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**UNIVERSITY OF SOUTHERN QUEENSLAND**  
**FACULTY OF ENGINEERING AND SURVEYING**

**USE OF ROAD ASSET MAINTENANCE PLANNING  
SOFTWARE IN QDMR**

**A dissertation submitted by**

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**In fulfilment of the requirements of**

**Courses: ENG 4111/4112 – RESEARCH PROJECT**

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## **Abstract**

Asset Management has over the last decade become the primary focus and objective of any worthwhile road authority. The focus of Road Asset Management is not merely of asset preservation but seeks to maintain the asset at a level, which optimises the returns to the community at large. These aims are achieved by continuously assessing the condition of the road network storing and synthesising the data and subsequently prioritising on the requirement hence providing the optimum treatment at the opportune time.

In this background, Main Roads have progressively developed planning software - SCENARIO Millennium to assist their managers in developing maintenance strategies for their road networks. Considerable savings can be generated through timely maintenance and rehabilitation interventions and Main Roads envisage that their newly introduced SCENARIO software will be used as part of the program development process by their regions and districts.

This dissertation explores the use of SCENARIO in the Southern District and process of identifying a program for rehabilitation works. This investigation of Scenario application follows a thorough review of the road asset management and the particular aspects of life cycle analysis.

The report generally found that emphasis of asset management has in the last decade been fully recognised and embraced in the whole life management of assets. The use of SCENARIO software in the Southern District is yet to be implemented due to several reasons, such as the success in the current practices, staff shortfall and the fact that the software still requires a lot of local development to succeed etc.

The report has found that Scenario could in addition to the identification of programmed maintenance requirements be tailored as an effective tool to timely predict the rehabilitation requirements. This involves further engineering analysis of the development of pavement weaknesses. Development of rules and different rehabilitation treatments would be an interesting regime that deserves further attention.

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I further certify that the work is original and has not been previously submitted for assessment in any other course or institution, except where specifically stated.

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Date

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**Appendix A – Project Specification**

**Appendix B – Map of Southern District**

**Appendix C – Scenario Elements**

**Appendix D - 18B: Warrego Highway attributes**

**Appendix E - 28B: Gore Highway attributes**

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## **Glossary of Terms**

AAADT - Average Annual Daily Traffic

AMG - Asset Maintenance Guidelines

AMP - Asset Management Planning

APWA - America Public Works Association

ARMIS – Asset Road Management Information System - for the Department of main roads/ Queensland Transport

Benkelman Beam - An instrument for measuring pavement degradation caused by a standard axle.

Benchmarking - is a structured process for identifying best practice and using that information to improve productivity and performance.

CONDAS - Condition Data Acquisition System

CORS - Condition Reporting System

DVR - Digital Video Road

EVA - Ethylene Vinyl Acetate - is the addition of Polymer to hot bitumen used to modify seal coat

FHWA - Federal Highway Administration

GSK Study - Refers to the author's SCENARIO software study folder

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HV - Heavy Vehicles

IBCR - Incremental benefit cost ratio

IMS - Infrastructure management system

LV - Light Vehicles

M, R & R - Maintenance, rehabilitation and renovation, replacement, and reconstruction

NAASRA – National Association of Australian State Road Authorities

NH - National Highways

NPV - Net Present Value

NRC - NAASRA Roughness Counts

NSV - Network service vehicle

PM - Programmed maintenance

PMS - Pavement Management system

QDMR - Queensland Department of Main Roads

RAMPS – Road Asset Management Planning System

RIP - Road Implementation Program

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Road Asset – This term is considered to include pavements, bridges, surfaces, formation & drainage structures, traffic control systems, signage and other associated infrastructure.

RUC - Road User Costs

SCENARIO (Also referred simply as ‘Scenario’ in the dissertation) - This is a decision support tool designed to assist asset managers in developing maintenance strategies for road networks

SCR - State Controlled Road

SBS - Styrene Butadine Styrene - is the blending of 4 – 5 % or more polymers prior to supply for modifying seal coat.

Treatments – These are the pavement intervention methods meant to improve the condition and other road attributes (eg. pavement width, seal age, etc.) change

VOC - Vehicle Operator Costs

18B – QDMR code for Warrego Highway

28B – QDMR code for Gore Highway

421 – QDMR code for Dalby to Jandowae Road

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# Chapter 1 Introduction

Before the 1990s, Australia and other parts of the world had a great focus on the construction of new assets. Management of existing assets was a low priority until recently and much development did not consider maintenance, future rehabilitation / renovation and or replacement activities in the overall planning and costing. Scheduled maintenance has been generally based on experience or on “crisis” urgency. The quality of the service falls with age and as capital ceased to be readily available, the focus changed to maintenance and life extension. This brought the concept of life cycle analysis and ongoing planned monitoring.

Road pavements (infrastructures) are valuable economic and social asset. The way in which they are maintained should depend on their strategic importance within an overall transport plan that takes into account the needs of various users, value for money and environmental needs. This concept of asset management provides a business framework for infrastructure managers to effectively manage their road system. The emphasis has thus shifted to information asset registers, valuation, and information collection data systems and recognition of the need to have systematic processes and procedures in place, which would enable business decisions based on the information available.

Queensland Department of Main Roads (QDMR), in this proactive management concept has progressively developed a Software package called SCENARIO Millennium (also referred as Scenario in this dissertation). This is a decision support tool to assist managers in developing maintenance/rehabilitation strategies for road networks.

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This dissertation sets out to establish the use and application of QDMR SCENARIO Software in the Southern District of QDMR with particular reference to identifying sections for rehabilitation.



**Figure 1.1 - Map of Southern District of QDMR**

The dissertation had an overall scope as follows;

- Review Literature with particular reference to road asset management
- Review and define road programmed maintenance & road rehabilitation works.
- Gather data on the existing factors that influence the road rehabilitation planning works/process.
- Investigate the application of Scenario Software in the Southern District.
- Examine procedures for use of Scenario Software for sample road section and assess the results with reference to identifying sections for rehabilitation.
- Preview development of trial new rule sets and output assessment including any relevant suggestions if necessary.



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## Methodology

The first section of the dissertation reviews the available literature on asset management, maintenance and rehabilitation, pavement management and evaluation procedures.

The second section describes the SCENARIO software, provides a detailed analysis of same sample roads, modifications necessary and gives a thorough evaluation of the results.

In the last section, conclusions have been drawn, and recommendations cited in the development for the use of this software in the Southern District.

This study has found that currently maintenance/rehabilitation of the road network in the Southern District is wholly based on subjective procedures, which have been very efficient and effective in this district. SCENARIO software has essentially not been embraced fully in this district and its only relative use is in assisting to set their budgets.

This dissertation has found that Scenario millennium could be used successfully in establishing basis for rehabilitation identification techniques. This would require some further works aimed at making these particular rules. It further established that the use of Scenario in the Southern District has yet to be appreciated and implanted as a tool for developing maintenance strategies.

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## **Chapter 2 Road Asset Management**

### **2.1 Introduction**

The understanding of the term 'Road Asset' is considered to include pavements, bridges, surfaces, formation & drainage structures, traffic control systems, signage and other associated infrastructure.

For the purpose of this project, road asset has basically been interpreted in the context of Pavement and Pavement Management system. In this chapter the endeavour is to lay a background foundation on the development of road assets, review the concept of asset management and the life cycle analysis of issues involved.

### **2.2 Worldwide Development of Road Asset**

In general, like the basic needs of food, water, shelter and clothing, transportation is an integral part of human culture and indeed movement of people and goods is as old as humanity itself. For a great variety of ways all the populations are reliant on transportation individually or by others to provide goods and services we need in every day life (Ayers 2003, pg. 1.1).

This goes back from the early prehistoric days to the present, with the improvement in the means of transport marked in three stages of sophistication - primitive, transitional and advanced. In the primitive stage use is made of a vehicle in the form of humans themselves or by the use of domesticated animals which became the beast of burdens eg horses, donkeys' etc and no much effort was made to improve it. In the transitional stage the vehicle is improved - perhaps to a great extent as with a clipper ship - but still no improvement is made to the 'way' (the path of travel). In the advanced stage, improvement is made to both the vehicle and the way (Ayers 2003, pg. 1.1).

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The success and progress of human society depends on the physical infrastructure required for distributing resources and essential services. The quality and efficiency of this infrastructure affects the quality of life, the health of the social system, and the continuity of economic and business activity. A nation's economical wealth is reflected in its physical infrastructure assets and many historical examples can be cited (Hudson et al 1997, pg. 3).

In about 30 BC to around 400 AD, the Romans built a strong empire by constructing all-weather roads and viaducts totalling about 80,000 km of hard surfaced highways around the Mediterranean, North Africa and across Europe to move people, goods and water. They believed that a road needed good foundations so they started with a trench about a metre deep, which they filled with layers of masonry and topped it with cobblestones. Such a road is reasonably durable and in fact some of the Roman roads are still there and in use to date. However, during the Dark Ages many fell into disrepair or were torn apart and unfortunately by the time this era ended the technology for good road building was forgotten until after transport became mechanised (Hudson et al 1997 pg. 3; Ayers 2003, pg. 1.2).

In the colonial era of the 16<sup>th</sup> to 19<sup>th</sup> centuries, European nations emerged as strong shipbuilders and explorers. This was followed by the products of the industrial revolution, particularly the use of steam engines for ships and rail transport. In the United States and other regions of the world, historical development of the economic and social systems closely parallels phases of infrastructure development. Demands on infrastructure and related services increases as people expect a higher standard of life and public services. Importantly infrastructure facilitates a higher quality of life (Hudson et al 1997, pg. 3).

'A World Bank study by Queiroz (1992) provided by on Road infrastructure and economical development showed a very strong relationship between these aspects' (Hudson et al 1997, pg. 3). As such, in all of the transport modes, road transportation system is recognised worldwide to have the greatest of influence in a country. This is

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fundamentally as a facilitator of rapid economic growth and construction, poverty eradication and wealth creation for the country. This is perhaps because it is the basic transport mode, which is cost effective, and logically flexible for highly extensive use of the day-to-day mobility.

In the last millennium there was great developments to the road infrastructure, which includes the superb road networks in the cities/towns regulated with adopted traffic codes and rules to streamline the traffic flow and also the national rural region roads whose contribution is usually underestimated (Ayers 2003, pg. 1.5).

### **2.3 Perspective of Road Asset in Australia**

A good road network provides a great base for economic development and indeed it has a competitive edge in moving goods efficiently and economically. The importance of this is very apparent in developing countries as it plays an essential role in marketing of agricultural products and providing access to health, education and other services.

Any nation's infrastructure represents a sizeable asset, and in Australia the infrastructure boom of the past few decades (30 – 50) years has realised a total road length of 800,000km. Annual spending on operation, maintenance and additions to the road network is about Aus. \$4 billion. Arterial roads comprise 16% of the total length, carry 75% of total travel, and attract 60% of total spending. Per capita, Australia is the world's most intensive user of road freight, with 6,000 tonne km per capita per annum. Freight travel in Australia is predicted to double in the next 15 years. The estimated written down value of the Australian road system is about Aus. \$80 billion (excluding land under roads), or approximately Aus. \$4,000 per capita. There are about 750 road controlling agencies (QDMR Asset Maintenance Guidelines 2002, part 1, pg 18-28).

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Basically, the roads in Australia are classified as follows;

- ◆ The state controlled road network (SCR network)
- ◆ Local roads
- ◆ National Highways (NH)

⇒ **The State Controlled Road Network (SCR network)**

The various states' main roads departments or agencies are responsible for roads designated as part of State Controlled Road (SCR) network. These basically include state highways and major connecting roads between towns.

⇒ **Local Roads**

The local government is responsible for all other local roads that are within their jurisdiction.

⇒ **National Highways (NH)**

The National Highways (NH) network around Australia is made up of the highways that are considered to be the most crucial to transport on a national basis. The federal government is responsible for funding works on these roads however Main Roads manage the NH in Queensland on the behalf of the Federal government.

(Asset Maintenance Guidelines (AMG) 2002, part 1 pg 18)

## **2.4 Queensland Road Asset**

The Queensland Department of Main Roads (QDMR) is responsible for approximately 34,000 km of State Controlled Road (SCR) network, which includes 7,200 km of unsealed roads. In June 2001 this asset stood as Queensland's (QLD) most valuable physical asset with a replacement value of over Aus \$26 billion. (Asset Maintenance Guidelines (AMG) 2002, pg 18)

However, this asset is ageing steadily and much of the network is considered fragile in regard to its ability to withstand environmental effects and traffic loadings. With a depreciation value of approximately Aus \$530 million per annum the importance of

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effective management is thus paramount. After accumulated depreciation, the SCR network has a net book value of \$ 13.8 billion.

At the same time, the traffic operating on these roads involve road user costs of approximately \$ 11 billion per annum.

Maximising the performance of this asset, therefore, delivers benefits to road users and the community far in excess of the cost of upkeep of the infrastructure itself (Asset Maintenance Guidelines (AMG) 2002, part 1, pg 18).

## **2.5 Southern District Road Asset**

The Southern District of QDMR (refer appendix B.2.1), with the head office in Toowoomba is one of the four districts that comprise the Southern region of QDMR. The Southern district is responsible for approximately 3005 km of the 12,000km of the State Controlled Road network under the jurisdiction of Southern region.

(P Tweddell 2004, pers. Comm. on 7 October)

## **2.6 What is Asset Management?**

There has been much efforts and recognition for Asset Management especially in the last decade by various people and organizations. From the research carried out many large organisations defines asset management as the process whereby they collect and maintain a comprehensive list of the items they own such as hardware and software. This data is used in connection with the financial aspects of ownership such as calculating the total ownership, depreciation, licensing, maintenance and insurance etc.

Below are some of the different definitions' offered by various organisations based upon their entities perspectives and or principal drivers.

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In accordance with Austroads which is the leading roads governing body in Australia and New Zealand, Asset management may be defined as a comprehensive and structured approach to the long-term management of assets as tools for the efficient and effective delivery of community benefits, (Asset Maintenance Guidelines, 2002).

(Hudson et al 1997, pg 30) states that *Infrastructure (physical asset) Management* includes the systematic, coordinated planning and programming of investments or expenditures, design, construction, maintenance, operation and in-service evaluation of physical facilities. It is a broad process covering those activities involved in providing and maintaining infrastructure at a level of service acceptable to the public or owners. These activities range from initial information acquisition to the planning, programming, and execution of new construction, maintenance, rehabilitation and renovation.

Other international definitions (Source: Midwest University Regional Transportation Centre, 2002) offered are as follows;

- ◆ ‘Asset management is a systematic process of maintaining, upgrading, and operating physical assets cost-effectively. It combines Engineering principles with sound business practices and economic theory, and provides tools to facilitate a more organized, logical approach to decision making. Thus, asset management provides a framework for handling both short and long range planning. *(AASHTO and FHWA)*’
- ◆ ‘Asset management is a systematic process for maintaining, upgrading and operating the physical assets of a transportation system. Asset management employs engineering principles, economic theory, sound business practices, and information systems to determine short and long term resource allocations. *(Transportation Research Board)*’
- ◆ ‘An asset is a physical component of a facility which has value, enables services to be provided, and has an economic life greater than twelve months. Assets management is a methodology to efficiently and equitably allocate resources

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amongst valid and competing goals and objectives. (*American Public Works Association (APWA)*)’.

