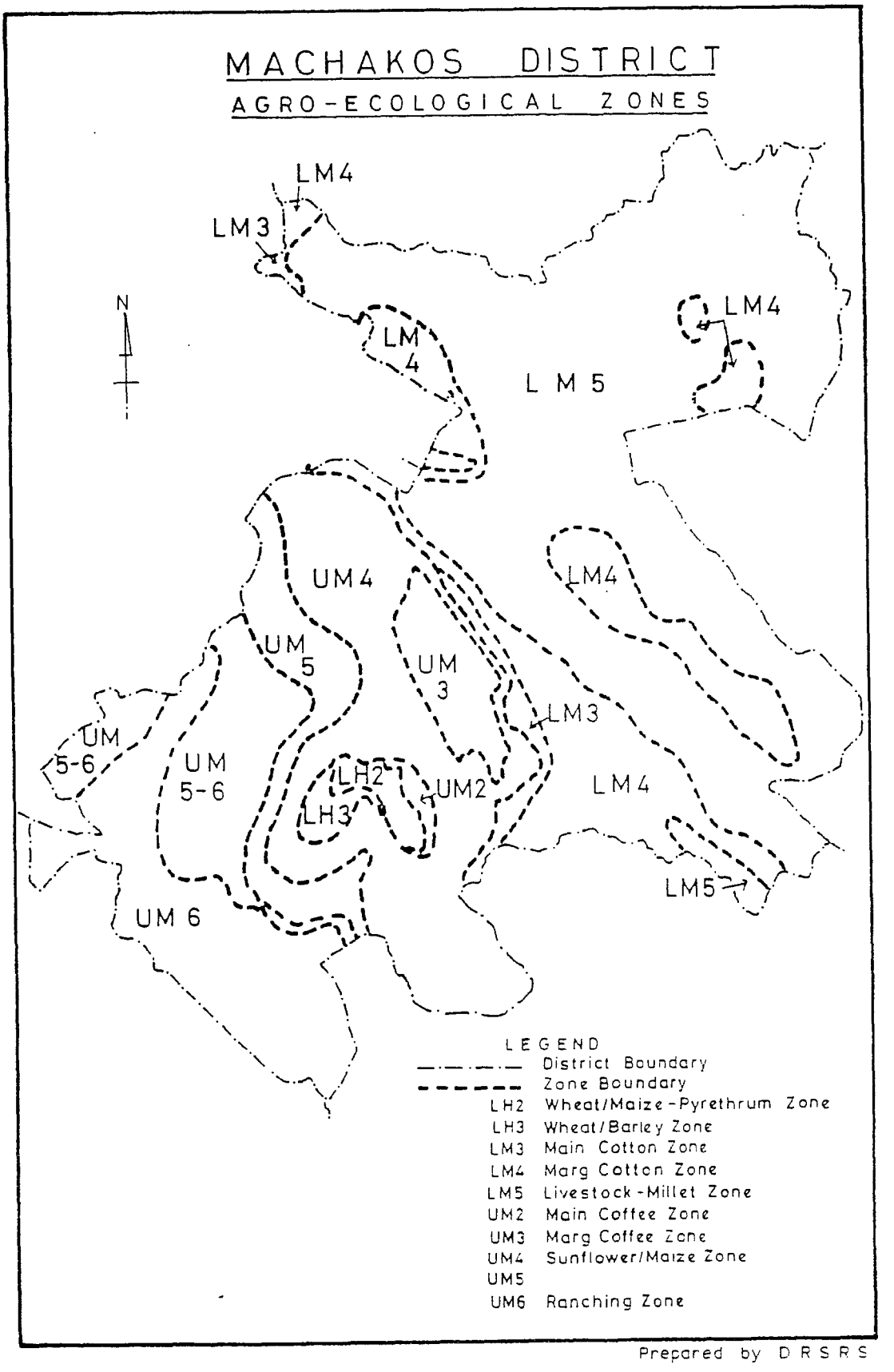


MAP 6: Kiambu District Agro-Ecological Zone Map

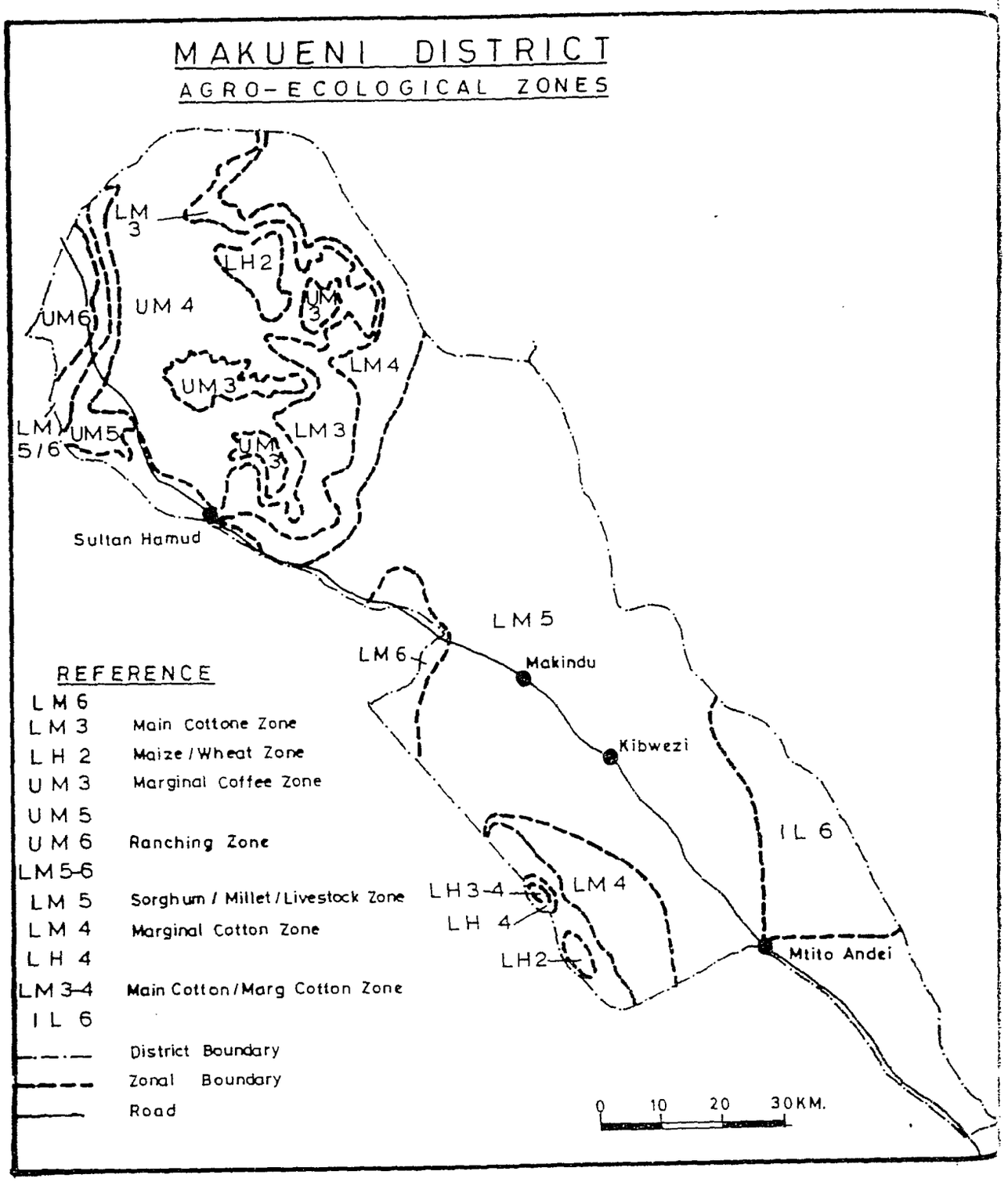
Map No. 3



MAP 5: Thika District Agro-Ecological Zone Map

