Foreword

The Roads Department is constantly striving to increase the efficiency and effectiveness with which the management and maintenance of the road network are carried out. This is motivated by the recognition that the country's Public Highway Network of over 18,300 km constitutes one of the largest assets owned by the Government (estimated value in 2009 of 15 billion Pula), and that a less-than-optimal system for the management and maintenance of that asset, results in huge losses for the national economy. This occurs not only in the form of road deterioration and substantial reductions in road asset value but, even more so, in the form of increased vehicle operation costs which have to be borne by road users and which reduce the competitiveness of the country in an increasingly global economy.

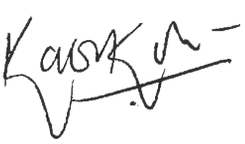
In exercising its vision "to have world class roads leading to prosperity", its mission "the Roads Department exists to enable provision of safe, reliable and cost effective road infrastructure in an environmentally sustainable manner" and its values "botho, transparency, accountability and integrity", the Roads Department has directed the development of a series of Design Manuals, Guidelines and Standards of which the **Botswana Roads Maintenance Manual** (**BRMM**) is one.

The purpose of the BRMM is to serve as a nationally recognised document, the application of which is deemed to serve as a standard reference and source of good practice for road management and maintenance by both public and private sector practitioners.

The major benefits to be gained in applying the BRMM are the harmonisation of professional practice and the ensuring of cost effective execution of maintenance operations to appropriate standards. This approach will contribute directly to the preservation of the substantial investments made in road provision and facilitate the attainment of appropriate levels of service on the road network and, ultimately, preservation of the substantial investments made in road provision.

The Manual, by its very nature, will require periodic updating to take account of the dynamic nature of developments in road technology. The Roads Department, therefore, would welcome comments and suggestions from any stakeholders as feedback on all aspects of the Manual during its implementation. All feedback will be carefully reviewed by professional experts with a view to amending future updates of the Manual.

Gaborone, May 2010



Mr. Kabo Phillip Kote
Ag. DIRECTOR OF ROADS
Roads Department
Ministry of Transport and Communication

Acknowledgements

This Manual is one of a series of technical manuals and guidelines produced under the Institutional Co-operation Agreement between the Roads Department and the Norwegian Public Roads Administration (NPRA). This Agreement fell under a NORAD Technical Assistance Programme to Roads Department that was co-funded by the Kingdom of Norway and the Government of the Republic of Botswana.

The Roads Department gratefully acknowledges the valuable contributions made by the Steering Committee that guided the project and reviewed the Manual as well as the Project Team that was responsible for writing the Manual.

Steering Committee

Roads Department

E. Masimega (Chairman)
P.G. Alpajora
M.S. Baele
O.S. Dijokota
T. Giddie
J. Kamona
B. Kemsley
K.P. Kotokwe
M. Kowa
G.L. Letsatsi
K.M. Mmopa
T. Moilwa
B. Mokgethi
B. Moetse
P. Mungoo
A. Nkaro
J. Nwako
M.P. Ramolefhe
O. Ramontsho
A. Saha
J. R. Sello
T. Sikalesele
D. Silanda

Gaborone City Council
K.C. Jain
M. Katorah

Norwegian Public Roads Administration (NPRA)
J. Dahlen
C. Overby

Project Team

Gicon A/S, Norway (Lead Consultant)
O. Kr. Sylte (Gicon)

Group Consult, Botswana (Regional Consultant)
M.E. Chiwanga
D.K.H. Mungure
H.G. Urio

InfraAfrica (Pty) Ltd (Sub-Consultant)
M. I. Pinard (InfraAfrica)

Photographs

C. Overby, J. Dahlen (NPRA); H.G. Urio (Group Consult); V. Arya, A. Kalasi, M. Sarma, M.S. Baele (Roads Department).

Abbreviations

A

AADT	Annual Average Daily Traffic

B

BRMS	Botswana Road Management System
BRMM	Botswana Road Maintenance Manual

D

DSS	Decision Support System
DCP	Dynamic Cone Penetrometer
DLO	Direct Labour Organisation

F

FWD	Falling Weight Deflectometer

H

HDM	Highway Design and Maintenance Standards Model

I

IQL	Information Quality Level
IRF	International Road Federation

K

km	Kilometre

M

m	Metre

N

NORAD	Norwegian Agency for Development Cooperation
NPRA	Norwegian Public Roads Administration
NPV	Net Present Value

O

OPRC	Output and Performance Based Road Contract
OECD	Organisation of Economic Cooperation and Development

P

P	Pula (currency of Botswana)
PIARC	Permanent International Association of Road Congresses
PHN	Public Highway Network

R

RMS	Road Management System

S

SABITA	Southern African Bitumen Association
SADC	Southern African Development Community

T

TRL	Transport Research Laboratory (UK)
TRRL	Transport and Road Research Laboratory

V

VCI	Visual Condition Index
vpd	Vehicles per day

TABLE OF CONTENTS

Section C: Annexes

List of Figures

List of Tables

1. INTRODUCTION

1.1 The Road Network

1.1.1 Botswana has developed a modern, functionally classified, Public Highway Network (PHN) of approximately 18,300 km (2009) of Primary, Secondary, Tertiary and Access roads. Responsibility for the management of the PHN is shared between Central Government, administered by Roads Department, and Local Government, administered by the City Council and a number of Town and District Councils. In addition to the PHN, there are over 3000 km of primary and secondary roads and streets in urban areas (city, towns and villages) which are the responsibility of the City, Town or District Councils. There are also some 15,000 km of access tracks, quasi-private roads, minor tracks, etc. Thus, the total length of the road network in Botswana is approximately 36,500 km (2010).

1.2 The Road Asset

1.2.1 Currently, the road network represents one of the country's largest public sector assets with replacement costs of the main (primary and secondary) roads alone amounting to more than P15 billion (2009). This astronomical investment in the road network reflects its multi-purpose role in the national economy involving social, business and commercial travel as well as freight and private transport, all of which use the same network. This network provides the dominant mode of freight and passenger transport and carries approximately 90% of the total volume of passengers transported.

1.3 Importance of Maintenance

1.3.1 With the backbone of the national road network in place, development expenditure in relation to recurrent expenditure has begun to taper off. Thus, in order to preserve the huge investments that have been made in the provision of road infrastructure, maintenance funding will continue to rise and to eventually exceed development expenditure (ref. Figure 1.1). This will require that emphasis is placed on carrying out road maintenance in a pro-active and efficient manner. Moreover, it will also require that cognizance be taken of international developments and trends in road maintenance in which the private sector is playing an increasingly significant role.

1.4 Need for a Maintenance Manual

1.4.1 The need for a comprehensive Road Maintenance Manual to assist roads agencies in maintaining the road network in an efficient manner has long been recognized as being of critical importance to all stakeholders in both the public sector (Roads Department and other roads agencies) and the private sector (consultants, contractors, materials suppliers, etc.). To this end, the Ministry of Transport and Communication, with the support of the Norwegian Public Roads Administration (NPRA) has embarked on the development of such a Manual and has engaged consultants to undertake this task under the direction of a Steering Committee from Roads Department.

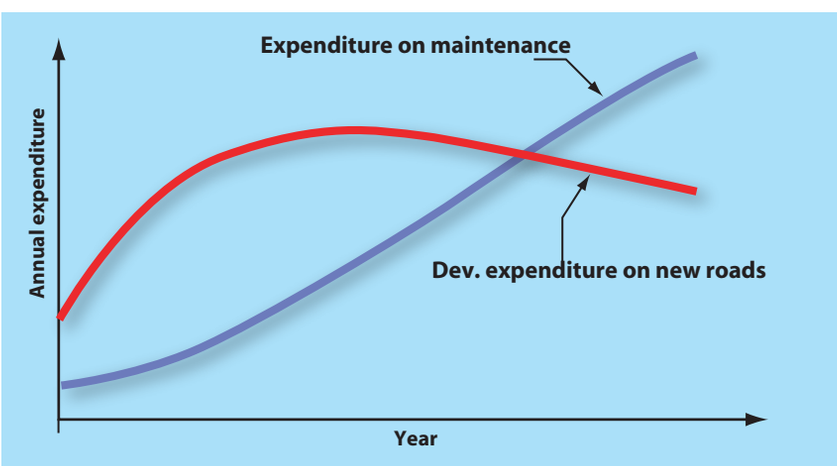


***Figure 1.1** – General trend in expenditure on roads*

Year	Budget (P million)	
	Dev.	Maint. *
1999/00	461	64
2001/02	576	71
2003/04	435	83
2005/06	349	81
2006/07	456	94
2007/08	434	130
2008/09	370	117
2009/10	460	136
2010/11	940	136

** Money given from vote no 00811 Roads.*

2. THE ROAD MAINTENANCE MANUAL

2.1 Purpose

2.1.1 The main purpose of the Botswana Road Maintenance Manual (BRMM) is to serve as a nationally recognized document, the application of which is deemed to serve as a standard reference and ready source of good practice for road maintenance management and operations. In so doing, the objective is to *improve the efficiency and effectiveness of road maintenance in Botswana*. In this regard, the Manual provides guidance to a spectrum of stakeholders on maintenance standards, specifications and operational procedures for maintenance works on both paved and unpaved roads. The Manual is based on maintenance activities relevant to the Botswana environment and is tailored for execution of maintenance works by either in-house units, by contracts based on unit rates or by Output and Performance-Based Road Contracts (OPRC).

2.2 Structure and Contents of Manual

2.2.1 The Manual is divided into four separate parts as follows:

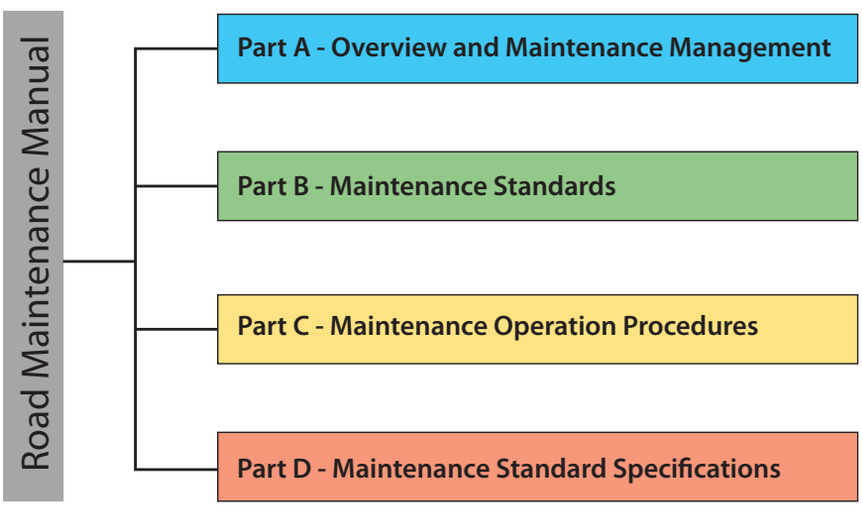


Figure 2.1 *– Components of the Road Maintenance Manual*

2.2.2 The contents of the Manual are as follows:

Part A – Overview and Maintenance Management

Section A: Provides a general introduction to the Manual including its purpose and scope, approach to its development and means of updating.

Section B: Presents an introduction to maintenance management in Botswana and summarizes the general policies and objectives of the Roads Department that seek to optimize the overall performance of the road network over time. Also reviews the planning, programming, preparation and operations functions carried out by the department.

Part B – Maintenance Standards: Provides service quality standards defined through threshold levels and response times in relation to road function and traffic levels for a complete set of maintenance activities.

Part C – Maintenance Operational Procedures: Provides a description of the operational procedures for a complete set of maintenance activities applicable to both labour and equipment based methods. For each method, a description is provided for the required resources, work procedure and average production.

Part D – Maintenance Standard Specifications: Contains details of the standard specifications related to a wide range of both routine and periodic maintenance activities on both paved and unpaved roads as well as bridges and drainage structures.

Parts B, C and D collectively provide a complete, inter-related set of maintenance standards, operational procedures and maintenance specifications for an extensive range of maintenance features and related interventions and activities as listed in Annex D. Typical output of Parts B, C, and D of the Manual are presented in Annex E.

2.3 Development of the Manual

2.3.1 The means of achieving the purpose of the Manual hinges critically on its adoption by stakeholders in practice. To this end, the Manual has been developed with a high level of participation by local practitioners, led by a Steering Committee at Roads Department. As a result, it has been possible to incorporate a significant amount of local, practical knowledge in the document based on local best practice.

2.4 Benefits of Using the Manual

2.4.1 The major benefits to be gained in applying the Manual are harmonization of professional practice and the execution of maintenance activities in a holistic manner. This will ensure uniform execution of the various maintenance activities and facilitate the attainment of appropriate levels of service and cost-effective preservation of Botswana's road asset.

2.4.2 The Manual will be of interest to a range of stakeholders at roads authorities as well as in the private sector including the following:

- Top level management of roads authorities.
- Regional maintenance engineers.
- Road maintenance supervisors & technicians.
- Road maintenance consultants.
- Road maintenance contractors.
- Training institutions.
- Community leaders.
- Road users.

2.5 Service Levels for the BRMM

2.5.1 Three *Service Levels* are adopted in the Manual for both paved and unpaved roads. These Service Levels are used to define a measure of the extent of Deficiencies and Defects the Road Authority is willing to tolerate over a specified time span on individual roads, depending on traffic levels and road function. The three Service Levels are as follows:

- **Level A:** All strategic/reference routes A1, A2 and A3 and any other road with AADT ≥ 1000 vpd.
- **Level B:** 500 < AADT < 1000 vpd.
- **Level C:** AADT ≤ 500 vpd.

2.6 Updating of the Manual

2.6.1 There are continuing developments in maintenance management and practice as a result of which it will be necessary to update the Manual periodically to reflect current best practices. The format of the *Manual* enables its expansion, refinement and updating over time on the basis of experience.

2.6.2 The intention is to issue amendments periodically which replace or amplify particular aspects of the manual. Either full sections or particular figures, tables or appendices may be replaced. When this is done, details of the change should be recorded in the Amendment Sheet at the front of the document as more information becomes available from the development of new technologies and practices.

2.7 Sources of Information

2.7.1 In addition to the references cited at the end of each part of the manual, a bibliography has also been compiled for those readers who wish to obtain additional information on any of the topics dealt with in the manual.

3. INTRODUCTION

3.1 Background

3.1.1 Under the policy direction of the Ministry Transport and Communication, Botswana's road network is regarded as a national asset that must be managed cost-effectively to enable an efficient transport sector to support socio-economic growth and development in the country. As the Ministry's executing agency, the Roads Department is charged with the responsibility of proper management of the road network. Implied in this far-ranging responsibility is a need to invest maintenance funding in a way that returns maximum benefit to road users and the communities which they serve. In so doing, the department is expected to maintain the road asset to a standard that will optimise road user costs and the cost of maintenance. This concept is fundamental to the national economy, the pursuit of international competitiveness and the achievement of ecologically sustainable transport and imposes on the Roads Department an obligation to undertake the management of road maintenance in an efficient and cost-effective manner – an issue which is addressed in this document - Part B of the Road Maintenance Manual.

3.2 Definitions

Maintenance

3.2.1 The road is a capital investment which deteriorates in the same way as any other asset, whether used or not. Maintenance is necessary to lessen the rate of deterioration and, also, less frequently, to restore service levels to earlier values. In this context, ***road maintenance*** may be defined as *"any works of every description which are required for the preservation and upkeep of a road or its associated works or both, so as to prevent the deterioration of quality and efficiency to a noticeable extent below that which pertained immediately after construction"*. Many users see the quality of the road in visual terms and so appearance cannot be neglected.

3.2.2 In Botswana, as in many other developing countries, the focus of attention is now shifting from building new roads to maintaining existing roads. Whereas design and construction are dominated by engineering issues, maintenance is essentially a multi-dimensional issue in which the management and technical aspects are influenced by political, social and institutional issues.

Maintenance Management

3.2.3 Road maintenance management aims to identify the need for maintenance works and potential improvements of the network in order to achieve or maintain standards. In conjunction with road planning, appraisal and design processes, it attempts to optimise the overall performance of the road network over time. At a practical level, it aims to ensure that the correct activities are performed on the network *at the right time, and to the desired quality*. The process comprises a series of management functions. These are carried out by different staff in the roads agency, relate to both short term and long term decisions, and concern both the whole network and individual lengths of road.

3.2.4 In simple terms, maintenance management aims to get the *right* people, materials and equipment, to the *right* place on the road network, to carry out the *right* remedial or preventative work, at the *right time*.

3.3 Purpose

3.3.1 Against the above background, Section B of this part of the Manual presents an in-troduction to road maintenance and maintenance management in Botswana and summarises the general policies and objectives of the Roads Department that seek to optimize the overall performance of the road network over time.

3.4 Structure and Scope

3.4.1 Section B is divided into three sections as follows:

Sub-Section 1 (this section) – *Introduction:* Highlights the importance of effective maintenance as an enabler of efficient road transport, defines the terms maintenance and maintenance management and outlines the main objectives of Section B (this part) of the Botswana Road Maintenance Manual.

Sub-Section 2: *Maintenance Issues:* This section highlights the significance of the road maintenance cycle; the economicand financial importance of road maintenance and the consequences of inadequate road maintenance as a motivation for emphasising the importance of road maintenance management.

Sub-Section 3: Management Issues: This section focuses on the primary management functions of planning, programming, preparation and operations.

4. MAINTENANCE ISSUES

4.1 The Significance of Road Maintenance in the Project Cycle

4.1.1 As illustrated in Figure 4.1, the maintenance and operations phases of a typical road project occupy by far the largest proportion of the total project cycle. Moreover, there is now a much better understanding than hitherto of the important role that maintenance plays during the later stages of the project cycle in realising and sustaining the benefits for which the road was originally constructed.

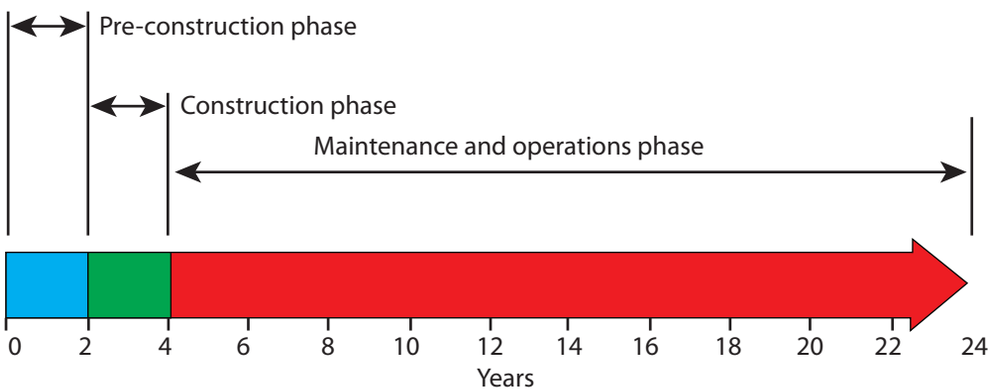


Figure 4.1 *– The road project cycle (SADC, 2003)*

4.1.2 Although the pre-construction and construction phases are extremely important, in economic terms they are only "cost" phases – no benefits are incurred during these phases. From an economic point of view it makes sense to shorten these phases as much as possible and to begin incurring benefits as soon as possible – hence the reason for applying liquidated damages to contractors when construction deadlines are not met, i.e. due to losses in benefits to the public. On the other hand, it makes sense to prolong the maintenance phase as much as possible in order to:

- Extend the useful life of the project and the period of time during which benefits are incurred, and
- Postpone, as long as possible, the need for capital replacement.