- ◆ ‘Asset management is the programmed approach to operating, preserving, and restoring physical assets to meet predetermined standards. (*VMS, Inc*)’
- ◆ ‘Asset management is the systematic process of maintaining, upgrading, and operating assets, combining engineering principles with sound business practices and economic rationale. (*UK Highways Ministry*)’
- ◆ ‘The sum of all those activities related to an asset's life that result in a safe and efficient inter-modal transportation system that contributes to the social and economic well being of its benefactors. (*Darrel Rensink, Iowa DOT*)’
- ◆ ‘An integrated set of processes and systems to achieve optimal and cost-effective use of assets throughout their service life, including identification of the need for an asset, acquisition enhancement of assets, utilization-operation, maintenance, and improvement, and disposal of assets. (*David Ekern, Minnesota DOT,*)’
- ◆ ‘Assets Management is a methodology to efficiently and equitably allocate resources amongst valid and competing goals and objectives. (*American Public Works Association*)’
- ◆ ‘The core components of asset management are data collection, preservation, economic analysis, management orientation, and integration. (*FHWA*)’



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## 2.7 Road Asset Management focus

Asset management has come of age because of:

- ◆ changes in the transportation environment,
- ◆ changes in public expectations, and
- ◆ advances in technology

(Midwest University Regional Transportation, 2002)

Asset management looks at all of the assets, not solely from an engineering perspective, but from the user perspective as well. For the developed world, the construction of their Interstate highways and road network system are virtually complete. The state and federal highway/road agencies are therefore shifting their attention to preserving and operating this multi-million dollars investment in highways, roads and bridges. This change in focus reflects a new concept that's referred to as asset management.

That is, the asset management approach is not just concerned with constructing new road network but as well emphasizes the preservation, rehabilitation, upgrading, and timely replacement of highway/road assets through cost-effective planning and resource allocation decisions.

At the same time this new concept of asset management approach incorporates the economic assessment of trade-offs among alternative investment options and uses this information to help make cost-effective investment decisions.

A typical state/road agency's assets include infrastructure items such as pavements, bridges, and tunnels, as well as construction and maintenance of equipment, vehicles, and the human resources of its staff. As an agency evaluates its assets, key questions to consider would include:

- ◆ What was the past condition and performance of our assets?
- ◆ What is the current and predicted future condition and performance of our assets?
- ◆ How can we best manage our assets in order to least inconvenience the motoring public when we repair or replace these facilities?

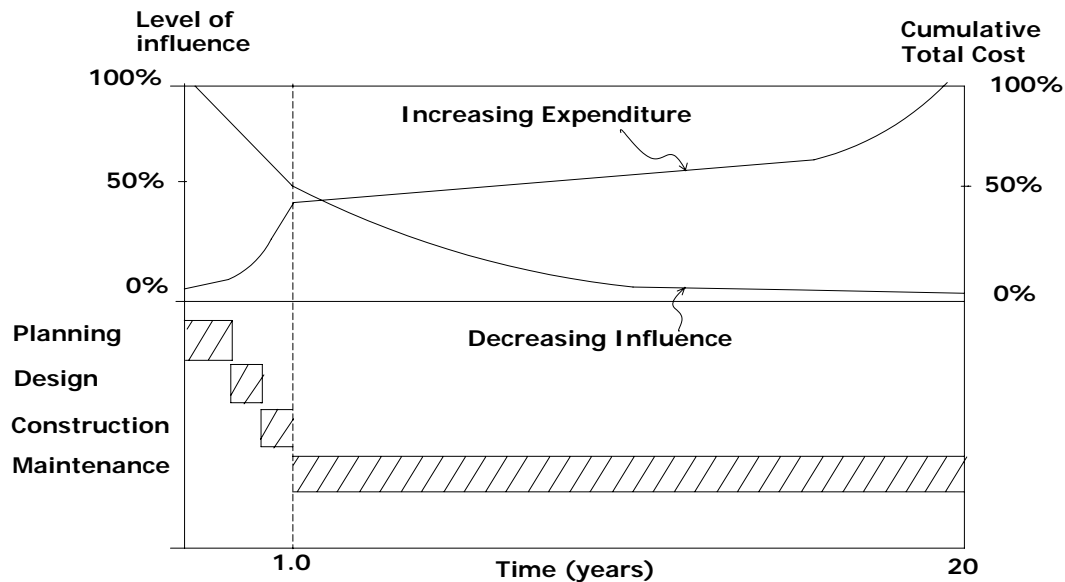
- 
- ◆ What are the consequences of not maintaining our assets?

(Federal Highway Administration (FHWA) 2000 pg. 43-67)

## 2.8 Asset Management Planning (AMP)

### 2.8.1 Assets level of influence

Four of the major components or sub systems (planning, design, construction and maintenance) have important but changing impacts in terms of ‘levels of influence’ concept. The bar-chart figure below presents a simplified form of the length of time each major component acts over the life of the infrastructure facility.



**Figure 2.1 - Influence levels of sub systems on the total costs. (Haas 1994, pg 17)**

The initial phase of the essence of an asset primarily involves making a decision and commitment on whether to build / acquire an asset or not? The agency at this stage controls all (100 percent influence) factors for determining future expenditures.

Once the decisions are firm and commitments are made on the scope of works, the investment quality has a certain influence on future project costs.

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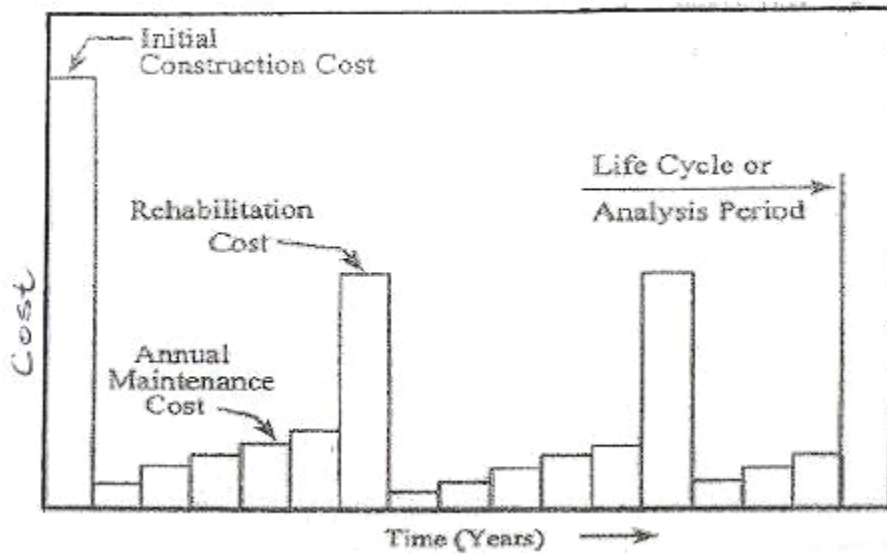
In the same manner quality control decisions made during construction even with the remaining level of influence can greatly impact on the costs of maintenance or rehabilitating the infrastructure. Both of these stages while they have far greater relative influence on the costs of maintenance and rehabilitation they cannot entirely eliminate their importance. (Hudson et al 1997, pg 39 & 40)

### **2.8.2 Life cycle analysis concepts**

Physical infrastructure assets are generally fixed assets and from a design and analysis point of view, some finite number of years of the design life/analysis period is associated with each component of infrastructure. In reality the public and users expect the infrastructure to provide a particular service forever, unless a catastrophic failure occurs or the area is uninhabited. However, the responsible agency managers and decision makers know that there comes a time when the infrastructure can not provide adequate service because of one or more reasons;

- ◆ Structurally unsafe
- ◆ Functionally obsolete
- ◆ Causes delays and inconvenience to the users due to overuse and demand
- ◆ Costly to maintain and preserve

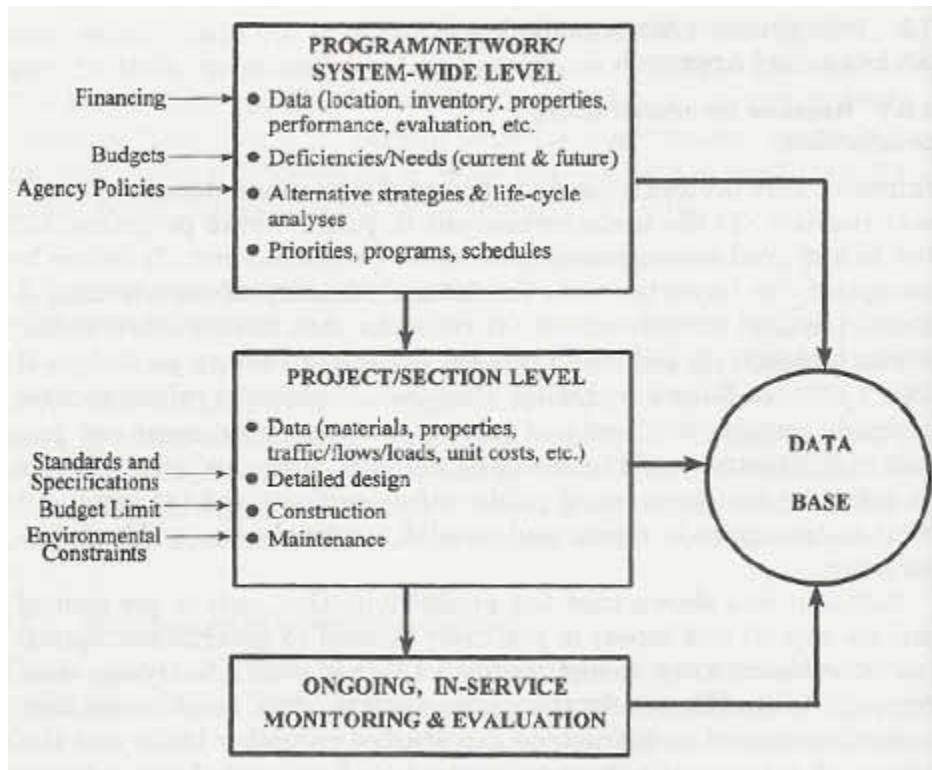
This leads to the concept of the ‘service life’ of an infrastructure within a life cycle. Unlike the design/analysis period, service life is typically not a single number. The same type of an asset may have a wide variation in its initial and total service life because of traffic history, environmental inputs, and maintenance practices. Maintenance history has a significant influence on total service life. An adequately maintained facility will have a better probability of extended service life as compared to a poorly maintained facility. A good infrastructure management system recognises the importance of service life analysis including agency costs (for construction, maintenance, rehabilitation and renovation/replacement) as well as user costs and benefits. The figure below illustrates cost streams for infrastructure analysis (Hudson et al 1997, pg. 19, 41 & 42).



**Figure 2.2 - Life cycle cost analysis** (Source: Hudson et al 1997, pg. 19)

### **2.8.3 Infrastructure/Asset planning**

Planning is a focus word for dealing with future related activities that are concerned with achieving desired goals. An overall framework for any infrastructure management system can be divided into two distinct but closely integrated levels: program/network/system-wide and project/section as illustrated by the figure below.



**Figure 2.3: Overall framework for infrastructure management**

(Source: Hudson et al 1997, pg. 26)

Key elements of the overall framework for infrastructure management are ongoing, in-service monitoring and evaluation, and a database. Each of the two levels must consider exogenous elements over which little or no control may exist such as financing, budgets and agency policies for the network level, standards and specifications, budget limits and environmental constraints for the project level.

Modern concepts of planning recognise two distinct approaches as follows;

- ◆ Strategic planning – is generally long-range and reflects financial and business aspects of planning, involving senior administration and/or corporate managers.
- ◆ Tactical planning - usually reflects technical aspects of facilities and involves technical managers who are responsible for facility management and future expansion within the bounds of the strategic plans in consultation with senior administration and/or corporate managers.

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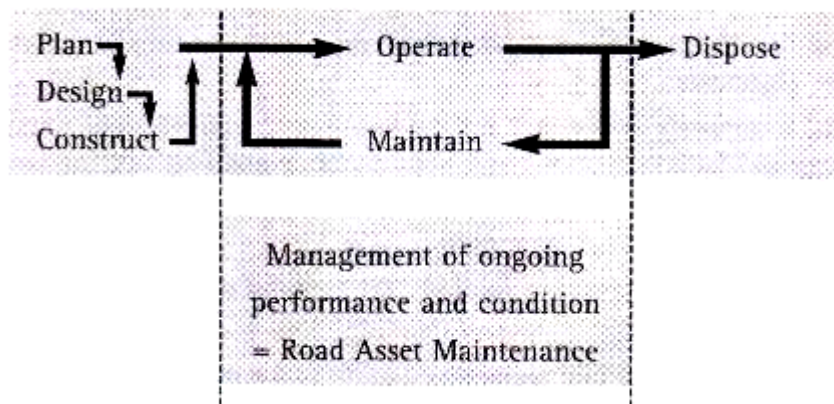
The major emphasis of tactical planning is on network-level needs, including such activities as preparing and updating master plans, assessing needs and budgets, predicting future demands and developing strategies to preserve and upgrade facilities and annual and multi year programming. A practical and effective infrastructure management system (IMS) integrates planning, design and construction with the service-life activities of maintenance, rehabilitation and renovation, replacement, and reconstruction (M, R & R) (Hudson et al 1997 pg 25, 26 & 45).

To assist in this process, government through the road agencies have developed guides that offer advice on applying asset management principles and provide examples of best practices already underway in most of the states.

## **2.9 Asset management approach by ‘AustRoads’**

The emphasis is on the assets as being a means to an end and not an end in them. For the purposes of this strategy, asset management comprises the elements shown in figure 2.3 below, all focused on facilitating the delivery of community benefits. The main streams of the asset management are:

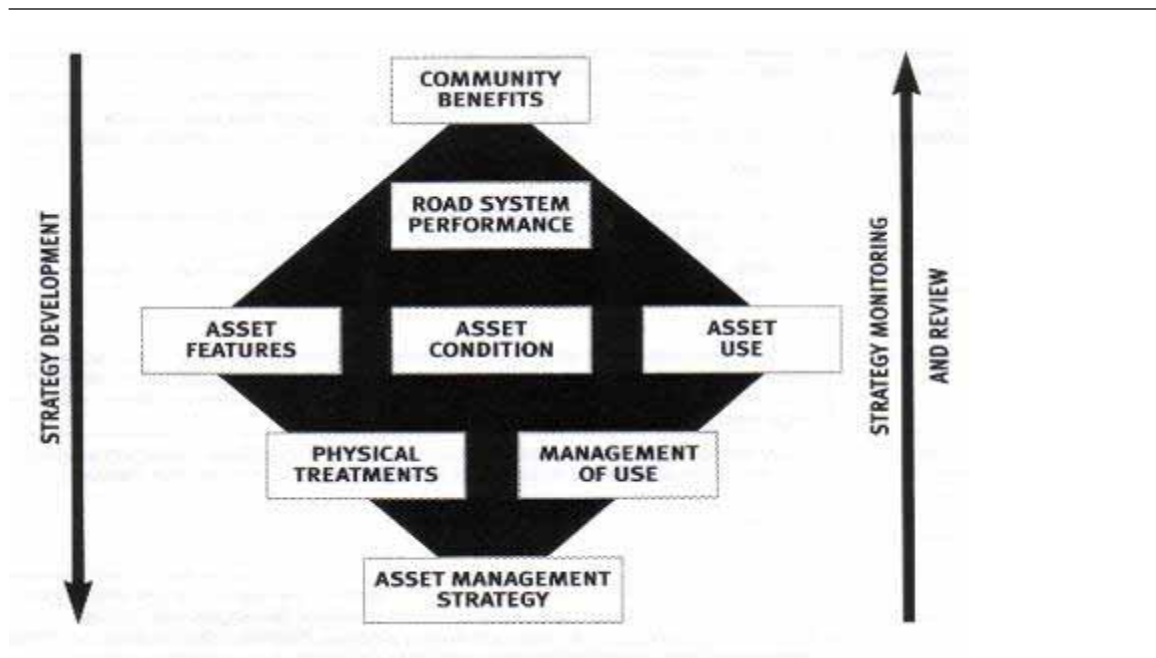
- ◆ identification of the need for an asset;
- ◆ provision of an asset including its ongoing maintenance and rehabilitation to suit continuing needs;
- ◆ operation of the asset; and
- ◆ disposal of the asset when it is no longer needed or no longer appropriate to be retained;



**Figure 2.4 - Asset life cycle** (Source: Asset Maintenance Guidelines, 2002 part 1 pg. 20-28)

Austrroads, in its capacity of providing strategic direction for the development, management and use of the Australian and New Zealand road systems, has identified asset management as a major issue in its strategic planning, and has produced comprehensive guidelines on road asset management.

The Austrroads, Road Asset Management Guidelines produced in 1994 were fundamental in the development of road asset management in Australia. They introduced the concept of Total Asset Management to the management of road networks. The 1994 Austrroads Guidelines also identified the main elements of road network asset management as: community benefits, road system performance, asset features, asset use, physical treatments, and management of use and asset management strategy (See figure 2.5 below).



**Figure 2.5 - Framework for Road Asset Maintenance** (Source: Asset Maintenance Guidelines, 2002, part 1 pg. 22-28).

Asset management comprises the elements shown in this figure 2.5, the Austroads diamond which is focused on facilitating the delivery of community benefits such as accessibility, mobility, economic development and social justice.

Austroads recognises that there are opportunities to improve the practice of asset management. Some of the main steps towards best practice are:

- A more detailed understanding of the needs and expectations of road users, and the ability to correlate user aspirations with road and bridge construction and maintenance standards;
- The study of road user costs, and the development of tools to develop cost effective construction and maintenance standards that take road user costs into account;
- Developing deterioration models for a range of pavement types for different scenarios such as changes in traffic volumes, increases in axle limits, a range of climatic conditions, etc;



- 
- Collecting and recording quality affordable road and bridge inventory and condition data;
  - The development and use of tools to confidently predict the remaining service life of the major components of a road asset, particularly road pavements and bridges;
  - The ability to demonstrate future actions and budgets required to maintain the road network to a standard that will provide a satisfactory level of service to road users; and
  - Conducting internal and external performance measurement and benchmarking.

(Asset Maintenance Guidelines 2002, part 1 pg. 22-28)

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## **Chapter 3 Maintenance and Rehabilitation**

### **3.1 Introduction**

In practice there is a wide divergence in the definition and understanding of maintenance, particularly in the dividing line between maintenance and rehabilitation. The condition of the assets can be preserved over their service life if proper understanding and the condition-responsive maintenance and rehabilitation actions are properly timed.

The aims of this chapter are to clearly describe and differentiate the road programmed maintenance and road rehabilitation works. Also to discuss in details the road rehabilitation works in QDMR and finally to describe the role of data in asset management with a perspective of programming for Maintenance & Rehabilitation.

### **3.2 What is Construction, Maintenance & Rehabilitation?**

Legally the word 'road' refers to the road reservation between property boundaries, however this project generally uses the word 'road' to refer to the portion of the reservation formed to carry traffic.

Roads, and to a lesser extent, bridges, deteriorate over time due to traffic loading and climatic influences. They often become technically deficient or obsolete because of changing user requirements and vehicle characteristics, such as larger, faster and heavier vehicles. Additionally they are subject to changes as a result of different uses of land and economic activity. Hence, the need for a road, bridge or pedestrian overpass may expire well before it is physically unfit for use.

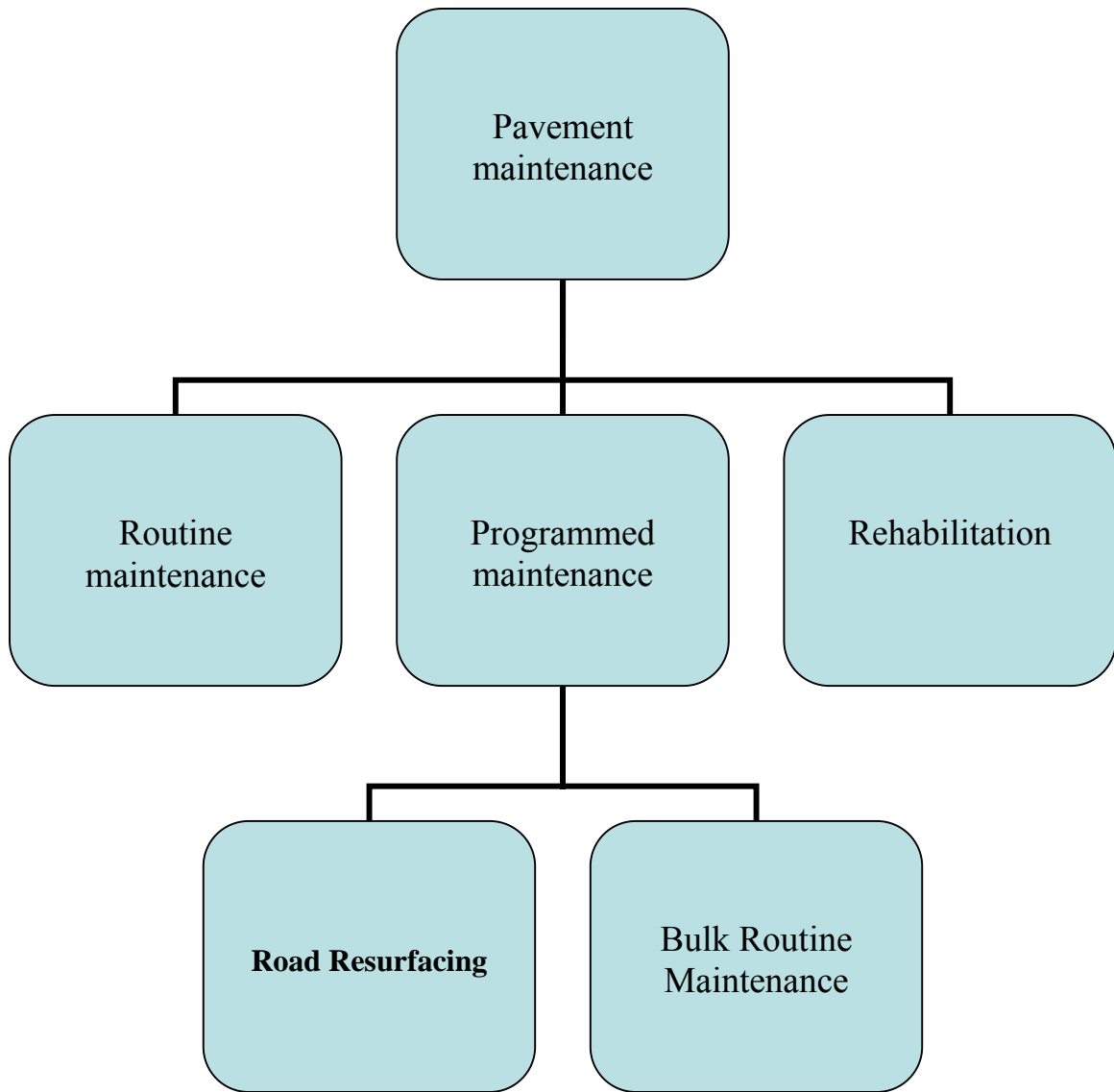
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The term Construction refers to the initial formation of a road across vacant land while maintenance is considered as all the other activities of the day-to-day or long-term care of a road and its operation in optimum condition.

(Asset Maintenance Guidelines 2002)

### **3.2.1 what is Maintenance?**

- ◆ The Oxford English dictionary definition of maintenance is ‘the action of keeping in effective condition, in working condition, in repair.
  
- ◆ (Hudson et al 1997, pg. 231) defines maintenance, ‘as that set of activities required to keep, a component, system, infrastructure asset or facility functioning as it was originally designed and constructed to function’.
  
- ◆ QDMR *in the Asset Maintenance Guidance (2002)* defines ‘Road asset maintenance as management of ongoing performance and condition of the road asset’. Further this is broken down to the three principal components of management that is:
  - Routine maintenance,
  - Programmed maintenance, and
  - Rehabilitation as indicated in figure 3.1



**Figure 3.1 - Pavement Maintenance Categories** (Source: Asset Maintenance Guidance 2002, part 4 pg 3-54)

### **3.2.2 Routine Maintenance**

Comprise of those activities, which maintains the shape or profile of pavement, and amenities of the road corridor. These are generally reactive in nature such as pavement/pothole repairs, road furniture and verges maintenance, but should also include preventive works such as cleaning drains and culverts, vegetation control, grading of unsealed roads etc.

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Routine maintenance is, in effect a defined set of prioritised activities, which are triggered, by a set of intervention standards, up to the current budget. The purpose of routine maintenance is to control the rate of deterioration of pavement and other road infrastructure assets and to react to safety and usability needs.

### **3.2.3 Programmed Maintenance**

Also referred to as proactive maintenance and focus mainly on the surfacing, and aims to preserve the investment in the road system, thus extending the pavement life. It is the timely application of carefully selected surfacing and other treatments to maintain a pavement's effective service life and is further separated into two categories of road resurfacing and bulk routine surfacing.

Road resurfacing are those activities, which restore the road surface integrity, and can be predicted and planned by engineering and pavement techniques. Note this programmed maintenance road resurfacing does not include the restoration of pavement shape prior to resurfacing and also does not constitute new or reconstructed pavements or any activity that significantly increases the structural capacity of the existing pavement.

Bulk routine maintenance – these are activities that can be described in terms of maintenance features but are scheduled as projects for delivery process. Examples are a program of pavement recycling in preparation of reseals where it is not full width or does not exceed 150mm depth for granular or 75mm for asphalt; A program of sign refurbishment; A program to repair significantly long lengths of deteriorating seal edge and/or shoulders, etc.

(Asset Maintenance Guidelines 2002, part 4 pg. 4-54)

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### 3.3 Rehabilitation

(Hudson et al 1997, pg 231) defines ‘Rehabilitation as the act or process of making possible compatible use for a property through repair, alterations and additions while preserving those portions that convey its historical, cultural or architectural values’ A key idea would be to repair deteriorated features and replace a severely deteriorated feature with matching features in which substitute materials may be used.

The QDMR Asset Maintenance Guidelines (AMG), August 2002 defines Road Rehabilitation as ‘activities carried out to achieve full width pavement strengthening. These activities restore the structural capacity and condition of the carriageway *without altering the geometric standards*, and can normally be predicted and planned by engineering and pavement techniques. Works that include the provision of higher quality materials, or that result in an improved pavement structure, are also classified as rehabilitation provided the preceding conditions are satisfied’.

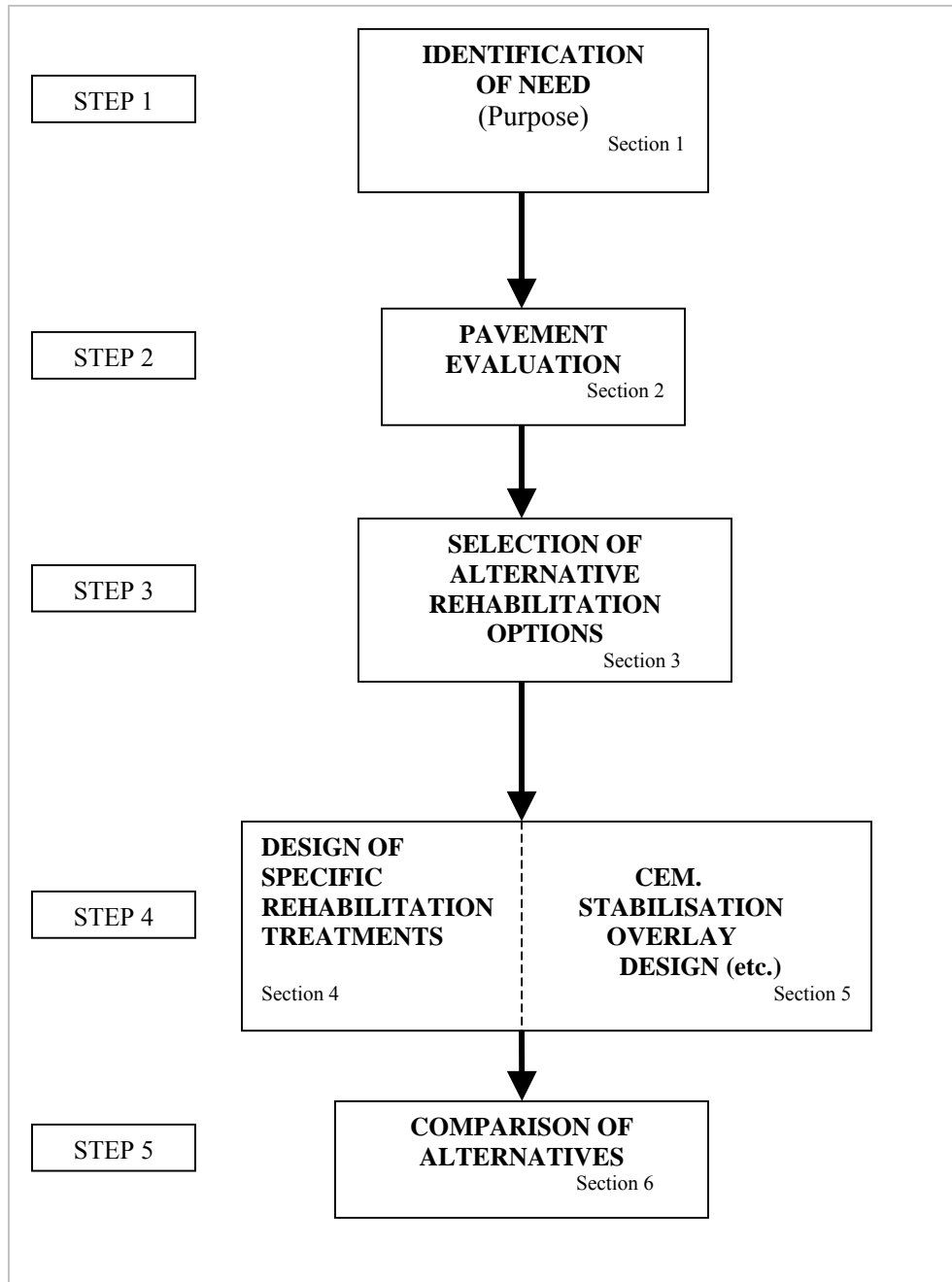
Examples include the following;

- ◆ Full width full recycling and/or stabilisation
- ◆ Granular overlay including formation widening to maintain existing seal width
- ◆ Asphalt overlay of greater than 75mm depth

(Queensland Transport 1992) *Pavement Rehabilitation Manual* refers to rehabilitation as ‘any activity, which improves the functional or structural condition of a pavement while utilising its existing structure’.

### 3.4 Evaluation procedures for effective rehabilitation

The pavement rehabilitation system presented by (Queensland Transport (QT) 1992) Pavement Rehabilitation manual) consists of five steps, which are shown in Figure 3.2;



**Figure 3.2 - Pavement Rehabilitation System** (Source QT Pavement Rehabilitation Manual 1992, section 1 pg. 1-4)

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Step 1: Identification of the need for an asset;

The purpose of the rehabilitation proposal is outlined as the work on pavement considered necessary because of its current condition or has the increasing traffic volume necessitated an upgrading of the road's capacity? Such questions must be asked in order to identify the purpose and therefore the subsequent direction of the investigation and design process.

Step 2: Pavement Evaluation;

The pavement's present condition is evaluated. It firstly involves collecting data from a number of sources including historical records, routine or specific condition assessments and testing programs, and then interpreting this data to identify the pavement distress mechanisms. The evaluation process needs to be carried out irrespective of whether the purpose is restoration or upgrading, as the present pavement condition is relevant in both cases.

Step 3: Rehabilitation Options;

A number of alternative rehabilitation strategies are developed, and includes identifying the purpose, the pavement type, the distress mechanisms, and relevant design and construction considerations are taken into account when determining which of the wide variety of available rehabilitation treatments are appropriate.

Step 4: Rehabilitation Treatments Design;

The technical details of the alternative strategies are determined. This process may range in complexity from the design of a structural asphalt overlay to a simple decision as to whether an Ethylene Vinyl Acetate (EVA) or Styrene Butadiene Styrene (SBS) polymer should be added to a modified seal coat. EVA is the addition of Polymer to hot bitumen while SBS is the blending of 4 – 5 % or more polymers prior to supply.



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Step 5: Comparison of Rehabilitation Options;

The available strategies are compared and the optimal solution selected. The basis of the comparison is primarily economic, as the design and construction considerations have already been dealt with in step 3.