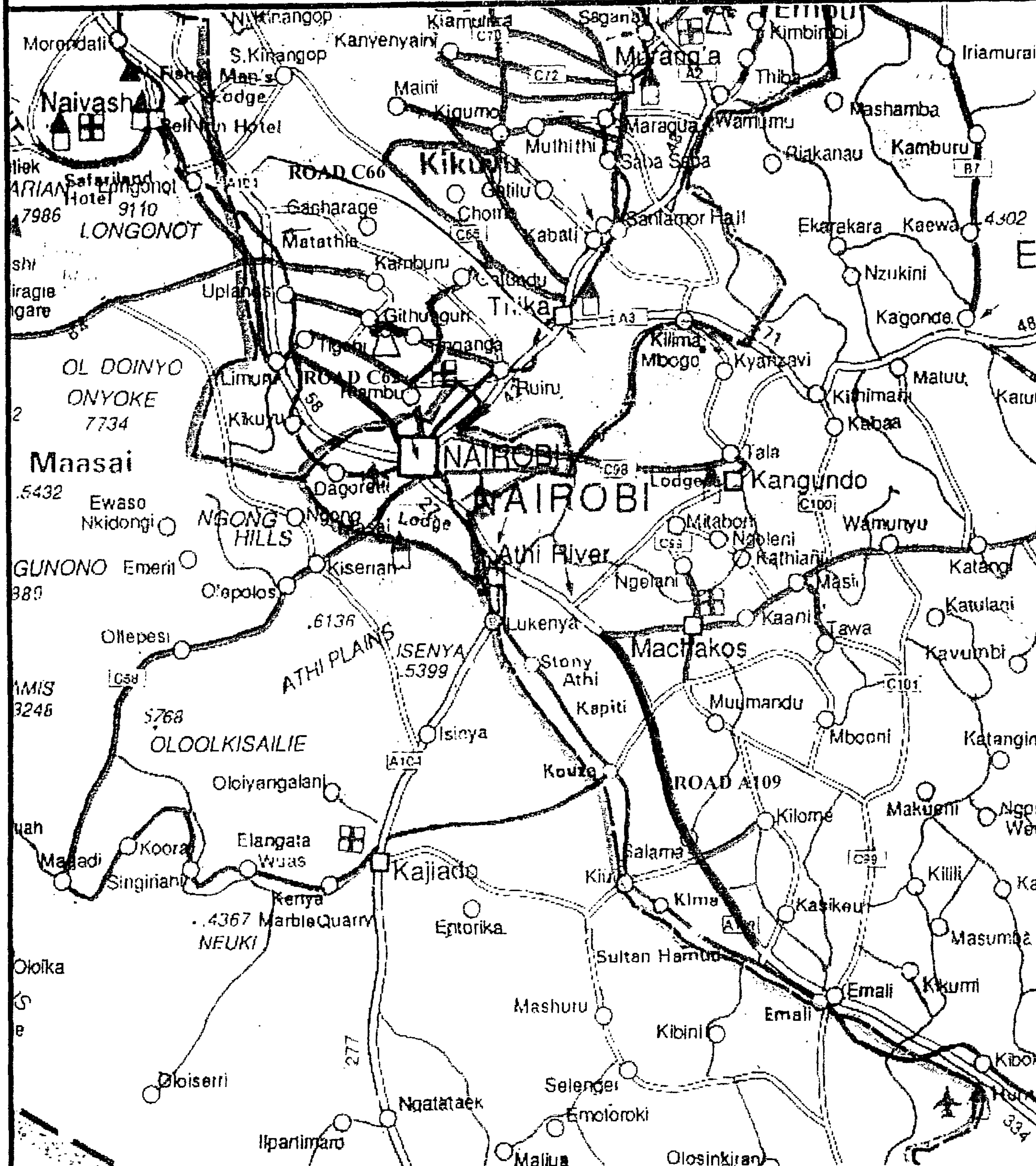


MAP 4: Machakos District Agro-Ecological Zone Map



MAP 3: Makueni District Agro-Ecological Zone Map

LOCATION MAP OF PROJECT ROADS