The above can only be accomplished through efficient and effective road maintenance .

4.2 Deterioration Characteristics of Roads

4.2.1 Even with strict adherence to proper standards of construction, roads deteriorate with the passage of time. The rate of deterioration may vary greatly depending on the climate, the strength of the pavement and underlying subgrade, the traffic volume and axle loads. The wear and tear of road surfaces by traffic is aggravated by rainwater and by changes in temperature. Cracking occurs in the bituminous surfacing which, together with the ingress of rain water, often leads to pavement failures. Figure 4.2 illustrates how road condition deteriorates with time and how road life may be extended by uncontrolled and controlled maintenance.

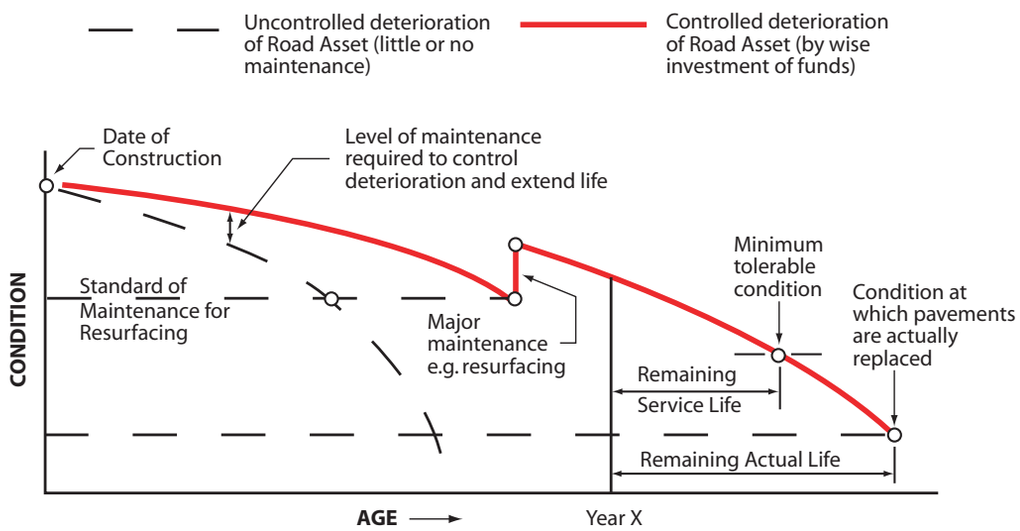


Figure 4.2 *– Typical road performance relationship: controlled and uncontrolled deterioration*

4.2.2 Of particular significance in responding to the maintenance requirements of roads in Botswana is the fact that, apart from urban roads in the main city and towns, and a few of the main corridors, such as the North-South corridor between Ramatlabama and Ramokgwebana, the majority of the Public Highway Network carries relatively low traffic levels of less than 500 vpd. For such relatively low-volume roads, the proportion of distress resulting from environmentally-related influences is very high, as illustrated in Figure 4.3 and emphasises the need to pay particular attention to all environmentally-related aspects of maintenance, particularly drainage.

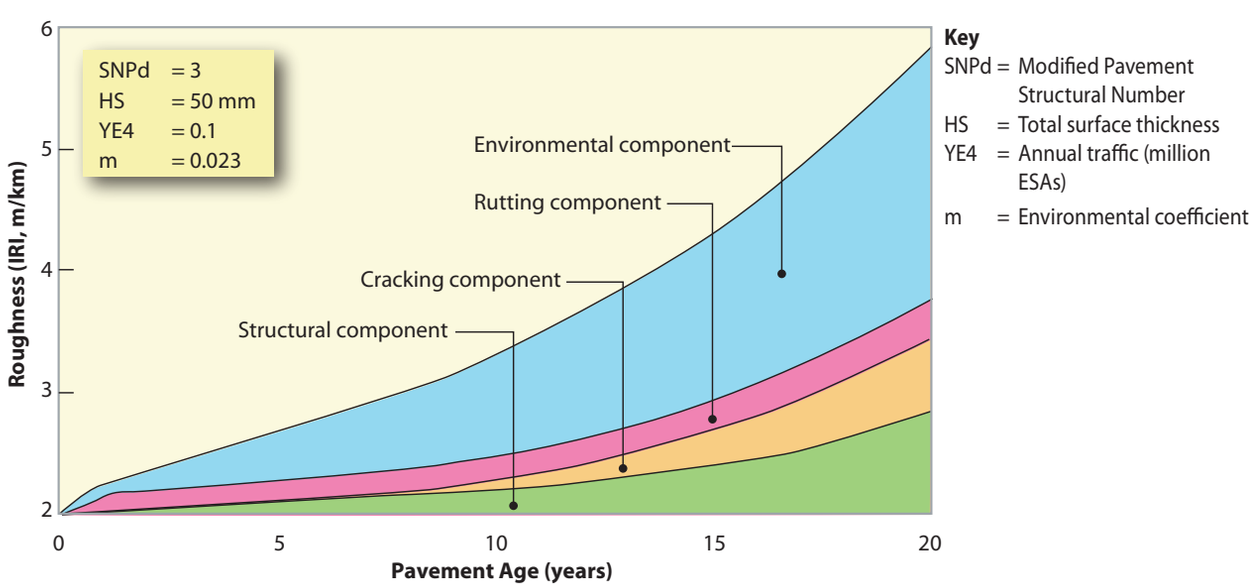


Figure 4.3 *– Contribution to total predicted road roughness of different modes of deterioration for a low-medium volume paved road (Gourley et al, 2001)*

4.3 Importance of Overload Control

4.3.1 Overload control in Botswana is a critically important aspect of asset preservation which falls under the responsibility of the Maintenance Division of Roads Department. Because of the exponential relationship between axle load and road damage, overloading can have a significant impact on reducing the life of a road pavement (ref. Figure 4.4). This reduction in pavement life emphasises the importance of the roads agency pursuing an overload control strategy that seeks to minimise the adverse impact of overloading pavements in Botswana, many of which are constructed of natural gravels that are sensitive to such overloading.

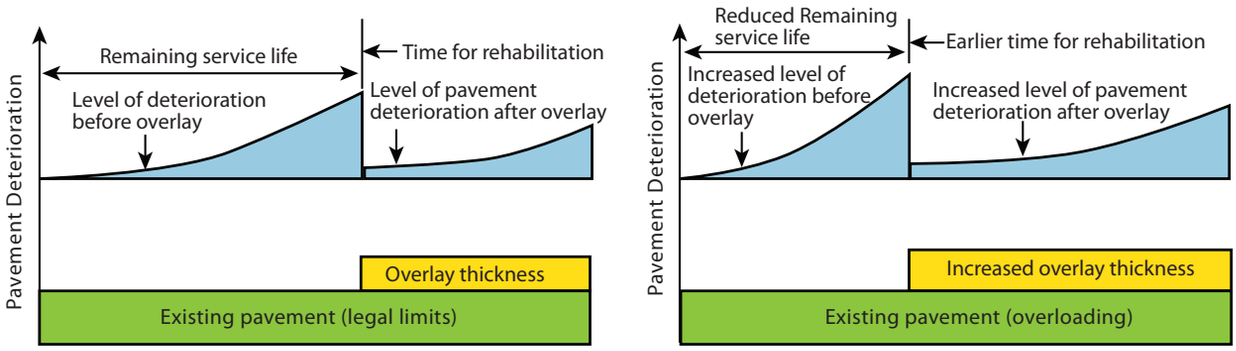


Figure 4.4 *– Implications of overloading on pavement life*

4.3.2 As of 2010, twelve permanent weighbridges are currently installed at eight borders and at four inland locations in Botswana. All the original weighbridges installations were 1 m x 3.2 m single axle scales which were located at the border posts or inland roadside locations with fairly rudimentary facilities in terms of layout, office and accommodation facilities. These first generation weighbridges are gradually being upgraded to either 3.2 m x 4 m axle scale or 3.2 m x 22 m multi-deck bridges at the main border posts and some inland locations.

4.4 What Maintenance Entails

4.4.1 Maintenance embraces a wide variety of different activities which are employed in response to the appearance of different defects. They are normally planned on the following basis:

- A reactive (i.e. condition responsive) basis in response to a defect exceeding a certain condition state;
- A cyclic (i.e. programmed) basis where work is undertaken at a set frequency or a particular time of the year, the interval often varying as a result of environmental as opposed to traffic responses.

4.4.2 Terminology which describes different activities varies between countries, and local conventions and financing opportunities will determine which budgets are used for funding works. Various conventions are used, and amongst the most popular are those by TRL (TRL. 1987) and by PIARC (PIARC, 2004). For convenience the latter classification has been adopted throughout this Manual.

4.4.3 The types of maintenance works activity used can be divided into different works categories and types. Descriptions of each are given in Table 4.1. They comprise those under the following categories:

- routine maintenance
- periodic maintenance
- special works

4.4.4 A major difference between the classification below and that of earlier classifications is that all works which aim to prolong the useful life of a road structure, barring any significant change in traffic or structural capacity, including pavement reconstruction, are classified as maintenance. The aim is to help remove what are essentially artificial barriers to the effective planning, and ultimate preservation of road infrastructure.

Table 4.1 *– Maintenance works activities for paved roads*

Works Category	Works Type	Description	Example activities
Routine Maintenance Works that may need to be undertaken each year. Recurrent Budget.	Cyclic	Scheduled works whose needs are dependent on environmental effects rather than traffic	Vegetation control Clearing side drains Re-cutting side drains Scour protection Clearing culverts Repairing road signs
	Reactive	Works responding to minor defects caused by a combination of traffic and environmental effects	Linear crack sealing Sealing cracked areas Patching cracked areas Patching potholes Edge repair
Periodic Maintenance Planned to be undertaken at intervals of several years. Recurrent budget*.	Preventive	Addition of a thin film of bitumen to improve surface integrity and water-proofing	Fog seal/surface rejuvenation
	Resurfacing	Addition of a thin surfacing to improve surface integrity and water-proofing	Single surface treatment Thin (< 30 mm) asphalt overlay
Periodic Maintenance Planned to be undertaken at intervals of several years. Capital Budget.	Overlay	Addition of a thick overlay to improve structural integrity and increase pavement strength	Thick (> 30 mm) asphalt overlay
	Pavement reconstruction	Replacement or reprocessing of the existing pavement and surfacing	Hotmix asphalt overlay Base reconstruction and resur-facing
Special Works Frequency cannot be estimated with certainty in advance. Recurrent budget or contingency funds	Emergency	Works undertaken to clear a road that has been cut or blocked	Traffic accident removal Cleaning debris Reparing washouts
	Spot improvements	Works undertaken to restore passability across short sections damaged by natural events or by traffic	Various activities depending on the nature and severity of distress (see later in Table 4.2)

* Given the lengthy, annual process involved in the procurement of periodic maintenance works, there is merit in considering the funding of such works under the Capital rather than the Recurrent budget, more so as such works are being outsourced to the private sector. There are not only efficiency gains to de derived from such an approach but, also, it avoids the current problem of lapsing of recurrent funds at the end of the financial year.

4.5 The Need for Effective Road Maintenance

4.5.1 Table 4.2 gives details of the three important conclusions which have resulted from research and which all serve to underline the need for effective maintenance (IRF, 2004).

Table 4.2 *– Road maintenance – Why the need?*

ROAD MAINTENANCE: WHY THE NEED?

Highway Safety	Full Life Investment	Highway User Cost
Problem	**Problem**	**Problem**
There are many features of a road which present, or can lead to, the formation of safety hazards to road users, including: – vegetation growth which can obscure visibility – potholes in the road surface – flooding resulting from blocked culverts – faint road signs – damaged bridges & guard rails – scoured highway shoulders	Most long-term road feasibility and design strategies assume that regular pavement strengthening will be required to arrest deterioration and that some care will be taken to deal with localised imperfections as they arise. For example, cracks in a pavement which remain unsealed will permit ingress of surface water and lead to premature weakening of the pavement foundation.	A clear need has been established between pavement condition (roughness) and vehicle operating costs. The relationship is embodied as an essential part of the cost/ benefit analysis within the World Bank HDM transport investment model. If the rate of pavement deterioration is not contained, surface roughness increases at an accele-rating rate.
Effect	**Effect**	**Effect**
More road traffic accidents	**Additional costs to the roads agency**	**Additional costs to road users**
Apart from the cost to human suffering, traffic accidents result in: – the need for additional emergency services – a requirement for increased hospital facilities and staff – higher vehicle insurance premiums – loss of productive working time amongst the injured	Failure to control deterioration rates results either in an earlier requirement for strengt-hening or a substantially increased cost for re-construction. This represents inefficient and ineffective use of scarce public funds in the maintenance of the road network.	An increase in surface roughness causes vehicle operating costs to increase. Such costs represent the largest component of total transport costs and increase with increasing traffic levels.

SOLUTION
EFFECTIVE AND TIMELY ROAD MAINTENANCE

It is a function of the Road agency to ensure that the safety standards are established and maintained. Routine inspections will identify deterioration likely to contribute to a reduction in road safety. Recording and analysis of accident data can provide clues to maintenance deficiencies.	Judiciously applied maintenance aims to arrest the rate of deterioration and to preserve the structural integrity of each road link over its design life. This serves to provide maximum protection to capital investment. This is the basis for the development of a Road Management System.	Economic analyses show high rates of return in investment because the impact is immediate and benefits accrue in the short term. The attainment of these benefits is through a Maintenance Management System which identifies programmes and controls maintenance operations.

4.6 Consequences of Inadequate Road Maintenance

4.6.1 The cycle of inadequate maintenance is illustrated in Figure 4.5. As illustrated in the figure, inadequate maintenance leads to poorly maintained road surfaces which results in increased vehicle depreciation, tyre wear, vehicle maintenance and spare parts needs. The user costs and operating inefficiency related to these increases are substantial for the entire fleet of vehicles in Botswana, much of these costs being in foreign exchange. Thus, the provision of effective and efficient road maintenance by roads authorities is of critical economic importance to Botswana.

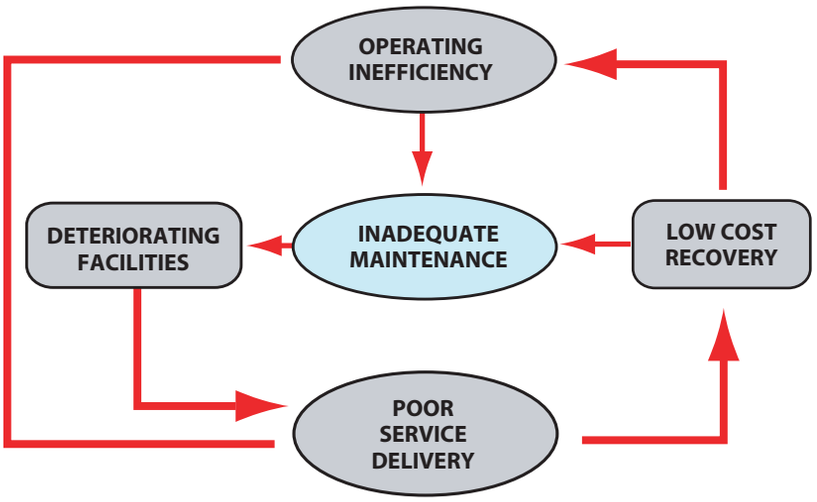


Figure 4.5 *- Cycle of inadequate road maintenance*

4.6.2 In quantitative terms, when a road is not maintained adequately and is allowed to deteriorate from good to poor condition, each pula saved from not carrying out maintenance increases vehicle operating costs by two to three Pula. Thus, as illustrated in Figure 4.6, far from saving money, cutting back on road maintenance increases the costs of road transport and raises the net cost to the economy as a whole. This fact is a powerful one which any roads agency can use to convince their government of the high cost that countries pay for inadequate road maintenance funding.

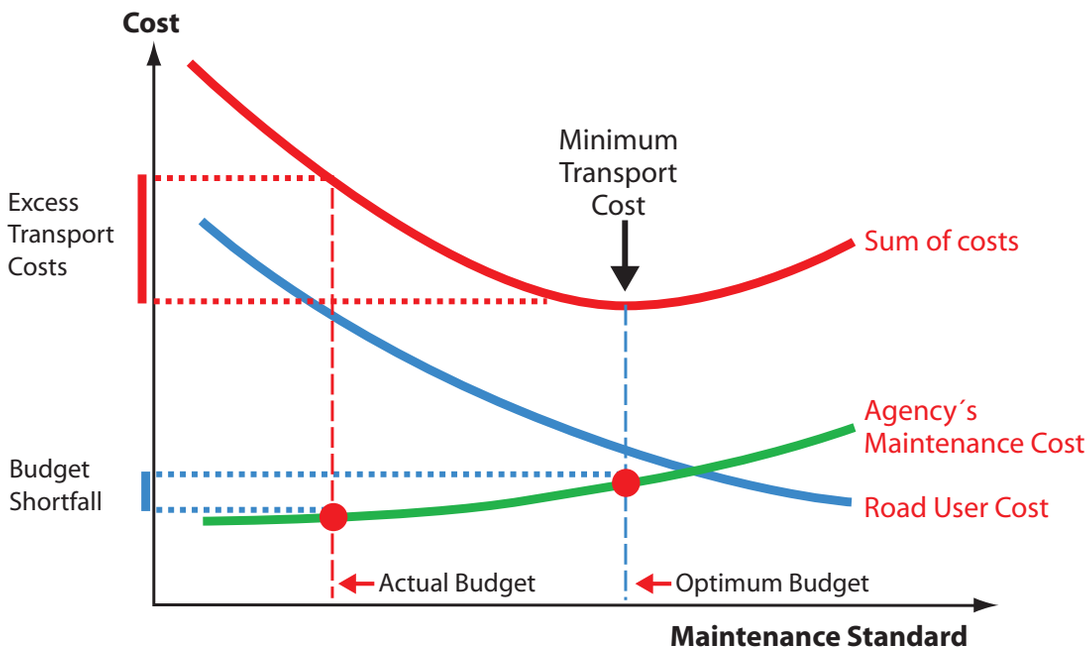


Figure 4.6 *– Relationship between maintenance standard and transport cost (SADC, 2003)*

4.7 Need for Sound Maintenance Management

4.7.1 Inefficient use of limited funds for road maintenance is often closely linked to poor maintenance management in terms of poor planning, programming, preparation and implementation of maintenance works. Improvement in maintenance management practice is therefore a pre-requisite to improving maintenance capability. Such practice has the following main objectives:

- To encourage the use of a systematic approach to decision-making within a consistent and defined framework;
- To provide a common basis for assessing maintenance needs and resource requirements;
- To encourage the adoption of consistent maintenance standards;
- To assist in the effective allocation of resources;
- To encourage regular review of policies, standards and the effectiveness of programmes and resource requirements.