(QT Pavement Rehabilitation Manual 1992, section 1 pg. 1-2)



**Figure 3.3 - Road rehabilitation activities** (Source: Better Roads Magazine 2000, pg 33)

### **3.5 Perspective on M, R &R**

The Road Asset and Maintenance Policy and Strategy (RAMPS) provide the framework for the management of maintenance of the existing road asset. The aim of RAMPS is to optimise the performance of the road asset for which the state government is responsible and this is achieved through their vision to maintain roads so that:

- ◆ Their whole of life performance is maximised, having regard to safety, road user costs, community benefits and Main Road outlays;
- ◆ Road maintenance is funded at levels consistent with this objective.

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This optimisation is to take account of road safety, environment, employment, regional development, social equity considerations and broader government objectives.

(Pavement Management Notes, 1999)

Provision of all M, R &R is quite hard due to limited funds hence a host of factors must be examined to ensure optimal scheduling of M, R &R. These include but are not limited to the following factors;

- ◆ Maintaining the safest possible infrastructure
- ◆ Improving public convenience
- ◆ Preserving the financial investment
- ◆ Providing efficient routes for emergency services
- ◆ Preventing traffic delays or disruption that would incur higher user costs
- ◆ Provide economic routes for the transport of goods and services
- ◆ Correcting deficiencies within a reasonable time
- ◆ Allocating funds that best serve the long-range needs to the public
- ◆ Using engineering and maintenance personnel efficiently
- ◆ Using funding sources efficiently
- ◆ Minimising life cycle analysis

(The Journal of Computing in Civil Engineering 1996)

The QDMR additionally describes that possible scenario for maintenance and development of the national assets in this case road network depends on strategic programs and project analysis of the whole road network. Government through the road agencies has to compromise between two basically contradictory actions:

- ◆ Improving the quality of road network for road users and
- ◆ Minimizing costs of improvement in order to provide this quality

These aspects presuppose that to effectively and efficiently manage multi-million dollar road assets, road asset managers need to be able to accurately define and understand a number of issues including:

- 
- ◆ the quantity and nature of the road network asset for which they are responsible;
  - ◆ the present condition of their road network and the rate of change of those conditions;
  - ◆ feasible maintenance and rehabilitation treatments (e.g. structural overlay, major patching, reseal/resheet, crack sealing), their costs and their effects on the condition of the area treated;
  - ◆ standards of conditions regarded as acceptable by relevant stakeholders (e.g. road users, local residents, funding providers politicians, government officials);
  - ◆ the planning time period (e.g. 5, 10, or 20 years);
  - ◆ the purpose of the roads (e.g. recreational, industrial, arterial, local access); and
  - ◆ current traffic loadings and any changes expected within the time period being considered (e.g. land use, changes in bus routes, new haul routes)

(QT Pavement Rehabilitation Manual 1992)

### **3.6 Road Data, Asset management and M & R**

Road Rehabilitation/upgrading tend to reduce transport costs by minimizing the road maintenance and vehicle operating costs. The decision that controls the effectiveness of the upkeep and replacement of pavements is a key investment and if we can be more effective in targeting that investment according to the strategic need, then saving of funds would be achieved for future Main Roads budgets for investing in other areas.

#### **3.6.1 The Role of Data in Asset Management**

To perform asset management effectively, there are four information processes that require data inputs and outputs at each level

**a) Data Management** - measured data, including quality auditing, storage, and summarisation

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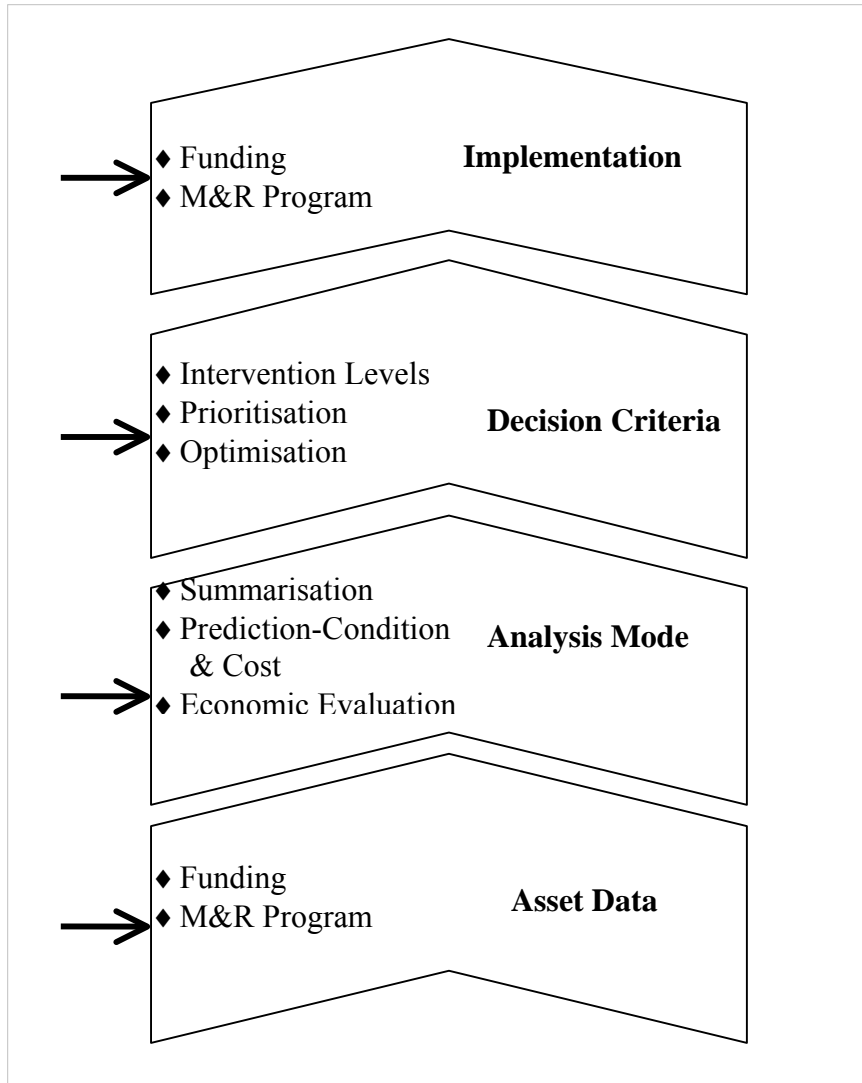
**b) Analysis Models** – data is fed through analysis and modelling software to produce predictions in terms of the future condition of the asset and the costs likely to be incurred, given certain strategies. For example roughness deterioration rate can be determined from roughness counts over previous years. This also allows for the economical evaluation of strategies.

**c) Decision Criteria** – given this information, intervention levels can be included in the evaluation, including prioritisation of candidate projects and the optimisation of resources and treatments.

**d) Implementation** – With this body of information supporting proposed strategies can be presented for funding and included in the maintenance and rehabilitation program.

(Pavement management notes, 1999)

Figure 3.4, presents a conceptual model of these processes - the flow and transformations of information involved in asset management



**Figure 3.4 - Asset Management Information process** (Pavement management notes 1999, pg 1-3)

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## Chapter 4 Pavement Evaluation & Management

### 4.1 Introduction

The procedures for determining the need for pavement maintenance and rehabilitation are similar. This chapter describes the Southern District rehabilitation procedures, the Main Roads evaluation & management concept and then, discusses the difference between Pavement Management and Asset Management.

### 4.2 Factors Influencing Rehabilitation Planning

The needs of the road network are initially determined from the analysis of pavement condition data usually determined by visual assessment. A condition indicating the need for maintenance and rehabilitation are very much similar, and as such their distinction is necessary. At times, maintenance may be required pending the rehabilitation work being programmed and carried out. The particular analysis for certain road segments in the Southern District is influenced by the following factors;

- ◆ **Road Users complaints or needs;**

Main Roads carries out further investigation on road sections when repeated complaints are received regarding deterioration in condition, inadequacies or other failure. This would generally involve immediate remedial works if safety is compromised in any manner.

- ◆ **Persistent weakness;**

For sections of roads that experience regular routine maintenance applications/costs due to constant failures or inadequate provisions further critical assessment would be required. Thus establishing an optimum treatment, that would be best for such sections. This would generally prescribe the rehabilitation requirements.

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◆ **Contractors Advice and Employment Continuity;**

There are 17 Local governments (referred to as contractors by Main Roads) maintaining the roads on behalf of Main Roads – Southern District. They advise Main Roads on the road conditions in their jurisdiction for either maintenance and or rehabilitation depending on the levels of need/ deterioration. Where safety is not compromised, priorities by Main Roads are then essentially worked on each contractors schedule /requirements to maintain and keep employment of their staff.

(P Tweddell 2004, pers. Comm., 7 Oct.)

### **4.3 Panel Inspection for M & R Planning**

The first step in further investigations is the panel inspection. The select panel of inspectors would consist of a District engineer or his representative, the road superintendent, a person in charge of seal designs and a PMS representative. They would generally give guidance on the overall planning of the network maintenance and rehabilitation programme depending on various facets, including the following;

◆ **PMS Procedures**

Following the initial and detailed evaluations and proposals on the type of seal or other action to be taken, the panel inspectors would then confirm the priority of the project. This is based on the visual evaluation by the panel as well as any other external factors known to the panel. The priority is used to programme the projects for further investigation by consultants.

◆ **M & R Category**

The type of action to be taken on a road and the related cost may influence the need for further investigation. For instance due to surface distress some routine/preventative maintenance may be confirmed after visual assessment. On the other hand, extreme rehabilitation projects will require further detailed investigation before final programming and execution can take place.

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### ◆ Road Importance

The importance of a road will have an influence on the need for further investigation. An important road with high traffic volumes is much demanding to be free of potential problems, both physically and politically, than a low volume, secondary road.

Based on the above mentioned facets, panel inspections can have one of the following two objectives;

a) Results used for prioritisation only;

In this case the projects are prioritised for further investigation. Normally panel inspections of the important roads and/or projects in the major M&R categories will have this objective.

b) Results used for final programming

The panel inspection of less important roads and/or projects in minor M&R categories (e.g. reseal) could have this objective. The purpose of these inspections is to confirm the M&R measures (e.g. type of seal), to determine the type of pre-treatment and to determine the urgency for action (priority)

Note, when a seal is required as a holding action until funds become available for a rehabilitation measure, it may be possible to place projects into both rehabilitation and periodic maintenance.

(P Tweddell 2004, pers. Comm.; Pavement Management Notes 1999, pg. 86-88)

## 4.4 Pavement Evaluation Procedures

The basic intention is to provide a standardised procedure for the functional and structural evaluation of existing pavements, including the provision of details on the interpretation of test data, and the criteria to be used in structural assessment of existing pavements.



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This procedure is intended to provide a uniform approach, throughout Main Roads, for evaluating pavement condition. The first step in the optimisation of a road condition is the knowledge of what that condition is and how it changes over time.

## **4.5 Evaluation Concept**

The objective of pavement evaluation is two fold:

- ◆ To investigate factors that has affected the performance of existing pavements. Various tests and procedures are used to determine the functional condition (how the road satisfies the needs of the user) and structural condition (response to load) of the existing pavement.
- ◆ To determine the functional adequacy and structural capacity of an existing pavement to withstand the traffic and environmental forces expected over the pavement life of the pavement and necessary to design rehabilitation measures to ensure the design life is attained.

### **4.5.1 Functional Evaluation**

The functional condition of a pavement is described in terms of factors, which affect the road user with regard to user costs, discomfort or safety. These are not necessarily indicators of a structural condition. The extent to which a pavement meets its functional requirements is termed the serviceability of the road and varies with time due to traffic and environmental factors. The serviceability may be considered in terms of the following;

- Roughness (has the most influence on rehabilitation requirements).
- Geometric properties (surface drainage, crossfall, width)
- Surface texture characteristics (skid resistance, surface noise)
- Presence of severe defects (potholes)

(Transport Technology 1989, Technical Note 4)

#### **a) Roughness**

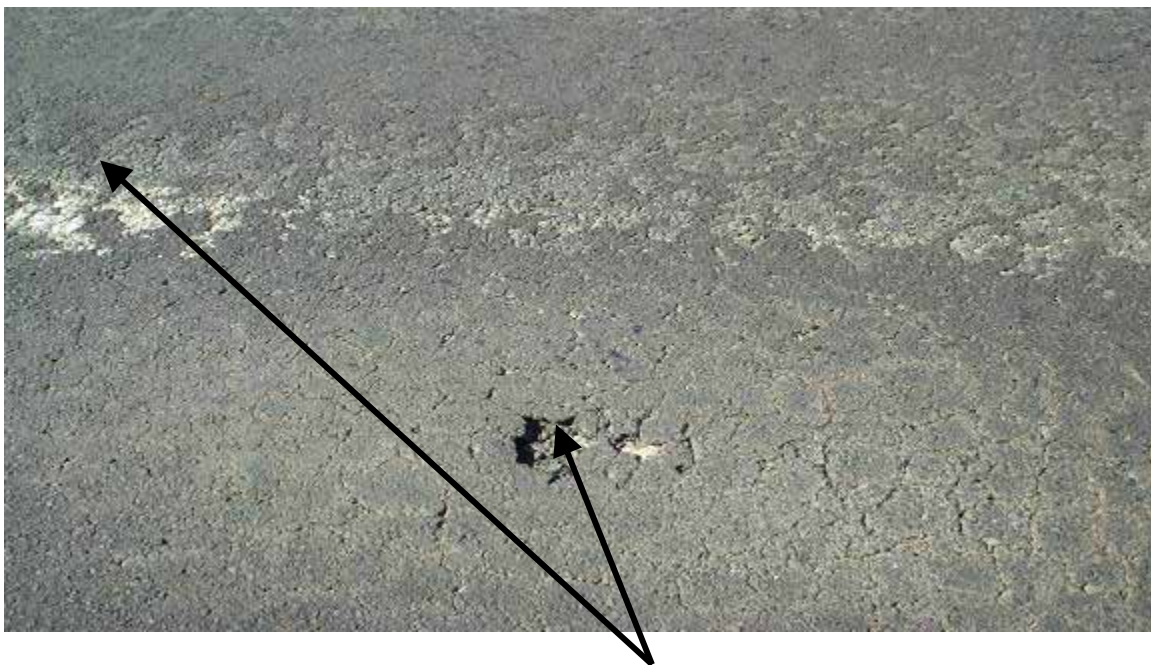
This refers to the ride quality and to be used as a decision tool it is teamed with traffic volume, the vehicle types and Vehicle Operator Costs (VOC). The roughness of a pavement usually increases with time from initial construction through the life of the

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infrastructure. The discomfort values are an indication of desirable retirement values of the pavement. However ultimate retirement (reconstruction) does not occur until all these values are greatly exceeded. The following table indicates the various roughness values throughout the pavement life from initial construction to the average roughness prior to reconstruction for various road categories. (Transport Technology 1989, Technical Note 4)

**Table 4.1: Roughness indicator of Pavement Functional Adequacy**

<b>Roughness status</b>	<b>NAASRA Roughness Counts (NRC)</b>
Roughness at construction	40 - 60 – Main and secondary roads
Roughness at retirement based on Discomfort	110 – Urban Arterials, Sub Arterials & NH 140 – Main Roads & Secondary Roads
Roughness at retirement based on Discomfort	200 – Urban Arterials, Sub Arterials & NH 230 – Main Roads & Secondary Roads



**Figure 4.1: Warrego Highway (18B) Typical Roughness Issues; potholes, cracking**

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#### 4.5.2 Structural Evaluation

The objective of a structural evaluation is to determine the structural capacity of a pavement to withstand the traffic and environmental forces over the design life. Some indirect indicators that determine the structural capacity of a pavement are as follows;

- Pavement surface condition (rutting, cracking and shoving)
- Structural response to load (deflection data); measured by pavement deflections
- Pavement and subgrade properties & drainage;

##### a). Rutting:

Rutting is a feature on the road whereby there is depression along the wheel tracks. This may be just surface failure but if there are high rutting levels it's appreciated that this could be of a structural nature and may require major rehabilitation or reconstruction.

Rutting is made up of three elements of:

- ◆ Particle reorientation of the surfacing
- ◆ Densification of the pavement materials (including loss in asphalt)
- ◆ Plastic deformation of the subgrade

The first two mechanisms generally occur within the first 12 months of “life” of the pavement then slow to almost nothing, whereas subgrade deformation occurs throughout the life of the pavement in line with traffic loading.

(Transport Technology 1989, Technical Note 4)

Rutting and cracking can reflect either:

- The permanent deformation of the subgrade due to the repetition of load or
- Instability in the upper pavement layers



**Figure 4.2: 18B Highway Roughness, Rutting & Shoving Issues**

The adopted terminal criteria for rutting are as tabulated below;

**Table 4.2: Rutting – Adopted Terminal Criteria**

	<b>Terminal Rut Depth</b>	<b>Length of Road &gt; Terminal Rut</b>
<b>Heavily Trafficked AADT &gt;2000</b>	20	20%
<b>Lightly Trafficked AADT &lt;2000</b>	30	20%

The presence of ruts only becomes of significance when ruts reach a depth that they allow ponding of water of water in the wheel paths and can cause or contribute to aquaplaning. This ponding can occur on sealed surfaces with 3% cross fall when the rut reaches 20mm. (Transport Technology 1989, Technical Note 4)

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b). Shoving

Shoving represents a gross deformation of the pavement, which rapidly leads to disintegration. It should not be tolerated. It generally occurs due to:

- ◆ Inadequate strength in surfacing or base material
- ◆ Poor bond between pavement layers
- ◆ Lack of containment of the pavement edge
- ◆ Inadequate pavement thickness over stressing the subgrade

c). Cracking:

Cracking reflects the permanent severe deformation of the subgrade due to repetitive loading instability in the upper pavement layers or repeated deflections causing fatigue in the surfacing. The crack initiates at the bottom of the top surfaces where tensile stress and strain is highest under a wheel load. Crocodile or fatigue cracking is series of interconnecting cracks caused by fatigue failure of the surfaces (or stabilized base) under repeated traffic loading.

The adopted terminal criteria for crocodile cracking are as tabulated below; (Transport Technology 1989, Technical Note 4)

**Table 4.3: Crocodile Cracking– Adopted Terminal Criteria**

	<b>Length of Road Cracked</b>
Urban Arterials and Urban Sub Arterials	5%
Highways, Main Roads and Development Roads	20%
Secondary Roads	30%

In this context, terminal cracking is taken to be distinct crocodile cracking (2mm wide) in a clearly defined pattern. With the development of PMS, other forms of cracking especially the longitudinal cracking are now evaluated too. Others to follow include the transverse cracking. (Transport Technology 1989, Technical Note 4)



**Figure 4.3: Crocodile cracking profile**



**Figure 4.4: 18B Highway Patching & Cracking Issues**

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### **4.5.3 Structural Response to Load**

A deflection survey is carried out on the section of existing pavement requiring evaluation of pavement strength. The most common test apparatus for deflections evaluations are the Benkelman Beam Rebound Deflections and Falling Weight Deflectometer. (Transport Technology 1989, Technical Note 4)

### **4.6 Requirements for Pavement Performance Verification**

An essential element of pavement evaluation for rehabilitation design is to assess whether the condition of the pavement is consistent with the measured levels of deflection. The idea is that the engineer may decide on the aspects of works if for instance they feel that the previous maintenance has been excessive. A pavement section can actually be kept in a serviceable condition almost indefinitely if extensive maintenance is performed. However the disadvantage of this strategy would include the following aspects;

- ◆ Overall cost
- ◆ Downtime
- ◆ Increase in roughness caused by excessive patching, etc.
- ◆ Limitation of manpower and equipment

Therefore further analysis needs to be evaluated regarding the deterioration criteria, and some of the aspects that should be monitored are as follows:

- ◆ Structural capacity;
- ◆ Roughness
- ◆ Safety
- ◆ Riding comfort

Some of the factors, which can be considered in investigating the abovementioned deterioration algorithm, include the following;

- ◆ A change in traffic levels
- ◆ The strength/stiffness of the pavement
- ◆ Roughness occurrence and progression

- 
- ◆ Rut occurrence and progression
  - ◆ Crack occurrence and progression
  - ◆ Pothole occurrence and progression

The core philosophy would be to defer some programmed maintenance where it is cost effective and safe to do so and give priority to programmed rehabilitation works. The general approach will be to have remedial routine maintenance in the intervening time.  
(QDMR Pavement Management Course 1998)

#### **4.7 Pavement Management System (PMS)**

Organisations responsible for managing road systems typically spend well over 50% of their road investments on pavement related works such as the wearing surfaces and the subsurface drainage. In this context and generally, the pavements works are divided into three categories, construction, maintenance and rehabilitation that essentially define the lifecycle of the road asset. This fundamental background has firmly rooted the principles of pavement management systems.

The term pavement management system (PMS) is used to describe tools, which help identify the nature and timing of pavements treatments. Usually these tools are computer based but that is not necessarily essential.

The essence of pavement management is a structured and proactive approach to road maintenance with the emphasis on the long term preservation of pavements, usually at minimum cost.

(QDMR Pavement Management Course 1998)



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## 4.8 Definition of PMS

Usually, definitions by different countries differ though the principle remains. The common PMS definitions appreciated in Australia are:

In Australia (early Australian definition by Porter & Lainson, 1984):

“Techniques which assist decision makers in finding optimum strategies, for providing and maintaining road pavements in a serviceable condition over a given period of time”  
(QDMR Pavement Management Course, 1998)

In Australia (by Mulholland, 1991):

“A method of information collection, analysis and decision-making, designed to permit the optimisation of resources for the maintenance, rehabilitation and reconstruction of pavements”  
(QDMR Pavement Management Course, 1998)

In USA (by Monismith et al., 1988):

“A systematic procedure for scheduling maintenance and rehabilitation activities to optimise benefits to the users of the facilities, and to minimise the cost to the agency responsible for the system”  
(QDMR Pavement Management Course 1998)

Software system is not mentioned in PMS, as the essential element is that decisions be made in a consistent and objective manner. Successful pavement management relies on both of the following:

- ◆ a suite of tools, known as the PMS; and
- ◆ an organisation culture underpinning a proactive and structured approach to decisions about investment in new or existing pavement.

(QDMR Pavement Management Course 1998)

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## **4.9 Pavement Management Vs Asset Management**

Asset management in a roads context relates to management of a road as a whole and with particular focus on the purpose and value of the road to the community, from the earliest strategic and conceptual planning phases through detailed design, construction, maintenance and possibly eventual discarding.

The focus of pavement management and PMS's is on the pavement alone, usually including pavements related components such as shoulders, drainage and including traffic loading, but excluding considerations of roadside furniture, batter stability and traffic congestion. (National Asset Management Manual 1998)

### **4.9.1 PMS methodologies (QDMR Pavement Management Course 1998)**

There are four main methodologies for PMS that are used in Australia. These are as follows and in their increasing order of sophistication.

#### **a) Pavement Condition Analysis (e.g. ROMAN, TNOS)**

- ◆ Condition parameters are weighted;
- ◆ Condition data used to determine a condition index;
- ◆ Priority ranking of segments and treatments using condition index;

#### **b) Priority Assessment Models (e.g. ARRB, PARMMS, & SMEC)**

- ◆ Candidate treatments are ranked according to:
  - ability to influence future condition
  - corresponding effect on future agency and road user costs.

#### **c) Network Optimisation Models (e.g. FNOS, TNOS, dTIMS)**

- ◆ Initial analyses select the optimum mix from a range of management strategies or treatment choices for the whole network.
- ◆ Schedules for specific segments are then identified conforming to the network optimum.

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**d) Rule Based Iterative Model** (e.g. Scenario)

- ◆ Initial analyses select a mix of treatments according to a set of rules for the whole network
- ◆ Specific treatments for segments are identified to conform with the rules
- ◆ The rules are modified and run again until an acceptable budget and condition is achieved

(QDMR Pavement Management Course 1999)

Note:

This dissertation would concentrate only in the use of this QDMR maintenance planning software – SCENARIO, and with reference to relating and identifying sections for rehabilitation in the Southern District.

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## **Chapter 5 SCENARIO Suite Millennium**

### **5.1 Introduction and General Background**

The requirement that Assets perform as intended and provide the best value per dollar spent is a key feature nowadays. Predicting pavement performance and designing the most appropriate M & R demands thorough research, careful analysis, and well-informed recommendations. In the last decade concerted efforts by different countries, bodies such as World Bank and other interest groups have been studying/implementing computer techniques to optimise the process of pavement maintenance management. On the same note, in introducing such technology, pavement practitioners demand simplicity, customisability, and user-friendliness in a software tool. This is the context upon which QDMR in their proactive management concept has progressively developed Software called SCENARIO Millennium.

SCENARIO software, which is a rule based iterative model, was developed following the use of the original Paminet software and HDM software by the then Main Roads Transport Technology Division in the mid 1990's. Following better testing by QDMR-Northern district, a full-scale pilot was conducted with one district from each of the five regions in early 1999. In June 1999, the Road Asset Maintenance approved the full implementation of SCENARIO across Main Roads, with the aim of using the product to assist in the development of the 2000/2001 Road Implementation Program (RIP). The SCENARIO Suite Millennium, the latest version was then released in January 2002. (Asset Maintenance Guidelines (AMG), 2002)

This chapter aims to introduce the QDMR road asset management planning software - SCENARIO Suite Millennium, highlight the direction regarding its context, usage and expectations.

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## **5.2 What is SCENARIO Suite Millennium?**

SCENARIO Millennium is a decision support tool designed to assist asset managers in developing maintenance strategies for road networks. It is a rule based system, where users have the freedom to develop their own rules or to adopt the corporate rules. In the same mode users can adopt the corporate pavement condition deterioration model or can create their own local model. (QDMR Scenario Manual 2004)

### **5.2.1 SCENARIO Suite Millennium**

The suite of SCENARIO Millennium contains the following integrated modules:

- ◆ Scenario Millennium – main pavement management system analysis module.
- ◆ Viewer Millennium – reporting module
- ◆ Budget Millennium – budget constraint analysis module.
- ◆ Ruler – The Scenario Game i.e. a game for introduction of users to rules construction. (QDMR Scenario Manual 2004)

### **5.2.2 Other Links**

Scenario is in addition linked to the Digital Video Road (DVR) and Chartview.

- ◆ DVR link – The advent of digital video technology has provided an opportunity for the user to access the major roads video images. This has effectively been in place since 2001 and helps with the decision making in collaboration with other analysis.
- ◆ Chartview launcher – provides the means of viewing data in chart form with the chainage along the road displayed on the x-axis and on the y-axis one of the road attributes (roughness, rutting, seal age, seal width, etc).

(Pavement Management Notes 1999; QDMR Scenario Manual 2004)

## **5.3 Concept Underlying SCENARIO**

The basic concept of using a rule based pavement management decision tool such as Scenario in Main Roads is driven by the following;

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- 
- ◆ A desire to minimize the whole of life costs of pavement to society
  - ◆ The high priority placed on preventive or programmed maintenance
  - ◆ A need to treat pavements appropriately once they reach an unacceptable condition
  - ◆ District level maintenance program development in a regional funding allocation setting. (QDMR Scenario Manual 2004)

## **5.4 SCENARIO Basis**

Scenario Millennium relies on a wide range of input data to produce results for analysis. Any database with the required information can be used to provide data for input into SCENARIO. For QDMR the asset management data file is available from the department database ARMIS – (Asset Road Management Information System) that comprises the entire road segments data (QDMR Scenario Manual 2004). The following are the key components that constitute the framework of this software;

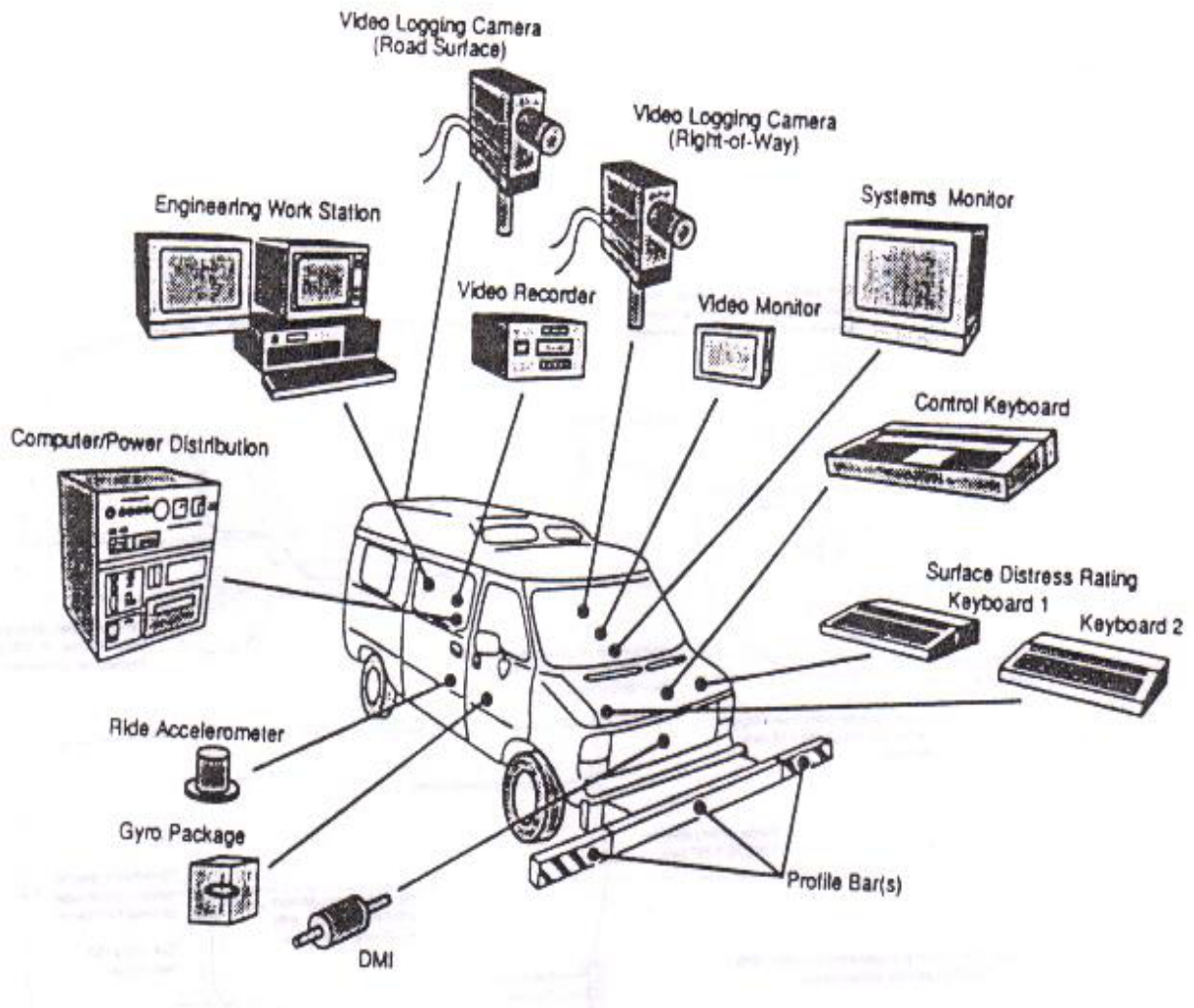
### **i). Road Segments Input Data**

Road segments are road sections usually of 1km length. A range of data is used to define the details of a road segment.

- ◆ Reference (chainage, segment, length carriageway code etc);
- ◆ Inventory (current seal type, seal width, seal age, etc);
- ◆ Traffic (AADT, % heavy vehicles, traffic % growth);
- ◆ Condition (roughness average, rutting 80 percentile, cracking long % and cracking);
- ◆ Environmental Zone Data (combination of annual rainfall and soil reactivity data)

(QDMR Scenario Manual 2004)

Input Data requirement - The QDMR policy promotes consistency and quality in measuring and reporting their inventory (seal or Pavement age) condition data (roughness, rutting and cracking) i.e. the pavement condition. Hence, from 2001 the Network Survey Vehicle (NSV) (**Figure 5.1: below**) is used to collect and record the data.



**Figure 5.1: Network Survey Vehicles (NSV)** (Source: QDMR Asset Maintenance Guidelines (AMG) 2002)

**ii) Rules (or treatment Strategies)** - determines the intervention levels. There are two categories of rule sets that come with SCENARIO Millennium;

- ◆ Base rule sets (do minimum approach) – aims to achieve a level of service that could be achieved with minimum dollars.
- ◆ Project Rule sets - the aim of rule sets it to achieve a predetermined level of service.

(Refer Appendix C for Corporate Rule Sets)

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**iii) Categories** – road segments (usually of 1 kilometre long) are allocated to categories comprising segments of similar pavement type (surface and pavement), environmental characteristics i.e. sub-grade reactive or non reactive soil; rainfall effects; and traffic characteristics, i.e. traffic type, speed limit & AADT

**iv). Analysis period** – the time period usually 20 years that is analyzed using SCENARIO

**v). Deterioration Profile** – curves used to predict how individual road segments will deteriorate over time and after treatments. There are currently curves for roughness, rutting, cracking and seal age.

**vi). Treatments** (refer Appendix C for Corporate Treatments) – remedial process applied to a road segment; planned treatments within a maintenance program, triggered when rule condition is met.

**vii) Segment Groups** – groupings of like road segments to be analysed in a particular SCENARIO. Various segment groups are needed to separate road segments that need to be run with different run options, rule sets, treatments and or treatment costs. These are such as SCR network, NH or local roads.

**viii) SCENARIO** – the results of the analysis conducted using specified rules and segment groups (a scenario run is an analysis for a segment group with specific rules).

## **5.4 SCENARIO Corporate Elements**

For analysis process SCENARIO Millennium has a number of elements developed and in-built in the program. These are the corporate elements, which are common across the state and provide the basis for analysis and comparison between district and regions. The concept of using statewide standards may result in compromising the accuracy of relative components, requiring further local refinements to produce more accurate results may be necessary.



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The following corporate elements are built into SCENARIO;

- ◆ Corporate Rule Sets (base and project)
- ◆ Corporate Treatments (refer appendix E .1.1)
- ◆ Corporate Categories
- ◆ Corporate Deterioration Model
- ◆ Corporate Economic Treatment Group

For further analysis the following components of Scenario are not the same statewide and have been categorised at district/regional levels. Their further developments to suit local criteria are expected;

- ◆ Incremental Benefit Cost Ratio (IBCR) cut off values;
- ◆ Treatment costs;
- ◆ Annual Routine Maintenance costs;
- ◆ Seal Age values for reseal;

(QDMR Scenario Manual 2004)

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## **Chapter 6 Application of SCENARIO**

### **6.1 Introduction**

This chapter gives the QDMR background objectives for SCENARIO, the set out applications and discusses the level of its usage/success in the Southern District and the current applications.

### **6.2 Strategy & Direction in Using Scenario**

In Main Roads, the policy directing pavement maintenance is contained in the Road Asset Maintenance Policy and strategy (RAMPS). This sets out the strategy for the Asset Maintenance System including pavement maintenance, whilst the Road Network Strategy document (Regional or District maintenance strategies) sets the objectives and targets for asset managers.

With the Scenario, the primary purpose is to assist District asset managers develop maintenance programs for approval and input into their Road Implementation Programs (RIP). The aim of QDMR Road Asset Maintenance Policy and Strategy (RAMPS) is to optimise the performance of the road asset, for which the State Government is responsible. Taking a “whole-of-life” view of road assets and optimising the combination of road user costs and Main Roads costs will achieve this optimum performance.

Optimising the performance of this asset, would deliver benefits to road users and the community far in excess of the cost of upkeep of the infrastructure itself. This optimisation is to take account of road safety, environment, employment, regional development, social equity considerations and broader government objectives, and be pursued within the level of funding made available by government.

(Pavement Management Notes 1999; QDMR Scenario Manual 2004)

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### 6.3 What it does & how it works

- ◆ Assists in road maintenance programming;
- ◆ Selects treatments based on rules;
- ◆ Setting budgets - Calculates costs and benefits;
- ◆ Predicts condition according to deterioration models

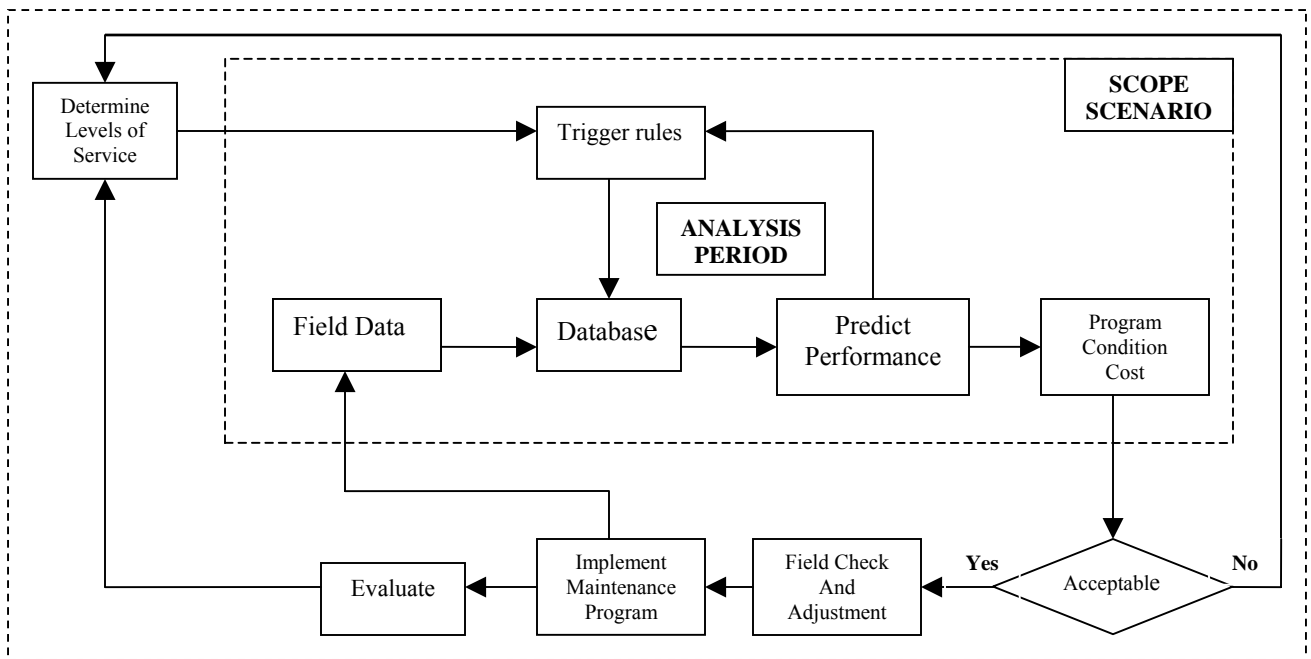
This involves running a Scenario, which means that the system evaluates each road segment in the segment groups and produces resulting maintenance strategies and their associated costs according to the rule sets. The maintenance strategy depicts the kind of treatment scheduled for specific road segments for certain period (years of running).

In running the Scenario, various run options should be set to customise the scenario run.

These run options include;

- real discount rate;
- inflation rate;
- IBCR cutoff value;
- seal age value;
- default routine maintenance cost;
- number of years to predict;
- the start year of the analysis period;
- treatments to exclude

The following figure 6.1 models the scenario analysis and applications:



**Figure 6.1: How SCENARIO Works** (source: QDMR Scenario Manual 2004)

## 6.4 SCENARIO Application in the Southern District

The Southern District is responsible for 3005 km of the State Controlled Road network, which has relatively been maintained in good condition with regards to their policy aims and rationale. The use of Scenario has been limited in this district with only minimal use to set budgets/procurement of programmed maintenance (PM) costs for the region.

### 6.4.1 Limiting factors in Scenario Usage

The use of this promising relatively new/young software, SCENARIO in the Southern District has not had much as yet due to a number of reasons. These are principally follows;

- ◆ The current success with the use of subjective methods, which have been very effective and have served the district quite efficiently. The motivation to accommodate new technology which is yet to be fully developed is thus compromised by that fact and other logistics in the district e.g. staffing
- ◆ Lack of sufficient staff - owing to the fact that the district does not have sufficient staff to dedicate to the tasks of having to learn the effective use of Scenario, which should include a lot of modelling to suit the local conditions/purposes.

- 
- ◆ New Technology – being new software, which is still developing, demanding not only pavement education but also further training in the system and modification to achieve acceptance has slowed the full embracing and implementation.

At this stage the only usage of SCENARIO has been in the process of setting the budgets and subsequent procurement of funds for reseals/programmed maintenance for the whole of the Southern region. This is discussed below.

(P Tweddell 2004, pers. Comm. on 8 July)

#### **6.4.2 Setting Budgets - Procurement procedure**

The current use of SCENARIO program in this district and in fact for the whole region is to give guidance in matters concerning the budgetary requirements. This involves running a scenario for the whole regional network in a similar manner as for sample roads evaluated in this dissertation. From the scenario results window and or Benefits vs. Cost graphs the expected programmed maintenance costs are allocated for each year of evaluation.

This dollar costs forms the platform upon which the region targets the funds it will source from the state government. This then depends on the real priorities for the region since certainly all the costs programmed, as is the case, may not be forthcoming. Finally on receipt of whatever lump sum dollar from the state government they divide the amounts based on a ratio of requirements amongst their four districts in the southern region.

The key point in this analysis process is to find and program the dollars required to achieve the ten year reseal cycles. The scenario analysis of the whole region network is not feasible herein due to the critical run time entailed. With a simple 128 MB computer it would take a long time in terms of several days/weeks. This process is however similar to the analysis for sample roads carried out in the next chapter of this dissertation depicting the amounts of Programmed Maintenance (PM) costs. Refer also to similar results for other cases in the relevant corresponding appendices.

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## **Chapter 7 Investigation of Application & Modifications of SCENARIO for Use in Southern District**

### **7.1 SCENARIO Study Analysis**

At the onset, several initial evaluation tests of scenario package were run to investigate the software procedures. To analyse the SCENARIO Millennium relevance and make a report some particular dedicated studies were carried out and their results correlated with the field results and current planning situation.

Three major roads under Southern district (see Appendix B) jurisdiction, which are either undergoing rehabilitation works or have advanced plans for rehabilitation were thus found to be suitable case studies. These were 421 – Dalby to Jandowae; 18B-Warrego Highway the road section between Toowoomba-Dalby, and lastly 28B-Gore Highway, the section from Millmerran to Waggamba;

### **7.2 Execution Methodology (GSK (author's) Study)**

Main Roads recognizes that the guiding input into maintenance intervention rules lies in the relevant investment strategy. So, to effectively research the development of any rules to input in Scenario this must be in the context of meeting the objectives of their strategic and policy directives. SCENARIO Millennium relies on a wide range of input data to evaluate and produce results for analysis of any Road segments.

The general **testing procedure** followed in GSK-study and in all studies undertaken is described here below. (Further refer to Appendix C; Scenario Millennium Reference Card - general, summary of a study). This forms the basis for the execution methodology outlined below:

- 
- ◆ Create a particular study or studies for testing. This would involve selecting a certain road(s) and input their condition data. This would entail establishing data for the Road segments for testing – a set of condition, inventory and traffic data for homogeneous sections of road. The segments contain both high and low traffic areas, and a variety of pavement conditions.
  - ◆ Run the Scenario. This is by Sub-Scenario criteria of using corporate base and project rule sets.
  - ◆ Analyse the results and compare alternative performance standards i.e. the rule sets. Investigate the development of a local rehabilitation program and also evaluated on the current field results or planning practices.
  - ◆ Make Critical Analysis of the Results and any other Comments!

### **7.3 Modifying Scenario defaults** (case used 421-Dalby Jandowae)

The road section coded 421 has a total length of 47km and is generally two-lane, two-way spray sealed surface road and commences from Dalby to Jandowae. It formed the initial Scenario analysis and was first evaluated using the default settings as follows;

#### Scenario Value Options

Real Discount Rate - **0**

Inflation Rate - **0**

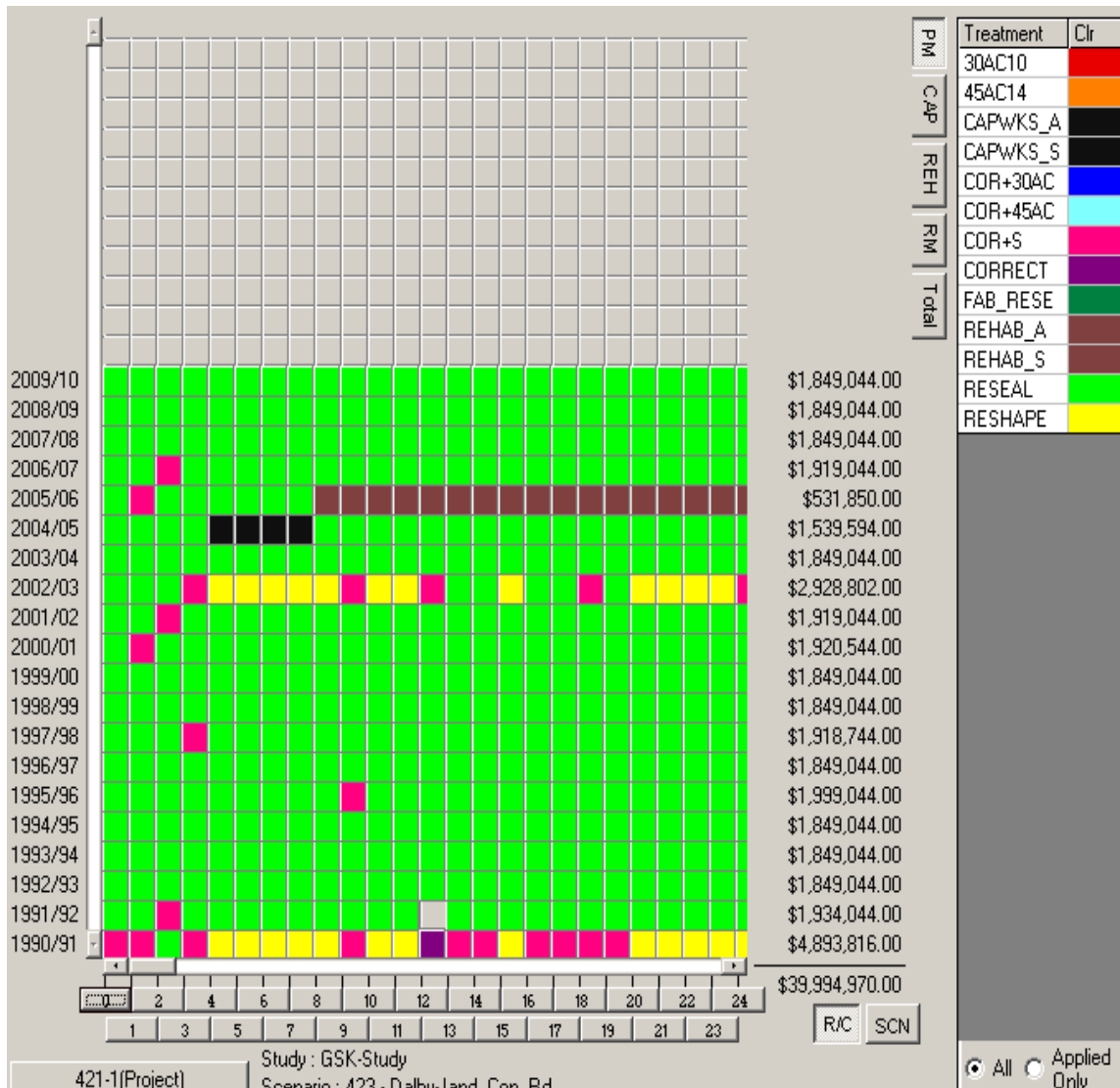
IBCR Cut-Off Value - **0**

Seal Age Value - **2**

Default Routine Maintenance Cost - **\$1000.00** per km (for the treatment year)

The datum current financial date for running Scenario was set to 1990/1991 with the number of years to predict set at 20 - the analysis period was back dated to assist in analysing the past & current field results.

Results – On running the Scenario with the defaults value options the results in **Figure 7.1: 421–Dalby to Jandowae (original)** were returned. This detailed information of individual road segments (from 0 -24km) with the required treatments triggered as appropriate through the analysis period.



**Figure 7.1: 421-Dalby to Jandowae Road (original)**

Discussing Results – From a quick review it would be difficult to justify the annual reseals in most of road segments in the successive years. In the datum year Reshape or Cor+S (Corrector and reseal) treatments are triggered. In the following year and the next over 10 successive year’s reseals were triggered for each of those years. That cost would



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not be justified and as well if the road segments would have such a demand a thorough investigation would be necessary.

The author did an investigation of this output and it was clear the value options required to be reset to reflect the district value options. Mr. Phil Tweddell Manager Main Roads suggested the following Scenario value options as the regional standards

Scenario Value Options – The modifications were set as follows:

Real Discount Rate - **6**

Inflation Rate - **3**

IBCR Cut-Off Value - **3**

Seal Age Value - **10**

Default Routine Maintenance Cost - **\$5000.00** per km

(P Tweddell 2004, pers. Comm. on 8 July)

The other entire Scenario analysis was similar to the previous i.e. the datum current financial date set to 1990/1991 with the number of years to predict set at twenty.

Results – On running the Scenario with the modified value options the results in **Figure 7.2: 421–Dalby to Jandowae (refined)** were returned. The detailed information of individual road segments (from 0 -24km) with the required treatments triggered as appropriate through the analysis period.



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## **7.4 Procedure for use of Scenario in the Southern District**

Adopting and firming on the modified Scenario value options suggested as suited for the district the following two cases were analysed using those values Scenario analysis, results and discussion were made for the following two cases.

### **7.4.1 Case Study 1: 18B-Warrego Highway (Toowoomba –Dalby)**

This road section coded 18B has a total length of 84km and is generally two-lane, two-way spray sealed surface road and commences from the intersection of Warrego and New England Highway in Toowoomba and ends in Dalby at the intersection with Bunya Highway. The choice was especially influenced by the fact that it is probably one of the most important and major roads in the southern district carrying relatively high Average Annual Daily Traffic (AADT) comprising both heavy and light vehicles. It's actually part of the national highway and forms the corridor that opens the western countryside's of Queensland and beyond.

From the ARMIS data assessed in the scenario process and as can be seen in Appendix Figure D: 18B Segment Group we have the following conditions;

- ◆ the initial road carriageway ( $\approx 8$ km) just leaving Toowoomba, are dual carriageway, mostly dense graded asphalt flexible pavement and having high AADT  $> 5000$ ;
- ◆ Then the next 20km which runs to just past Oakey junction is a two way two lane spray sealed flexible pavement and with an AADT  $> 5000$ ;
- ◆ Then for the rest of the road section to Dalby the road continues as a two way two lane spray sealed flexible pavement but with an AADT  $< 5000$ ;
- ◆ To note also is the relatively high percent of heavy vehicles along the route (averaging 18.6%).
- ◆ The nature of soils along the route is basically dry reactive (DR) soils with only the initial Toowoomba environs where it is described as having Wet Reactive (WR) soils.

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#### **7.4.2 Case Study 2: 28B-Gore Highway (Millmerran to Waggamba)**

This road section coded 28B has a total length of 49km and is generally two-lane, two-way spray sealed surface road and commences from Millmerran to Waggamba at the border with the Southwest District. This national highway connects southern district on the southwestern side and carries substantial Average Annual Daily Traffic (AADT) comprising both heavy and light vehicles.

From the ARMIS data assessed in the scenario process the data for this road segments is as follows;

- ◆ The road carriageway is a two way two lane spray sealed flexible pavement and with an AADT < 5000, actually approximately 1500 vehicles per day;
- ◆ Relatively high percent of heavy vehicles along the route (averaging 37%).
- ◆ The nature of soils along the route is basically dry reactive (DR) soils with only the initial Toowoomba environs where it is described as having Wet Reactive (WR) soils.

Note that the Scenario analysis for this section was run together as a whole of Gore Highway, which is 28A and 28B totalling 121km. The results of the Scenario run are in Appendices E, which is the last section of 28A just before Millmerran from Toowoomba and the last section of 28B at Waggamba respectively.

Results: These are contained and discussed in chapter 8.

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## Chapter 8 Discussion of SCENARIO Results

### **8.1 Analysis and identifying sections for Rehabilitation;**

The Scenario results window provides detailed information on individual road segments and their treatments that sets the stage for the output data which has herein been analysed be evaluating the:

- The colour coded Scenario treatment window
- Evaluation of the linked Chartview

First, Understanding that programming for capital works and rehabilitation works is based on the engineering judgment by the managers upon analysing the results is essential as Scenario is mainly a programmed maintenance tool. It uses the deterioration model profiles to predict all attribute values for the analysis period. It analysis the current attribute value with respect to attribute profile status, then for the analysis period it follows the deterioration profile and the attribute values obtained by adding the next increment to the current value.

From the following results obtained for the two experimental cases tested and their discussions this has been used to suggest a possible method for identifying sections due for rehabilitation.

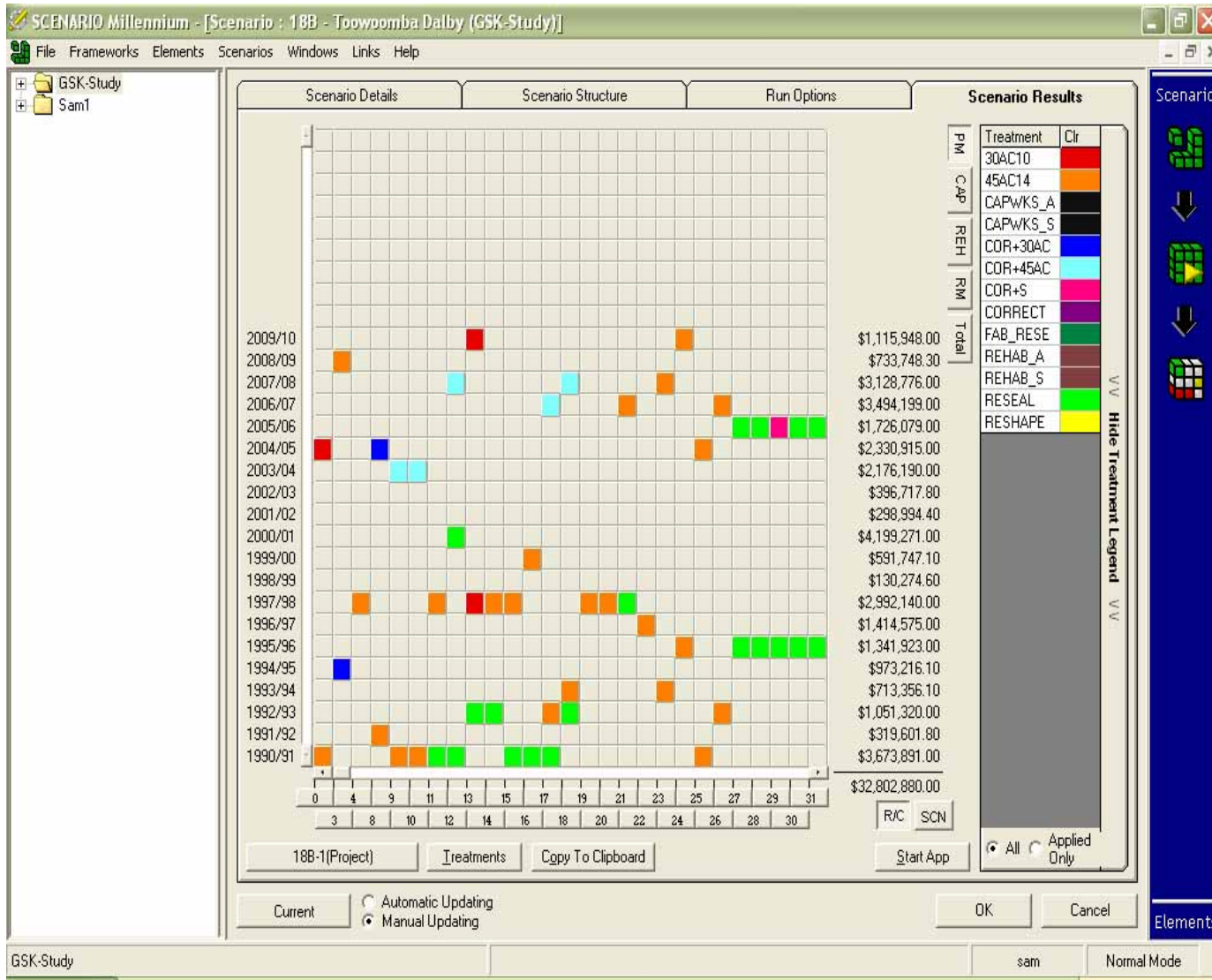


Figure 8.1(a): 18B- Warrego Highway (Road Segments; 0-31km)

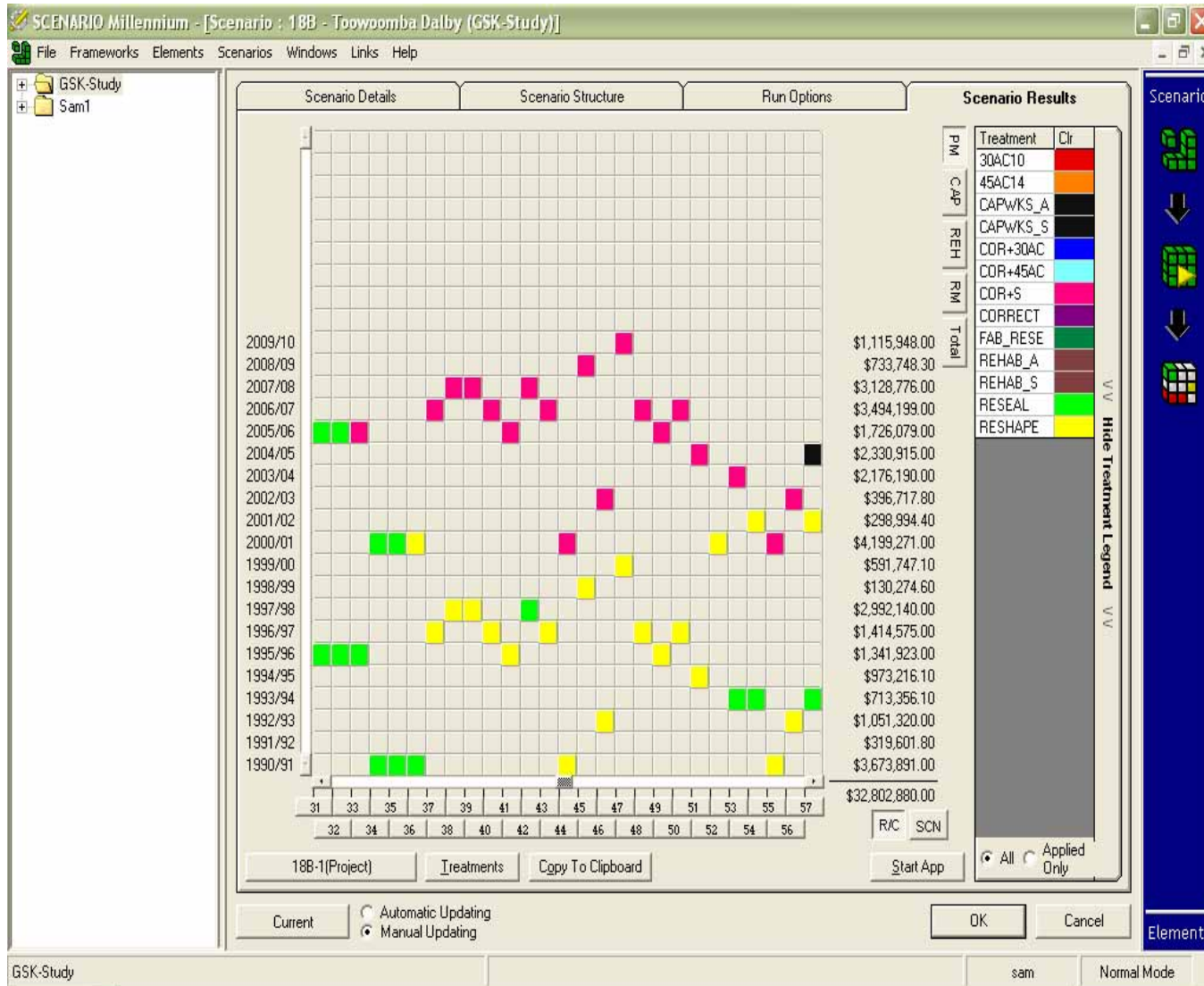


Figure 8.1(b): 18B - Warrego Highway (Road Segments; 31-57km)

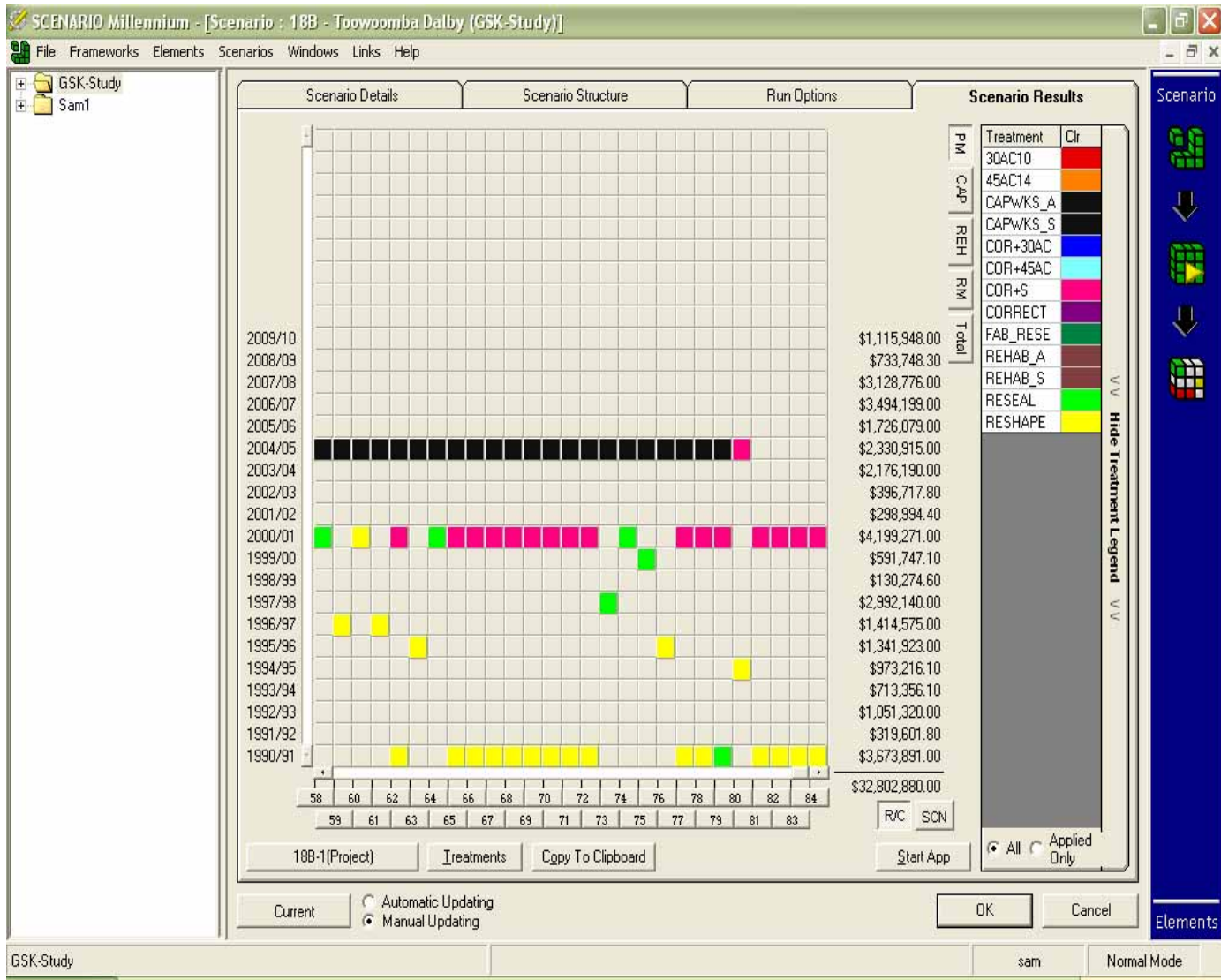


Figure 8.1(c): 18B - Warrego Highway (Road Segments; 58-84km)



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## 8.2 Case Study 1, 18B: SCENARIO Treatments Triggered;

- ◆ The basic SCENARIO treatment for the initial road segments i.e. 0-31km in **figure 8.1(a)** over subsequent years is generally **Thick (45mm) asphalt overlay (45AC14)**. This is a non-structural, 45mm asphalt overlay with 10mm stone size. The thick asphalt overlays are targeted at high traffic categories (AADT > 5000) and high-speed regimes (>80km/hr) for roughness reduction and seal age resurfacing. This is typical of the section of Warrego Highway as you leave Toowoomba for Dalby, which from the scenario ARMIS data the AADT range is about 10,000 per day. The roughness levels as confirmed with the chart-view (refer Appendix D) linked to Scenario indicate the roughness levels averaging 110 NRC.
- ◆ In **figure 8.1(b)** for the road segments 31-57km the initial (approx. 5yrs) years of analysis the road segments seem to be in good condition and hardly any treatments triggered. This could have been that the stretch had received some reseal programmed treatment a year or so before the analysis period. In the next set of approx. 5 years over most of the segments the fired treatments is **Reshape**. This indicates that roughness issues again are the dominant criteria and Reshape targets roughness reduction treatment for segments in reactive areas where asphalt overlays are inappropriate. The period following the Reshape treatments sees the road condition improved and retarding development of any failures for a period of 10 years. Interesting is that in lieu of triggering a typical reseal treatment only a **Corrector and reseal (COR+S) treatments are anticipated**. This indicates that with the roughness issues addressed by Reshape treatment the progression of rutting levels is not wholly addressed and would predictably be the next trigger mode. The corrector course with reseal which targets rutting with seal age resurfacing would be ideal as it does entail the 10 year reseal cycle as well.
- ◆ The last **figure 8.1(c)** for the rest of the road section (58-84km) commences with **Reshape** treatment triggered over the initial years of the analysis period. Again in an almost predictable version (similar to the previous Reshape treatment aftermath) the rutting intervention standards are next on line.

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Of much interest in this last figure is the capital works coming barely 5 years after a corrector and reseal which would be expected to categorically address any rutting issues adequately. This works scheduled in this financial year (2004/2005) form the interest of this study and would be discussed further in analysis of the results.

- ◆ For a general observation across all the road segments, i.e. for the few ones that do not have the roughness and rutting weaknesses triggers, these have been the usual programmed reseals triggered at the intervals of 10years which is the standard intervention period programmed for the Southern Region.

#### **Segments 57-84(figure 8.1(c))**

As discussed, under the scenario treatments the initial years of the segments 57 – 84 km had **reshape** treatment followed by **Cor+S** treatment. These treatments were aimed at targeting roughness and rutting failures.

However, in this region as discussed under the current subjective maintenance practices is that when failures commences/or are experienced on certain road segments the general trend is that remedial works such as a routine maintenance/and or reseal treatment is undertaken. This helps maintain the pavement surface integrity and indeed would at the same time retard the development of the failure. In this context, QDMR appreciates that to avoid total failure major works would be necessary and scheduled the capital works to happen in this current financial year. And the next question would be why capital works and not rehabilitation? This is explained by the fact that this is a major NH and carrying substantial heavy vehicles and the need for improvement – climbing lane etc be provided. Such works though inclusive of rehabilitation works are classified as capital works for the purposes of sourcing the large funds required.

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On the basis of that concept we can formulate the major works expected for the other segments to happen in years to come. This would be very realistic treatment that is based on the engineering and scenario analysis.

**Segments 31-56 (figure 8.1(b))**

The condition of the pavement as discussed earlier has a similar treatment pattern to the last section i.e. Reshape followed by Cor+S treatments. In this section the Reshape treatments are triggered from on average the year 1996/97, while for the Cor+S triggered to happen in the year 2005/06/07. For all intents it will be expected that with remedial works going on in the intermediate years then rehabilitation/and or Capital works programmed shortly after that period. This could happen from the years 2006/07 but certainly by 2009/10

**Segments 0-30 (figure 8.1(a))**

The flexible pavement in this section consists of part dense graded asphalt and spray seal surfaces but in common the traffic volume is high. The treatment triggered commonly in this section is 45AC14 and happens on average in the year 1997/98. This treatment reducing the roughness and seal age resurfacing, rutting & roughness issues are experienced after about 10 years i.e. 2007/08. Again with expectation that remedial works are going on in the intermediate years then rehabilitation/and or Capital works would be programmed shortly after that period. This could and should happen from the years 2008/09 but certainly by 2011/12.

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### **8.3 Case Study 2, 28B: SCENARIO Treatments Triggered;**

There are two Scenario results window referred to in this case. Further reference is made to the Chartview as necessary.

#### Appendix E1: Twba - Millmerran section; 49 – 75km

This section was analysed because Main Roads has scheduled rehabilitation works to be carried out from road segment 49 to 119 a total of 70km. That is section approaching Millmerran and all the way to Waggamba. The SCENARIO treatment for the road segments in this figure indicate that a reseal was undertaken in the fiscal year 1993/94, however recurrence of mainly Cor+S triggers was experienced from the next fiscal year becoming common and worsening in most segments from 2000/01. This presupposes that there is a high rutting failure criterion.

#### Appendix E2: Millmerran - Waggamba section; 95 – 121km

This is the last section of 28B and going into Waggamba and to the district border. It's analysed as it presents the typical situation through the length of 28B in terms of the treatments triggered and the scheduling for rehabilitation works. The SCENARIO treatment for the road segments in this figure indicates that a reshape was generally undertaken in the fiscal year 1990/90 for most segments. This implying roughness and seal age resurfacing was initially the principal criteria. Then, rutting triggers are experienced after about 10 years i.e. 2000/01. This rutting situation is further shown for the entire 49km on Appendix figures E3 & E4 –Chart views'. With remedial works being undertaken in the intermediate year's as necessary the rehabilitation works has been programmed for the fiscal year 2004/2005.

#### **Conclusion;**

From this analysis it's concluded that rehabilitation works would correctly be prescribed from Scenario analysis. The rehabilitation intervention appears generally to follow the rutting criteria. This can actually be made better if rules to trigger rehabilitation treatments can be built in the Scenario.

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## Chapter 9 Program Development Methodology

### 9.1 Introduction

The QDMR has set the objective of having all the regions/districts optimizing the software to achieve use of local condition parameters to suit the local requirements. They also strongly recommended that the maintenance program produced by SCENARIO be taken into the field and checked on the road segments to ensure the treatment selected and timings are appropriate. Usually this is a task requiring the skills of maintenance staff from both the programming and execution phases of maintenance.

This chapter highlights the QDMR rule sets, the entailed concept and the procedure in making example rules.

### 9.2 Rule sets

Rule sets contain the intervention standards (i.e. a set of conditions) and treatments. When a scenario is run, treatments are triggered on road segments in the year the intervention level/criteria are reached. SCENARIO Millennium has two inbuilt rule sets (refer Appendices C) that are used to compare treatment strategies across the state. Rule sets are used to target specific weaknesses in the network or to keep certain road categories in better condition than others;

- ◆ **Base Rule Set** – this is similar to “do minimum” approach. It aims to achieve a level of service that could be achieved with minimum dollars applying the minimum number of treatments. The base treatment strategy is used as a common starting point when economically comparing treatments within a scenario and in multiple project treatment strategy comparisons. As the main concern is to minimise cost and there is little emphasis placed on condition, no economic based treatment selection are used.

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- ◆ **Project Rule sets** - the aim of rule sets is to achieve a predetermined level of service. This level of service is achieved by using rules that trigger treatments when a given road condition has reached or exceeded the desirable condition. As optimum performance for money is the goal, treatments can be cost optimised by using economic selection rules.

(QDMR Scenario Manual 2004)

Rule sets can contain two main types of rules. These are as follows;

A select rule – This contains an economic based treatment selection as used in the Corporate Project Rule Set.

A “one on one” rule – this is where one specific treatment is applied to correct specific conditions or a combination of conditions. “One on one” rules are used in the base rule set and the follow on treatments in the project rule set. This is such as at the start of the rule set to define capital, rehabilitation or program works currently in the Road Implementation Program (RIP)

### **9.3 Rules Construction**

The guiding input into maintenance intervention rules is the relevant investment strategy, which sets targets for condition parameters that can be used in the rule development. The Main Roads Asset Maintenance Policy strategy should be kept in mind in this process as it provides a vision for how Main Roads plans to manage the maintenance of the asset.

‘The Austroads report which sets out the best practice pavement condition measures for local roads in Australia, (Austroads, 1999) specifies the three range of drivers around which a rule set could be constructed. These are safety, serviceability, and structural capacity and the following table indicates the suggested measures for condition based results,’ (QDMR Scenario Manual 2004)

**Table 9.1: Measures for condition based results (Source; QDMR Scenario Manual 2004)**

<b>Driver</b>	<b>Measure</b>	<b>Criteria</b>
Safety	Rut depth	Rut depth in mm
	Edge defect	Edge break + drop off
	Texture depth	Mean Texture Depth
	Skid resistance	F60 or SFC <sub>50</sub>
Serviceability	Roughness	NRM
	Environmental cracking	Area cracked or seal age
	Potholes	Area of potholes
	Ravelling/Stripping	Area of Ravelling/Stripping
	Ravelling/Stripping	Area of Ravelling/Stripping
Structural Capacity	Fatigue cracking	Area of fatigue cracking
	Remaining life	Rutting rate & or deflection data

The development of rules to input into Scenario should be in the context of meeting objectives of Main Roads strategic and policy directions and with the aim to put a more comprehensive benchmark rule set, covering all three drivers, if possible.

Local rule sets can be created at a district or regional level to reflect district/region specific common practices. The type of attributes used to define the criteria in the rule sets are as follows and any can be used to create local intervention standards:

- Condition – roughness, rutting, and cracking;
- Age – seal or pavement age;
- Location/Environmental characteristics – reactive/non-reactive soil, temperature /and or rainfall effects;
- Physical properties – seal type, speed limit and traffic

(QDMR Scenario Manual 2004)

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## 9.4 Treatment Conditions

The treatment selected is one that will perform at or just better than the vision standard for the road segment. This way the treatments are tailored to provide an optimum solution (i.e. highest BCR)

In the attempt to develop draft local rules for the southern district, the process adopted was similar to the pilot process used by Northern-(Townsville) district. That is to determine the trigger year for treatment, and then determine the most effective treatment to be applied at that time. The parameters used for determining trigger year are:

- ◆ Roughness
- ◆ Rutting
- ◆ Seal age

Other conditions to evaluate these parameters with include the following;

- ◆ Zone Type
- ◆ AADT
- ◆ Speed Limits
- ◆ Surface Type

## 9.5 Rule Basics & Construction of rules

Rules specify how a road segment with certain attributes should be treated;

### Example 1:

A road segment has an AADT > 2000 and a roughness of 130 NRC

A rule says “when AADT <5000 and roughness > 120NRC apply a RESHAPE treatment.

*Now when the scenario is run a **reshape** treatment would be triggered to that segment*



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Example 2:

A road segment has an AADT < 2000; roughness of 110 NRC and rutting >20mm

A rule says “when AADT < 5000 roughness > 120NRC and rutting =20 apply a Cor+S treatment.

*Now when the scenario is run a **Cor+S** treatment would be triggered to that segment*

Example 3:

A road segment has an AADT < 2000; roughness of 110 NRC; rutting >20mm and Reshape previously undertaken = 5 years ago

A rule says “when AADT < 5000 roughness > 120NRC and rutting =20 apply a Rehabilitation (Rehab) treatment.

*Now when the scenario is run a **Rehab** treatment would be triggered to that segment*

Comments:

A pseudo code for referring to the previous treatment would be ideal in establishing the next step for Scenario to stipulate the requirements for rehabilitation and or capital works.

This should include the cases when prescribed treatments are overlooked and only routine maintenance or reseals undertaken to either delay or hold for other works.

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## Chapter 10 Conclusions & Recommendations

### 10.1 Objectives Achievement

This dissertation set to establish the use and application of QDMR SCENARIO Software in the Southern District of QDMR with particular reference to identifying sections for rehabilitation. To lay the necessary background the success of the related scope of objectives was done and had the following results;

The first task was to undertake a thorough review of road asset management. This has been extensively described in chapter 2 of this dissertation and in brief found that within all QDMR levels completely comprehend and follow the whole of life principles in managing their assets. This includes proactive measures to maintain these assets in serviceable and safe nature despite the budgetary shortfalls by seeking optimal solutions to their networks.

This was followed by a successful analysis and definition of the terms constituting the management of ongoing performance of the road asset. These in particular were maintenance and rehabilitation. It was analysed that though the requirements for each could be well established, the rectification often is not achievable due to budget constraints and thus the new concept of need to optimise treatments. achieved some phenomenon results that would contribute in the SCENARIO program enhancement not only for the Southern District but as well for the QDMR purposes. These were both on general and specific notes as follows;

Regarding use of SCENARIO use and application this is yet to be fully appreciated mainly because it is relatively new/young software and still at a stage requiring more development not only in the Southern district but also in the entire state. As with any such inventions there are many challenges / ‘teething’ hassles involved, the common

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being the need by all involved to diligently learn its use and development principles. Bearing the limitations commonly presented by staff shortage this is making it even more difficult. And the fact that like in Southern District there has been success with other methods hence some element of unwillingness to change especially as the going is still good.

Finally from the Scenario results and evaluation it was seen that this software can in addition to the programmed maintenance identification be used to correctly identify sections due for rehabilitation in the Southern district and very likely the procedure could be followed for other districts (Northern Townsville district has taken the lead). The indication from this achievement is that if rehabilitation treatment is effectively achieved savings would be achieved for the whole network and this would allow better funding programming and assist in formulating long term maintenance strategies.

## **10.2 Recommendations & Further Works**

As SCENARIO is basically a programmed maintenance tool, the further development and resolution of rehabilitation rules would be required. Currently rehabilitation programmes are based on subjective methods used in the region, which are successful and this may form a good platform to contribute effectively in the rules introduction and modelling.

Some articulated rules to consider the fact that in the Southern district as may be the case in most regions / districts, not all the Scenario treatments triggered are definitely applied due to various logistic reasons. A Scenario rule option should be devised whereby when treatments are ignored and or replaced by remedial works such as reseals, the user can reprogram and run the Scenario analysis to evaluate the overall effect to the stakeholders and benefits that may be achieved.

For the accelerated development and optimisation of scenario tool and the Local regional /and or district Rules construction, Main Roads needs to have dedicated staff in every

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region/district who will coordinate the process including submitting feedbacks over a certain period.

To further compliment this process, they should step up the training and re-training of this staff benchmarking the standards/mission/suite of performance even at regional level. A case in point for the author while carrying out this Scenario analysis only attended three day training. This could be sufficient to start off but with no Scenario skilled persons in the Toowoomba office where I was based, there were difficulties / delays or even no response in liaising with the QDMR relevant personnel in Brisbane. For the future student interested in carrying out this works they should bear that in mind and probably be ready to establish immediate physical contacts with the Brisbane personnel. The author though received great technical and substantial ideals on Scenario from Mr. Phil Tweddell besides his busy schedule and that formed a great base for my proceedings analysis for my dissertation.

Note that the entailed methodology and direction of resolution for rehabilitation identification techniques is by no means just one of the ways of looking at the problems, and it is recommended that further considerations would have to be made. Finally all facts and write up was correct to the best of knowledge of the author and while containing researched material is meant for education purposes only and may require further detailed analysis.

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