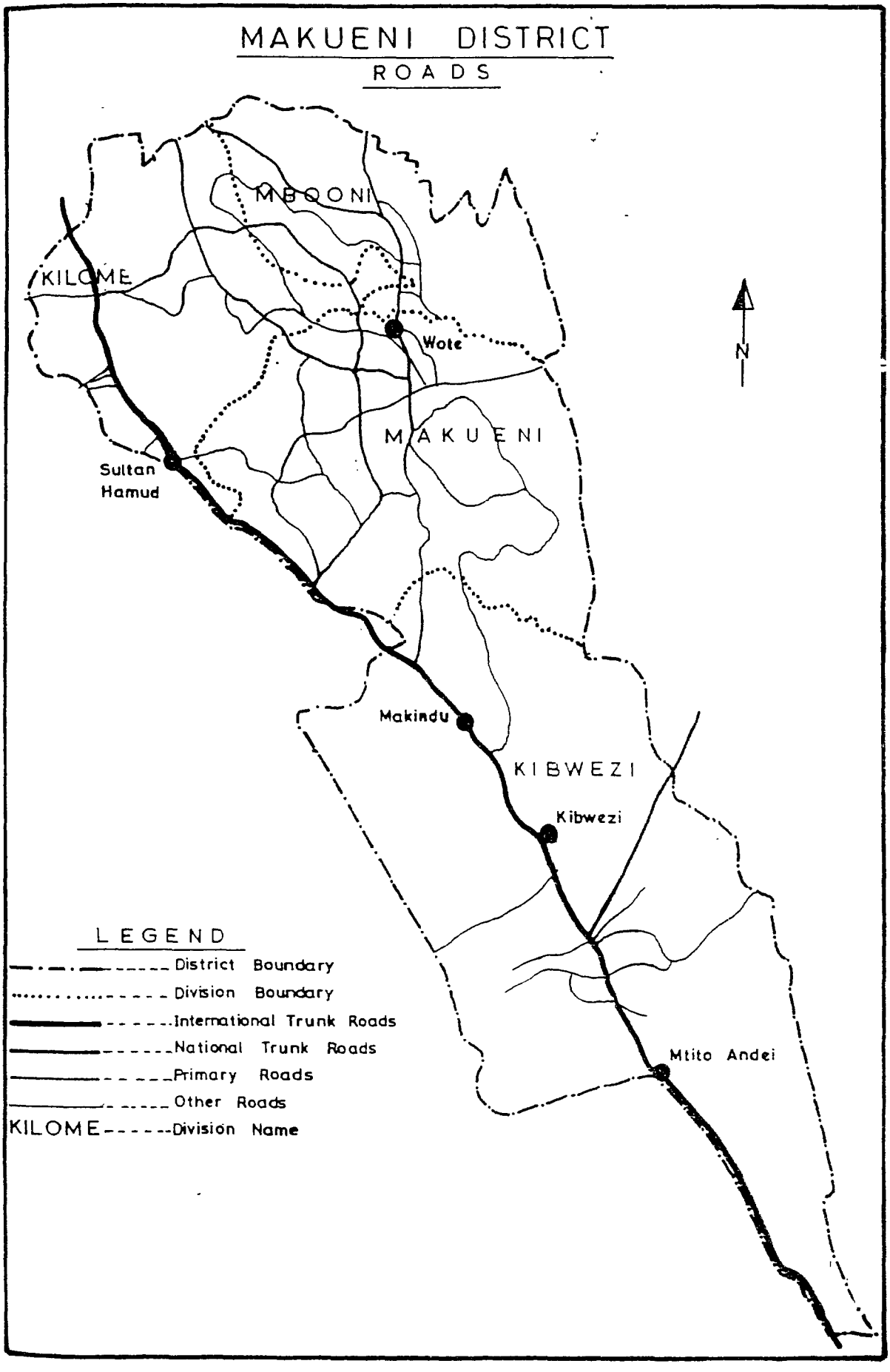


KEY

Nairobi - Limuru - Kamandura Road C62

Thika - Kamae - Magumu Road C66

Machakos Turnoff - Ulu - Sultan Hamud Road A109



MAP 1: Location of the A109 in Makueni District

APPENDIX B

REFERENCES AND TOPOGRAPHICAL MAPS

APPENDIX B: REFERENCES AND TOPOGRAPHICAL MAPS

REFERENCES

Beentje HJ; *Kenya Trees, Shrubs and Lianas*; National Museums of Kenya; 1994.