4.7.2 Against the above consideration of various maintenance issues, the next chapter considers the cycle of activities that constitutes maintenance management.

5. MAINTENANCE MANAGEMENT

5.1 Introduction

5.1.1 Maintenance management is essentially a systematic means of efficiently planning, programming, budgeting, scheduling, controlling, data collection and monitoring of maintenance works. In conjunction with the road planning, appraisal and design processes, it attempts to optimise the overall performance of the road network over time. At a practical level it aims to ensure that the correct activities are performed on the network at the right time, to the desired quality. The challenge is to set policies which can contribute the greatest benefit to communities whilst supporting broad national goals.

5.1.2 The undertaking of the various inter-related activities associated with the management of maintenance can be facilitated by the use of an appropriate maintenance management system. Such a system must be well conceived and careful consideration must be given to pursuing a strategy for its development which should be based on methodologies, techniques and resources that are matched to the roads agency's institutional arrangements and local circumstances.

5.2 Components of Maintenance Management

5.2.1 There are four distinct and inter-related components of road maintenance which, together, comprise a management framework for successfully addressing the maintenance challenge. As illustrated in Figure 5.1, these are: Planning, Programming, Preparations and Operations.

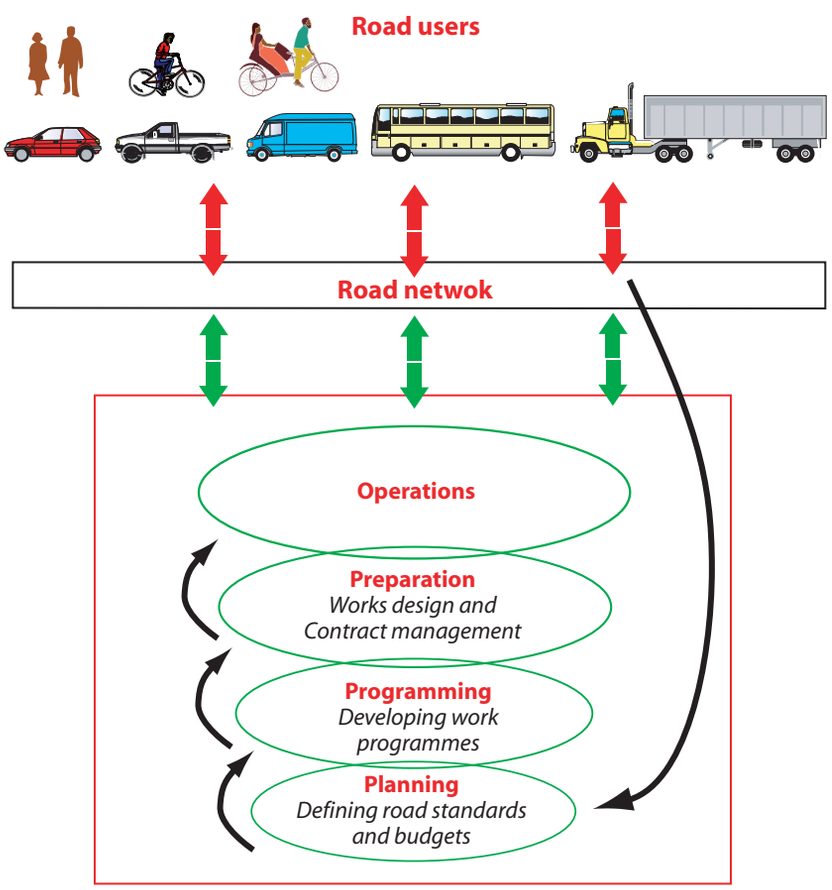


Figure 5.1 *– Road maintenance management functions (Robinson et al, 1998)*

5.2.3 An implication of Figure 5.1 is that, if road maintenance at the point of delivery is to be optimised, then there is also a need to *optimise* the higher level functions of planning, programming and preparation. However, the higher level functions will need to reflect the needs of road users on the network – an issue that has taken on added significance with the more commercialised approaches to road management currently being pursued in the SADC region in which road users have become *"customers"* of road agencies as *"service providers'*. The challenge is to set policies which can contribute the greatest benefits to stakeholders whilst supporting broad national goals.

5.3 Management Cycle

5.3.1 Maintenance management strives to achieve maintenance policy objectives through a series of well defined, organised and executed functions. The actual tasks are numerous and involve different staff in a variety of organisations with varying areas of primary responsibility. They relate to both long and short term decisions, and concern the whole network, sub-networks and individual lengths of road. The sequence of activities moves in a cycle that begins with planning and moves through programming, preparation and then operations in the manner shown in Figure 5.2. If carried out in a systematic manner, significant benefits can be gained from effective maintenance management.

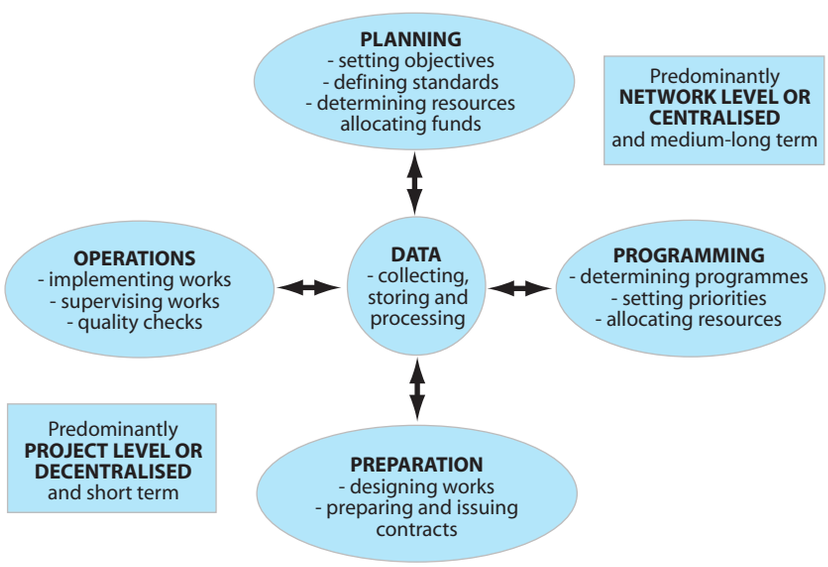


Figure 5.2 *– The cycle and scope of maintenance management functions (SADC, 2003)*

5.3.2 In essence, the various activities that are carried out on an annual basis include the following:

- Setting of maintenance policy, objectives and standards;
- Classification and preparation of a road inventory;
- Assessment of maintenance needs;
- Calculation of resource requirements;
- Assessment of priorities and related funding;
- Executing of works;
- Monitoring performance.

5.4 Maintenance Policy, Objectives and Standards

5.4.1 A policy framework is required to provide the context within which road maintenance is carried out in Botswana. The Roads Department's Maintenance policy supports Government policy in the roads sector as given in the National Development Plan. Increasingly, such policy is now focusing on broader national issues pertaining to the attainment of socio-economic goals, greater involvement of the private sector and more attention to fulfilling user expectations.

5.4.2 In line with the broad policy objectives of Government, some of the more explicit objectives of the Roads Department as regards maintenance include:

- Ensuring the comfort, convenience and safety of all road users;
- Poverty reduction through employment creation and the related use of labour based methods for routine maintenance works wherever feasible;
- Local community involvement in the planning and execution of maintenance of road facilities;
- Private sector involvement (local contractors) in road maintenance (rather than undertaking such maintenance by force account operations);
- The use of the most cost-effective rather than most technologically advanced approaches in carrying out road maintenance;
- Minimising the environmental impact of material resource developments by adopting Environmental Impact Assessments;
- The use of maintenance standards that balance life cycle costs (construction, maintenance and vehicle operating);
- The use of simple contract documents appropriate for use by small contractors.

5.4.3 Maintenance standards also reflect departmental policy as included in ***Part B of the BRMM – Road Maintenance Standards.*** In Part B, for example, the department's objective reflecting the "comfort, convenience and safety" aspect of the department's policy is that "on relatively high volume roads (Service Level A), potholes will be repaired within three days of being reported". This policy is related to the Service Level reflected in Part B of the BRMM.

5.5 Road Classification and Inventory

Classification

5.5.1 Levels of service and maintenance standards will vary depending upon the nature of the road and traffic. Roads are therefore, normally allocated to categories which form a hierarchy. In this regard, the Public Highway Network in Botswana has been classified on a functional basis into four separate categories as follows:

- **Primary Roads:** Link towns, district centres, major centres of population (i.e. more than 10,000 people) and important international border crossings;
- **Secondary roads:** Link villages with a population in excess of 0.15% of national census, established border posts and sites of international/national interest;
- **Tertiary roads:** Link settlements with a population of 500 or more as established at a national census, or link into the network additional settlements of population exceeding 100 within 10 km of another tertiary road;
- **Access roads:** all additional roads not included in the above categories, normally determined by District Councils in anticipation of their conducting some form of maintenance.

Division of responsibilities

5.5.2 The division of responsibilities for management of the Public Highway Network is as follows:

- primary roads } generally to be the responsibility of the Roads Department
- secondary roads } " " " " " " " " "

- tertiary roads } generally the responsibility of the District Councils
- access roads } " " " " " " "

Route numbering

5.5.3 The Public Highway Network has been route numbered based on the following three Reference Routes:

- A1: Ramatlabama Border Post – Gaborone – Francistown – Vakaranga Border Post.
- A2: Pioneer Gate Border Post – Lobatse – Kanye – Ghanzi Junction – Mamuno Border Post.
- A3: Francistown – Nata – Maun – Sehitwa – Ghanzi Junction.

Other primary routes are numbered with reference to the Reference Routes with which they are associated. The same principle then applies to secondary routes, where reference is to both reference routes and primary routes. The Road Network Classification is shown in Figure 5.3.

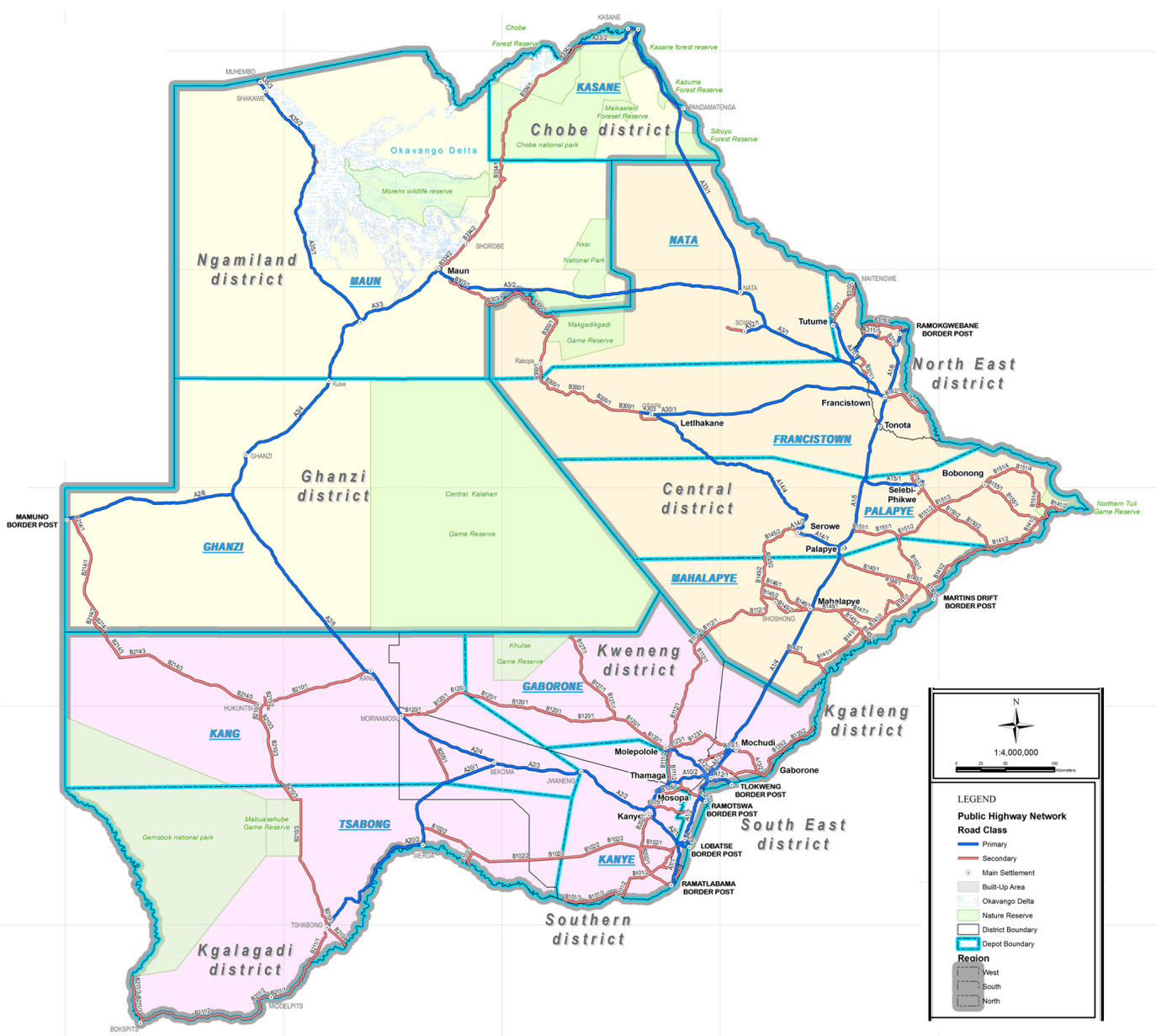


Figure 5.3 *– The Road Network Classification*

Road Inventory

5.5.4 The road inventory is used as the basic reference for planning and carrying out maintenance and inspections. The PHN has been broken down into a series of links and nodes, each defined by a specific number and each being identified physically on the road. The essential elements of each link include route name and length, functional classification, pavement and surfacing type, etc.

5.6 Assessment of Maintenance Needs

Condition survey

5.6.1 Road condition surveys are an important aspect of the maintenance process and are carried out by Roads Department at specified intervals to establish maintenance requirements and, subsequently, priorities. Such surveys are carried out in two stages:

- Visual condition surveys (annually);
- Detailed pavement testing (every three years).

5.6.2 The visual condition surveys are guided by the following two documents:

- Botswana Road Management System (BRMS): Raters Manual for the Visual Assessment of Paved Roads, and
- Botswana Road Management System (BRMS): Raters Manual for the Visual Assessment of Unpaved Roads.

5.6.3 Figure 5.4 gives a flow diagram of road condition surveys carried out in Botswana. Visual condition surveys, including a drive-over of the network, are normally adequate for relatively low-volume roads with a detailed walk-over survey done selectively for sections appearing to need major works. Detailed pavement testing, e.g. FWD and Benkelman Beam testing, would be required for pavement rehabilitation design which is not the main concern in this manual. The concept of Information Quality Levels (IQL) developed by Paterson and Scullion (Paterson and Scullion, 1990) gives further guidance on the level of detail to be collected on the roads network.

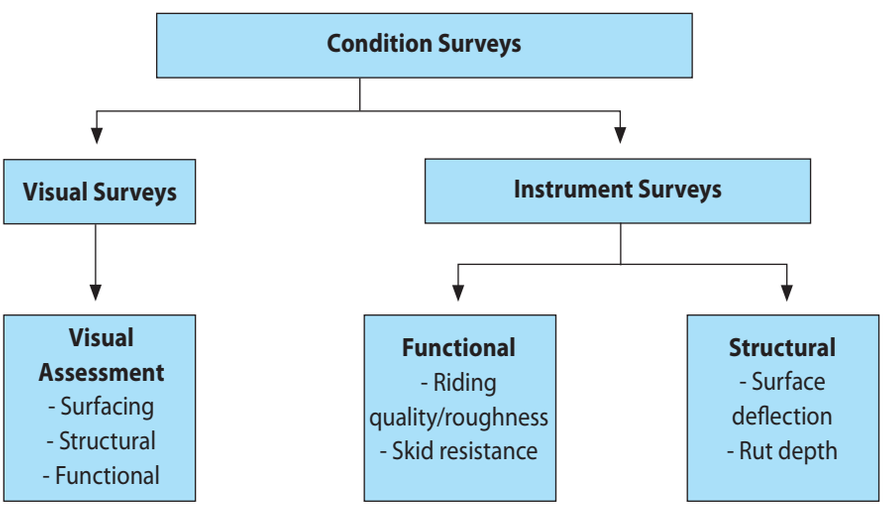


Figure 5.4 *– Flow diagram of road condition survey tasks*

5.6.4 The typical road condition data collected during the surveys is presented in Table 5.1.

Table 5.1 *– Condition data elements*

Data Category	Data Elements	
Surface condition: *Visual*	Texture Voids Surfacing failure Surfacing cracks	Aggregate loss Binder condition Bleeding/ Flushing
Structural assessment: *Visual*	Block cracks Crocodile cracks Longitudinal cracks Transverse cracks Pumping	Rutting Settlement Patching Potholes
Structural survey: *Instrument*	Deflection (e.g. FWD, Benkelman Beam) DCP Laboratory tests	
Functional or structural assessment: *Visual or instrument*	Rut depth Riding quality/ Roughness Skid resistance Surface drainage Cross - section	Side drainage Shoulder condition Edge break Passability
Indices: *Visual or instrument*	Visual Condition Index (VCI) Skid index Stiffness index	

Traffic counts and axle load measurements

5.6.5 A knowledge of the traffic volumes and distribution of axle loads on each link of the Public Highway Network is required for not only evaluating the need for traffic-dependent maintenance activities, such as resealing of roads but, also, for defining maintenance standards and threshold levels for triggering maintenance works.

5.6.6 The primary source of traffic data collection by Roads Department is through regular manual traffic counts along the Public Highway Network.

5.6.7 The various types and methods of traffic data collection employed by Roads Department provide a valuable source of information for planning of both development and maintenance of the Public Highway Network. This information is stored in the department's Road Management System and allows traffic loading by vehicle classification to be displayed on any link of the PHN. Guidance on collection and analysis of traffic data is provided in the Department's *Guideline No. 9 – Traffic Data Collection and Analysis.*

5.6.8 As part of its Pavement Monitoring programme, axel load surveys are carried out annually in Botswana at strategic locations along the PHN. The distribution of axle loads is normally measured by means of mobile wheel-weighing scales. Computer Programmes have been developed by Roads Department for analysing the axle load data to produce Vehicle Equivalence Factors for various vehicle classifications. Guidance on carrying out axle load surveys is provided in the Roads Department's *Guideline No. 4 – Axle Load Surveys (2004).*

Treatment selection

5.6.9 Traditionally, the choice of maintenance treatments in response to defects has been made by the Roads Department's technical staff based on engineering judgement. However, to ensure that treatment is cost-effective and consistent, more objective approaches are appropriate. Treatment selection rules can be formulated which relate maintenance treatments to defect threshold levels, or combinations of defects. The selection rules should reflect the maintenance standards. Part B of the BRMM contains such maintenance standards (see Annex E).

5.6.10 A more sophisticated approach to treatment selection considers a number of different alternative treatments for each link in the road network. This approach entails the use of an economic model such as HDM which, through economic optimisation techniques, determines the optimum maintenance works when taking a long-term view.

The Botswana Roads Department Road Management System allows such an approach to be adopted. The use of this model for determining optimum maintenance works on the Public Highway Network is discussed in Section 5.11.

5.7 Resource Requirements

5.7.1 Having identified the maintenance needs, the resource requirements are calculated in terms of money, personnel, equipment and materials. The resource requirements are related to the maintenance techniques utilised which may be either labour-based or equipment-based. The resource requirements depend on the productivity levels anticipated from different maintenance activities.

5.7.2 Part C of the BRMM - Maintenance Operational Procedures - presents recommended procedures for implementing each of the maintenance activities. The procedures are presented for both labour and equipment based methods depending on applicability. Emphasis is given on maintenance technique rather than on the strategy of implementation. The operational procedures are grouped by road features (road reserve, bridges, drains, etc). For each road feature the scope of maintenance works is described together with the required maintenance interventions (vegetation control, animals control, etc.) and for each intervention the relevant maintenance activities (grass cutting, fence repairs, etc.) are listed with corresponding operational procedures. A typical maintenance operational procedures is shown in Annex E.

5.7.3 For each maintenance activity a description and purpose is presented before detailing the operational procedures for that activity. The procedures are presented for both labour and equipment based methods depending on applicability. For each method a description is provided for the required resources (crew, tools/equipment and materials), work procedure and average production.

Resources (crew, tools/equipment, materials)

5.7.4 Resources indicated for each maintenance activity are based on a typical gang required to execute the activity at the work site. It does not take into account the planning and logistical aspects related to mobilization of the resources. These are covered in Section 8900 in Part C of the manual.

Work Methods and average production

5.7.5 A step by step procedure for executing each maintenance activity at the work site is described separating labour based techniques from equipment based methods. Average production rates are proposed for each activity per crew or workman depending on the nature of the activity e.g. de-stumping is specified per workman while resealing is per crew.

5.8 Priority Assessment

5.8.1 Even when standards have been developed on an economic basis, or in support of policy objectives, the fact that budgets are invariably less than the desired level means that choices must be made. The types of choices include whether:

(a) to delay investment until more funds are available;
(b) to lower standards; or
(c) to perform certain activities in preference to others.

5.8.2 Different approaches are available to prioritise works. Some depend on the type of road, works type and traffic levels, whilst others take account of issues such as population served, economic indices, social indices and strategic importance. They are often applied differently to paved or unpaved roads, and to high or low volume roads.

5.8.3 Three approaches are introduced below which span the range of available techniques and may be used to complement each other. They address the range of issues and potential conflicts important to low volume sealed road infrastructure. These are as follows:

- Treatment choice method (TRL, 1987).
- Cost effectiveness methods (World Bank, 2001).
- Economic NPV and NPV/Cost methods (World Bank, 2001).

Treatment Choice Method:

5.8.4 In this method, funds are earmarked for 'essential' maintenance activities such as addressing emergency works, access restoration (over short stretches), drainage maintenance and asset preservation. Remaining funds are distributed to more heavily trafficked roads justifying more expensive treatments, with unfunded works delayed or other budget sources sought. It is both simple and flexible, since the user can specify the order of importance based on local priorities. An economic underpinning does exist, in that it is widely recognised that routine maintenance provides a higher economic return than intervening after significant distress has occurred.

Table 5.2 *– Example of Treatment Choice method (TRL, 1987)*

Hierarchy of maintenance activity	Priority							
	Traffic hierarchy							
	1	2	3	4	5	6	7	8
Traffic range (vpd)	Strategic	> 1000	500-1000	200-500	> 200	< 200	50-200	< 50
Surface type	P	P	P	P	UP	P	UP	UP
Emergency	1	7	8	9	10	11	12	13
Cyclic drainage	2	14	15	16	17	18	19	20
Reactive pavement work	3	21	24	27	30	33	36	39
Periodic preventative	4	22	25	28	31	34	37	40
Other cyclic/reactive	5	23	26	29	32	33	34	35
Overlay/reconstruct	6	42	43	44	45	46	47	48

Cost effectiveness methods

5.8.5 These methods introduce other considerations into the prioritisation process which are not addressed by conventional transport economic approaches. These considerations include:

- Magnitude of population served.
- Weighting for degree of poverty in the communities.
- Potential for agricultural or other development.
- Number of social and other services.

5.8.6 The above approach might best be applied to rural feeder or collector roads, where the geographical area which benefits from an improvement can be precisely defined. It also lends itself for application at a local level through the direct participation of representatives of various stakeholder groups.

Economic NPV and NPV/Cost methods

5.8.7 These methods are appropriate to relatively heavily trafficked roads relying on user benefits to economically justify maintenance interventions. They are employed in economic models such as HDM which can be incorporated in a Road Management System as developed by the Roads Department and described in Section 5.11.

5.9 Execution of Works

Role players

5.9.1 There are a number of options open to Roads Department for carrying out maintenance works. The terms used to describe the various role players in these options is as follows:

(a) **Owner:** The organisation responsible for funding, establishing road policy and the legal and regulatory framework for management of the road network. Typically, this will be a ministry of transport or works actingas the de facto owner on behalf of the state.

(b) **Administrator:** The organisation, responsible for implementing policy and ensuring that the performance of the road network meets the overall political and economic aims of the owner. In many countries, this is referred to as the road agency or agency.

(c) **Manager:** The role, or organisation, responsible for specifying activities to be carried out, supervising, controlling and monitoring activities. In most situations, the manager role is combined with that of the administrator, but increasingly worldwide there is a move to appoint managers under contract (typically, engineering consultants).

(d) **Contractor:** The role, or organisation, responsible for delivery of operations by executing or undertaking works for the road administrator.

Models

5.9.2 The various models available to Roads Department for undertaking maintenance works are as follows [6]:

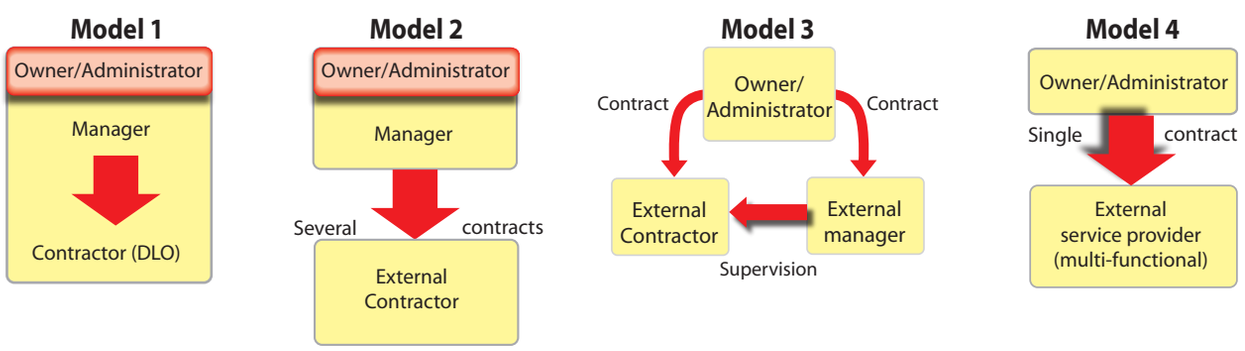


Figure 5.5 *– Contract arrangements for undertaking maintenance works*

(a) **Model 1** - In-house works Unit (Direct Labour Organisation): This is the traditional model for undertaking routine and, sometimes, periodic maintenance works. As a matter of policy, this approach is in the process of being phased out by Roads Department.

(b) **Model 2** - Conventional Contractor: In this model, the road administrator, who lets conventional civil engineering contracts to an external contractor for carrying out the works, takes the manager role. The model has been widely used for carrying out development and periodic maintenance works but is less widely used for carrying out routine and special maintenance works.

(c) **Model 3** - Conventional contractor-consultant: In this model, the road administrator lets contracts for both the manager and contractor roles. Consultants typically undertake the manager's role and have the task of supervising the work undertaken by contractors. Many roads agencies employ this model, but with the agency being bound by a Performance Agreement with the Owner Ministry. Their performance is monitored by a Roads Board which essentially fulfils an audit role.

(d) **Model 4:** Total Service provision: In this model, a single contract is let by the road administrator to the manager who is responsible for providing services to the administrator. The manager organisation may choose whether to undertake the contractor role itself, or to engage contractors.

5.9.3 ***Schedule of rates:*** This is the most common form of contract, Model 2 above, where the contractor is not subject to significant performance based requirements, and undertakes a prescribed set of activities at specified intervals, or when conditions exceed 'intervention standards'. Rates are negotiated, or in some cases stipulated by the purchaser, the reason for the latter being related to the stage of 'commercialisation' in the sector. The quality of workmanship will be specified, and work planning and method guidelines may be provided to ensure consistency in approach to each operation. Many road authorities in the region have adopted such guidelines.

5.9.4 ***Performance-based, short-term:*** Performance-based contracts require the contractor to accept the greater part of the risk and to plan and specify the short-term maintenance needs to satisfy the outcome-based performance

specification of the Client, and are usually lump sum contracts. The scope of works includes routine and emergency works and can extend to include periodic works, which requires approval processes to be executed by the Client. In many cases, the contract incorporates provision for periodic works, thus reducing the need for new procurement processes within the contract term and therefore providing a greater guarantee of workload for the contractor. Such contracts are generally termed *Network Maintenance Contracts* (in Australia) or *Term Maintenance Contracts* (in the United Kingdom), and are usually managed according to Model 3 above.

5.9.5 ***Performance based – long term:*** These extend the responsibilities to the service provider, in which they provide a 'total service' as illustrated in Model 4 above. The long term nature of these contracts means that substantial planning and management capability must reside within the service provider. Works will include all maintenance activities and rehabilitation. Key Performance Indicators need to be set by the Client for long term and short term attributes. It is then the contractor who specifies how the targets will be achieved and to incorporate this into their tendered proposals.

Performance-based vs. traditional contracts

5.9.6 Whereas traditional road maintenance is based on the amount of work to be done and paid for various work items, in contrast, performance-based road management and maintenance contracts define minimum conditions of road assets that have to be maintained by the contractor. They also define other services such as collection and management of asset inventory data, emergency response and replies to public requests, complaints and feedback.

5.9.7 Payment is based on how well the contractor manages to comply with the defined performance standards and not on the amount of work and numbers of services carried out. Performance-based contracts define the final product and it is up to the contractor to comply, so work selection design and delivery are all his responsibility. The same applies to choice and application of technology and pursuit of innovative materials, processes and management.

5.9.8 Performance-based contracts allocate higher risks to the contractor than traditional contracting arrangements. At the same time, they open up opportunities to increase profit margins where improved efficiencies and effectiveness of design, process, technology or management can reduce the cost of attaining the specified performance standards.

Acceptance of risk

5.9.9 The form of contract defines each party's responsibilities and allocates the various risks between them. Risks can be grouped according to those that affect:

- Quality - the possibility of the work not meeting the requirements of the client.
- Cost - the possibility of the cost of work being different from that predicted.
- Time - timely delivery is less of an issue for maintenance than for construction projects, and is closely related to cost.

5.9.10 The trend in recent years has been to transfer as much risk as possible to the private sector, but experience has now shown it is best allocated to the party most suited to cope with that risk. Table 5.3 illustrates issues of risk allocation for road maintenance.

Table 5.3 *– Contracting strategies and risk allocation*

Issue	Client to manage risk	←		→	Contractor to manage risk
Type of contract	Hourly rates	Single activity	Grouped activity	Performance based (short)	Performance based (long)
Payment method	Cost reimbursable	Target cost	Schedule of rates		Lump sum
Term of contract	Short term	←		→	Long term
Packaging	Many small contracts	←		→	Few large contracts

5.10 The Botswana Road Management System (BRMS)

System Framework

5.10.1 The system has been designed to assist the Roads Department in undertaking a wide range of road management functions including:

- the construction of new facilities;
- the adequate maintenance of existing facilities;
- the upgrading of facilities to meet required standards.

5.10.2 The essential concept behind the design of the BRMS is that of an integrated, modular, computerised system in which an Information System (Central or Core Data-base) is linked to and interacts with a number of Decision Support Systems (DSSs) that are both providers and recipients of data from the centre (ref. Figure 5.6). Thus, while each system performs a specific useful function within its own sphere of need, each system should still be seen as part of a larger road management decision making process.

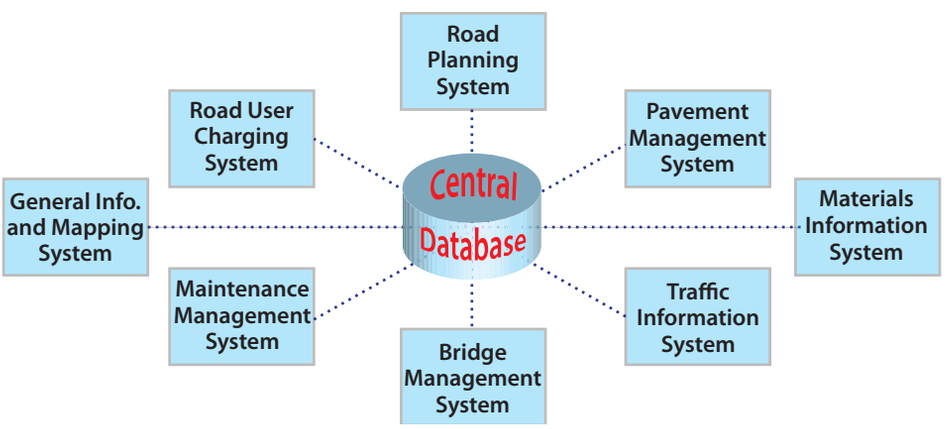


Figure 5.6 - *Schematic illustration of the Botswana Road Management System (BRMS)*

System Attributes

5.10.3 The integrated, modular approach adopted in the design of the BRMS provides the following attributes:

- offers potential to undertake total infrastructure management in a comprehensive and coherent manner;
- allows application modules to be introduced separately as and when required without affecting the integrity of the system;
- benefits from data integration and centralised maintenance and upkeep of a common database;
- allows operation with less than the full complement of DSSs;
- offers flexibility for operation of the Decision Support Systems either by individual divisions of the department or by a dedicated Road Management Unit.

5.10.4 To achieve a capability for formal economic prioritisation and optimisation, the World Bank's HDM-4 model has been incorporated as the basic analytical tool for the RMS. However, in support of the need for a continuous check on the predictive relationships in this model, a number of representative sections on the Public Highway Network have been monitored and the results have been used to refine the predictive capability of the model.

System Components

5.10.5 The BRMS offers the capability of accommodating a large number of DSSs which are normally used by a road agency in managing its road system. Not all the DSSs illustrated in Figure 5.5 have been installed. However, the architecture of the system allows it to be expanded easily in the future, as and when required.

5.11 Application of the BRMS

Areas of application

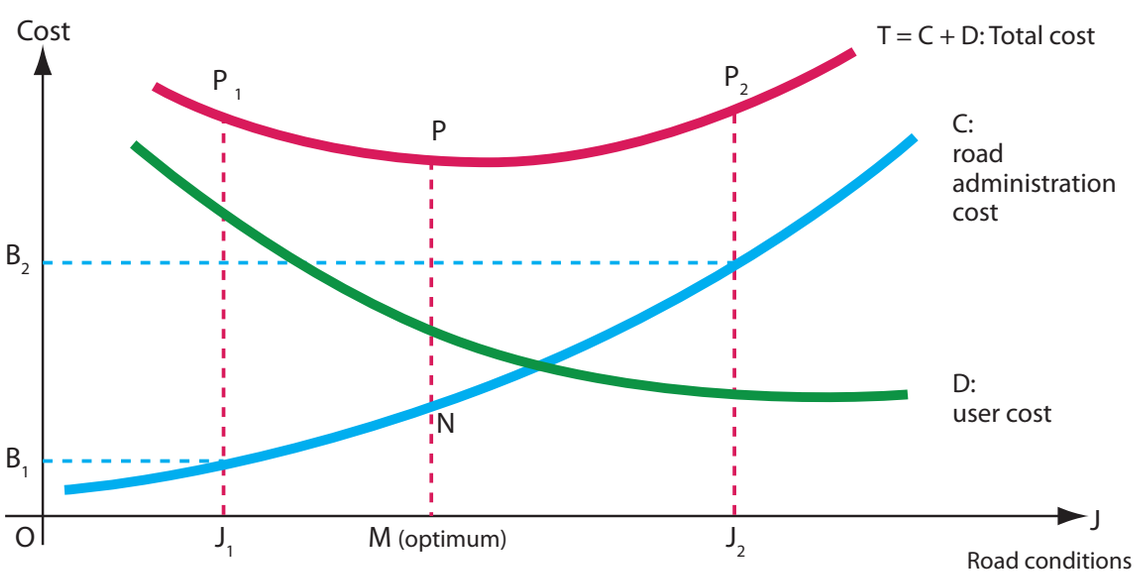
5.11.1 The BRMS can assist roads agencies in the economic and effective management of the PHN in four main areas of application :

(1) Strategic planning;
(2) Programme Analysis;
(3) Project Analysis; and
(4) Research and policy studies.

5.11.2 Each of the above levels of application represent successive levels of decision making, each of which takes decisions at its respective level and assigns a total amount of funding to the level below together with objectives and instructions to implement these objectives as well as possible and in greater detail. The following sections illustrate how the BRMS can be operated at various levels of application to achieve the desired objectives of roads authorities in Botswana.

Strategic level application

5.11.3 The focus at the strategic level of application is on policy in which the roads agency pursues its over-riding goal of managing the road asset efficiently and cost-effectively. In terms of "best practice" in resource allocation decisions, the road agency's goal would typically be minimization of total transport costs to society. This concept is shown conceptually in Figure 5.6 which refers to a road network and which indicates the network wide optimal road standard and the budget associated with that standard.



J : road condition indicator
D : user cost
C : road administration cost
T : total cost (T = C + D)

M : Optimal road condition
MN : Budget to sustain optimal condition
MP : Total cost minimum for the optimal road condition

Figure 5.7 *– Effects of budget and road condition constraints on optimising road maintenance and rehabilitation (OECD, 1994)*

5.11.4 In Figure 5.7, the total cost curve T is the sum of the road user costs (D) and road administration costs (C) which decrease and increase respectively with improving road conditions and has a minimum cost value at P which represents the theoretical economic optimum which minimises the total costs of road transport. The shape of the curve is very much traffic related in that cost shares under optimal maintenance conditions vary quite significantly in relation to traffic levels.

5.11.5 Should there be under-funding of maintenance, then the implications would be as illustrated clearly in Figure 5.7. If the available agency budget is only B_1, i.e. less than the optimum, then the best the roads authority can do, *if the available money is optimally spent, is to deliver a road condition at J_1*. The consequence of this funding constraint is that for the society, the costs will be J_1 P_1 which is much more than the minimum social cost MP. In such a situation, the road users pay more out of their pockets than what is saved in the agency budget. Worse, if the full costs of maintenance are to be recovered through an appropriate road user charge, then road users will be paying more for roads whose condition will be getting worse! This approach to road network level management provides the roads agency and road fund administration with basic information with which to inform the public about their policies. It also provides an informed basis for public debate about them.

Development of Road Maintenance Strategies

5.11.6 Should the optimal maintenance funding required to minimize total transport costs not be available, what strategy should the roads authority pursue to ensure that it spends its limited budget in the "best" way? The "best" way will depend on the policy objectives of the authority. What should such policy objectives be? The following are the typical options open to the authority:

- Policy 1: Fix worst roads first?
- Policy 2: Conduct maintenance according to a priority index?
- Policy 3: Conduct maintenance to maximize pavement condition?
- Policy 4: Conduct maintenance to minimize total transport costs?

5.11.7 The BRMS has the capability to evaluate the consequences of each policy in terms of their impact on such parameters as overall network condition, long-term changes in the network's asset value, total transport costs or vehicle operating costs. Such an analysis was carried out by the Roads Department to investigate the long-term consequences of the above maintenance policies and budget levels on their paved road network (Rohde et al, 1996. The outcome of such an analysis for each of the four policy objectives indicated above is illustrated in Figure 5.8 in terms of the following:

- Overall decrease in network condition after 10 years;
- Long-term network condition in terms of backlog maintenance;
- Loss of asset value Road network condition.

5.11.8 **Network Condition:** Figure 5.8 illustrates the overall decrease in network condition after 10 years for each of the four policy objectives evaluated. For each road class, the network condition was calculated based on the weighted condition and length of each road segment. The graph illustrates that the worst first policy clearly resulted in the greatest decrease in road condition.

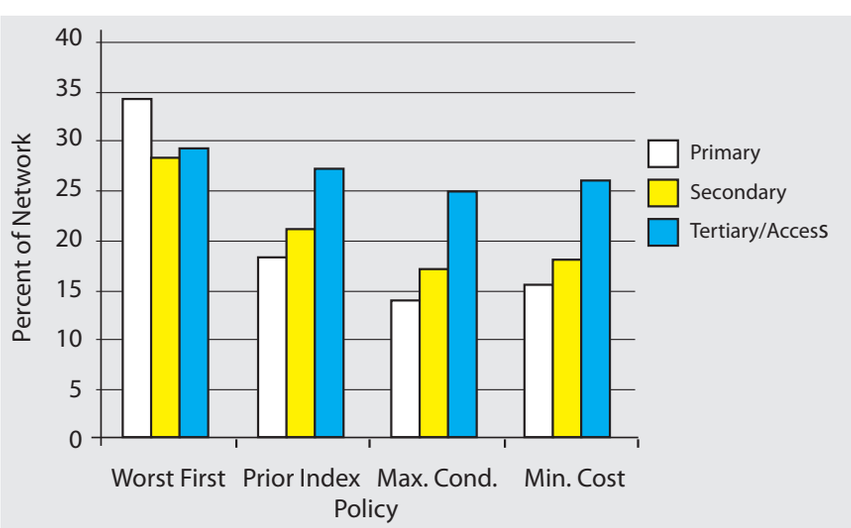


Figure 5.8 *– Road network condition versus policy objective (Rohde et al, 1996)*

5.11.9 **Backlog maintenance.** Figure 5.9 illustrates the effect of policy on backlog maintenance. As shown in the graph, the largest backlog, defined as the percentage of the network in poor to very poor condition, is expected under a worst-first policy.

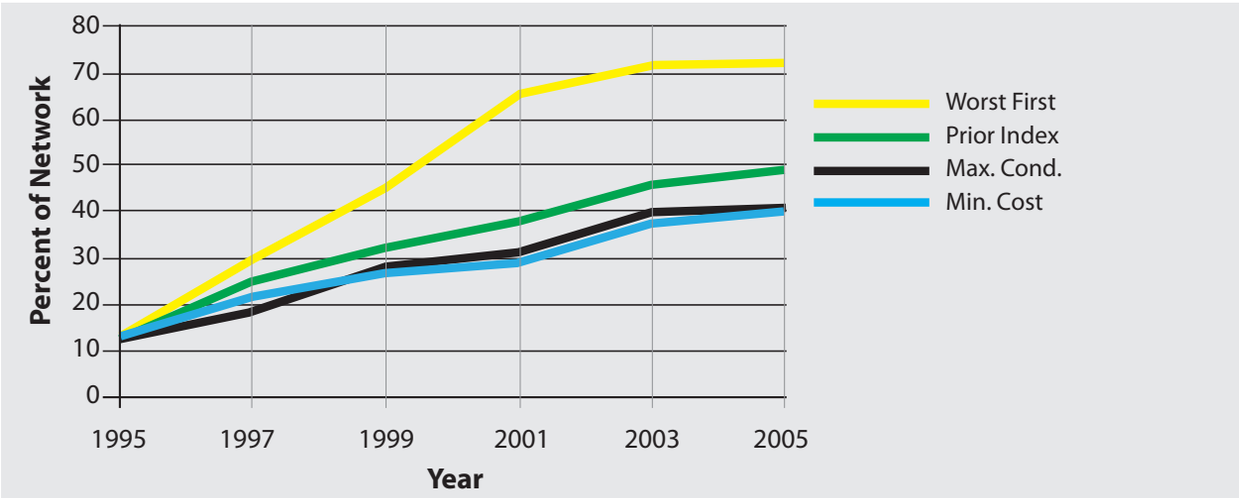


Figure 5.9 *– Percent of road network in backlog condition (Rohde et al, 1996)*

5.11.10 **Asset value.** Figure 5.10 shows the results of the analysis of loss of asset value over the next 10 years, per road class. In this example, the asset value is representative of the residual value of a facility at any given time. The graph illustrates the largest loss in asset value under the worst-first scenario.

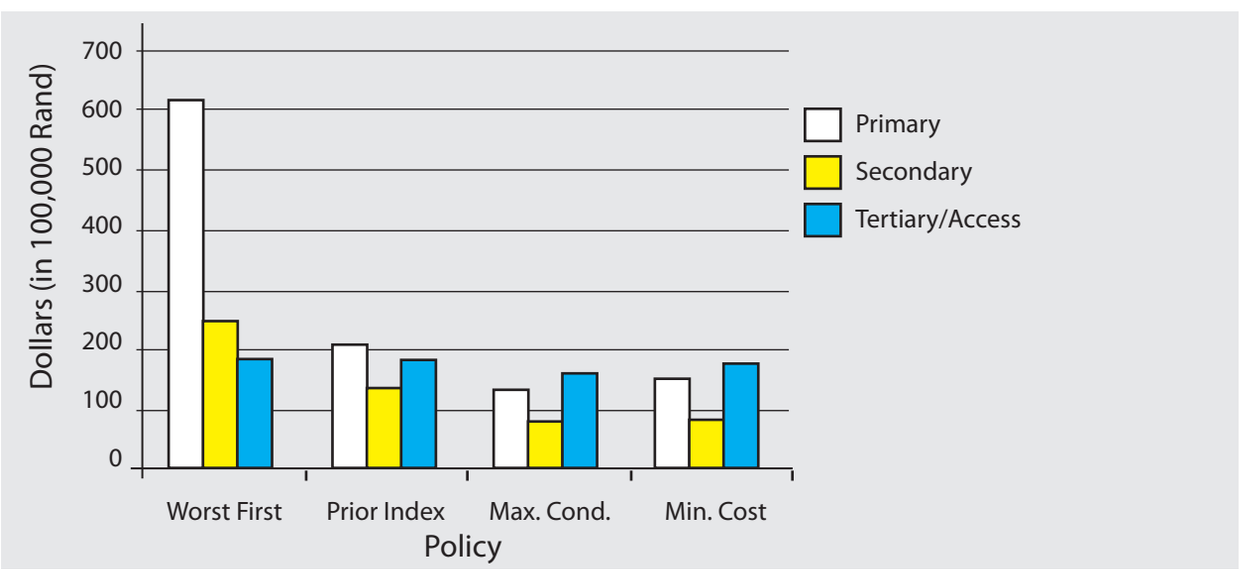


Figure 5.10 *– Asset value versus road policy (Rohde et al, 1996)*

5.11.11 What Figures 5.8 to 5.10 clearly illustrates is that the policy objective used in selecting maintenance strategies has widely varying long-term performance and cost implications on a road network and its users. It is therefore essential that the roads authority selects an appropriate long-term policy objective and structures its maintenance policy to achieve its objective. From the output of the various analyses illustrated above, it appears that Policy 3 should be followed if it is the road agency's objective to preserve the road network. If on the other hand, the agency strives to minimize transport costs to society, then it should pursue Policy 4. Policy 1 would normally not be the preferred policy.

Programme level application

5.11.12 At programme level, the challenges faced by the roads authority is to ensure that the most economical maintenance or road improvement options are applied to individual road sections in accordance with the chosen strategy adopted from the strategic level analysis and subject to technical and local constraints. Numerous strategies are available, each with differing life-cycle costs and, ultimately, differing economic returns on the investment. For example, as illustrated in Figure 5.11, one strategy might be to reseal quite frequently whilst the road is in relatively good condition, while another strategy might be to apply a thin overlay when the road is in relatively poor condition. These alternative strategies would be influenced by the type of road, traffic volumes, available budgets, etc.

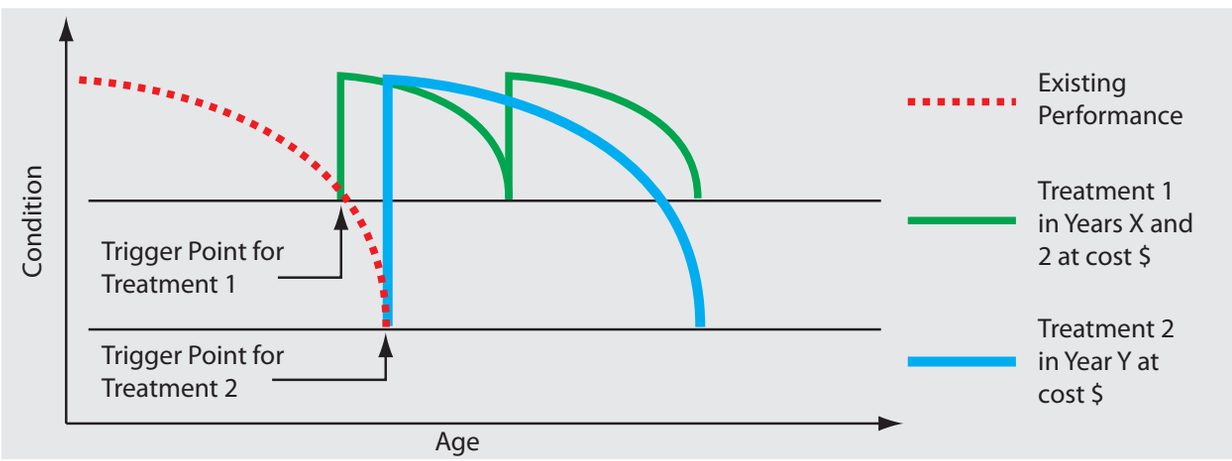


Figure 5.11 *- Alternative feasible maintenance options*

5.11.13 To select the best strategy at programme level, optimization techniques can again be used to determine the strategy that gives the best economic return for a specified budget (Haas et al, 1994). Such a technique allows all strategies for each network element to be plotted on an "economic efficiency frontier" as illustrated in Figure 5.12. The most cost-effective strategies are the ones that lie on the efficiency frontier. For example, in Figure 5.12, Strategy 3 and Strategy 6 have approximately the same cost, but strategy 6 has almost twice the benefits. The strategy at the top of the list provides the most benefits per dollar spent. If the budget allows, this strategy should be selected, otherwise the next one down on the efficiency frontier should be selected (Strategy 4).

Project Level Application

5.11.14 At project level, the roads agency is concerned with the detailed evaluation of one or more road projects or investment options. Road sections with user-specified treatments are analysed over a specified design period to estimate the engineering or economic viability of the project. This would normally entail performing a life-cycle analysis of pavement performance, maintenance and/or improvement effects together with estimates of road user costs as a basis for choosing the most appropriate design.

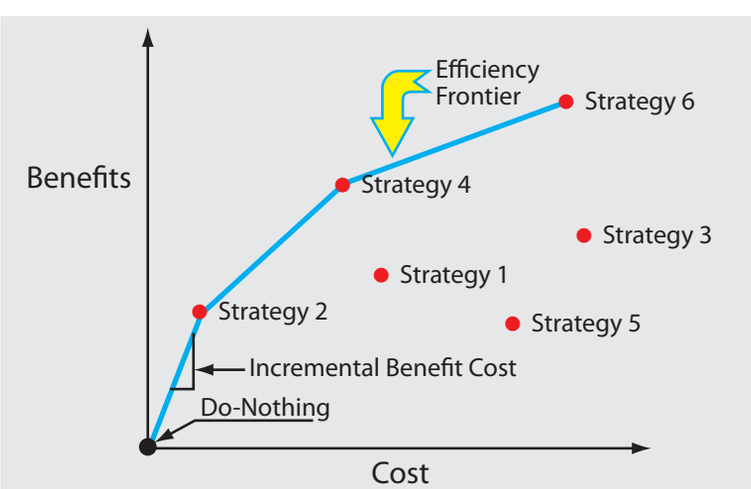


Figure 5.12 *- Economic Efficiency Frontier*

Determination of Optimal Budgets

5.11.15 In selecting an optimal budget the long-term consequences as described above should also be considered. Figure 5.13 shows typical output from the BRMS used in selecting an appropriate budget for maintenance and rehabilitation of the paved road network.

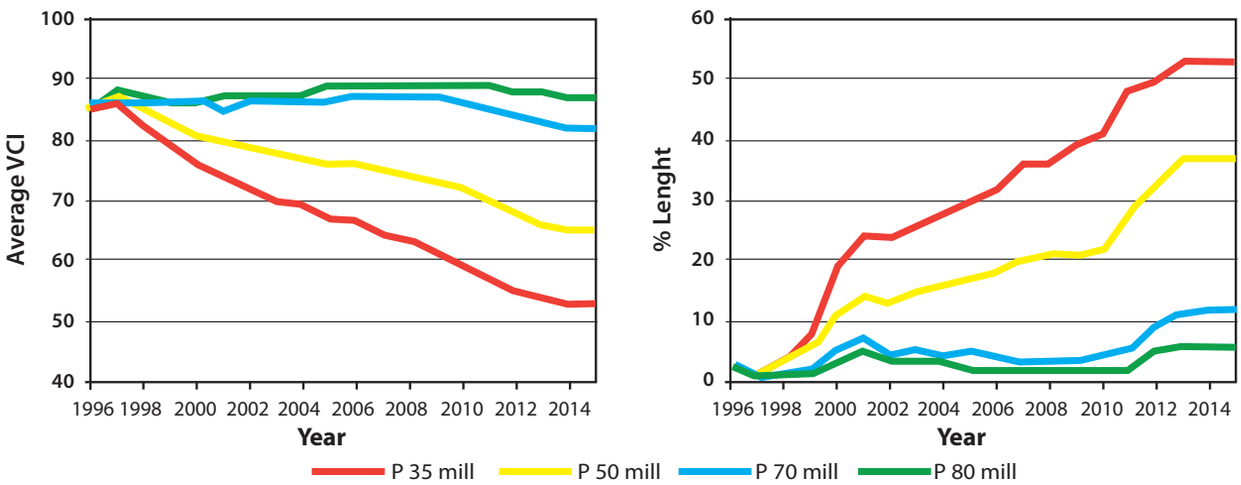


Figure 5.13 *- Future condition for different budget levels (Roads Department, 1996)*

Network condition by budget level

5.11.16 Figure 5.14 shows the network condition distribution for two of the budget levels considered above, P 35 million and P 70 million. As illustrated in the figure, the impact of an inadequate budget (P 35 million) will result in an increasing proportion of roads in very poor condition (increasing backlog maintenance) with a commensurate decrease of roads in very good condition. In contrast, the impact of a P70 million budget will result in maintaining the proportion of roads in very good and good condition with a commensurate decrease of road in very poor condition (at least maintaining the asset level).

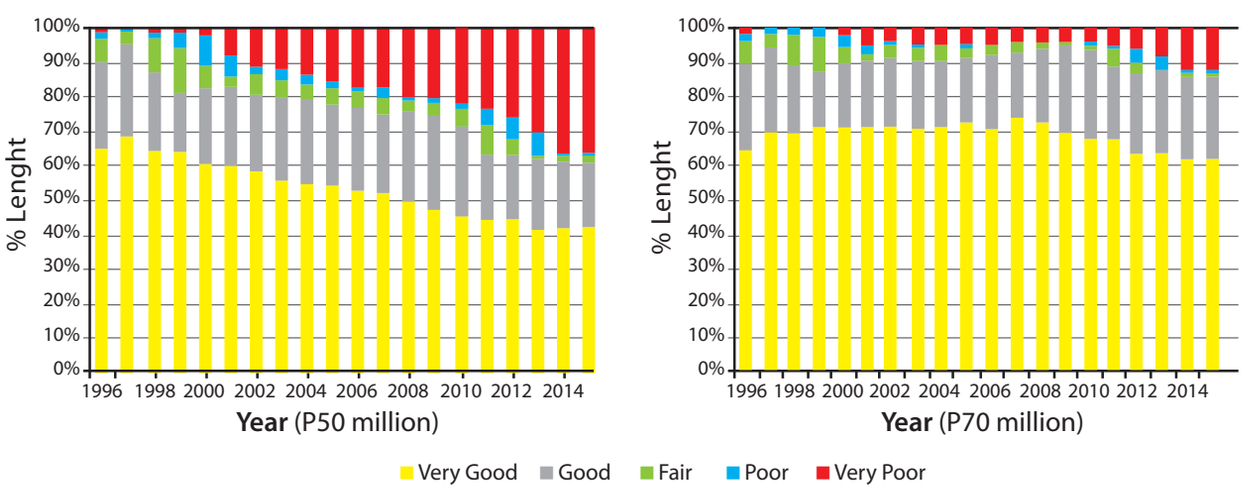


Figure 5.14 *– Network condition distribution for an inadequate budget and an adequate budget (Roads Department, 1996)*

Effect of various budget levels on asset value

5.11.17 The BRMS also has the capability of determining the asset value for any budget level considered. Thus, a sub-optimum budget level would result in the long-term loss of asset value and vice-versa, as illustrated in Figure 5.15.

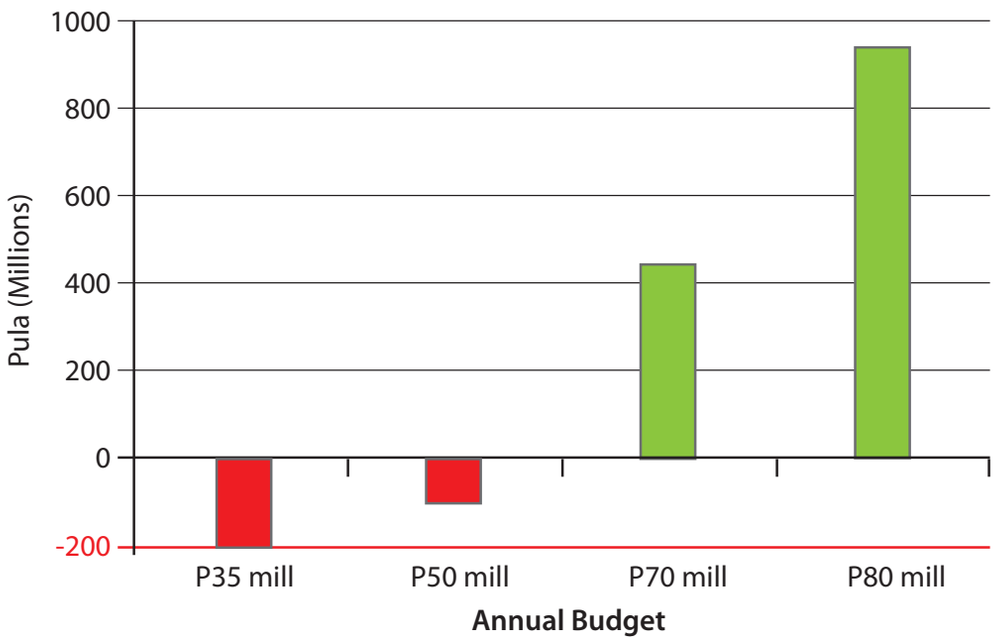


Figure 5.15 *– Change in road asset value versus road budget (Roads Department, 1996)*

Graphical outputs

5.11.18 Information on the extent, usage and condition of the road network is essential at both the strategic and tactical planning levels of a road agency. The BRMS General Information and Mapping sub-system can provide such information in a variety of outputs including strip maps and graphs that summarise road network conditions. Figure 5.16 shows a typical output of the BRMS which has proven to be valuable in marketing strategy to politicians and road users.

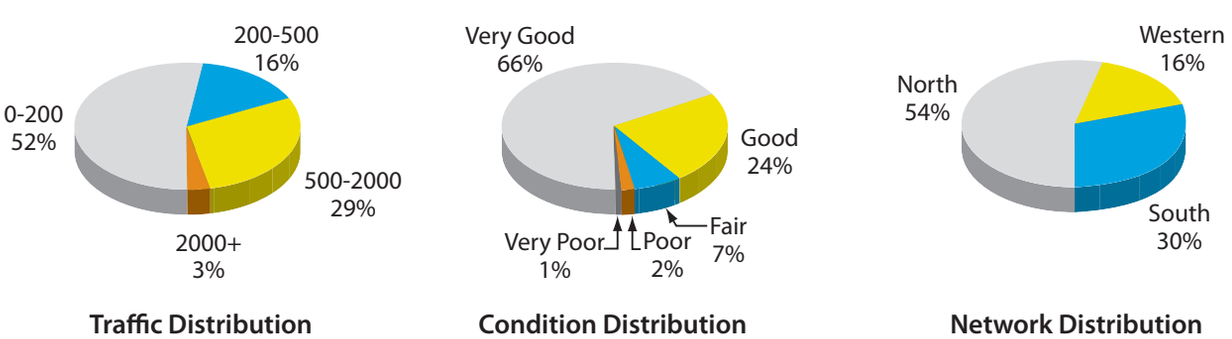


Figure 5.16 *- Typical graphical output from the BRMS (2005)*

Summary

5.11.19 The BRMS provides the Roads Department with a very powerful decision-making tool capable of providing decision support at all three levels of management, namely policy/executive, planning and execution. The BRMS has a number of capabilities including an ability to provide the Roads Department with a multi-year maintenance plan for any given budget, including an optimum one without budgetary constraints. The BRMS can be used to refine the maintenance standards contained in Part B of the BRMM.

REFERENCES

Botswana Roads Department (1996): ***1996 Maintenance and Rehabilitation Plan for the Botswana Paved Road network. Roads Department,*** Gaborone, Botswana.

Haas, R., Hudson. W. R. and Zaniewski, J. (1994). ***Modern Pavement Management,*** Kriegeler Publishing Co. Florida, USA.

International Road Federation (2004). ***The Organisation of Road Maintenance,*** Washington D.C., USA.

Morosiuk, G, M Riley and J B Odoki (2001). ***Modelling road deterioration and works effects***. Draft Volume 6 of the HDM-4 series of publications. PIARC ISOHDM. World bank, Washington, D.C, USA.

OECD (1994). ***Road maintenance and rehabilitation: Funding and allocation strategies.*** OECD, Paris, France.

Paterson, WDO and T Scullion (1990). ***Information systems for road management: draft guidelines on system design and data issues.*** Infrastructure and Urban Development Department. Report No INU 77. The World Bank. Washington DC, USA.

PIARC (2000). HDM-4. ***Highway Development and Management Series.*** The World Road Association (PIARC), Paris, France.

Robinson, R, U Danielson and M Snaith (1998). ***Road Maintenance Management, Concepts and Systems.*** MacMillan Press Ltd, Basingstoke, UK.

Rohde, G.T., Pinard, M.I. and E. Sadzik (1996). ***Long-term Network Performance – A Function of Maintenance Strategy.*** Proceedings Roads 96 Conference, Christ Church, New Zealand, 2-6 September, 1996.

SADC (2003). ***Guideline on Low-volume Roads.*** SADC Secretariat, Gaborone, Botswana.

TRL (1987). ***Maintenance management for district engineers.*** Overseas Road Note 1. Transport Research Laboratory. Crowthorne, UK.

World Bank: (2001). ***Technical Paper No. 496 – Design and Appraisal of Rural Transport Infrastructure: Ensuring Basic Access for Rural Communities.*** World Bank, Washington, D.C., USA.

Botswana Roads Department (2004). ***Guidline No. 4 – Axleload Surveys.***

BIBLIOGRAPHY

Andersson, C-A, A Beusch A and D Miles. (1996). International Labour Organisation. ***Road maintenance and regravelling (ROMAR) using labour based methods.*** Intermediate Technology Publications Ltd, London.

ARRB (1993). ***Unsealed Roads Manual – Guidelines to Good Practice.*** ARRB Transport Research Ltd., South Vermont, Victoria, Australia.

ARRB (1995). ***Sealed Local Roads Manual – Guidelines to Good Practice for the Construction, Maintenance and Rehabilitation of Pavements***. ARRB Transport Research Ltd., South Vermont, Victoria, Australia.

Gourley C S, T Toole T, and R C Petts, (2001). ***Improving Local Resource Utilisation in Roadworks in Developing and Emerging Countries.*** 14th IRF World Congress, International Road Federation, Paris, France.

Gyamfi P and G Ruan, (1996). ***Road Maintenance by Contract:*** Dissemination of good practice in Latin America and the Caribbean region. Regional Studies Program, Report No.44, The World Bank, Washington DC., USA.

Hewitt N C, T Mutowembwa, and T Toole (1998). ***The Zimbabwe Road Deterioration Study.*** Secondary and Feeder Roads Development Programme (SFRDP) Workshop, Harare, Zimbabwe, June 1998. PA 3396/98, Transport Research Laboratory, Crowthorne, UK.

Katala J and T Toole (2000). ***Road Management Systems: The Development of the Road Mentor System in Tanzania.*** Fourth Annual Transportation Conference. 23rd – 25th November, 2000, Dar es Salaam, Tanzania.

Lantran J M and C Morse (1995). ***Development of the Private Sector (Module 6). Framework and Competi¬tion and Procurement and Contract Management.*** Proceedings of The Highway Policy Seminar for the Countries of the Former Soviet Union, Moscow, 15 - 19 May 1995. Washington DC: The World Bank.

Larcher P and D Miles (2000). ***Roads and Realities: how to Promote Road Contracting in Developing Countries.*** Institute of Development Engineering, Loughborough University, UK.

Martin T C (2001). ***Is Local Road Maintenance Meeting the Community's Needs***. Proceedings of the Institution of Civil Engineers. Municipal Engineer 145, Issue 2. London, Institution of Civil Engineers, UK.

Miles D W J (1996). ***Promoting Small Contractors in Lesotho: Privatization in Practice.*** Proceedings of the Institution of Civil Engineers (Civil Engineering), 114, August, pp124-129.

OECD (1990). ***Road Monitoring for Maintenance Management: Vol. 1 – Manual for developing countries.*** World Bank, OECD.

OECD (1990). ***Road Monitoring for Maintenance Management – Vol. 2 – Damage catalogue for developing countries.*** World Bank, OECD.

PIARC (1994): International Road Maintenance Handbook: Volume I – ***Maintenance of Road Side Areas and Drainage.*** TRL, UK.

PIARC (1994). ***International Road Maintenance Handbook, Volumes I – IV.*** TRL, Crowthorne, Berkshire, UK.

Robinson, R (1988). ***A View of Road Maintenance Economics, Policy and Management in Developing Countries.*** Research Report 145. TRRL, Crowthorne, Berkshire, UK.

Robinson R, U Danielson and M Snaith, M (1998). ***Road Maintenance Management, Concepts and Systems.*** MacMillan Press Ltd, Basingstoke, UK.

Annex B - Bibliography

SADC (2003): ***Guideline on Low-Volume Sealed Roads.*** SADC Secretariat, Gaborone.

SABITA (1993): ***Labour enhanced construction for bituminous surfacings.*** Manual 11. SABITA Ref. No. 01591.

Scott Wilson Kirkpatrick (1993). ***Road maintenance Study, Roads Department,*** Ministry of Works, Transport and Communications, Gaborone.

TRRL Overseas Unit (1985). ***Maintenance techniques for district engineers. Overseas Road Note 2***. Crowthorne., UK.

TRRL Overseas Unit (1998). ***Guidelines on the Design and Operation of Road Management Systems. Overseas Road Note 15.*** Crowthorne, UK.

TRRL Overseas Unit (1987). ***Maintenance Management for District Engineers. Overseas Road Note 1.*** TRL, Crowthorne.

TRRL Overseas Unit (1988): ***Overseas Road Note 7 (Vol. 1). A guide to bridge inspection and data systems for district engineers.*** Crowthorne.

TRRL Overseas Unit (1988): ***Overseas Road Note 7 (Vol. 2). Bridge Inspector's Handbook.*** Crowthorne, UK.

TRL. Overseas Road Note 18 (1989): ***A guide to the pavement evaluation and maintenance of bitumen-surfaced roads in tropical and sub-tropical countries.*** TRL, Crowthorne, UK.

PIARC (2000). HDM-4. ***Highway Development and Management Series.*** The World Road Association (PIARC), Paris, France.

Robinson P (1998). ***Maintenance by Contract: Is it Delivering Value for Money?*** Proceedings of the National Workshop, Melbourne, Australia, November 2000. ARRB Transport Research Ltd, South Vermont, Victoria, Australia.

Robinson R (1988). ***A View of Road Maintenance, Management and Economics.*** TRL Research Report RR 145. Crowthorne, UK.

Transport Research Laboratory (1985). ***Maintenance Techniques for District Engineers.*** Overseas Road Note 2. TRL. Crowthorne, UK.

Transport Research Laboratory (2001). ***Management of Rural Road Networks.*** Overseas Road Note 20. TRL, Crowthorne, UK.

World Bank (1998). ***Road Deterioration in Developing Countries: Causes and Remedies.*** World Bank, Washington, D.C., USA.

GLOSSARY OF TERMS

Abutment
A structure that provides support to a bridge deck and retains the road embankment.

Activity
Works to rectify a defect.

Adhesion
The action by means of which a fluid or plastic substance sticks to the surface of a solid body, for example, holding aggregate to the binder in chip sealing. It arises through intermolecular attraction between the contact surfaces.

Adhesion Agent (Anti-stripping Agent)
A substance used for the purpose of improving the adhesion between a bituminous binder and the aggregate in the presence of water. It may be added to the binder or coated on to the aggregate in a solvent.

Aggregate
A granular material produced from deposits of sand, gravel, rock or metallurgical slag, using one or more of the following processes: selective extraction, screening, blasting, crushing.

Apron
Floor of concrete, masonry or stone at the inlet or outlet of a culvert or water way to prevent scour.

Asphalt Concrete
A mixture to predetermined proportions of aggregate, mineral filler and bituminous binder material prepared off the road and usually placed by means of a paving machine.

Base Course
A layer of material of defined thickness and width constructed on top of the subbase or, in the absence thereof, on top of the subgrade. A base may extend to or outside the carriageway.

Benching
A stepped platform cut in an embankment to prevent earth slipping. Can also be used as stepping to provide a level base for additional fill material.

Berm
A low ridge or bund of soil to redirect surface water.

Bicycle Path
A delineated path which may be part of or separate from the main carriageway of a road which is reserved for use by bicyclist.

Binder
Bitumen or bitumen emulsion, used to bind a wearing course, usually aggregate, to the pavement surface which may or may not have been previously primed or sealed. A binder is also used to hold aggregate together in bituminous mixtures.

Bitumen
Bitumen is a black to dark brown sticky material composed principally of high-molecular-weight hydrocarbons. Most bitumen is derived from the distillation of crude oil. Bitumen is a thermoplastic material that gradually liquefies when heated.

Bleeding
The exuding of the bituminous binder of a sealed pavement to such an extent that the binder may be picked up and spread by the traffic. This occurs mainly in warm weather.

Blind
To spread a thin layer of suitable material to absorb excess binder or to assist in remedying a slippery or loose condition, or to fill excess surface voids.

Borrow Area
An area within designated boundaries, approved for the purposes of obtaining borrow material. A borrow pit is the excavated pit in the borrow area.

Borrow Material
Any gravel, sand, soil, rock or ash obtained from borrow areas, dumps or sources other than cut within the road prism and which is sued in the construction of the works. It does not include crushed stone or sand obtained from commercial sources.

Box Culvert
A culvert of rectangular cross-section constructed of reinforced concrete.

Bridge
A structure erected over a depression, river, water course, railway line, road or other obstacle for carrying motor, railway, pedestrian or other traffic, or services, and having a length measured between the abutment faces along the centre line at girder bed level, of 6 m or more, except that road-over-rail or rail-over-road structures are always classed as bridges.

Brooming
The use of a broom for distributing aggregate over the surface of a pavement or removal of loose material from a pavement prior to or after the application of a bituminous treatment.

Camber
The road cross-section in which each lane is sloping down from the crown towards shoulder breakpoint on a section of straight road alignment.

Cause
The reason that a defect has arisen.

Causeway
Low-level structure constructed across streams or rivers with openings to permit water to pass below road level.

Carriageway
The area normally travelled by vehicles and consisting of one or a number of contiguous traffic lanes but excluding shoulders.

Catchment Area
The area from which water runs off the surface by gravity to a collecting point.

Catch Drain
A surface drain constructed along the high side of a road or embankment outside the batter to intercept surface water.

Catchpit
A covered, accessible chamber with a sump for collection of silt forming part of the drainage system and permitting inspection and maintenance of underground drainage pipes.

Centre-line
The middle of the carriageway of an engineered road.

Compaction
Tamping of soil by hand rammers or mechanical rollers to increase the soil density.

Corrugation
A surface deformation into marked wave-like shapes at approximately equal distances and transverse to the line of traffic. (More common in unsealed gravel surfaces).

Crazing (Crocodiling)
The cracking of a surface seal into small irregularly shaped contiguous areas.

Cross-fall
The transverse gradient or fall across a formation or pavement or carriageway.

Cross-section
Section through the road construction at right angles to the centreline.

Crown
The highest part of a cambered surface, usually on or near road centreline.

Crushed Gravel
A gravel in which all or some of the particles have been crushed.

Crushed Rock
An aggregate made by crushing rock, as distinct from crushed gravel.

Crusher Run
An aggregate produced by crushing without subsequent screening.

Crusher Dust
The dust or fine particles produced by the crushing of gravel or rock.

Culvert
A structure, other than a bridge, which provides an opening under the carriageway or median for drainage or other purposes.

Cut (Cutting)
Excavation from the road prism, including side drains, excavations for crossroads, interchanges and, where classified as cut, excavations for open drains.

Cut-back Bitumen
Bitumen, the viscosity of which has been temporarily reduced by the addition of a suitable volatile solvent, usually power kerosene.

Cut-off Drain
A drain cut to intercept surface water flowing from adjacent land and to prevent it reaching a pavement or other prepared surface.

Cut-off Wall
An impervious wall to prevent seepage or movement of water under or past a structure.

Cut Slope
A soil/rock plane cut at an angle to the horizontal.

Cycle Path (Cycle Lane)
A track which is used mainly for bicycle traffic. The track is separated from the rest of the road by kerb stone, similar structures or road marking.

Defect
The term Defect refers to the visible evidence of an undesirable condition in a Road Feature. A Defect may affect the safety, the serviceability, structural capacity or appearance of the asset.

Ditch (Drain)
A long narrow excavation designed or intended to collect and drain off surface water.

Drainage
The interception and removal of ground and surface water by artificial or natural means.

Drainage Channel
A waterway or gutter to carry away surface water.

Drift
A stream or river crossing at bed level over which the stream or river water can flow.

Dry Grading
Removing surface unevenness or corrugations using a grader without adding moisture.

Dry Grading (Spoor)
Making furrows in the sand track to assist drivers maintain position in the track.

Edge Break
The failure of the edge of the surfacing up to a minimum width of 300 mm from the continuous edge of the surfacing.

Edge Damage
Damage to the road edge surface by potholes, erosion runnels, corrugations, loss of cross-fall, edge drops and grass growing on unpaved shoulder.

Edge Fretting
Loss of the seal and pavement material along the edge of a pavement which may vary in depth and severity.

Earthworks
General term of construction works involving excavation, loading, hauling, spreading and compaction of soil and rock.

Embankment Slope
An artificially constructed soil plane at an angle to the horizontal.

Emergency Works
Any repair needed without delay for the purpose of ensuring public safety, relieving unnecessary traffic congestion, or maintaining structural integrity of a part of the road.

Emulsified Bitumen
The suspension of bitumen, in a state of extremely fine division, in water by means of one or more suitable emulsifying or stabilising agents. There are two types of emulsified bitumen: Anionic in which the bitumen particles are negatively charged and Cationic in which the bitumen particles are positively charged.

Encroachment
Unauthorized placing and leaving wilfully on the road or road reserve of signs or other objects, materials, physical structures or interventions of any kind, fire or matters causing offensive smell or other offensive matter.

Enrichment Seal (Fogspray)
A light application of bituminous material, with or without a fine aggregate cover for the purpose of increasing the binder content of a bituminous road surface.

Fatty Surface
A sealed pavement containing an excess of bituminous binder which may be in contact with the traffic. The wearing course is either partly or completely submerged.

Fill (Embankment)
The portion of the subgrade composed of approved imported material which lies above the road bed and is bounded by the side slopes, shown on the typical cross-sections on the Drawings, running downwards and outwards from the outer shoulder breakpoints and on which the selected subgrade, subbase, base, shoulders and, in the case of dual carriageways, the median are to be constructed. Material which is imported to replace unsuitable material excavated from the roadbed is also classified as fill.

Foamed Bitumen
Hot bitumen greatly expanded in volume by the introduction of steam.

Footbridge
The overpass bridge crossing carriageway/railway to ensure the safety of pedestrian and smooth passage of vehicular traffic.

Footpath (Walkway, Sidewalk)
A track used for passage of pedestrians. The track may be separated from other parts of the road by kerb stone, similar structures or road marking.

Gabion
A steel mesh cage filled with cobble stone or crushed stone and mainly used for revetment and slope protection.

Gravel
A non-cohesive coarse granular material, resulting from natural disintegration of rock with or without fine material.

Guardrail
A safety barrier on an embankment or river crossing, footbridge, pedestrian way, etc.

Gutter
A shallow waterway provided at the edge of the road to carry surface water away from the road.

Headwalls
The walls located on the top of outlet/inlet of culvert. The walls of inlet direct the flow into the culvert while the walls of outlet provide a transition from the culvert to the outlet channel. Headwalls also protect the embankment from erosion by flood waters.

Heaving
Upward movement of material caused by expansion of displacement resulting from causes such as moisture absorption.

Hungry Surface
A surface in which the binder appears deficient, or to have hardened and become rigid and which may be cracked and crazed but is otherwise sound. The surface may be porous.

Inlet
The point at which surface water enters a culvert.

Invert
The lowest point of the internal cross section of a ditch or culvert, etc.

Key Performance Indicators (KPI)
The term Key Performance Indicators is used in the Manual to describe performance indicators that are selected to enforce an OPRC by verifying if the agreed Service Levels have been complied with by the contractor, without having to monitor the performance of all activities. KPIs have been selected for each Intervention and generally from the activity or activities that most affect the performance of the Intervention.

Labour Based
Work methods which use a combination of equipment and labour. The combination is often chosen to achieve a balance between employment generation and productivity while remaining cost effective.

Labour Intensive
Work methods which use labour wherever possible and machinery only when necessary.

Lane
The width of carriageway required to accommodate one line of traffic.

Maintenance
All works of every description which are required for the preservation and upkeep pf a road or its associated works or both, so as to prevent the deterioration of quality and efficiency to a noticeable extent below that which pertained immediately after construction.

Maintenance Standards (MS)
The term Maintenance Standards is a generic term used in the Manual to embrace all other terms that define when, why and how maintenance activities should be carried out.

Maintenance Performance Standards (MPS)
The RD's minimum maintenance operational standards for all defined maintenance Activities at three different Service Levels (SL). The MPS for each Activity includes a description of the maintenance intervention and the objective of doing it; the Defect(s) that necessitate the Activity, its Causes and Effects as well as defined Threshold Levels and Response Times. The methods to be used for each repair Activity, the materials, workmanship and miscellaneous other requirements are described in MOPRBW.

Maintenance Performance Indicators (MPI)
Describes the tool used to verify or evaluate compliance with set goals and objectives.

Manhole
Accessible chamber with a cover forming part of the drainage system and permitting inspection and maintenance of underground drainage pipes.

Measurement Contract
A contract where payment is made on the basis of the quantity of work completed to a technical specification.

Mitre Drain
Drain constructed at an angle to the centre line of the road to divert water from the side drains. Mitre drains include mitre banks placed across side drains.

Nominal Size
A designation of an aggregate, chosen to give an indication of the largest size particle present.

Open Sub-soil Drain
An open drain provided for the collection and removal of sub-soil water rather than surface water.

Original Ground Level
Line of natural ground.

Outfall
The point at which water discharges from a pipe or box culvert.

Outlet
Channel along which water is discharged from culverts, stormwater conduits and minor bridges.

Paved Road
For the purpose of this Manual a paved road is a road with a concrete surface, concrete block, bituminous surface or surface dressing.

Pavement
The upper layers of the road comprising the selected subgrade, subbase, base, shoulders and surfacing.

Pavement Distress
The deterioration of the pavement evidenced by visible surface defects.

Patching
The filling up or repair of depressions, holes, or other defective places in a carriageway with additional material to restore the surface.

Pedestrian Path
A track used for passage of pedestrians. The track may be separated from other parts of the road by road marking, kerb stone, or similar structures.

Performance Contract
A contract where payment is made when the condition of the road is at or above a defined performance standard or level of service.

Performance Specifications.
The term used for what is part of the standard bidding documents for OPRC and would typically include:

(i) A specification of the Service Levels (Maintenance Standards) required on the roads included in the contract;

(ii) the methods and procedures to be applied for measuring compliance with service quality levels;

(iii) the penalties and/or payment reductions applied in case of non-compliance,

(iv) the initial rehabilitation works and the improvement works the contractor will have to carry out in addition to the general Management and Maintenance Services and Works, and

(v) other aspects, such as the internal organization of the contractor, etc. (Items (i) and (ii) above would be included in the MSRBW).

Periodic Maintenance
Activities that are required only at intervals of several years. need to be carried out on a road after a number of years. For example regravelling of unpaved roads or resealing of paved roads.

Pedestrian Way
A walkway permitting pedestrians to go from one place to another without passing through traffic.

Pipe Culvert
A culvert of circular cross section usually constructed in precast concrete.

Polished Surface
A sealed surface where traffic has so worn the exposed aggregate that there is insufficient frictional grip between the aggregate wearing course and the traffic tyres, especially in a wet condition.

Pothole
A hole in the surface of a pavement frequently rounded in shape, resulting from loss of pavement material, which is the initial stage may be the depth of the seal only, or in the advancing stages may result in the loss of pavement material, the subgrade and the shoulder pavement edge support.

Precoating
The coating of aggregate with a liquid to improve the arte at which it is wetted by a bituminous binder.

Premix
Premix is a paving material manufactured by mixing aggregates, filler and bitumen. Most premix is mixed and placed hot. Premix is used in the construction of wearing course, binder courses and base courses.

Prime
A low viscosity binder applied to a prepared pavement prior to the initial application of a seal.

Profile
The shape of a pavement surface or layer measured as vertical distances from some datum. Profiles may be longitudinal (parallel to the traffic flow) or transverse (at right angles to the traffic flow).

Railway Crossing
Level intersection of road and railway tracks.

Ravelling
The loosening of stones or particles forming the wearing course of a sealed pavement.

Reflection Cracking
A visible crack in the wearing course resulting from the propagation of cracks in the underlying pavement layer.

Recurrent maintenance
Activities that are required at intervals throughout the year, but whose frequency varies with traffic. Examples include grading of unpaved roads or pothole repairs on a paved road.

Reseal
A sprayed seal applied to an existing sealed surface.

Regravelling
Adding a layer of gravel to a gravel surfaced road.

Reshaping
Heavy grading to restore the road formation.

Response Time (RT).
The term Response Time is used in the Manual to describe the maximum time, from the time the deficiency was detected or reported until such time when the Contractor (or RD) must complete the described Maintenance Activity by repairing the Deficiency/Defects indicated. For periodic maintenance activities, or for routine maintenance activities that require a long

time to complete, the response time is defined the maximum time from the time the deficiency/defect was detected or reported as until the Contractor or the Road agency undertakes the execution of the intervention as set out in the applicable Maintenance Standard.

Retaining Wall
A wall built to hold back earth or other solid material.

Road Feature
The term Road (Maintenance) Feature is used to identify a physical element of the road infrastructure asset which is the subject of a maintenance Intervention/Activity, e.g. Road Feature=Road Reserve - Code 8100; Road Intervention = Rest Area Maintenance-Code 8130; Road Activity = Rest Area Cleaning-Code 8131.

Road Furniture
Road or street furniture e.g. traffic sign, traffic board, traffic signal, lane marking, guardrail, street light, etc.

Road Reserve (Servitude)
The area of land reserved for the construction and maintenance of the road and for the accommodation of utility services.

Roadway
The area normally used by vehicles and consisting of one or a number of contiguous traffic lanes, including auxiliary lanes and shoulders.

Routine Maintenance
Activities that are likely to be required irrespective of the engineering characteristics of the road or the volume of traffic. Examples include grass cutting and drain cleaning.

Rutting
The vertical deformation of a pavement surface measured in a wheel path relative to a straight edge placed at right angles to the traffic flow and across the wheel path.

Sand
Natural mineral particles which will pass through a defined sieve (normally 4.75 mm or 2.36 mm sieve) and which are free of appreciable quantities of clay and silt.

Sand-aspahlt
A mixture of bitumen and sand, with or without a filler.

Sand Cushioning
Laying a thin layer of sand on a hard gravel surface.

Scour Checks
The structures to prevent scouring of drains. Simple scour checks may be constructed of wood pegs or stones. All scour checks should have an apron downstream built of stones or grass turfs pinned to the ditch invert with wooden pegs.

Segregation
Separation of the coarse aggregate from the remainder of the bituminous mix.

Service Quality Standard (SQS).
The term Service Quality Standard is used at activity level to describe the desired standard of a road (maintenance) feature. A Defect on a road feature means that the required SQS is not attained.

Shoulder
(a) When the shoulder is referred to as a surface: The area between the outside edge of the carriageway and the shoulder breakpoint. (b) When shoulder is referred to as a pavement layer: The layer on top of the subbase or, in the absence of a subbase, on top of the subgrade and lying between the outside edge of the base and the shoulder breakpoint.

Shoulder Drain
A drain through the shoulder to drain the pavement and/or the subgrade.

Shoving
Lateral displacement of a pavement structure (usually bitumen bound) by braking, accelerating or turning vehicles.

Side Drain
Open longitudinal drain situated adjacent to and at the bottom of cut or fill slopes.

Slick surface
A surface that reflects light to the extent that the motorist is aware of the condition. Droppings of oil, petrol and grease from traffic can sometimes cause these conditions.

Slope
Unless otherwise stated, slope is given in terms of the ratio of vertical difference in elevation between any two points and the horizontal distance between them.

Slurry
A road surface treatment consisting of a thin layer of a mixture of bitumen emulsion, water and fine aggregate applied to a surfacing in the form of a slurry.

Spot improvements
Maintenance or rehabilitation activities at isolated sites along a road to provide basic access. The appearance of the road will vary along its length.

Stripping
The loss under traffic of the aggregate wearing course from a bituminous sealed pavement.

Stockpile
A heap or stack of material held in stock for future use.

Straight-run Bitumen
The bitumen obtained after the final stage of distillation of a crude petroleum.

Subbase
The layer of material of specified dimensions on top of the subgrade and below the base and shoulders.

Subgrade
The earthworks constructed on then roadbed up to the floor of the subbase or, in the absence of a subbase, up to the floor of the base and shoulders.

Subway
A structure providing passage for vehicular and/or pedestrian traffic under an existing road, railway, etc.

Superelevation
The raising of the outside level of the road on curves to reduce the effect of centrifugal forces and improve road holding quantities.

Surfacing
Top layer of the pavement. Consists of wearing course, and sometimes a base course or binder course.

Surface Treatment
The sealing or resealing of the carriageway or shoulders by means of one or more successive applications of bituminous binder or tar and crushed stone aggregate, natural gravel, river sand, crusher dust or Kalahari sand.

Table Drain
A side-drain of a road adjacent to the shoulders, and part of the formation.

Threshold Level (TL)
The term Threshold Level (TL) describes the maximum tolerable deficiency, such as roughness, rutting and cracking on a paved road.

Tack Coat
Asphalt material to bond lower layer (asphalt material or cement) and upper layer (asphalt mixture). It is sprayed on surface of lower layer.

Technical Specification
Describes the detail (dimensions, materials, etc.) of a road, or the output of a maintenance or rehabilitation activity.

Traffic Lane
The portion of the carriageway defined by road marking for the movement of a single line of vehicles.

Transverse Joint
A joint at right angles to the road centreline.

Transverse Joint Taper
Slope or ramp of asphalt mix at the end of a freshly laid asphalt course.

Unpaved Road
For the purpose of this Manual an unpaved road refers to a road with a gravel or earth/sand surface.

Upgrading
Activities to increase capacity or arise a road to a higher road type, for instance providing an improved surface to a gravel road.

Veterinary Dip
A concrete structure constructed as a drift on the carriageway or off the roadway used for animal disease control purposes.

Water Table
The level at which ground water would finally stand in an unpumped hole or depression.

Wearing Course
The part of the road surface in contact with traffic wheels.

Wing-Wall
A wall at a bridge or culvert abutment to retain and protect the embankment fills behind the abutment.

Waterway
The area along a river or a stream.

Wet Grading
Removal of surface unevenness by grading a moistened surface.

LIST OF MAINTENANCE FEATURES, INTERVENTIONS AND ACTIVITIES

8100 ROAD RESERVE
8101 Scope

8110 Vegetation Control
8111 Grass Cutting
8112 Creeper Grass Removal
8113 Bush Clearing
8114 Trees Trimming
8115 Trees Removal
8116 Morama Tuber Removal
8117 De-stumping
8119 Other Vegetation Control

8120 Animals Control
8121 Fence Repair
8122 Gate Repair
8123 Cattle Grid Repair
8124 Keeping Animals off Road Reserve
8125 Moles Control
8129 Other Animals Control

8130 Rest Area Maintenance
8131 Rest Area Cleaning
8132 Rest Area Facilities Repair
8133 Rest Area Reshaping
8134 Rest Area Regravelling
8135 Rest Area Resealing
8136 Rest Area Fogspray
8137 Rest Area Bituminous Overlay
8139 Other Rest Area Maintenance

8140 Litter Control and Obstacles Removal
8141 Litter Collection and Removal
8142 Obstacles Collection and Removal
8143 Dead Animals Removal
8144 Abandoned Vehicles and Scrap Removal
8145 Anthills Removal
8146 Illegal Signs and Other Encroachments Removal
8149 Other Litter Control and Obstacles Removal

8150 Slopes Maintenance
8151 Slope Erosion Prevention
8152 Slope Erosion Repair
8159 Other Slopes Maintenance

8160 Landscaped Areas Maintenance
8161 Trees, Grass and Flowers Planting
8162 Trees, Grass and Flowers Watering
8163 Trees, Grass and Flowers Cutting and Trimming
8164 Special Features Maintenance
8165 Landscaped Areas Cleaning
8169 Other Landscaped Areas Maintenance

8200 PAVED ROADWAY
8201 Scope

8210 Bituminous Paved Roadway Routine Maintenance
8211 Paved Roadway Cleaning
8212 Rutting and Depression Repair
8213 Pothole Patching, Edge Damage and Surface Failure Repair
8214 Unpaved Shoulder Maintenance
8215 Crack Sealing
8216 Bleeding Repair
8217 Salt Blisters Repair
8219 Other Bituminous Paved Roadway Routine Maintenance

8220 Bituminous Paved Roadway Periodic Maintenance
8221 Fogspray
8222 Resealing
8223 Bituminous Overlay
8224 Unpaved Shoulder Regravelling and Edge Drop Repair
8225 Unpaved Shoulder Reshaping
8229 Other Bituminous Paved Roadway Periodic Maintenance

8230 Concrete Paved Roadway Maintenance
8231 Concrete Roadway Cleaning
8232 Concrete Roadway Crack Sealing
8233 Concrete Roadway Spalling Repair
8234 Concrete Roadway Pothole Repair
8235 Concrete Roadway Joint Stepping Repair
8236 Concrete Roadway Slab Repair
8239 Other Concrete Paved Roadway Maintenance

8240 Block Paved Roadway Maintenance
8241 Block Paved Roadway Cleaning
8242 Block Paved Roadway Deformation Repair
8243 Paving Blocks Replacement
8244 Blocked Paved Roadway Grass Removal
8249 Other Block Paved Roadway Maintenance

8250 Paved Footpath and Cycle Path Maintenance
8251 Paved Footpath and Cycle Path Cleaning
8252 Paved Footpath and Cycle Path General Surface Repair
8259 Other Paved Footpath and Cycle Path Maintenance

8300 UNPAVED ROADWAY
8301 Scope

8310 Unpaved Roadway Routine Maintenance
8311 Dragging
8312 Maintenance of Sand Cushioning Layer
8313 Dry Grading
8314 Unpaved Roadway Pothole Patching
8315 Unpaved Roadway Erosion Runnels Repair
8316 Dust Prevention
8319 Other Unpaved Roadway Routine Maintenance

8320 Unpaved Roadway Periodic Maintenance
8321 Wet Grading
8322 Reshaping
8323 Regravelling
8324 Sand Cushioning
8329 Other Unpaved Roadway Periodic Maintenance

8330 Unpaved Footpath and Cycle Path Maintenance
8331 Unpaved Footpath and Cycle Path Cleaning
8332 Unpaved Footpath and Cycle Path General Surface Repair
8339 Other Unpaved Footpath and Cycle Path Maintenance

8400 DRAINAGE FACILITIES
8401 Scope

8410 Culvert Maintenance
8411 Culvert Cleaning
8412 Culvert Headwall, Wing Wall and Marker Post Repainting
8413 Culvert Headwall, Wing Wall, Inlet and Outlet Structure Repair
8414 Culvert Repair
8415 Culvert Marker Post Reinstatement/Replacement
8416 Culvert Marker Post Reflector Replacement
8419 Other Culvert Maintenance

8420 Drain Maintenance
8421 Drain Clearing, Cleaning, and Desilting
8422 Unlined Drain Erosion Repair
8423 Unlined Drain Reshaping
8424 Drain Lining Repair
8425 Concrete Lining Joints Repair
8426 Concrete Lining Weep Holes Cleaning
8427 Drain Cover Repair/Replacement
8429 Other Drain Maintenance

8430 Catchpit, Manhole and Drainage Pipe Maintenance
8431 Catchpit, Manhole and Drainage Pipe Cleaning and Clearing
8432 Manhole/Catchpit Cover Replacement
8433 Drainage Pipe Relaying/Replacement
8434 Catchpit/Manhole Repair
8435 Drainage Pipe Repair
8439 Other Catchpit, Manhole and Drainage Pipe Maintenance

8440 Erosion Protection Works Maintenance
8441 Stone Pitching Repair
8442 Concrete Erosion Protection Works Repair
8443 Gabion Repair
8444 Scour Check and Chute Repair
8445 Berm Maintenance
8449 Other Erosion Protection Works Maintenance

8500 BRIDGES
8501 Scope

8510 Bridge Routine Maintenance
8511 Bridge Deck Cleaning
8512 Bridge Joints, Scupper Drains and Weep Holes Cleaning
8513 Bridge Bearings Cleaning
8514 Bridge Erosion Repair
8515 Bridge Concrete Repair
8516 Bridge Wearing Surface Maintenance
8517 Bridge Rail, Safety Barrier and Parapet Maintenance and Minor Repairs
8518 Bridge Steel Component Repair
8519 Other Bridge Routine Maintenance

8520 Bridge Periodic Maintenance
8521 Bridge Bearings Realignment and Replacement
8522 Bridge Rust Removal and Repainting
8523 Bridge Steel Component Replacement
8524 Bridge Inspection
8529 Other Bridge Periodic Maintenance

8530 Waterway Maintenance and Repair
8531 Waterway Debris and Obstacles Removal
8532 Waterway Erosion Repair
8533 Waterway Desilting
8539 Other Waterway Maintenance and Repair

8600 MISCELLANEOUS STRUCTURES
8601 Scope

8610 Drift, Causeway and Ferry Landing Maintenance
8611 Drift, Causeway and Ferry Landing Structure Damage Repair
8612 Waterway Cleaning and Clearing
8613 Unlined Drift Reshaping
8614 Marker/Guide Post Reinstatement/Replacement
8615 Marker/Guide Post Repainting
8616 Marker/Guide Post Reflector Replacement
8617 Grouted Stone Pitching Repair
8619 Other Drift, Causeway and Ferry Landing Maintenance

8620 Retaining Wall Maintenance
8621 Retaining Wall Minor Repairs
8622 Retaining Wall Weep Holes Cleaning
8623 Retaining Wall Vegetation Clearing
8629 Other Retaining Wall Maintenance

8630 Railway Crossing Maintenance
8631 Railway Crossing General Repair
8639 Other Railway Crossing Maintenance

8640 Veterinary Dip Maintenance
8641 Veterinary Dip General Repair
8649 Other Veterinary Dip Maintenance

8650 Subway Maintenance
8651 Subway General Repair
8659 Other Subway Maintenance

8660 Weighbridge Area Maintenance
8661 Weighbridge Area General Repair
8669 Other Weighbridge Area Mainenance

8700 ROAD FURNITURE, SIGNS AND TRAFFIC MARKINGS
8701 Scope

8710 Road Furniture Maintenance
8711 Guardrail Maintenance
8712 Kerbstone Maintenance
8713 Kerb Maintenance
8714 Distance Marker Maintenance
8715 Pedestrian Railing Maintenance
8716 Street Lighting Maintenance
8717 Traffic Signalling Devices Maintenance
8719 Other Road Furniture Maintenance

8720 Road Signs Maintenance
8721 Road Sign Cleaning
8722 Road Sign Repainting
8723 Road Sign Repairs
8724 Road Sign Replacement
8729 Other Road Signs Maintenance

8730 Road Marking Maintenance
8731 Road Marking Repainting
8732 Reflective Stud Maintenance
8739 Other Road Marking Maintenance

8740 Rumble Strips and Speed Hump Maintenance
8741 Rumble Strips Maintenance
8742 Speed Hump Maintenance
8749 Other Rumble Strips and Speed Hump Maintenance

8800 EMERGENCIES
8801 Scope

8810 Flooding and Washout Repair
8811 Traffic Control, Safety Measures and Notification
8812 Construction of Diversions
8813 Excavation and Removal of Unsuitable Material
8814 Reinstatement of Roadway Structure
8819 Other Flooding and Washout Repair

8820 Land Slide Removal
8821 Traffic Control, Safety Measures and Notification
8822 Construction of Diversions
8823 Excavation and Removal of Material from Roadway
8824 Reinstatement of Roadway Structure
8829 Other Land Slide Removal

8830 Major Obstacles Removal
8831 Traffic Control, Safety Measures and Notification
8832 Construction of Diversions
8833 Removal of Major Obstacle
8834 Repair Damage to Pavement
8839 Other Major Obstacles Removal

8840 Damaged/Washed Out Culvert Replacement
8841 Traffic Control, Safety Measures and Notification
8842 Construction of Diversions
8843 Removal of Existing Culvert
8844 Repair and Replacement of Culvert
8845 Excavation and Backfilling
8846 Reinstatement of Pavement and Embankments
8849 Other Damaged/Washed Out Culvert Replacement

8850 Damaged/Washed Out Miscellaneous Structures Replacement
8851 Traffic Control, Safety Measures and Notification
8852 Construction of Diversions
8853 Removal of Existing Structure

8854 Repair and Replacement of Structure
8855 Excavation and Backfilling
8856 Reinstatement of Pavement and Embankments
8859 Other Damaged/Washed Out Miscellaneous Structures Replacement

8860 Repair to Damaged Utilities Within the Road Reserve
8861 Traffic Control, Safety Measures and Notification
8862 Construction of Diversions
8863 Repair of Damaged Utilities Within the Road Reserve
8864 Reinstatement of Roadway Structure
8869 Other Repair to Damaged Utility Within the Road Reserve

8890 Other Emergencies

8900 MISCELLANEOUS FEATURES
8901 Scope

8910 Traffic Control and Safety Measures
8911 Placement of Warning Signs Only
8912 Lane Closure
8913 Barricading Work Area
8914 Diversions
8919 Other Traffic Control and Safety Measures

8920 Procurement of Materials for Maintenance Works
8921 Determining Materials Required
8922 Identifying Sources of Material
8923 Procurement of Materials
8924 Storage of Materials
8925 Transportation of Materials to Site
8929 Other Procurement of Materials for Maintenance Works

8930 Process and Quality Control Testing
8931 Process Control Testing
8932 Quality Control Testing
8939 Other Process and Quality Control Testing

8940 Sourcing and Extraction of Borrow Materials
8941 Investigation of Potential Borrow Area/Quarry
8942 Selection of the Most Suitable Borrow Area/Quarry
8943 Opening of Borrow Pit/Quarry and Extraction of Materials
8944 Loading and Hauling Borrow Materials
8945 Rehabilitation and Closure of Borrow Area/Quarry
8949 Other Sourcing and Extraction of Borrow Materials

8950 Tools and Equipment
8951 Safety and Health Tools
8952 Monitoring and Supervision Tools and Equipment
8953 Working Tools and Equipment
8954 Usage and Maintenance of Hand Tools
8955 Usage of Equipment and Vehicles
8956 Maintenance of Equipment and Vehicles
8959 Other Tools and Equipment

8960 Labour
8961 Recruitment of Labour
8962 Conditions of Work
8963 Safety and Health of Personnel
8964 Payment of Wages
8969 Other Labour

8970 Reporting Forms
8971 Resource Requirements and Cost Estimates for Maintenance Works
8972 Work Report and Resources Utilization
8979 Other Reporting Forms

8990 Other Miscellaneous Features

EXAMPLES OF MAINTENANCE STANDARDS

FEATURE	ROAD RESERVE	CODE:	8100
INTERVENTION	VEGETATION CONTROL	CODE:	8110
Activity	Grass Cutting	Code:	8111

Defects, Main Causes and Effects

Defects: Too high or unwanted vegetation on roadside areas and on roadway.

Main Causes: Grass, shrubs and weeds have been allowed to grow unattended.

Effects:

- Surface water can pond at the edge of the carriageway and weaken the pavement structure.
- Silt accumulates at the edge of the carriageway.
- Visibility for road users is reduced with increased risk of accidents with persons and/or animals and vehicles.
- Vegetation can block the drainage system.
- Increased fire hazard in the dry season.
- Attracts domestic animals onto the road reserve.

Purpose and Description

The purpose of this activity is to:

- Improve vision to maintain safe sight distances, visibility of signs, markers and animals within the road reserve.
- Improve the general appearance of the roadside.
- Reduce the need for weed and brush control.
- Prevent roots from penetrating the surface and pavement layer.
- Reduce the effort required to maintain roadside ditches and shoulders.
- Ensure healthy growth of landscaped areas.
- Reduce fire risk during dry season.

The activity includes, mowing of grass and vegetation by hand-mower and/or brush cutter (or other hand equipment) in medians, drains and around roadside furniture or elsewhere as required. Grass cutting shall be done within the entire road reserve or to such other width as determined by the Engineer. Grass shall be defined as any plant having a girth of not more than 60 mm measured at a height of 300 mm above ground level.

Service Quality Standard

- Caution must be taken not to remove the grass roots on areas where the grass is needed for erosion protection, i.e. on side slopes, in drains etc.
- The grass shall be cut evenly and to a maximum height of approximately 50 mm above ground level. Two types of standards apply for grass cutting:
  - i) Within the entire road reserve.
  - ii) Within width W m from the shoulder breakpoint on both sides of the road, and on danger points (inside sharp curves, junctions, bus stops, lay-byes and railway crossings), the grass must not exceed height H mm at any time throughout the year.
  - iii) Shoulders and medias not more than 150 mm.
- Vegetation shall be controlled in accordance with the threshold levels and response times given in the table below. Response time for Grass Cutting shall be until when cutting operations start.

Threshold Level - Response Time					
Service Level A		Service Level B		Service Level C	
Threshold Level	**Response Time**	**Threshold Level**	**Response Time**	**Threshold Level**	**Response Time**
Road Reserve:		Road Reserve:		Road Reserve:	
i) H = 500	2 w	i) H = 600	3 w	i) H = 700	4 w
ii) W =12; H = 300	2 w	ii) W = 6; H = 300	3 w	ii) W = 6; H = 500	4 w
Shoulders, medians:		Shoulders, medians:		Shoulders, medians:	
H = 150	2 w	H = 150	3 w	H = 250	4 w

MAINTENANCE OPERATIONAL PROCEDURES

FEATURE	ROAD RESERVE	CODE:	8100
INTERVENTION	VEGETATION CONTROL	CODE:	8110
Activity	Grass Cutting	Code:	8111

Purpose and Description

The purpose of this activity is to:

- Improve vision to maintain safe sight distances, visibility of signs, markers and animals within the road reserve.
- Improve the general appearance of the roadside.
- Reduce the need for weed and brush control.
- Prevent roots from penetrating the surface and pavement layer.
- Reduce the effort required to maintain roadside ditches and shoulders.
- Ensure healthy growth of landscaped areas.
- Reduce fire risk during dry season.

The activity shall involve cutting any form of plant growth including small shrubs in the entire road reserve including medians, drains and around road furniture or elsewhere as required. Unless specified otherwise, grass shall be defined as any plant having a girth of not more than 60 mm measured at a height of 300 mm above ground level. Grass shall be cut by labour based methods or where instructed, by mechanical mowers.

Overgrown grass encroaching onto the carriageway

LABOUR BASED METHOD

CREW

- 1 foreman
- 2 drivers
- 20 – 25 workmen

TOOLS AND EQUIPMENT

- 1 slasher per workman
- 1 bush knife per 5 workmen
- 1 rake per 5 workmen
- 1 measuring wheel or 50 m measuring tape
- 1 pick-up vehicle
- 1 tractor and trailer or one 7,0 tons flat bed truck

APPROVED MATERIALS

Not applicable

EQUIPMENT BASED METHOD

CREW

- 1 operator for tractor or hand guided sickle-bar power mower
- 5 to 10 workmen to clear obstacles ahead of mower and to clear vegetation in ditches and around fixed furniture left un-cleared by the mower.
- 1 flagman to accompany motorized mower

TOOLS AND EQUIPMENT

- A tractor with mower or rotary brush cutter attachment and fitted with high intensity amber flashing lights, or as an alternative to the tractor mower, a hand guided sickle-bar power mower.
- 1 measuring wheel or 50 m measuring tape.
- 1 tractor and trailer or 7 tons flat bed truck

APPROVED MATERIAL

Not applicable

WORK METHOD

(a) Place warning signs in accordance with the guidelines given in Feature 8900 for safety of workmen and traffic control.
(b) Assign each workman an area to work.
(c) Cut all the grass evenly using slashers or machetes to a maximum height of 50 mm above surrounding ground level. Grass shall be cut while facing the road, pedestrian walkway, cycle path or animal drawn track so that any flying objects due to slashing are not thrown onto the carriageway, pedestrian walkway, cycle path or animal drawn track. When cutting grass workmen shall ensure that no damage is caused to fixed objects such as road signs, kilometre marker posts, guardrails, etc.
(d) Uproot all shrubs to prevent re-growth.
(e) Rake all cut grass and transport to designated disposal sites. Burning of grass is not allowed.
(f) Remove cut grass from the carriageway, pedestrian walkway, cycle path or animal drawn track side drains, mitre drains and inlet and outlet structures of culverts/drainage structures and transport to designated disposal sites or as directed by the Engineer.
(g) Measure and record the total length and width of roadside cut.
(h) Remove all temporary signs and devices.

AVERAGE PRODUCTION

2,000 - 2,500 m^2 per day per workman.

WORK METHOD

(a) Place warning signs and safety devices in accordance with guidelines given in Feature 8900 for safety of workmen and traffic control.
(b) Assign workmen to various tasks to be carried out manually.
(c) Workmen to work well ahead of the mower to hand-pick and remove obstructions, debris and bush stems in the intended path of the mower.
(d) Mow grass using tractor mower or a hand guided sickle-bar power mower only on level ground free from obstructions and debris. Do not mow when grass is wet.
(e) Workmen to work behind the mower to clear ditches and areas around fixed road furniture of all unnecessary vegetation, rake, load onto trucks and transport to designated disposal sites.
(f) Workmen to remove grass cuttings left behind by machines from the carriageway, pedestrian walkway, cycle path or animal drawn track side drains, mitre drains and inlet and outlet structures of culverts/drainage structures, load onto trucks and transport to designated disposal sites. Burning of grass is prohibited.
(g) Measure and record total length and width of roadside mowed.
(h) Remove all temporary signs and devices.

AVERAGE PRODUCTION

- 500,000 - 750,000 m^2 per day for tractor with mower.
- 25,000 - 50,000 m^2 per day for hand guided sickle-bar power mower.

Mowing grass using tractor mower

Cutting grass in wrong orientation can be traffic hazardous leaving grass on the carriageway

Correct orientation of cutting grass with slashers near the carriageway

Burning of grass is not allowed

MAINTENANCE STANDARD SPECIFICATIONS

FEATURE	ROAD RESERVE	CODE:	8100
INTERVENTION	VEGETATION CONTROL	CODE:	8110
Activity	Grass Cutting	Code:	8111

8111.1 Scope

Grass Cutting includes mowing of grass and vegetation by hand-mower and /or brush cutter (or other hand equipment) in medians, drains and around roadside furniture and signs or elsewhere as required. Grass shall be cut within width W m from the shoulder breakpoint on both sides of the road and on danger points (inside sharp curves, junctions, bus stops, lay-byes and railway crossings), the grass must not exceed height H mm at any time throughout the year. (W and H are defined in the MSRBW 8111). The Activity also includes cutting of grass by tractor or other mechanical means. Grass shall be defined as any plant having a girth of not more than 60 mm measured at a height of 300 mm above ground level.

The following operations shall be included as part of this Activity:

- Traffic control.
- Supply of all materials.
- Mowing of all required areas to a height that meets the quality standards specified.
- All other operations necessary in accordance with applicable specifications.
- Clean up of site including disposal of any waste or any excavated material.

8111.2 Description and Requirements

Work method for Grass Cutting shall be in accordance with MOPRBW 8111 and will normally include but will not be limited to the following operations:

- It shall be done within the entire road reserve between the boundaries or to such other width as determined by the Engineer. Grass shall be cut within the specified area or otherwise as directed by the Engineer and in conformity with the applicable Maintenance Standards.
- Uprooting of all shrubs to prevent re-growth.
- Distribution of all cut grass evenly by raking and leaving to rot. Burning of grass is prohibited unless approved by relevant authority.
- Removing cut grass from the carriageway, side drains, mitre drains and inlet and outlet structures of culverts/drainage structures to be disposed of at designated spoil areas or as directed by the Engineer.

Operational Requirements:

- Place warning signs in accordance with the guidelines given in MOPRBW 8900 for safety of workmen and traffic control.
- The mower shall travel in the direction of traffic when any part of the equipment is on the roadway surface.
- When cutting by labour, the gang should be distributed across the width to be cut and move forward at an even pace to ensure that all the grass is cut evenly and around all fixed objects. Obstructions must be removed as they are encountered.
- Grass shall be cut while facing the road so that any flying objects due to slashing are not thrown onto the carriageway. When cutting grass workmen shall ensure that no damage is caused to fixed objects such as road signs, kilometre marker posts, guardrails, etc.
- Burning of grass is prohibited.
- Tidy up the site.
- Remove all temporary signs and devices.

8111.3 Standards, Materials and Tolerances

- The grass shall be cut evenly and to a maximum height of approximately 50 mm above ground level.
- Cut grass and vegetation shall be removed from side drains and placed away from the road. It shall not be allowed to block any drains or drainage structures. Caution must be taken not to remove the grass roots on areas where the grass is needed for erosion protection, i.e. on side slopes, in drains etc.
- Care shall be taken not to damage roadside fixtures, such as signs and posts. Cutting of grass around such fixtures is included in the Activity.
- All road reserve areas, medians and raised islands and drains shall be mowed to meet the described maintenance performance standards at the intended Service Levels.
- Salvaged material shall be placed in a manner which will not create a hazard to traffic and shall be removed within two weeks of being produced.

Grass Cutting in designated areas shall be performed to meet the Maintenance Performance Standard for the intended Service Level as described in MSRBW 8111.

8111.4 Measurement and Payment

The unit rate for Grass Cutting shall be full compensation for labour, equipment, tools and transport required to carry out the prescribed works.
Measurement and payment for Grass Cutting shall be per square metre of area cut.

Pay Item No	Pay Item	Pay Unit
8111.41	Grass Cutting when left to rot	m^2
8111.42	Grass Cutting to be transported away	m^2