Republic of Kenya; *Environmental Impact Assessment (EIA) (Guidelines and Administrative Procedures)*; National Environmental Action Plan (NEAP) Secretariat, Ministry of Environment and Natural Resources, August 1996.

Republic of Kenya; *Kiambu District Development Plan 1997-2001*; Office of the Vice President and Ministry of Planning and National Development; Government Printer, Nairobi.

Republic of Kenya; *Machakos District Development Plan 1997-2001*; Office of the Vice President and Ministry of Planning and National Development; Government Printer, Nairobi.

Republic of Kenya; *Makueni District Development Plan 1997-2001*; Office of the Vice President and Ministry of Planning and National Development; Government Printer, Nairobi.

Republic of Kenya; *Thika District Development Plan 1997-2001*; Office of the Vice President and Ministry of Planning and National Development; Government Printer, Nairobi.

Republic of Kenya; *Economic Survey 1998*; Central Bureau of Statistics, Ministry of Planning and National Development; Government Printer, Nairobi; May 1998.

Republic of Kenya; *Kenya Gazette Supplement* No. 24 Bills 1999 (Bills No.4); Government Printer; 7th May 1999.

Republic of Kenya; *1999 Population and Housing Census, Volume I*; Central Bureau of Statistics, Ministry of Finance and Planning; Government Printer, Nairobi; January 2001.

Sombroek WG, HMW Braun and BJA Van der Pouw; *Exploratory Soil Map and Agro-Climatic Zone Map of Kenya, 1980.* Exploratory Soil Survey Report No. E1, Kenya Soil Survey, Nairobi, 1982.

TOPOGRAPHICAL MAPS

- **Machakos Turn Off – Ulu – Sultan Hamud, Road (A109)**

East Africa 1:50,000 (Kenya) topographical maps. Published and printed by Survey of Kenya 1974.

- **Thika – Kamae – Magumu Road (C66)**

East Africa 1:50,000 (Kenya) topographical maps. Published for the Kenya Government by the British Government's Ministry of Overseas Development (Directorate of Overseas Surveys) under the Special Commonwealth African Assistance Plan 1975.

- **Nairobi – Limuru – Kamandura Road (C62)**

East Africa 1:50,000 (Kenya) topographical maps. Published for the Kenya Government by the British Government's Ministry of Overseas Development (Directorate of Overseas Surveys) under the Special Commonwealth African Assistance Plan 1976.

Kiambu, Kenya 1:50,000 topographical map. Published for the Kenya Government by the French National Geographic Institute 1997 under the Computer Assisted Mapping Project 1997. Printed in France by I.G.N. 1000/8/97.

APPENDIX C

MONITORING CHECK LIST

ɔnstruction and Operation Monitoring Checklist **Date:** _____

ɔad: _____

ɛction: Km_____ **to Km**_____ **information collected by:**_____ **Department:**_____

ɛm	Issue	(✓) tick one					
		Good	Moderate	No change	Poor	Comments	Responsibility
rainage	efficiency and condition of						
	drainage structures						
ɔil erosion	efficiency of erosion control						
	measures						
ir Pollution	dust at construction sites						
	and motor vehicle speed limits						
	planting of trees near						
	settlements						
oise pollution	motor vehicle speed limits						
	protective gear at constr. sites						

Monitoring checklist

:em	Issue	(✓) tick one					
		Good	Moderate	No change	Poor	Comments	Responsibility
Vater pollution	wastewater/sewage, oil and						
ivers/streams/	solid waste management						
stuaries etc.)							
Dil pollution	waste oil management:						
	maintenance activities on						
	constr. sites, disposal measures						
	of waste oil						
Gravel site/borrow	progress of rehabilitation (water						
pits	pans, fencing, terracing, grassing)						
Water sources	water usage, abstraction activities						
lakes, rivers	water storage						
streams, etc.)							
Construction Camp	wastewater/sewage, oil and solid						
	waste management						
	STD sensitisation campaigns						

Monitoring checklist

ɛm	Issue	(✓) tick one					
		Good	Moderate	No change	Poor	Comments	Responsibility
ɛviations	progress of rehabilitation						
ɛgetation	planting regime						
	landscaping						
vestock	livestock kills						
ſiidlife	wildlife kills						

lease note any other issues: