University of Southern Queensland
Faculty of Engineering & Surveying

Investigation of Relationships between Skid Resistant Deficient Pavement and Aggregate by GIS and Statistical Analysis

A dissertation submitted by

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in fulfilment of the requirements of

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towards the degree of

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Abstract

The provision of a safe road network for the public is one of the areas of strategic focus of the Queensland Department of Main Roads. One aspect that facilitates the delivery of this objective is the maintenance of road pavement surfacings to a standard that reduces the risk of road related accidents. Efficient and effective management of skid resistance is one aspect that contributes to this accident risk minimisation goal.

Skid resistance is affected by a multitude of variables that relate to factors such as the vehicle, climate, and road surfacing to name a few. This dissertation will focus solely on those factors that relate to the road surface. The majority of this data is already stored in electronic form albeit in a variety of databases and formats so a computer based approach was logical. To enable effective analysis to occur it was necessary to integrate all data into a single environment. One way to achieve this is through the use of a Geographical Information System (GIS). GIS brings a powerful data integration mechanism through which analysis, presentation and enhanced communication may occur.

The project was based on data captured in June 2004 covering 978.3 km of the 1758 km of road network that Main Roads' Mackay District is responsible for in Central Queensland, Australia. The project resulted in the development of an integrated approach to the analysis of skid related issues. This was achieved through the use of rigorous and consistent processes that support effective and efficient skid resistance management practices in the District environment.

In time trends in the rate of deterioration of different aggregates, construction methods and seal types in different environments will be able to be established allowing better planning of maintenance activities. From this information guidelines will then be able to be produced for use in the Mackay District with the knowledge gained adding to the existing body of information within Main Roads.

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Signature

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Acronyms

ARMIS	A Road Management Information System
INP	Inner Wheel Path
OWP	Outer Wheel Path
BWP	Between Wheel Paths
STD	Surface Texture Depth
SRD	Skid Resistance Deficiency
TDist	Through Distance
DVR	Digital Video Road Viewer
GIS	Geographical Information System
DCA	Definition for Coding Accidents
LGA	Local Government Authority
MapInfo	MapInfo Professional
GDA	Geocentric Datum of Australia
SDRN	State Digital Road Network
SQL	Structured Query Language
VKT	Vehicle Kilometres Travelled
AADT	Average Annual Daily Traffic
SPTD	Sand Patch Texture Depth
PAFV	Polished Aggregate Friction Value
MapView	Departmental add – on MapInfo application
RIDC	Road Information Data Centre
ARRB	Australian Road Research Board

CHAPTER 1 INTRODUCTION

1.1 Introduction

The provision of a safe road network for the travelling public is one of the areas of strategic focus of the Queensland Department of Main Roads Strategic Plan 2004 - 2009. An important aspect that facilitates the delivery of this objective is the maintenance of a road pavement surfacing to a standard that reduces the risk of skid related accidents. Efficient and effective management of skid resistance is one aspect that contributes to this accident risk minimisation goal.

The Mackay District is responsible for approximately 1758 kilometres of state controlled road network that span six local government areas over a land area of 38,410 square kilometres. This project investigates a representative selection of these roads which total a length of 978.3 kilometres that were tested to determine their skid resistance in June 2004.

The skid resistance testing was undertaken by the Departments' Pavement Testing Unit using a Norsemeter ROAR Skid tester. This skid tester is a variable slip unit calibrated against units used in the Permanent International Associate of Road Congresses (PIARC) International Trial which provides a report in terms of International Frictional Index (IFI). This test apparatus carries out a wet test by spraying a film of water 0.5 millimetres deep on the road in front of the test wheel and gradually braking the wheel until lockup occurs. An average test covers approximately 10 to 15 m of road and in network survey mode, testing at 80 to 90 km/h, an average of 1-2 tests per 100 meters are carried out.

The report produced from this testing indicated that some sections of road were below their relevant investigatory levels and suggested that the underlying cause of these problems needed to be determined via further investigation. It is emphasised that there can be high variability in test results even where the same test equipment is used (Baran, 2005). Therefore the results should be considered solely as a highlighter of possible problem areas that require prompt inspection to determine whether treatment is required. The report identified that approximately 16% of the National Highway and 11% of other roads in the District returned results below the investigatory level. In the case of the National Highway the majority of the identified skid deficient areas were restricted to two sections in the southern part of the District. Initial examinations of pavement information in these areas indicated that the source of the problem appeared to be aggregate related and recommended that this problem be further investigated. This projects aim is to carry out the further investigation suggested on these and other sections to determine the apparent primary and supplementary underlying causes in each case.

Skid resistance deficiency is often the result of several factors in combination rather than an individual factor. Skid resistance was described by Oliver (2002) as a term indicating how well vehicle tyres grip the road. Factors that may contribute to skid deficiency include seal age, surface texture, seal type, environment (climatic), traffic volume and mix, speed environment, road geometry, roughness, vehicle related factors and aggregate properties to name a few.

For example we may find that an area that is identified as possibly skid deficient also has a seal age of seven years, and marginal surface texture. Examination of the proposed maintenance works program may indicate that this section is due to be treated in the immediate future due to other intervention triggers such as age. This may indicate that the section is nearing the end of its design life.

Importantly, similar sections younger than the problem section can then be compared to establish whether the treatment interval is appropriate for the particular situation. This allows expected performance to be compared to actual performance which over time will allow informed management practices to be developed. It is emphasised and acknowledged that pavements are affected by a range of inconsistent factors during their lifetime. Therefore it is likely that only generalist guidelines will be developed which may be of assistance as a support for decision makers.

The pavement surface forms a critical component of the road network as it is what the end user physically drives on and although lack of skid resistance does not prevent usage of the network its presence is vitally important to the safety of road users.

This project seeks to identify the sources of skid deficiency on the network, suggest various options to mitigate any identified issues, and develop a uniform process which, if followed, will allow consistent monitoring of performance, development of standard practices, and aid in the decision making processes for construction and maintenance resources in Mackay District.

1.2 Aims and Objectives

The aim of this project was to establish relationships between sections of pavement with identified deficient skid resistance and their aggregate properties through the use of a Geographic Information System (GIS). MapInfo Professional was utilised to deliver the GIS components of the project as this software allows the detailed analysis to be undertaken and communicated in a user friendly way.

An additional aim of the project was to investigate the application of the methodology developed and findings to the remainder of the road network to determine whether predictive analysis can be applied. This will facilitate establishment of appropriate reseal intervals that ensure that adequate skid resistance is maintained for each pavement type. It is anticipated that before confirmation and adoption of the methodology can occur a second field collection of data will be required. This data is unlikely to be received in the District until after the submission of this dissertation.

By delivery of this project through a GIS environment the integration of a wide range of data from various sources into a cohesive and powerful decision support tool was achieved. The visual aspect of the GIS environment enhances communication and comprehension of the information required in a very simple and efficient manner.

Specifically the objectives of the project were:

1. Formatting, collection and collation of various data and information on pavement and event characteristics on selected road sections within the Mackay District of the Queensland Department of Main Roads
2. Development of a spatial information system to allow integration, analysis, presentation and assessment of a wide range of road related parameters and in particular skid resistance.
3. Design various processes that maximise the usage of the data in the system to assist in decision and prioritisation analysis support and works program development.
4. Design a user friendly interface that allows a variety of Main Roads staff with limited GIS knowledge to access the system, and
5. Design analysis tools that produce various prioritisation reports required for district operations

1.3 Expected Outcomes

In June 2004 Mackay District commissioned the Departments' Pavement Testing Unit to carry out a Skid Resistance Survey of selected sections of roadway. This project builds on the previous analysis and research that was completed in that survey. The report indicated that various sections of roadway in Mackay returned results lower than the relevant investigatory levels and were therefore possibly skid resistance deficient. It was concluded by Baran (2004) that the likely reason for this apparent deficiency was related to the properties of the seal aggregate used. It is expected that this finding will be confirmed by this research.

As this was the first collection of skid resistance data in this District the best way to examine the data in terms of effective and efficient analysis needed determination. A methodology with defined investigatory levels had been established by Baran (2004) but the evaluation methodology to deliver the assessment of relative priorities had not. As skid resistance is affected by many factors the final solution required the ability to integrate, query, analyse and present data in an easy to understand format. These features are all available in the GIS environment. An expected outcome of this project is the development of a GIS system to facilitate delivery of these needs.

It is unlikely that any single contributing factor will account entirely for the skid resistance or lack there of on a particular section of road. However, it is important to understand what the primary underlying causation is in each case so that should a particular consistent problem be identified it can be addressed through informed management in future works. In this way asset lifespan may be enhanced and efficient and effective asset management may take place.

Underlying causes of skid deficiency can arise due the following factors either individually or mostly likely in combination (Oliver, 2002);

- Surface Texture is inadequate due to stone loss, flushing, and so on;
- Aggregate Polishing through normal service wearing;
- The above two factors often become a factor as the Seal Age increases;
- Construction issues relating to seal type, spray rates, and so on;
- General pavement condition - roughness, rutting, patching and so on;
- Vehicle related factors – speed, tyre construction, wear, tread and inflation pressure;
- The particular binder used can affect the skid resistance properties of an aggregate;
- Traffic environment including volumes, percentage of heavy vehicles, and so on; and
- Climatic factors including regularity of rainfall and aggregate reactivity.

In general, it is expected that for this project the majority of issues identified will be age related. This project will also examine various combinations of relationships to establish what, if any correlations and effects are present between factors. The spatial nature of the system should highlight any problems relating to aggregate source through the geographical position of problem areas.

It is expected that the process developed will be able to be used across the Region to evaluate this information and thereby improve asset maintenance and management practices.

1.4 Overview of the Dissertation

Chapter 1 covers the introduction, aims and objectives, and a brief summary of the expected outcomes of this project.

Chapter 2 encompasses the literature review with an introduction and discussion on the importance and value of skid resistance data to the Department. Topics covered include asset implications, discussion on significance of relationships, prioritisation, data, and systems.

Chapter 3 provides the background to the project and a description of the environs of Mackay around which the project is centred

Chapter 4 covers information on the project data, its' sources, manipulation, quality issues and the effects these have on the project. This chapter also discusses the software used to deliver the project

Chapter 5 describes the methodology and procedures utilised in the delivery of this project.

Chapter 6 surmises the conclusions that resulted from the project, as well as commenting on the benefits of the project and possible future works.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

Main Roads recognises the importance of the provision of adequate infrastructure to support the road transport needs of Queensland. As the funding available to develop, maintain and enhance the road network is finite in nature it is important that decisions for works are based on appropriate priorities to ensure the maximum benefits for Queensland are realised. The road network and its' associated infrastructure has a total asset valuation in excess of $20 Billion (Main Roads, Annual Report 2003 – 2004, 2004). With total annual funding of approximately $2.3 Billion provided to carry out all works required on the 34,000 kilometres of network efficient and effective management is required to ensure that an adequate and safe network is provided to the people of Queensland (Main Roads, Annual Report 2003 – 2004, 2004).

As the majority of the network in the state is currently in a stable location the road network could be described as relatively mature. That is, today there are comparatively few main roads being built on new alignments compared with the past. A large proportion of funding is therefore focussed on maintaining and enhancing the existing asset. A key indicator used to prioritise funding is obtained through the measurement of pavement performance against various standards and parameters such as roughness, rutting, surface texture, and so on.

Road Safety is identified as a specific area for strategic focus in the Department of Main Roads Strategic Plan 2004 -2009 (Main Roads, 2004). A key initiative established to deliver the objectives of the Strategic Plan in terms of asset management related activities is the Road System Manager (RSM) framework. RSM provides a framework through which consistent understanding of asset management issues and implications on departmental business may be gained through the development of a Road System Performance Plan (RSPP). An RSSP focuses on maximisation of whole of life performance, having regard to safety, road user costs, community benefits, and Main Roads outlays.

Main Roads North Queensland Region based in Townsville published a strategy that addressed a wide range of factors that relate to outcomes identified by RSM in September, 2004. Element 29 of this strategy relates specifically to management of skid resistance. It provides guidelines and a vision for assessment, prioritisation, management, and performance measurement of skid resistance. In the development of this project the outcomes and strategies identified in the North Queensland solution were considered.

Pavement performance, both actual and expected is analysed using, along with other systems, a departmentally developed package called Scenario Millennium. This package uses a set of generic intervention levels and expected deterioration models determined on both a state wide and local level to prioritise sections of pavement that need treatment. The package is able to be used to analyse different scenarios and their effects. For example, what the effect of various changes to funding would have on the networks' condition. It is emphasised that all the systems involved including Scenario Millennium do not make the decisions, but rather provide information that allows focused investigation of possible problem areas by experienced engineers and managers. These people must take into account a variety of factors including, expected deterioration, available funding, political, legal and social implications to name a few in deciding the ultimate treatment priorities.

Whilst Main Roads experiences in asset management and valuation are still in a state of continued evolution, strong base methodologies have been enacted that provide a clear direction for the future management of the network. This future is likely to involve greater integration of information, data analysis, and reporting through computer systems that enable the best outcomes to meet the requirements of the Department and Queensland.

2.2 Terminology

Asset management has become an area of intense focus in road network management. To enable a clearer understanding of the significance of this topic it is necessary to examine the context of what is meant by this terminology.

Asset management was defined by the Departments' Roads Information Branch (2001) as consisting of four key elements:

- Knowledge of how the system is performing including
    - Condition
    - Traffic
    - Maintenance dollars input;
- Understanding of pavement technology and how pavements perform in service;
- The ability to convert this information into whole of life costs and benefits to the community at large; and
- Knowledge of how the road system can be expected to perform in the future, under varying funding / traffic scenarios.

These elements all provide a framework within which the road, its condition, usage, maintenance and stratagem to improve its performance can be managed.

Main Roads developed a Road Asset Maintenance Policy and Strategy (RAMPS) in 1999 which covers the maintenance of all State-controlled road assets. This policy defines the road asset as the pavements, bridges, surfaces, formation, drainage structures, traffic control systems, signage, and other associated infrastructure. Road Asset Maintenance is defined by the policy as preservation of the serviceability, load carrying capacity, and safety of the road asset throughout its service life and beyond. The policy describes an asset lifecycle which is depicted in Figure 2.1.

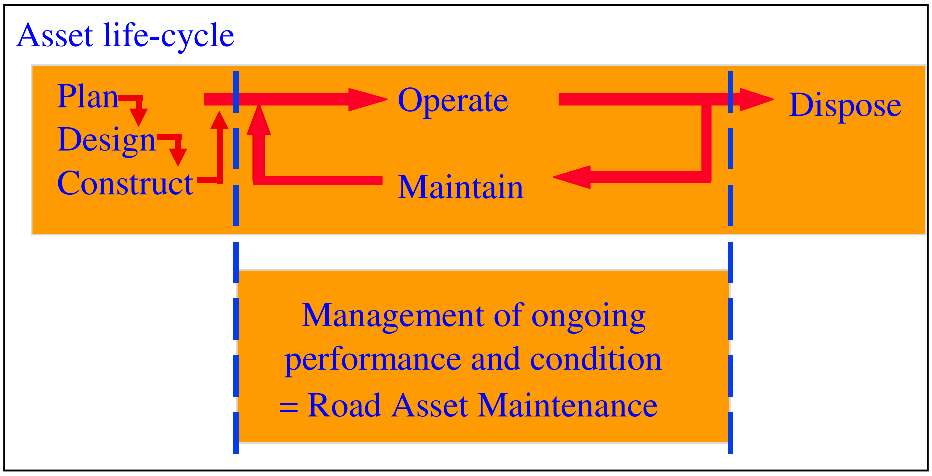


Figure 2.1 Asset Lifecycle (Source: Road Asset Maintenance Policy and Strategy, 1999)

The effect that the asset lifecycle has on a particular road section relates to the decisions made based on costs, expected deterioration rates, traffic environment including any foreseeable changes, set trigger points for treatment, and past experience in that environment with similar treatments.

2.3 Definitions

It is necessary to define the more tangible inputs that comprise the pavement so that their effects on the outcomes of the project may be understood.

Pavement is defined as the portion of the road, excluding shoulders, placed above the subgrade level for the support of, and to form a running surface for, vehicular traffic (AUSTROADS, 1992). Subgrade level may be defined as the point of deepest excavation of the natural landscape which forms a foundation surface on which the pavement rests. Pavement is made up of several components of which the most significant for this project is the pavement surface which is composed of aggregate and bituminous binder.

Aggregate may be defined as the predominantly uniform sized granular rock that forms part of the pavement surface in road construction. The aggregate used on all Main Roads projects is supplied to a standard specification which addresses issues such as cleanliness, uniformity of size, shape, hardness, durability, resistance to polishing and resistance to weathering. However, there are also local factors that affect the aggregate performance in service including climatic conditions, traffic environment, and reactivity to name a few. Several of the properties of aggregates are important to the provision of adequate skid resistance and are now discussed.

Surface texture of an aggregate is important on two levels, namely microtexture and macrotexture. Microtexture refers to those aspects of the aggregate that are less than 0.5 mm (Oliver, 2002) whilst macrotexture refers to those aspects between 0.5 mm and 50 mm. Microtexture is key to skid performance as aggregates with a harsh microtexture can break through a water film to give adhesion and therefore offer better skid resistance than those with a smooth microtexture (Oliver, 2002). Further, microtexture is responsible for provision of adequate friction to allow the manoeuvring of a vehicle (Baran, 2005) Macrotexture is important as it allows paths for water on the pavement to escape from the roadway. If there is a lack of escape paths for water the skid resistance available decreases (Oliver, 2002). The degree to which stone stands proud of the binder surface will also have a large effect on available pathways. Kwang et al (1992) advise that macrotexture's contribution to skid resistance is particularly important in high speed environments. These two properties are the key to the provision of adequate skid resistance.

A significant factor in the skid performance characteristics of an aggregate relate to its resistance to polish. Polishing of aggregates occurs through the abrasive action of traffic on the surface material. This has a tendency to smooth the aggregate and thereby reduce its desirable microtexture properties and hence reduce available skid resistance. An aggregate that polishes too readily will rapidly lose its microtexture and this will result in a shorter than desired service life.

The Standard Specifications for Aggregates specify a Polished Aggregate Friction Value (PAFV) which should provide aggregate that has adequate resistance to polishing. The PAFV, also known as Polished Stone Value (PSV) provides an indication of how susceptible an aggregate is to being polished through wearing. Baran (2005) advises that the PAFV test does not necessarily reflect in service PAFV levels. Further that a high PAFV does not ensure a high skid resistance. Baran (2005) concludes that PAFV is useful in ranking aggregates but it cannot be used to predict skid performance. Oliver (2001) advises that in Australia very high PAFV stones are not available and this is compounded by a shortage of moderately high PAFV aggregates. Consequently this factor may be the underlying issue in those areas which have returned results lower than the investigatory level. The pavement surface type also has a significant role to play in provision of skid resistance.

For this project the pavement surface types have been divided into two broad categories, namely asphalt and chip seal. Asphalt seals form a complete pavement layer and in many cases form a structural part of the pavement and are consequently quite thick (minimum of 40 millimetres – considered structural once >80 mm thick) whilst chip seals are generally a thin veneer like surfacing that protects the underlying base coarse material. Generally chip seals will have a greater surface texture depth whilst asphalt will provide a greater area of contact at the road tyre interface. The characteristics of these two broad surfacing groups are quite different in relation to skid resistance and therefore must be considered separately.

As aggregate ages in a pavement it gradually becomes more polished through wear and hence skid resistance decreases. There are a variety of factors that can affect the in service performance of the aggregate including the binder used, environmental factors, and the heavy loads that the pavement is subject to (Baran, 2004). The biggest in service contributor to polishing comes from heavy loads which can dramatically reduce the microtexture of the aggregate (Oliver, 2004). Thus an aggregate that may meet the specification in terms of PAFV may have a lesser than expected service life if it is exposed to certain environments.

Seal related properties may affect skid resistance in several ways. Firstly, the nature of the seal itself including aggregate size, and bituminous binder type may have an effect on the skid resistance. Aggregate size will naturally affect the macrotexture of the pavement surface with a larger stone generally providing more pathways for water to escape. The contact area at the tyre / road interface may also be significantly different between different aggregate size and pavement surfaces. Bituminous binder oxidises as it ages, thereby changing its' properties. This often results in the pavement becoming brittle which may result in cracking and stone loss which can in turn affect skid resistance properties through loss of contact area and macrotexture. Baran (2005) advises that skid resistance on newly treated road sections can also be affected by the type of binders used with polymer modified binders taking longer to wear off and therefore allow exposure of microtexture. These factors will vary for each combination and treatment type and are beyond the scope of this dissertation.

Seal age is defined as the period of time that has elapsed since a pavement surface was opened to traffic (Main Roads, 2002). Seal age is important because over time several changes can occur that affect the available skid resistance. These include loss of stone, impaction of stone, polishing of the stone through wear and tear, possibly flushing, increased roughness, oxidation of the bituminous binder, and rutting. The majority of these topics have already been discussed with roughness and rutting to be addressed later.

Flushing is defined by Transit New Zealand (2002) as a low textured road surface due to the upward migration of binder, reducing macrotexture. Thus surface water has fewer pathways through which to escape and resultant skid resistance is generally lower in a flushed pavement. An indicator of skid resistance deficiency may be the occurrence of aquaplaning and this is more likely to occur on flushed pavements where drainage pathways are minimal.

Aquaplaning or hydroplaning may be defined as the partial or full loss of contact between the tyre and the physical road surface due to surface water which removes any braking or cornering control from the vehicle operator (Oliver, 2002). Aquaplaning is therefore the result of insufficient macrotexture. Aquaplaning should not be confused with inundation of the road surface through ponding or cross pavement flows when assessing skid resistance. Whilst both involve a depth of water that results in a loss of traction the underlying cause is slightly different. The latter is more likely related to cross pavement drainage, or rutting issues rather than a skid deficiency issue. In both cases prompt inspection and treatment to mitigate the issue are required.

2.4 Asset Implications

In 1997 AUSTROADS published a Strategy for Improving Road Asset Management Practice which suggests that asset management comprises the elements shown in Figure 2.2.

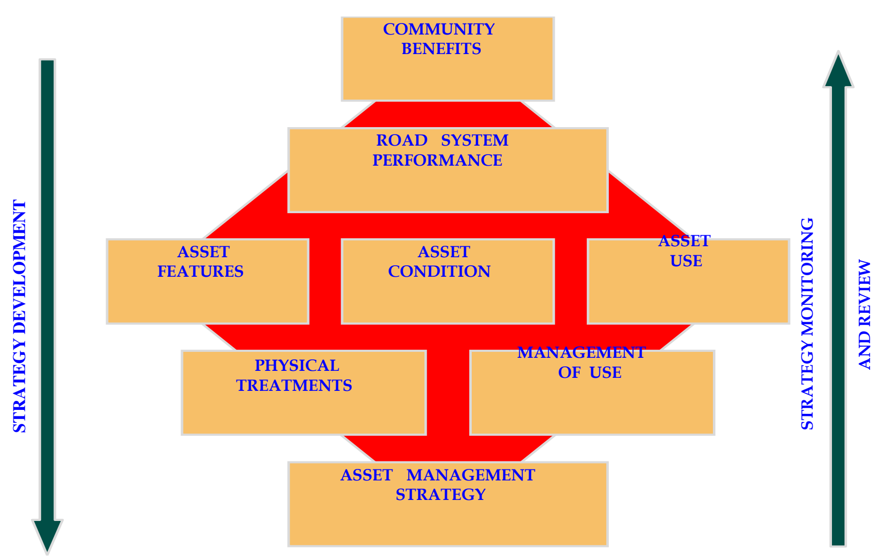


Figure 2.2 Elements of Road Asset Management

This view has been adopted as part of the departmental RAMPS initiative. The RAMPS initiative utilises the elements described in the figure by focusing on the effective delivery of benefits to the community. The main streams of asset management identified by RAMPS include:

- Identification of the need for an asset based on community requirements;
- 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 required or appropriate

Therefore effective management of the road asset is reliant on a complete picture of the factors impacting on the asset throughout its lifecycle. This project will provide an additional source of input into the asset management process and maintenance programs through a greater understanding of in service capabilities of pavements.

2.5 Skid Resistance

Skid resistance was described by Oliver (2002) as a term indicating how well vehicle tyres grip the road. Baran (2005) supports this view by defining skid resistance as the contribution the road surface makes to the available friction at the road / tyre interface. This premise will be adopted for this project.

Investigations into skid resistance have been carried out across the world with much research carried out in Europe and North America. Much of this research was carried out on concrete pavements and in climatic conditions vastly different from those in Australia. The significant relevant factors from this research are possible solutions with which to mitigate problem sections as well as the development of standard skid resistance testing and in particular the derivation of the International Friction Index (IFI). In May 2005, Baran presented findings from the International Surface Friction Conference – Roads & Runways held in New Zealand which suggested that IFI appeared to be the best performance indicator for high speed roads based on a trial at the Sydney Airport. The majority of the roads controlled by Main Roads are in high speed environments so this choice is logical.

Baran (2004) advises that the IFI has two components, F60 and SP.

- F60 is the standardised friction measure (friction factor) at a 60 km/hr slip speed.
- Sp is the gradient of the friction versus slip speed relationship and is an indicator of the speed dependency of the recorded friction value. Because F60 is dimensionless Sp (expressed in km/hr is generally referred to as the speed number. The Sp value is only used to adjust the tolerable F60 where slip speeds other than 60 km/hr are adopted.

Queensland Main Roads has developed Investigatory Criteria, based primarily on the VicRoads / RTA Investigatory Criteria, for three skid resistance demand site categories (Table 2.1) (AUSTROADS, 2005).

Skid Resistance Demand Category	Description of Site	Investigatory Levels F60*
High	Curves with radius < 100 m. Roundabouts. Traffic light controlled intersections. Pedestrian/school crossings. Railway level crossings. Roundabout approaches.	**0.35**
Intermediate	Curves with radius < 250 m. Gradients > 5% and > 50 m long. Freeway and Highway on/off ramps. Intersections	**0.30**
Normal	Manoeuvre – free areas of undivided roads. Manoeuvre – free areas of divided roads.	**0.25**

*These base levels are for a 60 km/hr slip speed (appropriate for 60-80 km/hr speed zones).

Table 2.1 Investigatory Friction Levels (Source: Baran, 2004)

Baran (2005) further advises that the investigatory levels presented in Table 2.1 are only considered appropriate for 60 – 80 km/h speed zones. Because skid resistance is dependant on slip speed, this criteria needs adjustment for other speed zones. Adopted slip speed for speed zones are presented in Table 2.2.

Gazetted Speed (km/hr)	110	100	90	80	70	60	50	40
Adopted Slip Speed (km/hr)	80*	80*	70*	60*	60*	60	50	40

*Assumes good visibility and some speed reduction occurs before panic breaking

Table 2.2: International Friction Index Slip Speed Categories (Source: Baran, 2004)

Base F60 levels require upgrading in speed zones of 100 and 110 km/hr to reflect the lower skid resistance available in these high speed environments (Baran, 2005). Conversely in low speed zones, Investigatory Criteria can be relaxed as greater friction is available at low slip speeds. For speed zones other than 60 – 80 km/hr Baran (2005) advises that the F60 criteria requires adjustment through applying the PIARC relationship of

$$F(S) = F60.e^{(S-60)/Sp}$$

Where S = the adopted slip speed (refer to Table 2) and

Sp = speed number (speed dependency of friction measure)

Whilst the investigatory levels have been established a process to prioritise the areas identified in terms of overall pavement performance has not and this is one of the key objectives of this project. It is emphasised by Baran (2005) that there can be high variability in skid test results even where the same test equipment is used. Therefore the results should be considered solely as a highlighter of possible problem areas that require inspection.

2.6 Relationship between accidents and skid deficiency

Road accidents are unfortunate events that have occurred since the first automobile and will continue to occur irrespective of our efforts to stop them. It is commonly acknowledged by all the research papers examined that inadequate skid resistance will normally lead to higher incidence of skid accidents. All the research material also acknowledged that skid resistance generally decreases in wet conditions through the reduction of friction available. For this reason skid testing is always carried out utilising a wet test environment (Summers, 2004). Typical factors underlying the contributing causes of wet weather traffic accidents are presented in Figure 2.4 below (Baran, 2005).

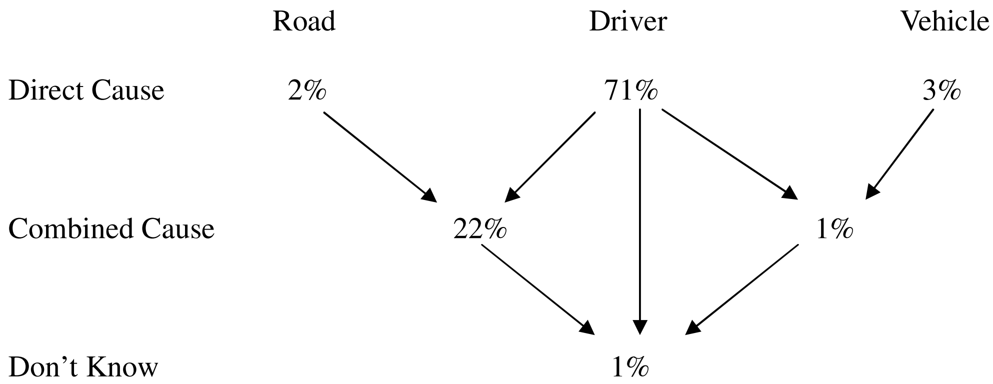


Figure 2.3: Accident Causation Factors (Source: Baran, 2005)

It is apparent from this research that although a very low percentage of accidents are directly attributed to the road there are a significant percentage of combined causes. These statistics support the need for regular monitoring of road surface conditions one of which is skid resistance to ensure that a maximised level of road safety is delivered.

Oliver (2002) advises that accidents are generally the result of a chain of events rather than a single factor. Factors may include driver fatigue, late detection of traffic devices, wet pavement with poor skid resistance, loss of control when braking, driver experience, and vehicle related factors such as tyre tread to name a few. This chain of events may be broken at many points which may avert or reduce the severity of the accident. The speed involved in a crash may have a significant effect on the outcomes (Oliver, 2002). Oliver (2002) concludes that by improving the skid resistance a significant reduction in speed can be achieved which is likely to have a substantial effect on crash outcomes. There are three main approaches used to examine the relationship between skid resistance and accidents (Oliver, 2002);

1. comparison of high accident sites with average;
2. correlate accidents and skid resistance; and
3. comparison of accidents that occur before and after treatment to improve skid resistance.

This project predominantly uses the second approach however an investigation of those sites on the network with high accident rates was also undertaken. Other indicators such as police reports were reviewed to establish whether skid resistance issues were apparent. It is emphasised that as part of normal Departmental operations all police accident reports are reviewed and if necessary investigated to ensure that any road related factors are identified and when appropriate remedial action is promptly taken. This is particularly the case where any possible road related factors are cited in the report. As there is an established correlation between skid resistance and accidents this comprises an important aspect of this project, of the provision of a safe road environment, and of asset management as a whole.

2.7 Risk Management and Legal Liability

The Queensland Department of Main Roads is defined as the legal custodian of the declared State Controlled Road Network and as such has certain obligations and responsibilities in relation to the network, its users and the infrastructure that it comprises. A key aspect of these responsibilities relates to the departments duty of care to the public with respect to the planning, operation, and maintenance of the network. In the past, all State Road Authorities (SRAs) in Australia were protected by legislation from charges of negligence. However decisions in the High Court on 31 May 2001 (Singleton Shire Council vs. Brodie and Hawkesbury Shire Council vs. Ghantos) mean that SRAs may be subject to common law negligence or non feasance (Oliver, 2001). It is acknowledged that the road does not have to be perfect but demonstration that reasonable measures have been taken to maintain a standard is required. Therefore failure to discharge this duty of care in an appropriate manner may result in the department being exposed to litigation if it or its agents are seen as negligent in their actions in a particular instance and set of circumstances.

As a methodology to minimise and manage risk the Department has always carried out regular field inspections and evaluations of how the asset is performing, sought to proactively identify potential problem areas, and expediently address any issues found. An area of strategic focus for the Department is the provision of a safe road network which is addressed through the Road Safety component of the Road System Manager framework.

Risk management was defined by DETIR (2000) as the identification, assessment, development and implementation of control measures and review of potential hazards that may arise during the execution of a task. The key factors in managing risks associated with skid deficiency are multi-faceted and as such vary from case to case. However, by the use of investigatory levels that relate to the specific environment it is possible to identify potential problem areas. This information when combined with field inspection, engineering input, other pavement information and parameters allows the relative priorities of each road section to be effectively evaluated.

A key aim of this project will be the development of a methodology to assess relative skid deficiency priorities. This approach should facilitate the realisation of a strategy that encompasses a wide range of factors and enables maximum benefits and outcomes for the general public. Decision makers will have a clear picture of the impacts that skid resistance has on the network and the underlying factors that need to be managed to ensure that the risks in these areas are either mitigated or removed in an appropriate and timely manner. This results in the added benefit of reducing the risk of litigation and follows the ideals of the asset management philosophy.

2.8 Surface Deterioration

Pavement surfaces naturally deteriorate as they age due to a wide range of factors in their service environment. This usually results in a loss of both microtexture through the polishing effect of traffic and macrotexture through stone loss or impaction, pavement flushing and wear (Oliver, 2002). These factors are affected by the characteristics of the pavement surface, climatic, and traffic environment. It is critical for effective asset management that strategies are in place that allow prioritisation of areas so that desired standards may be maintained. This is achieved through the use of a Pavement Management System (PMS) which identifies the nature and timing of pavement treatments (Main Roads, 2001). Main Roads developed Scenario Millennium which is such a PMS. Scenario Millennium utilises a set of predetermined trigger points and expected deterioration rates related to various attributes of the pavement to devise a list of priorities. The information extracted from this system is utilised to aid in the decision making processes for the maintenance works programs. This system does not currently consider skid resistance in the development of priorities. Skid resistance is a pavement attribute that has a valid role in the prioritisation of road maintenance works programs (Oliver, 2002).

2.9 Aggregate Treatments

If the goal of effective and efficient asset management is to be achieved, it is vital that the most appropriate treatments for each situation are utilised. A key aspect of this is the monitoring and evaluation of in service pavement performance against expected standards. The aggregate used has a significant role in the performance of a particular treatment and is assessed against a detailed specification. In most cases there is a variety of differing treatment options available to the Engineer, each of which will provide different qualities in the finished product for varying costs. Different treatments may also involve different aggregate mixes and so significant differences can occur based on the treatment used. If a treatment is ineffective there is recognition that the practices in place require review to ensure that performance is maintained and inefficient practices cease. It is also vital that a complete picture of all desired performance parameters of the pavement is gained to facilitate a solid decision making process.

Baran (2005) advises that there are a variety of different treatments available that generally focus on improving the micro and macrotexture of the pavement thereby increasing the skid resistance available. These include;

1. High pressure washing of the existing pavement to improve the available pathways through which water can exit the pavement. Figure 2.4 shows an example of the results of this treatment type. Note the greatly improved macrotexture on the treated (right side) of the photo. This treatment is quite expensive, but is also effective in extending the useful life of the surface. There are some additional negative effects related to the reduction of binder in the pavement which may allow moisture penetration into the underlying pavement;
2. Calcinated Bauxite is added to the regular aggregate mix. This material is very durable and has a high microtecture and macrotexture quality. It is however expensive;
3. Grooving of the pavement using a pavement profiler to create additional drainage pathways. This treatment is primarily utilised on concrete and asphalt surfaces to improve macrotexture; and
4. Carrying out a secondary seal with smaller rock of the same material which improves skid resistance through additional tyre / pavement contact area whilst maintaining similar macrotexture properties.

Figure 2.4 Results of High Pressure Washing (Source: Main Roads, Emerald)

It should be noted that mitigations other than reseals are also used to manage skid resistance. Measures such as warning signage, speed restrictions, changes to cross pavement drainage, and reducing manoeuvring demands all play important roles in the management of skid resistance.

The Department is constantly examining ways to improve pavement performance through research by the Pavement Testing Unit and field testing and trials of various treatment options by Districts. The findings of research are regularly disseminated throughout the Department so that optimal practices are maintained. Aggregate treatments and selection of the right aggregate for the particular environment are critical to the in service pavement and skid resistance performance.

2.10 Prioritisation Determination

A risk based intervention strategy is utilised by Main Roads throughout the majority of its management systems. In the case of skid resistance, departmental investigatory levels have been established for differing environments. However, pavement maintenance prioritisation involves a wide variety of factors some of which are based on subjective assessments. One of the expected outcomes of this project is to establish any trends between various pavement factors. For example, a trend where the skid deficient sections are all over a certain age on a certain section of road may indicate that the expected useful pavement life has been exceeded, especially if other indicators are also poor. In this way the treatment regime for the particular environment may be adjusted.

Prioritisation of pavement sections is therefore a multi facetted process with those sections that have multiple issues identified being likely to be targeted for treatment prior to those that have one defect. For example, if all skid deficient pavement on a particular road section is over a certain age, has high roughness and deep rutting it is likely to receive a higher priority than a section which has just one of these factors.

When the skid data is received from the field it is evaluated to establish whether there are any sections requiring immediate investigation (Baran, 2004). This initial investigation involves checking the sections for any apparent skid related accident history, visual inspection, checking whether the section is programmed to be treated, and comparison against other pavement parameters (Main Roads, 2004). As previously discussed all road accidents and in particular those where the road condition has been cited as a possible contributing factor in the police report receive prompt investigation with any remedial works required carried out as soon is practical. The skid data is also examined to ensure that an appropriate IFI has been used for each section as the data is not adjusted for sections where the practical speed is lower than the gazetted speed. Therefore where a mountain range section exists for example that is able to be negotiated at a maximum speed of 60 km/h yet the gazetted speed of the road section is 100 km/h the IFI used may be incorrect resulting in a deficient section being identified where there is none. This is because the field capture does not take into account advisory speed signs that exist within the gazetted speed zones. Appropriate prioritisation of problem areas of the road network is a key factor in the delivery of effective and efficient asset management.

2.11 Monitoring of Situation

This project is based on the first skid resistance data captured in Mackay District and as such this data will form a base for comparison with future capture programs. It is anticipated that over time trends will be able to be determined that will allow useful life guidelines to be determined for each aggregate and construction methodology combination. How these expected useful life guidelines will compare to other existing treatment triggers is unknown.

Oliver (2002) suggests that for surfaces greater than five years old it is important to monitor whether the crash rate is high or increasing which may indicate that skid resistance is becoming an issue. There are a range of factors that affect the rate of deterioration of the road surface such as traffic environment, climate, aggregate properties and construction method to name a few and so it is important to proactively monitor the condition state of the road asset.

2.12 Other Factors

Oliver (2002 identified a variety of other factors that may significantly affect the roads skid resistance properties. These include climate, traffic environment, tyres and construction methods each of which will now be briefly discussed.

Climate has several potential influences. Oliver (2002) advises that skid resistance can improve when regular rainfall occurs as the pathways through the pavement and microtexture of the aggregate are cleaned. Conversely during long dry periods skid resistance may reduce as the surface becomes clogged with detritus material and the stone polished. Oliver (2002) also advises that as temperature increases skid resistance tends to decrease. Baran (2005) advises that although limited data is available for Queensland conditions it is apparent that the effects of temperature appear minimal. This finding was based on an ARRB study (Oliver et al, 2002) that concluded that in all states except Queensland, there is substantial seasonal variation in skid resistance. Baran (2005) concluded that no correction for temperature need be applied when considering skid resistance in Queensland.

Reactive aggregates and environments may also affect the performance of a pavement through chemical reactions that affect the durability of the aggregate and thus its susceptibility to polishing and failure. These agents may also affect the binder through chemical reactions. These issues are normally considered and where required addressed during seal and pavement design.

The volume and type of traffic can have a significant effect on skid resistance. Main Roads attempts to compensate for the traffic environment related issues through the design of appropriate pavements. Oliver (2002) commented that sudden changes in traffic volume can also change the skid resistance properties of a section of road. Oliver (2002) advises that heavy vehicles are a major cause in the loss of microtexture in pavement surfaces through polishing. Skid resistance properties also vary considerably between pavement types and hence construction methods adopted will affect the useful life of the road section. Appropriate pavement design should minimise these issues.

Vehicle tyres have a crucial role to play in skid resistance as they are the point of contact between the vehicle and pavement surface. Factors such as the construction of the tyre, tyre wear, rubber in tread and inflation pressure all affect skid resistance (Oliver, 2002). As these factors are variable and no data is available on the test sections on these parameters they are acknowledged but will not be considered further in this dissertation.

2.13 Geographic Information System

Geographic Information Systems (GIS) are a powerful set of tools that facilitate the capture, input, data management (storage and retrieval), manipulation and analysis, and outputting of geographical data (Clarke, 1997). Geographical data may be described as data about an objects' spatial position relative to a known reference system, its relationship to other objects around it, and its associated physical attributes. GIS differs from other information systems such as spreadsheets through its ability to deal appropriately with spatial information which these other systems do not adequately cater for. GIS allows greater visualisation and enhanced communication than the tabular displays of other systems through its ability to create easy to understand map and graphical outputs. The ability to share maps through the digital environment whilst maintaining the ability to produce hard copy outputs is another key advantage of these systems.

The integration of a wide range of data into a single cohesive framework that allows the viewing of relationships between various attributes is a powerful feature of GIS which can facilitate informed decision making based on a broad view. The data used can be accessed in both tabular (textural or numeric) or geographical form (map objects) which allows collation of a wide range of information. Documents may also be 'hot linked' as attachments to map objects which allows more information to be accessed at the click of a button from within the package. GIS also offers an ability to query and interrogate spatial and statistical data based on user defined scenarios which may aid in decision making processes. The power of GIS as a data integrator, analysis and presentation tool make it an ideal choice for this project.

The GIS package utilised for this project is MapInfo Professional Version 7.5 which is a desktop level mapping application. This package provides the level of functionality required for this project in a user friendly manner and is currently widely available across Main Roads through an unlimited usage corporate licensing agreement. Over a period of time Main Roads has developed a series of tools to assist in the use of MapInfo for departmental needs. These tools are collectively known as the "Nerang Applications" in recognition of the District where the majority were developed. Main Roads asset information is currently based on a linear reference system and these tools utilise dynamic segmentation to produce the graphical representations of this data along the relevant road section.

In a linear reference system characteristics are described and located based on the distance along a linear feature, in this case a road. This approach to the mapping of data provides a viable conduit by which road asset data may be associated with other geographical data to enable effective and efficient decision making.

2.14 Spatial Data Integration

Spatial data integration is one of the key advantages of the GIS approach to this project. Not only in terms of the combinatorial ability to display the data but also because of the wide range of reporting formats available to enhance and communicate information on the particular focus of the display. A key benefit of integration is that the end user can visualise and gain an insight and clear understanding of complex relationships between the different datasets at a level that is not as available in traditional non-spatial databases. The strength of the GIS environment is the ability to bring data together into a single environment. This is particularly important for aiding in understanding multi facetted problems such as skid resistance.

2.15 Conclusions

The Department recognises that the delivery of a high level of road safety and services to the people of Queensland is achievable through the efficient and effective maintenance of the road asset. Asset management's influence on the operations of the Department is ever increasing and is the key to the delivery of this objective.

Main Roads and indeed all state road authorities have legal and moral obligations to proactively identify and manage all risks that may occur through the operation of their networks. These obligations include ensuring that strategies are implemented that outline identification, management, investigation, and remediation of defects in an appropriate manner. Main Roads has provided guidelines to address the gamut of road asset management issues through its Strategic Plan and Road System Manager Frameworks.

The testing and evaluation of skid resistance data is one aspect which can contribute to the delivery of a safe road network. Skid resistance of road pavements is a complex issue due to the wide range of factors that influence this attribute. Investigatory levels have been adopted with respect to the acceptable minimum skid resistance recommended for each road environment. It is critical to note that a test of skid resistance that indicates a section does not meet the relevant investigatory level only indicates that immediate investigation is warranted.

GIS allows effective management of spatial data and is an ideal platform for the examination of road asset information. Data integration facilitated by the GIS environment allows the development of a more complete appreciation of the state of the asset by the end user through bringing together many factors into a single environment. The visual impact of a map which shows how different factors interrelate enhances communication and understanding of the relationships being examined in ways not easily achieved through other means. The GIS environment provides a powerful tool for end users in the delivery of efficient and effective asset management.

CHAPTER 3 STUDY AREA

3.1 Introduction

The Mackay District located in the Central Queensland Region of the Department of Main Roads is one of fourteen Districts that combined form four Regions that cover the entire state of Queensland (Figure 3.1). The other regions are Northern Queensland, Southern Queensland and South East Queensland.

Examination of the State Digital Road Network indicates that there is currently approximately 255,000 kilometres of road casements in Queensland. Of this figure approximately 175,000 kilometres contain constructed public roads. Main Roads owns, manages, and operates the declared State Controlled Road Network which comprises over 34,000 kilometres of these roads with the remainder being under the control of Local Government Authorities. The network administered by the department comprises the major highways that link communities across the state, state strategic, arterial and sub arterial road networks.

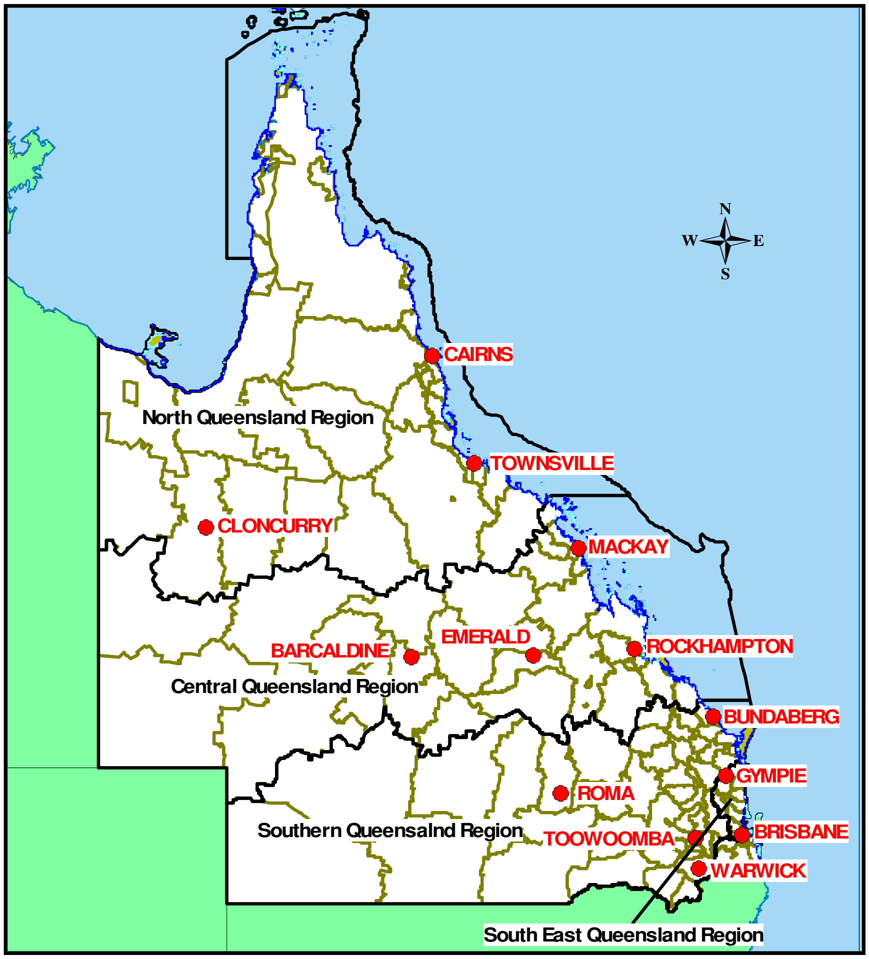


Figure 3.1 Queensland Department of Main Roads Regions

Several key initiatives identified in the Departments Strategic Plan (2004 – 2009) are delivered by the Department for the Queensland road system including:

- safer roads to support safer communities;
- fair access and amenity to support liveable communities;
- building Queensland's regions;
- efficient and effective transport to support industry competitiveness and growth; and
- environmental management to support environmental conservation.

3.2 The Mackay District

The Region stretches from North of Proserpine in the North to South of Miriam Vale in the South and West to the Queensland – Northern territory border covering an area of 576,488 square kilometres and a population of 300,000 (Main Roads - Roads Implementation Program 2004 – 05 to 2008 - 09, 2004) . In this area there are a diverse range of industries, environments and communities ranging from sparsely populated arid farming lands in the west to densely populated coastal cities with substantial rainfall. Major industries in the Region include mining, crop farming, sheep and cattle grazing, and tourism. The Central Queensland Region is directly responsible for 9916 kilometres of State Controlled Road Network which includes 1400 kilometres of National Highways. Mackay District is on of four districts in the Central Queensland Region with the others being Central West, Central and Central Highlands Districts (Figure 3.2). Mackay is located on the coast approximately 1,000 kilometres north of Brisbane

The Mackay District is centred on the City of Mackay which is a modern, progressive city of approximately 78,000 people, located on the Pioneer River in Central Queensland. Mackay District covers a land area of 38,410 square kilometres and encompasses six Local Government Authorities from Whitsunday Shire in the North to Broadsound Shire in the South to Nebo Shire in the West.

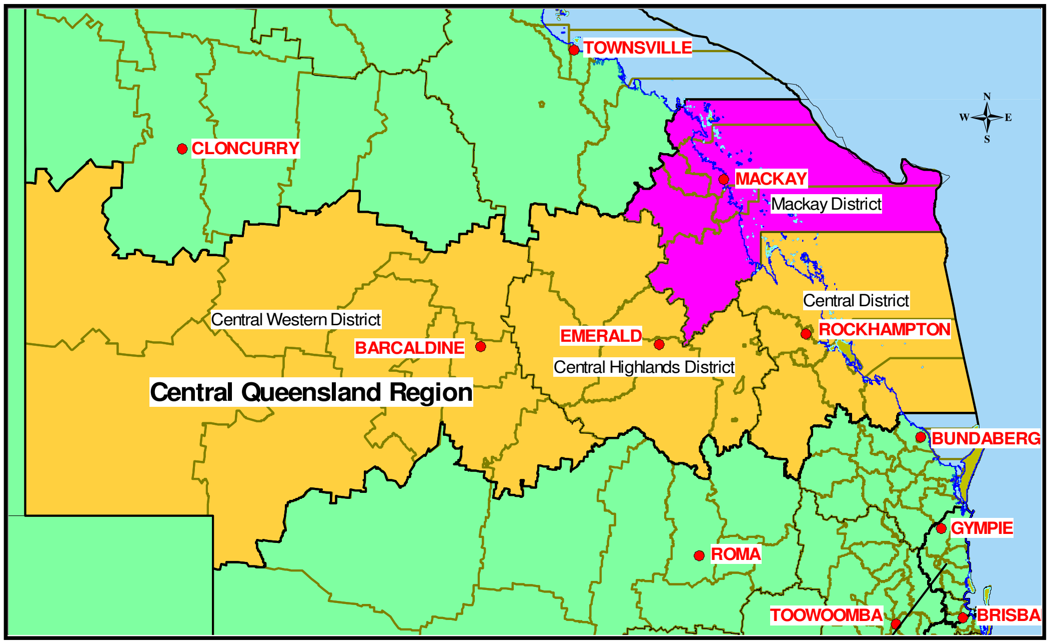


Figure 3.2 – Central Queensland Region and Mackay District

The city is relatively spread out with the core urban area covering approximately137 square kilometres. Mackay is a commercial centre servicing the Mackay and Whitsunday Region, Bowen Basin Coal fields and hinterland. The city is surrounded by a variety of industries including intensive agriculture based on the sugar and beef cattle industries, mining industry, port facilities for the sugar and mining industries, and tourism related activities. The urban areas are surrounded by highly productive agricultural lands (See Figure 3.3).

The region is the one of the largest sugar cane growing areas in Australia, second only to the Burdekin. Mackay is home to two of Australia's four Sugar Refineries and the largest bulk sugar terminal in the world with 8 million tonnes exported though the port in optimum growing years.

Figure 3.3: Mackay Central Business District and Environs
(Source: Courtesy of Wricor Photography)

The nearby Dalrymple Bay and Hay Point Coal loading terminals situated at the Port of Hay Point form one of the largest coal loading terminals in the world. Currently the terminals deliver a combined total of 80 million tonnes of coal to 8 countries around the world each year. The Dalrymple Bay facility is currently being expanded to cater for an additional capacity.

There are six Local Government Authorities encompassed in Mackay District (Table 3.1).

Mackay City Council	Whitsunday Shire Council	Mirani Shire Council
Nebo Shire Council	Sarina Shire Council	Broadsound Shire Council

Table 3.1: Local Government Authorities in Mackay District

Mackay District is responsible for approximately 1758 kilometres of declared State Control Road Network of which 1532.6 kilometres are sealed (Figure 3.4).

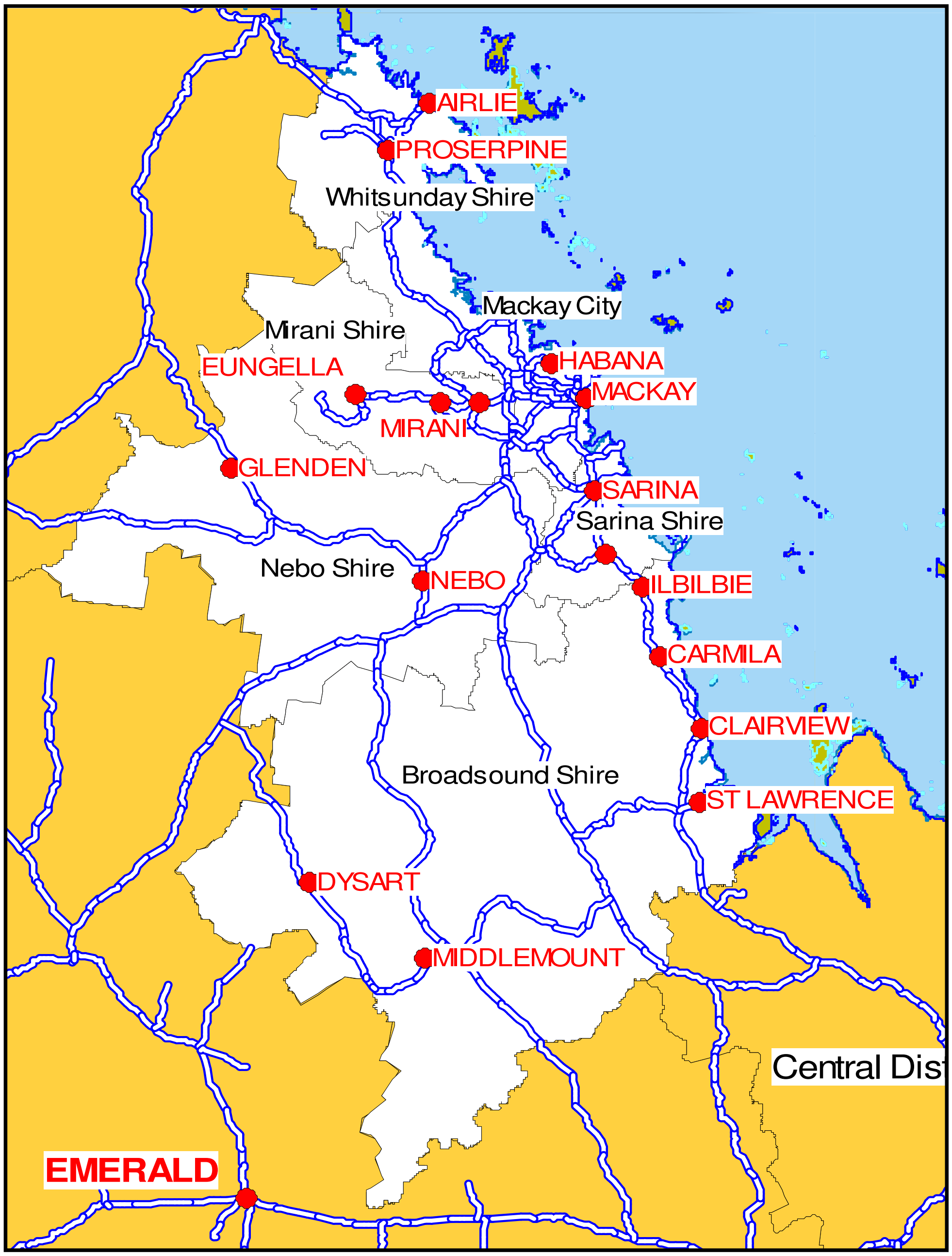


Figure 3.4: State Controlled Road Network in Mackay District

On these sealed roads there are 16 different surface seal treatment types that may be loosely grouped as either asphalt or chip seal treatments. The District currently has a total of approximately 225.5 kilometres of unsealed roads, 97.1 kilometres of asphalt with the balance being chip seal. The District is responsible for a total of 339 kilometres of National Highway.

3.3 The Study Area

The study area for this project was adopted to match the extents of the skid resistance testing project carried out in the District in June 2004 (Appendix B). The areas chosen for skid resistance testing were selected based on a series of predetermined factors and requirements which related to perceived risk exposure. Generally these areas were in high rainfall (>800 mm per year), high traffic and coastal areas which are considered areas of highest risk. The sections chosen total 978.3 kilometres of road network and extend to areas in each of the six local government areas. The test locales are highlighted in Figure 3.5 as those sections of network with a solid black linestyle.

Of the roads tested 16% of the National Highway and 11% of other roads recorded skid resistance results below the investigatory levels. The investigation of these sections is the focus of this investigation. The investigation of these sections is the focus of this investigation.

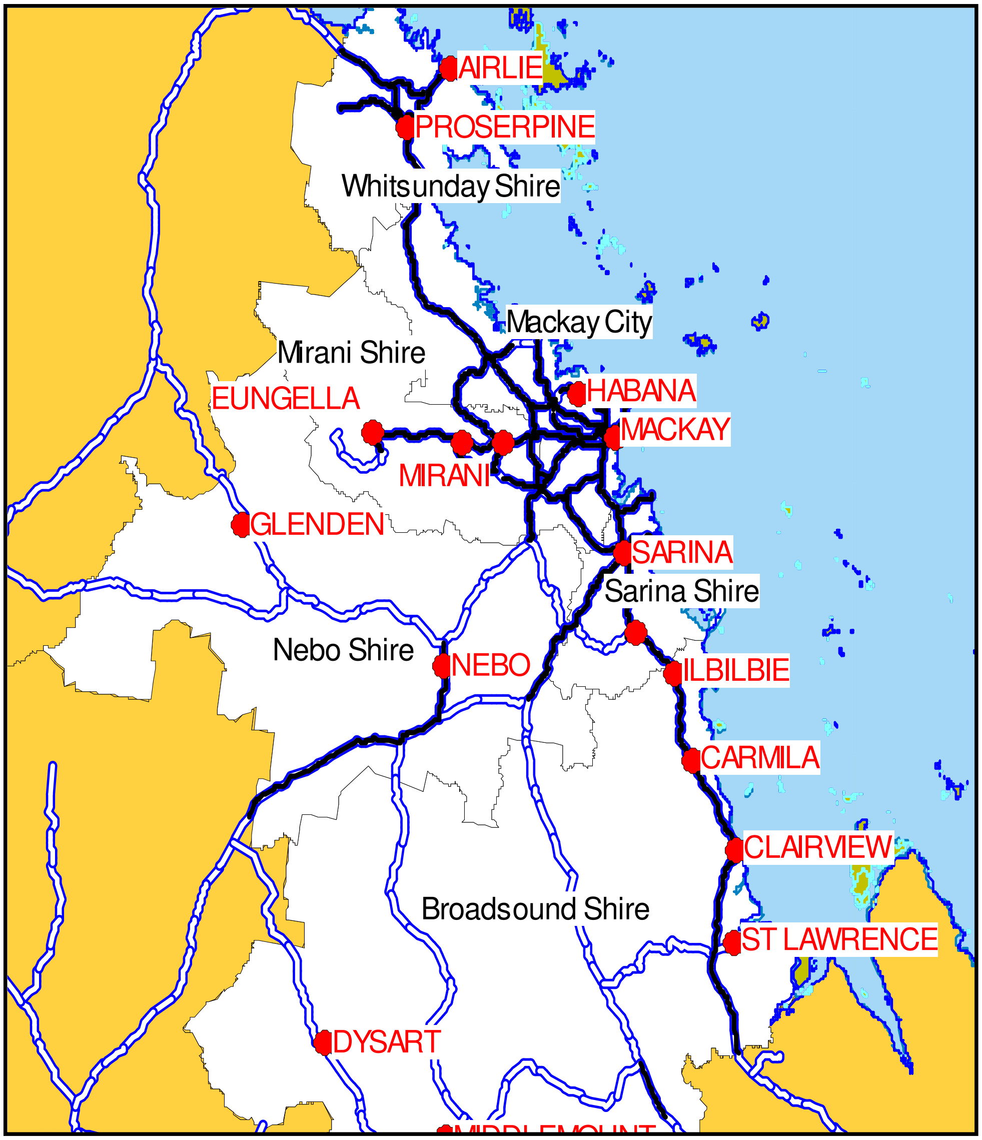


Figure 3.5: Extents of this project

Adjacent land use varies from urban housing through to rural farming, with traffic volumes varying from an AADT of 30 to greater than 32,000 vehicles per day. The major urban centres in the study area include Mackay, Proserpine, Sarina, Nebo, Airlie Beach, Marian and Mirani. Details of roads sections and respective lengths tested are shown in Table 3.2. It should be noted that in some cases only selected sections of the road are tested.

Road Number	Road Name	Length Tested (km)
10F	Bruce Highway (Rockhampton – St. Lawrence)	28.4
10G	Bruce Highway (St. Lawrence – Mackay)	156
10H	Bruce Highway (Mackay – Proserpine)	123.6
10J	Bruce Highway (Proserpine – Bowen)	31.3
33A	Peak Downs Highway (Clermont – Nebo)	76.2
33B	Peak Downs Highway (Nebo – Mackay)	48.9
512	Malborough – Sarina Road	70.7
516	Homebush Road	12.6
517	Sarina – Homebush Road	26.3
518	Eton – Homebush Road	10.4
530	Mackay Bypass Road	4.3
531	Rockleigh – North Mackay Road	3.5
532	Mackay – Eungella Road	69.9
533	Marian – Eton Road	15.7
534	Mirani – Eton Road	19.4
535	Marian – Hampden Road	8.8
536	Mirani – Mt Ossa Road	38
851	Proserpine – Shute Harbour Road	33.7
852	Hay Point Road	14.1
854	Mt Ossa – Seaforth Road	7.7
855	Yakapari – Seaforth Road	23.4
856	Mackay – Bucasia Road	10.8
857	Mackay – Slade Point Road	12.1
5126	Koumala – Bolingbroke Road	3.5
5302	Maraju – Yakapari Road	23.4
5323	Gargett – Mia Mia Road	15.8
5324	Eungella Dam Road	7.4
5332	North Eton Road	3.8

5342	Mia Mia Connection Road	5.1
5382	Crystal Brook Road	24.6
8501	Gregory – Cannon Valley Road	13.4
8506	Mackay – Habana Road	10
8509	Sarina – Coast Road	12.9
8554	Yakapari – Habana Road	8
8565	Eimeo Road	4.6

Table 3.2 – Road Sections tested for Skid Resistance, June 2004

Although in the past consistent maintenance programs for treatment based on expected pavement life were carried out, this was based on local experience and visual inspection. In more recent times corporately developed systems with specific rules and triggers have been used in combination with local knowledge to determine program priorities. This approach is aimed at allowing comparisons of relative priorities across District and Regional boundaries and additionally as a way to measure the effectiveness of different treatment methods utilised. This approach has resulted in an increase in the length of time between treatments in many cases. The effect of this approach on the pavement performance was only known subjectively through field inspection.

Skid resistance had not been tested in this Region previously and as such the results provide another source of information for consideration by decision makers. On initial inspection of the results it was immediately apparent that some sections recorded results lower than the suggested investigatory levels which made it imperative to determine the underlying causation in each case.

3.4 Conclusions

Main Roads owns, manages, and operates the declared State Controlled Road Network which comprises over 34,000 kilometres of roadways.

The Mackay District located in the Central Queensland Region of the Department of Main Roads is one of fourteen Districts that combined form four Regions that cover the entire state of Queensland. The District encompasses six local government authorities with 1758 kilometres of declared State Control Road Network under its' control.

The project area contains areas within all six local government authorities and comprises a total of 978.3 kilometres of declared State Controlled Road Network. Of the roads tested 16% of the National Highway and 11% of other roads were found to have record a result lower than the investigatory level for their particular environment. These investigatory levels are utilised to highlight specific areas requiring immediate inspection, however due to the variability of results and multi factor nature of skid resistance it is emphasised that this may not necessarily result in a requirement to treat a road section.

CHAPTER 4 DATA SOURCES AND SOFTWARE

4.1 Introduction

The finance and resource constrained environment that the Department exists in means that problem areas must be prioritised based on the seriousness of their effect on the wider network. In practice this means that an incremental program of works is carried out over a period of years with the highest priorities addressed first. To achieve efficient and effective prioritisation of works a considerable amount of data must be collected, collated, analysed, problems areas identified, prioritised, works programmed and then actioned.

It is important to note that the data contained in many of the systems is imperfect, in some cases of low quality or incomplete and for this reason a high degree of subjective assessment, inspection and local knowledge of the network is required for the development of appropriate priorities. In the majority of cases the data is captured in one traffic lane only and has been assumed to be similar for adjacent untested lanes. This assumption may not be universally valid and hence further detailed analysis is required of sections that involve such lanes.

Skid resistance is just one of numerous parameters and data sources considered in development of the works program. Apart from road surface conditions of which skid resistance is just one, other factors such as new developments or growth factors in an area, structure (bridges and culverts) conditions, traffic patterns, political imperatives and other parameters all impact on the overall prioritisation of works.

4.2 Skid Resistance Data

Skid resistance data was captured using a Norsemeter ROAR Skid testing device (Figure 4.1).

Figure 4.1: Norsemeter ROAR Skid Tester (Source: Courtesy E. Baran)

This device produces a report based on the PIARC International Friction Index. The data was captured in the outer wheel path which is often an area where pavement problems such as rutting first become apparent (Baran, 2004). This test apparatus carries out a wet test by spraying a film of water 0.5 millimetres deep on the road in front of the test wheel and gradually braking the wheel until lockup occurs. An average test covers approximately 10 to 15 m of road and in network survey mode, testing at 80 to 90 km/h, an average of 1-2 tests per 100 meters are carried out.

As with all field captured data there are some possible sources of error which can affect the data. One notable problem with skid data is that if the gazetted speed value is higher than a road user would normally be able to attain then the results may be erroneous. Examples of such events may be range sections where the gazetted speed may be 100 km/h but the fastest it is possible to drive is say 60 km/h. Often these sections have advisory speed limits however these are not able to be taken into account during the capture process. This means that the “f” (friction) value of the IFI used may be incorrect for the particular section. There may also be tracking errors where the operator has drifted slightly from the desired test position on the road, or places where the water sprayed in front of the test wheel had dispersed prior to the test wheel contacting the area. Sections of high roughness may also have an impact on skid resistance test outcomes. It is important to note that the data presented may be the result of several tests that are averaged over a section. The repeatability of the testing in terms of consistency is another area of concern as high variability in results over the same sections has been exhibited in testing. Generally 20% of road sections receive additional testing. Therefore, it is emphasised that a test result lower than the investigatory level only highlights that there is a need to investigate what may be a possible problem.

Figure 4.2 shows the mechanism for pre wetting the pavement in advance of the test wheel.

Figure 4.2 Pre wetting of the test wheel (Source: Courtesy E. Baran)

The areas chosen for skid resistance testing were selected based on a series of predetermined factors and requirements. Generally the roads tested were in high rainfall / high traffic coastal areas where a likely higher risk profile was expected. The sections in Mackay District chosen comprise a total of 978.3 kilometres of the network and involve some areas in each of the six local government areas. The testing report identified 16% of National Highway and

11% of other roads in the District where the skid resistance was below the investigatory levels and required further investigation. This premise forms a primary aim of this project.

4.3 ARMIS data

A key repository of road related data held by the Department is ARMIS which stands for 'A Road Management Information System'. This system is comprised of a variety of Oracle based databases which were developed by the Department and initially introduced in 1992. The system replaced the chart based system known as CHIMPS. The system has undergone many changes since its implementation including the addition of several new databases and a move towards a more user friendly graphical user interface (GUI).

As with all database systems ARMIS has the capability for collection, collation, storage, editing, retrieval, auditing, recording of metadata and reporting of road related data that is useful in the decision making processes of Main Roads. Although the data in ARMIS is being continually improved there are various issues that affect the data accuracy and quality that must be understood. An outline of the system components is shown in Figure 4.3.

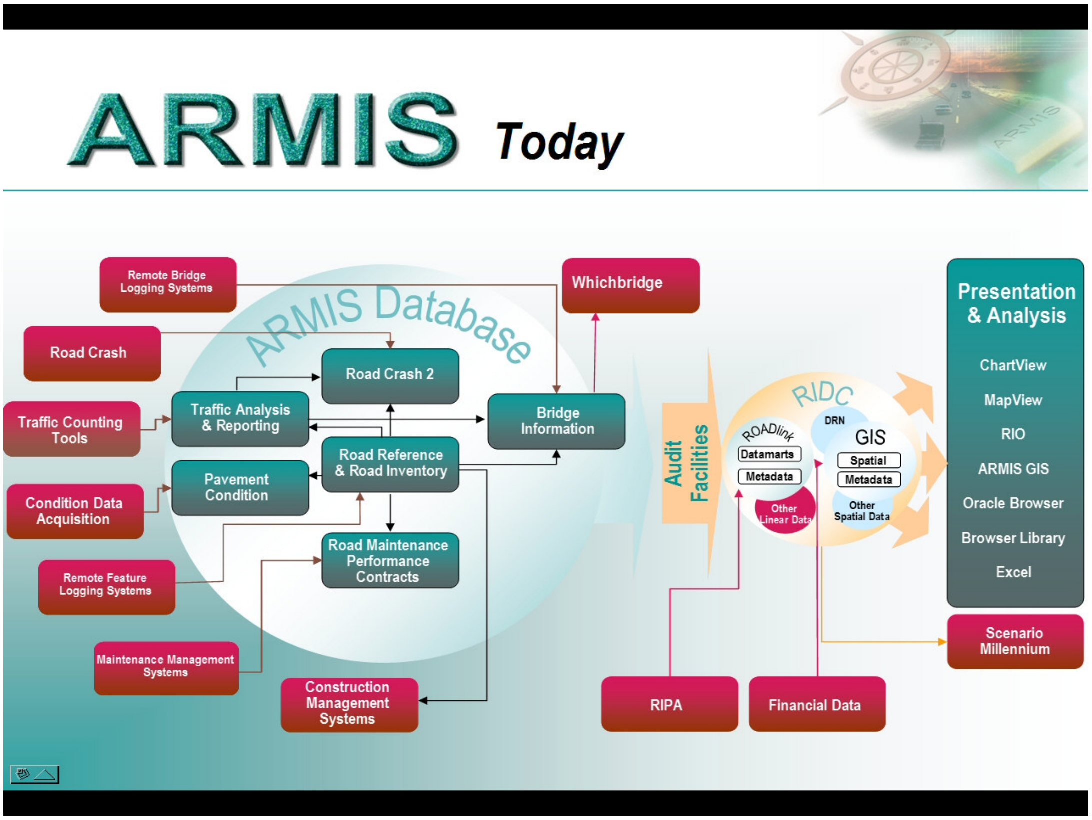


Figure 4.3: ARMIS Architecture (Source: Roads Information Branch – Main Roads)

The ARMIS databases include detailed information on the condition, location, and details of all road assets from signage through to major structures that together make up the road infrastructure of the network. This data is all related using a linear reference system that relates the physical location of each asset relative to the defined start of the road which is described using the term Tdist. Tdist stands for through distance. For example, for each of the wet road crashes shown in Figure 4.4 below each has through distance (Tdist) that relates to the start of the road. The data shown in the example has been mapped against a constructed road centreline dataset based on the centre of road casement indicated by the Digital Cadastre Database (DCDB) and as such its positional accuracy and quality is variable.

A current departmental initiative is the capture of the physical location of the centreline using GPS. This will markedly improve the accuracy of the centrelines location which has flow on benefits through the sharing of this information with the Department of Natural Resources and Mines (DNRM) to allow some large scale adjustments of the DCDB and other datasets. ARMIS data is regularly and routinely mapped against the road centreline via the road section and through distance parameters.

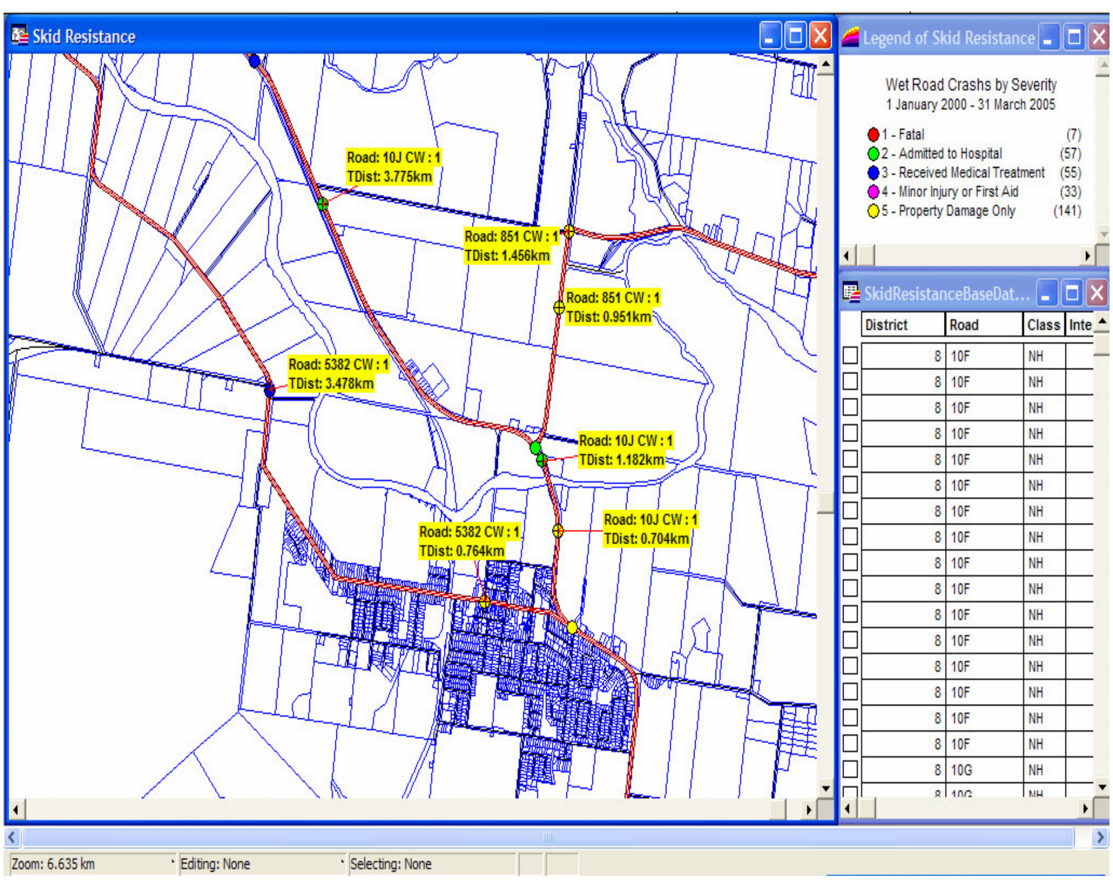


Figure 4.4: Linear Referencing of Wet Road Crashes

In this project data from a variety of ARMIS subsystems was utilised and each is now discussed. The vast majority of construction or maintenance operations carried out on any part of the road network will provide input to several ARMIS subsystems. In the case of construction related projects a wide variety of information is entered including pavement type and layer thickness, construction methods and completion date, costs, lane, seal and formation widths to name a few. From this information the user is able to view a wide variety of data which may be either derived or real. Two such project related parameters are Seal Age and Seal Type.

Seal age is defined as the time between the project completion date and the current date. For this project the 30 June 2004 was used as the date for determination of seal age which approximated the date of skid data collection. This is a significant variable for this project because there are a variety of factors such as stone polishing, stone loss or impaction, roughness, rutting, seal ductility, and porosity that change as the pavement ages. Of these factors the one that relates directly to the aggregate properties is polishing which occurs through the wear and tear of the road environment. Sources of this polishing may be due to traffic wear, environmental agents, and the properties of the aggregate itself. These factors mean that as a pavement ages it may become smoother through loss of microtexture and thereby decrease its desirable skid resistance properties. The seal age data is a mathematically derived value and as such is reliant on correct pavement history being stored within the ARMIS database for the road section. Whilst the vast majority of this data is correct the dataset suffers from some incompleteness due to incomplete or missing project information.

Additional sources of error may include projects that are not linearly referenced correctly resulting in short sections of incorrect seal age and data that was lost in the translation between the old CHIMPS system and new ARMIS system.

Seal type describes the specific makeup of the road surface. There were 16 different seal types identified in the District. To enable more effective analysis the surfaces were redefined as either Asphalt or Chip Seal as the types that technically make up these groups have specific general characteristics. It is acknowledged that a third type, namely Concrete, pertaining to bridges without a surface covering exists in the district, but the total length of these sections was very small on the tested road sections and is not considered further. Seal Type is entered as part of the as-constructed information immediately after the road section is opened to traffic. Problems with this data include incorrect or incomplete seal type data being placed in the system. Seal type is a significant dataset because the two types considered have different properties in terms of their skid resistance characteristics. Asphalt sections in Mackay District are generally located in urban areas, high traffic areas, on bridge decks and high stress areas. Traditionally asphalt pavements have been used in areas that expect to be subject to high demand and consequently high skid resistance environments.

Various pavement condition data is collected annually utilising a variety of Network Survey Vehicles. The most advanced of these shown in Figure 4.5 is utilised to capture various road roughness, rutting, digital video, cracking, and surface texture information simultaneously. This linearly referenced data is loaded into a variety of systems discussed below.

Figure 4.5 Network Survey Vehicle (Source: Courtesy Ed Baran)

The roughness, rutting, and surface texture information is primarily collected by utilising an array of lasers that are attached to the modified bumper bar of the vehicle which take continuous readings as the vehicle travels along the road at as near as practical to a predetermined position in the traffic lane at a constant speed. Figure 4.6 shows the laser configurations and their purposes.

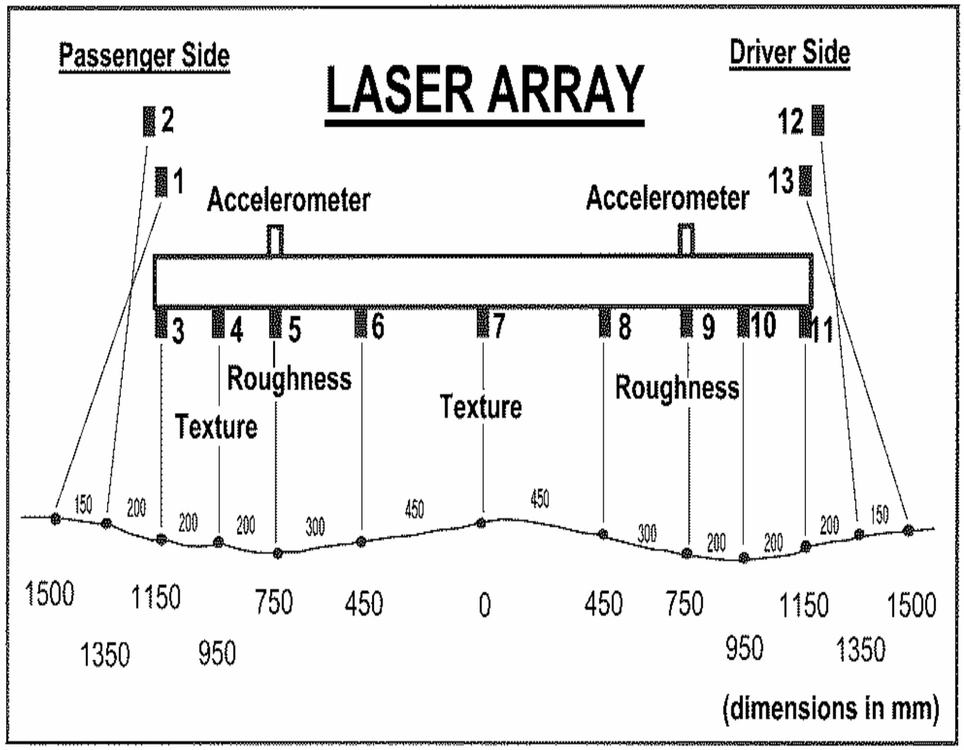


Figure 4.6: Network Survey Vehicle Laser Array Configuration

(Source: Courtesy: Ed Baran)

Roughness is a measure of the longitudinal profile of a road surface and is reported against the International Roughness Index (IRI). Roughness is captured by measuring the comparative rate of change in height between readings along each lasers path. This information is correlated to determine how many times the rate of change would result in a certain amount of movement in a vehicle suspension. Each time the amount of movement is exceeded a count is added which varies based on the magnitude of the movement. This information is summated into an average value for each 100 metre section of roadway.

Additionally data is also collected by mechanical means using a roughness tower. This data is utilised as a check on the accuracy of the laser data and as a back – up, should there be an apparent error in the laser data. Potential sources of error in the roughness data include Tdist related, vehicle tracking errors where the vehicle may drift from the desired optimum position, loss of laser signal (generally for a short section only), and limitations of the equipment. For the purposes of this project the primary focus is on the outer wheel path roughness as this correlates with the road position that the skid resistance data was captured on. It is acknowledged that roughness is a factor in skid resistance as high roughness road sections may result in loss of contact between tyre and pavement thereby resulting in a decrease in available skid resistance. Additionally the roughness parameter provides another guide to general pavement condition and therefore aids as supporting information in the prioritisation process.

Significant analysis tools already exist to identify and prioritise sections of roadway that exhibit high roughness. It should be noted that roads that exhibit high roughness are problematic for the skid testing equipment due to the inconsistencies they cause between the test wheel and pavement surface. Much of the variability in skid test results and need for retesting is a result of roughness related issues.

Rutting is a deformation of the pavement that occurs in the wheel paths resulting in a linear depression along the road. Rut filling operations over the past several years of those areas approaching the treatment intervention levels mean that rutting is not significant in the test areas. For this reason rutting will not be considered further for the purposes of this project. One observation made during the initial examinations was that in rut filled areas there was a substantial decrease in the surface texture depth. This may affect the macrotexture available for drainage although this has not resulted in any apparent issues to date it will be monitored.

Surface texture for this project utilised the Sand Patch Test Equivalent value for the outer wheel path (OWP) extracted from ARMIS. The Sand Patch Test involves the placement of a defined volume of sand on the pavement surface. The sand is spread across the pavement in a circular shape until all the voids in the pavement are full and the top level of the sand forms a flush level with the aggregate. The diameter of the circle is then measured with the texture depth being equal to the volume of sand divided by the area the sand covered. This parameter is captured utilising profiles obtained across the pavement with the laser array. As the resultant laser measurement is not a true measure of surface texture depth Main Roads has adopted a relationship between the two which is calculated by multiplying the laser measurement by 2.5.

Adequate surface texture is required to ensure that there is sufficient macrotexture to allow water to drain from a pavement thereby preventing aquaplaning. For the purposes of this project adequate texture depths were adopted based on seal type. Minimum surface texture depths of 1.0 millimetre for chip seals and 0.4 millimetres for asphalt surfacing were adopted based on AUSTROADS guidelines. In sections of asphalt where readings of 0.6 millimetres or less were found the depth was considered adequate but noted as marginal. As such where other factors also proved inadequate this parameter was used to aid in prioritisation. Flushed or slick pavements generally exhibit a low surface texture depth. Sources of error include Tdist related, vehicle tracking errors where the vehicle may drift from the desired optimum position, loss of laser signal (generally for a short section only), and limitations of the equipment.

Another important factor that surface texture depth provides to the picture of pavement performance is achieved through the comparison of the depths recorded between the wheel paths (BWP) and for the inner wheel path (IWP). Where readings between the OWP and / or IWP are considerably different than those recorded at the BWP position this may indicate a structural issue with the underlying pavement. That is, the loads on the trafficked parts of the surface have affected its profile compared to the unloaded areas. This may be visually confirmed via evidence of stones impaction, flushing, or rutting.

Accident information is collated in the Roadcrash 2 database. This database contains a wide range of data on individual accidents on the road network. Each crash record includes details of the road number, locality description, severity, contributing circumstances, vehicles involved, weather, time of day, type of accident and a textural description to name a few. The quality of this data varies considerably in completeness, positional accuracy, and detail and as such is only useful to determine trends and possible problem areas that require further investigation. A key priority on the reception of the skid deficiency data was the examination of individual crashes specifically targeting any correlations between skid deficient sections and crash rates. It would be expected that the accident risk would increase as the skid resistance decreased. A Black Spot criteria analysis was also undertaken utilising 1 kilometre sections and a 250 metre radius around intersections for accidents over the past 5 years.

The Traffic Analysis and Reporting System (TARS) is the departmentally developed source of the average annual daily traffic information (AADT) for road sections. It has been shown that heavy vehicles have the most impact on stone polishing (Oliver, 2002). However for the purposes of this analysis the mix of commercial vehicles (trucks) and cars is not investigated. It is likely however that where specific detailed investigations of areas identified through this process are carried out that this is a likely factor for analysis. This project will utilise AADT purely as a statistical measure. AADT also provides input into the TARP analysis process which uses the AADT to establish crash rates per vehicle kilometre travelled. Possible sources of error in the TARS data include, field data collection errors, equipment failure, processing errors and abnormal events affecting data collection and resultant output accuracy.

4.4 Spatial Data

A wide range of relevant spatial data is available in the District for integration and enhancement of map presentation. This data is stored centrally on the district server and utilises a structured directory approach to group similar datasets together. This data is currently obtained through a variety of sources including the Departments' Geospatial Technologies Branch, Roads Information Branch, various web servers, through field collection by District staff, and in some cases from local groups or organisations. Data is generally obtained in Mapinfo format. A typical example of metadata that is kept on datasets, giving accuracy, currency, and a myriad of other information, is the DCDB dataset which has been included in Appendix C of this dissertation.

Reference systems utilised for this and all other projects within Mackay District Main Roads include:

- Geocentric Datum of Australia 94 (GDA94) – horizontal reference system; and
- Australian Height Datum (AHD) – vertical reference system

This approach to reference management allows consistent integration of datasets. Key datasets utilised in the delivery of this project include, with the dataset name listed in brackets:

- State Controlled Road Centrelines (sc_roads) which consists of a state wide set of Main Roads controlled roads.
- State Digital Road Network (allroads) which consists of all road centrelines within the Mackay District. This dataset was utilised to assist the end user to visualise a location once the map is zoomed into an area of less than 10 kilometres.
- Digital Cadastre Database (DCDB) which consists of all land parcels, casements and easements within Mackay District. This data is comprised of many smaller datasets that cover each of the six Local Authority Areas. This data is set to display once a zoom level of 10 kilometres has been reached to aid in visualisation of a location.

- Queensland Coastline (Coast) is a representation of the coastline that aids in the visualisation and presentation of the map product
- Queensland Towns (Towns) is a representation of the named towns within the study area. This state wide dataset has been manipulated such that only major towns have been displayed.
- Ocean is purely included as a cosmetic layer to enhance presentation and is a derivation of the Coastline dataset used to represent the ocean.
- Queensland Local Authority (lga) boundaries dataset depicts the location of local authority boundaries across the state.

4.5 Digital Video Road

As previously discussed the network survey vehicles capture digital video images of the network as part of the annual road pavement condition testing program. For the sealed road network a four camera system is used that provides images of the road and features in the forward and reverse directions and left and right sides of the vehicle (Figure 4.7). This data is provided to the district in the form of a series of images at intervals of 10 metres along each road section. The data is placed on the district server and is accessed from individual personal computers by utilising a Digital Video Road Viewer. These videos provide valuable information about the nature of the pavement surface condition, asset locations, signage, and the general environment that a section of road exists in. This can be very useful in the preliminary investigation and identification of possible problem areas for a wide range of Main Roads activities. DVR also facilitates enhanced communication of issues through improved visualisation and provides a useful auditing tool.

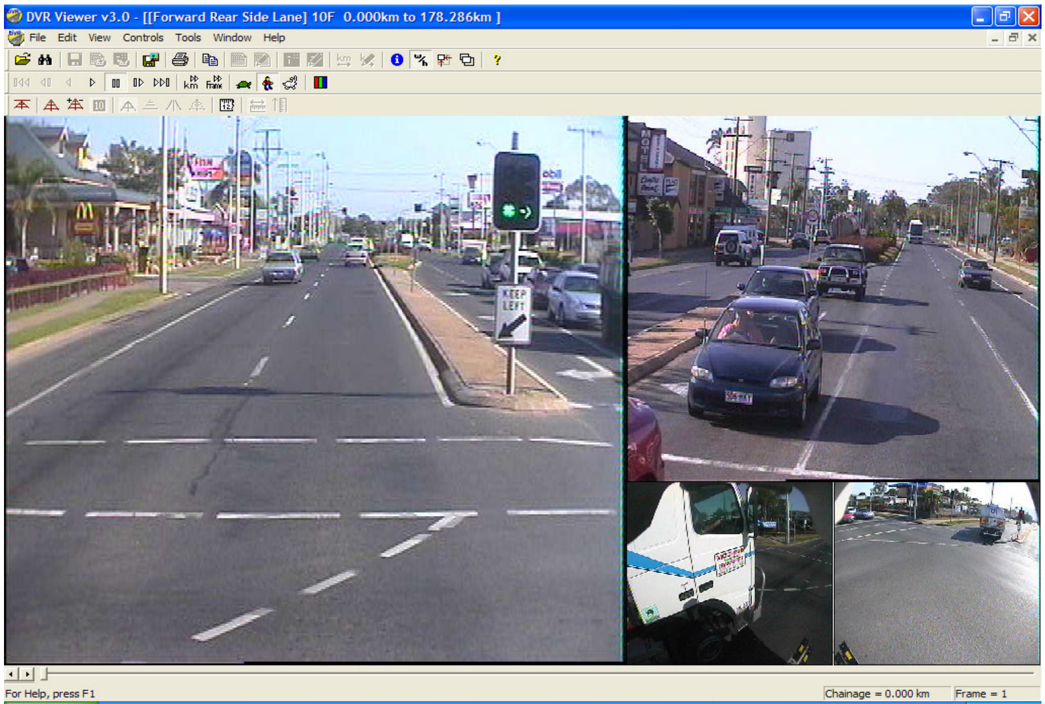


Figure 4.7: Digital Video Road Viewer (Source Department of Main Roads, Mackay)

For the project this system was used in the subjective assessment of possible problem areas and as a confirmation tool for perceived problems. Problems identified using a wide range of information could then be field inspected with confidence that a significant issue exists at the location rather than relying on perception thus reducing potentially wasted resources by inspecting areas identified due to erroneous data.

The incorporation of a dynamic link between DVR, GIS and other systems such as Chartview such that they may be viewed simultaneously is an additional enhancement that although beyond the scope of this project may be developed in the future. It is acknowledged that the capability to achieve this has previously been developed in the Departmental ARMIS GIS project, however this package is no longer actively supported and many aspects of its use required a high level of user skill.

4.6 Chartview

Chartview is as the name suggests a package that allows data to be displayed in a linear chart form (Figure 4.8). This tool accesses data from the RIDC, although it is also possible to create local data sources that may be charted.

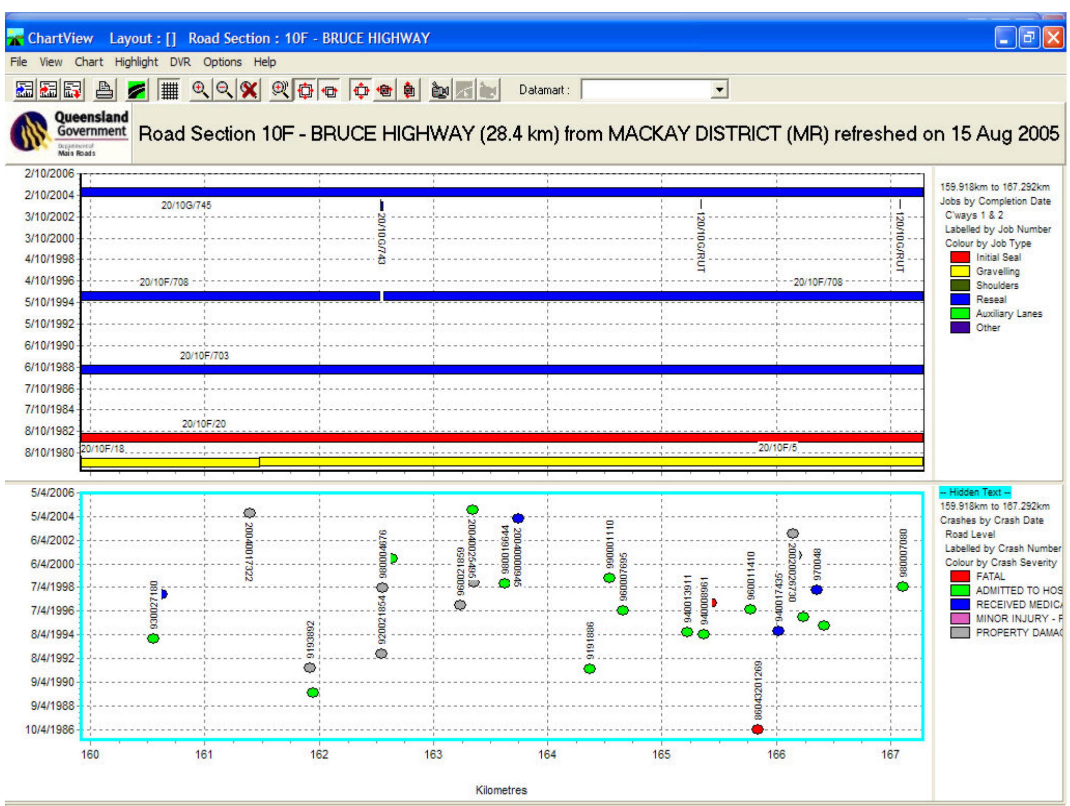


Figure 4.8 Chartview (Source: Department of Main Roads, Mackay)

Chartview was utilised as a visualisation tool in the subjective aspects of the assessment to confirm relationships between various factors. In the future this tool could be dynamically linked to the GIS system to further enhance communication of issues. Chartview already has a dynamic link established with DVR which enables simultaneous viewing. Chartview may be viewed as a graphical display of the data that allows relationships to be established between various features of the road network, but does not have the capability to allow the completely integrated association of the surrounding environment that can be achieved through a GIS. Chartview was utilised in this project to aid in quick assessment of pavement parameters.

4.7 Databrowser and other tools

Several other tools were utilised to access data and carry out assessments and each is now discussed.

Oracle Databrowser is a database querying tool utilised to link (join), query, export, and report data tables contained within ARMIS. Much of the data within ARMIS that was required for this project was stored in a wide range of Oracle based tables that had to be brought together into a usable format.

Mapview is a departmental add-on application to MapInfo. It is useful in the display of maps of ARMIS data which it sources from the Roads Information Data Centre (RIDC). The RIDC contains a selection of data parameters from the parent ARMIS systems, but does not contain the complete dataset. Other datasets are able to be associated with the resultant map product. For this project various datasets have been merged and information added and as such this environment does not offer an advantage. However, once the methodology for assessment has been established this system may be utilised to deliver future evaluations.

4.8 GIS Software

Geographic Information Systems (GIS) are a powerful set of tools that facilitate the capture, input, data management (storage and retrieval), manipulation and analysis, and outputting of geographical data. Geographical data may be described as data about an objects' spatial position relative to a known reference system, its relationship to other objects around it, and its associated physical attributes.

The GIS package utilised for this project is MapInfo Professional Version 7.5 which is a desktop level mapping application. This package provides the level of functionality required for this project in a user friendly manner and is currently widely available across Main Roads through an unlimited usage corporate licensing agreement. Over a period of time Main Roads has developed a series of tools to assist in the use of MapInfo for departmental needs. These tools written in MapBasic are collectively known as the "Nerang Applications" in recognition of the District where the majority were developed.

The Nerang Applications greatly improve the access to the systems by a wide range of people with varying amounts of knowledge of GIS through facilitation of a very user friendly intuitive environment. The applications range from those which facilitate tracking of land developments through to simple road centreline queries. The applications also facilitate the development and use of standard workspaces through a menu and layer control system that avoids the need for the end user to have a full knowledge of GIS. This is particularly useful for managers who with the click of several buttons can easily find the answer to basic queries.

This project makes extensive use of the Nerang Applications to enable a user friendly environment. Applications extensively utilised include Road Centreline Tools, Workspace Layer Control, and Menu Control. GIS offers an ability to query and interrogate spatial and statistical data based on user defined scenarios which may aid in decision making processes. The power of GIS as a data integrator, analysing and presentation tool all make it an ideal choice for this project.

4.9 Prioritisation Software

As previously discussed Scenario Millennium is the current departmental pavement management system for the identification, development, prioritisation, and management of pavements. However, Scenario Millennium does not consider additional aspects such as skid resistance when looking at the pavement performance. This project aims to bring the various aspects that are considered into a more inclusive environment. Although software development is beyond the intended scope of this project the development of methodologies that has occurred may be used in the future development or enhancement of existing systems. A key aspect of this project is the establishment of the nature of relationships between skid resistance and other pavement parameters. Only with this knowledge can informed decisions be made on the significance of the skid data in the prioritisation process. That is, it may be found that other aspects of the pavement trigger intervention prior to skid resistance becoming a factor. In any case it is likely that skid resistance data will give added support to competing sections of pavement in the prioritisation process. Skid resistance data is also likely to assist in identifying non performing aggregates, construction practices and treatments resulting in improved efficiency and effectiveness in the delivery of the road network to the people of Queensland.

4.10 Conclusion

To deliver the most appropriate road asset management solutions the Department needs to ensure that it considers a wide range of factors including skid resistance in the evaluation, planning, construction and maintenance of the network in a timely manner. The pavement is a key component of the road asset and represents a significant investment of resources.

Various tools exist to assist the Department to prioritise and evaluate what is required of the road asset. In terms of pavement management the departmentally developed Scenario Millennium represents a significant package through which effective decision making support is provided. However this system does not currently encompass all aspects required of a pavement management system with skid resistance being one of these areas. Scenario Millennium is a decision support tool which provides input through the identification, development, prioritisation, and management of pavements for the maintenance programs. Like many decision support tools Scenario Millennium is only as good as the data input it receives with many possible sources of error and therefore outcomes derived from the software must be validated by field inspection and the use of engineering judgement.

Skid resistance data was captured by the Pavement Testing Unit of the Department using a Norsemeter ROAR Skid testing device. The area chosen consisted of a variety of road classes and environments totalling 978.3 kilometres. The report received after the testing indicated that 16% of National Highway and 11% of other roads recorded levels below the relevant investigatory levels and require further investigation. Investigatory levels for skid resistance have been established however a methodology that is able to be consistently applied to assess the identified areas is yet to be developed. This is one of the primary aims of this project. The methodology that has been developed will facilitate the prioritisation and management of skid resistance whilst considering other pavement condition parameters across the district network.

The Department collects a wide range of asset information annually to enable effective management of the road asset. The majority of this information is collated in the ARMIS group of systems which include provisions for the entry, storage, auditing, manipulation, editing, and reporting of this data in a variety of formats. The data utilised for the project is of variable quality and as such a purely desktop solution is not achievable. The spatial datasets utilised in this project were sourced from a wide range of agencies in a MapInfo format. Appropriate metadata detailing ownership, custodianship, accuracy and currency is kept for each dataset. Other departmental systems were utilised to confirm various aspects of the assessment including Databrowser, MapView, Digital Video Road and Chartview.

MapInfo Professional Version 7.5 was utilised to deliver this project. Mapinfo has developed a programming language known as MapBasic that facilitates development and delivery of software to meet custom application needs. Main Roads has developed a series of customisations collectively known as the 'Nerang Applications' to enhance user friendliness of the system. Several of these customised applications were utilised in the delivery of this project.

A key aim and objective of this project is the development of an appropriate methodology through which skid resistance is able to be prioritised and managed efficiently and effectively in relation to overall pavement management strategies. An additional outcome may be contribution towards confirming the appropriate service life of particular pavement types in each environment.

CHAPTER 5 METHODOLOGY & ANALYSIS

5.1 Introduction

Road asset management is a very complex issue due to the wide range of factors that need consideration in deciding how to best allocate limited resources. It is vital to gain a "big picture" view of the entire network and the impact that each factor has on it and the relationships and any trends that may exist between them. As much of the data is in digital form it is logical that decision support tools be developed in a computer based environment that assist the Department to discharge its obligations in an effective and efficient manner.

There are many different approaches and systems available to the asset manager that may be used to analyse information, support decisions and identify priority areas for investigation. However, currently none of these provide a complete solution that identifies and takes into account all the possible factors that may or may not affect a given situation. The GIS environment with its ability to integrate a wide range of data lends itself to situations that involve complex issues such as this. It is emphasised that as with all data management and analysis systems the properties of the underlying data must be understood. In the case of pavement management assessment the results of analysis by computer systems should never be taken as certain or complete, but rather as a guide which is based on a series of factors at a given time. The priorities that are developed from these systems value is identification and highlighting of particular areas that appear to require further investigation and / or possible treatment. A purely desktop based solution is not advisable because if the analysis is based on poor or incorrect data the prioritisation will be incorrect. Thus it is essential that the other components of field inspection, technical knowledge and stakeholder involvement are utilised in the ultimate decision making process. As this was the first time skid related data had been collected it was essential that a clear picture of the issue on the district network was gained as only through knowledge can informed management occur.

5.2 Procedure

Although this project involves use of a diverse range of queries and analysis techniques several key generic processes are common across the project (Figure 5.1). It should be noted that some analysis undertaken builds on the results of other queries so some aspects of this procedure may not apply to each process. Generally where such processes occurred they are notated in the relevant section.

This approach to the system management process facilitates construction of a controlled and reliable environment that allows efficient and effective delivery and investigation of road information.

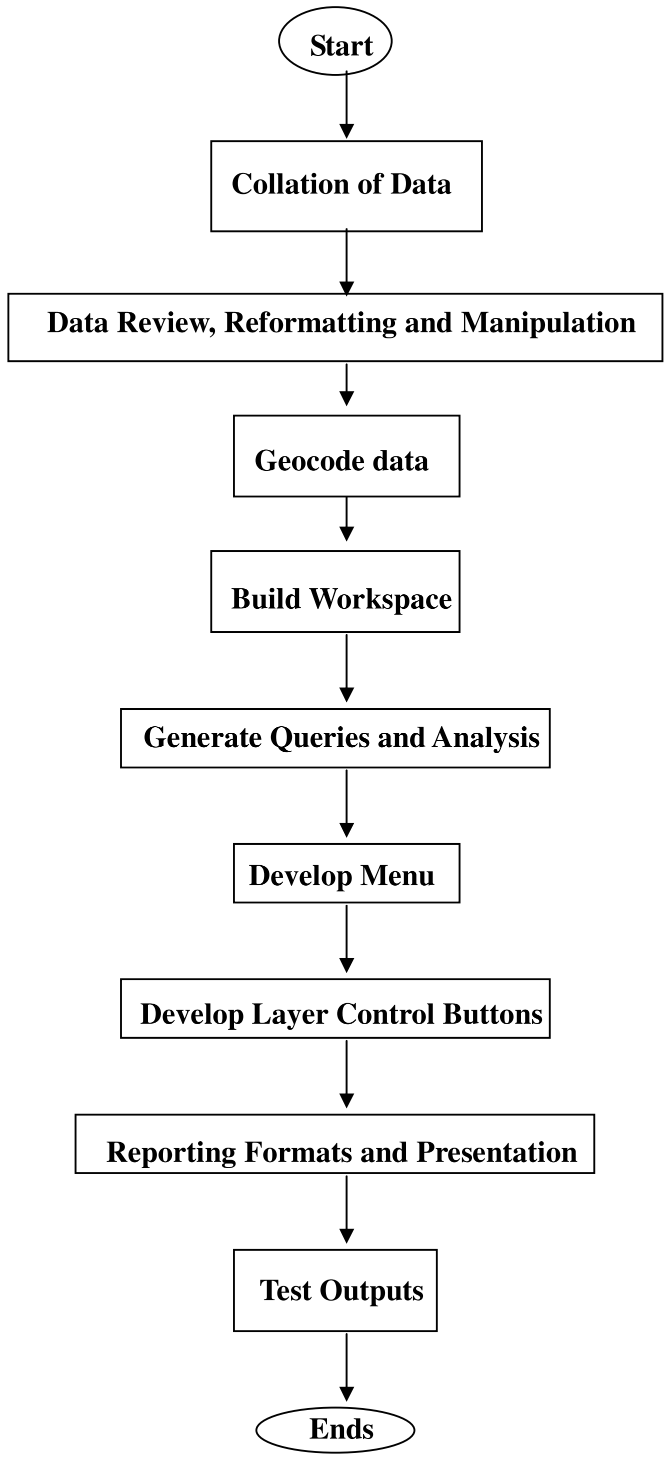


Figure 5.1 Procedure for Skid Resistance Evaluation System

The development of this system will enhance the communication and understanding of skid resistance issues in Mackay District. The GIS interface developed will allow non specialist GIS staff to access, interrogate, and evaluate a multitude of parameters and effects that skid resistance has on the District network. The analysis derived from this system will enable resources to be focussed on those areas that require priority inspection and provide staff with a clear view of what areas of the general issues faced in the road environment. This enhanced knowledge will in turn lead to a fuller understanding of issues, their effects and facilitate the development of a more rounded view of these issues. Such an approach should lead to a more informed decision making process and consequently a more effective and efficient placement of resources.

The 'Nerang Applications' has the capability to create menu items that appear as a drop down list in MapInfo. This provides users with easy access to core pre-built workspaces such as this one in addition to various spatial datasets, data capture tools, data maintenance facilities, spatial navigation engines, and facilitates the creation of high quality maps. Several 'Nerang Applications' were involved during the development of this project and will continue to be utilised during operational phases of the system. Applications utilised include the Road Centreline Tool, Workspace Manager, Menu and Layer Control Tools, Graphic Tool, and Hotlink Tool. Other documents, images and plans use the 'Hotlink' and Graphic tools in MapInfo, to enable the user access to additional information on each road section.

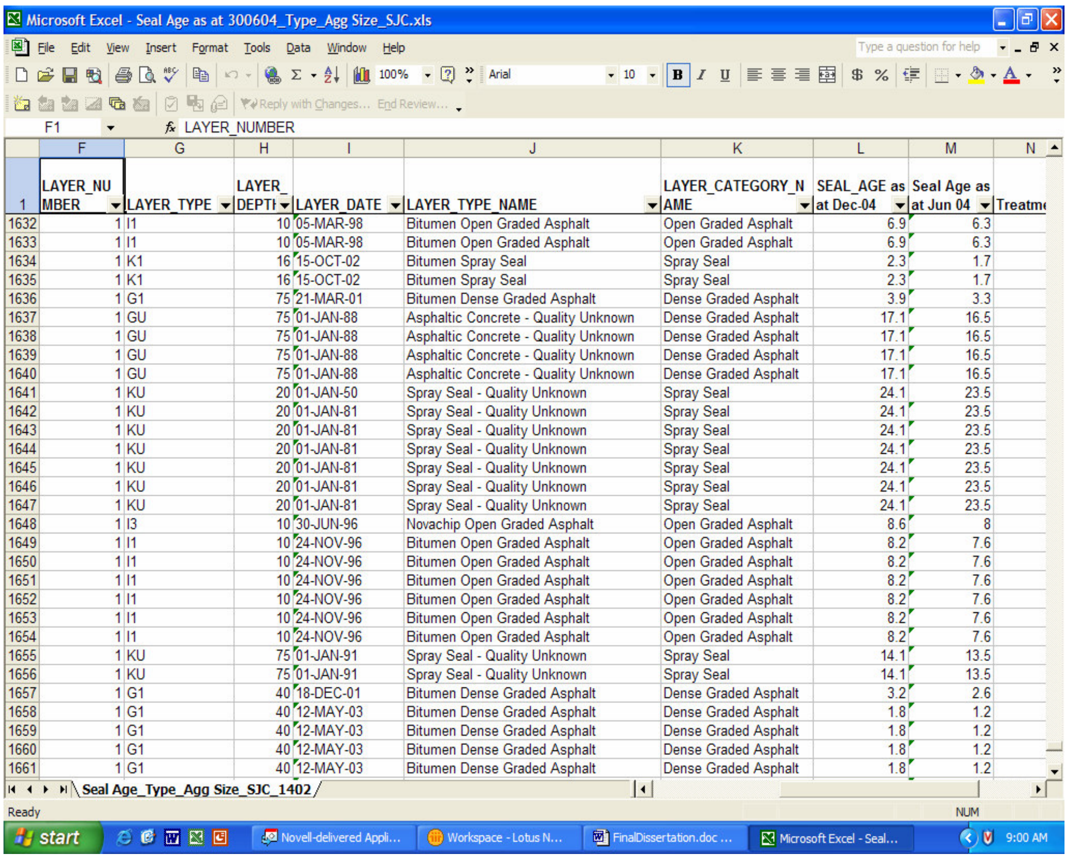
5.2.1 Initial Investigations

Initial investigations through inspection of various datasets indicated that the majority of the possibly deficient sections were nearing the end of their expected seal design life. Many of these aged sections exhibit sufficient surface texture depths (macrotexture) within AUSTROADS Guidelines (2003) so it is likely that the skid resistance issues are related to the in service polishing of the aggregate by traffic. Polishing has the effect of reducing microtexture and therefore the available friction. This provided a focus for further investigation.

Several methodologies were utilised to examine the data. These were based on firstly satisfying any issues that the testing identified that necessitated immediate actions, secondly on establishing underlying causation and relationships between skid resistance and other pavement parameters, and thirdly on development of methodologies and strategies to efficiently and effectively investigate, monitor and manage skid resistance. It is emphasised that many of the datasets utilised in this process are of variable quality, completeness and contain aspects that are the result of subjective assessment. As such the desktop solutions presented should be used as a guide to focus investigatory effort. The final decision making processes and prioritisation will include field inspection and engineering technical advice.

5.2.2 Obtaining Information

The majority of information utilised for this project was already held in a variety of systems within Mackay District. However considerable amounts of data required reformatting to enable it to be spatially enabled, ensure completeness and ensure that its useability was maximised. Typically this involved addition of columns that contained subjective data or positional information. A typical example using Seal age data where an adjusted seal age has been calculated is shown in Figure 5.2.



	LAYER_NUMBER	LAYER_TYPE	LAYER_DEPTH	LAYER_DATE	LAYER_TYPE_NAME	LAYER_CATEGORY_NAME	SEAL_AGE as at Dec-04	Seal Age as at Jun 04	Treatme
1632	1	I1	10	05-MAR-98	Bitumen Open Graded Asphalt	Open Graded Asphalt	6.9	6.3	
1633	1	I1	10	05-MAR-98	Bitumen Open Graded Asphalt	Open Graded Asphalt	6.9	6.3	
1634	1	K1	16	15-OCT-02	Bitumen Spray Seal	Spray Seal	2.3	1.7	
1635	1	K1	16	15-OCT-02	Bitumen Spray Seal	Spray Seal	2.3	1.7	
1636	1	G1	75	21-MAR-01	Bitumen Dense Graded Asphalt	Dense Graded Asphalt	3.9	3.3	
1637	1	GU	75	01-JAN-88	Asphaltic Concrete - Quality Unknown	Dense Graded Asphalt	17.1	16.5	
1638	1	GU	75	01-JAN-88	Asphaltic Concrete - Quality Unknown	Dense Graded Asphalt	17.1	16.5	
1639	1	GU	75	01-JAN-88	Asphaltic Concrete - Quality Unknown	Dense Graded Asphalt	17.1	16.5	
1640	1	GU	75	01-JAN-88	Asphaltic Concrete - Quality Unknown	Dense Graded Asphalt	17.1	16.5	
1641	1	KU	20	01-JAN-50	Spray Seal - Quality Unknown	Spray Seal	24.1	23.5	
1642	1	KU	20	01-JAN-81	Spray Seal - Quality Unknown	Spray Seal	24.1	23.5	
1643	1	KU	20	01-JAN-81	Spray Seal - Quality Unknown	Spray Seal	24.1	23.5	
1644	1	KU	20	01-JAN-81	Spray Seal - Quality Unknown	Spray Seal	24.1	23.5	
1645	1	KU	20	01-JAN-81	Spray Seal - Quality Unknown	Spray Seal	24.1	23.5	
1646	1	KU	20	01-JAN-81	Spray Seal - Quality Unknown	Spray Seal	24.1	23.5	
1647	1	KU	20	01-JAN-81	Spray Seal - Quality Unknown	Spray Seal	24.1	23.5	
1648	1	I3	10	30-JUN-96	Novachip Open Graded Asphalt	Open Graded Asphalt	8.6	8	
1649	1	I1	10	24-NOV-96	Bitumen Open Graded Asphalt	Open Graded Asphalt	8.2	7.6	
1650	1	I1	10	24-NOV-96	Bitumen Open Graded Asphalt	Open Graded Asphalt	8.2	7.6	
1651	1	I1	10	24-NOV-96	Bitumen Open Graded Asphalt	Open Graded Asphalt	8.2	7.6	
1652	1	I1	10	24-NOV-96	Bitumen Open Graded Asphalt	Open Graded Asphalt	8.2	7.6	
1653	1	I1	10	24-NOV-96	Bitumen Open Graded Asphalt	Open Graded Asphalt	8.2	7.6	
1654	1	I1	10	24-NOV-96	Bitumen Open Graded Asphalt	Open Graded Asphalt	8.2	7.6	
1655	1	KU	75	01-JAN-91	Spray Seal - Quality Unknown	Spray Seal	14.1	13.5	
1656	1	KU	75	01-JAN-91	Spray Seal - Quality Unknown	Spray Seal	14.1	13.5	
1657	1	G1	40	18-DEC-01	Bitumen Dense Graded Asphalt	Dense Graded Asphalt	3.2	2.6	
1658	1	G1	40	12-MAY-03	Bitumen Dense Graded Asphalt	Dense Graded Asphalt	1.8	1.2	
1659	1	G1	40	12-MAY-03	Bitumen Dense Graded Asphalt	Dense Graded Asphalt	1.8	1.2	
1660	1	G1	40	12-MAY-03	Bitumen Dense Graded Asphalt	Dense Graded Asphalt	1.8	1.2	
1661	1	G1	40	12-MAY-03	Bitumen Dense Graded Asphalt	Dense Graded Asphalt	1.8	1.2	

Figure 5.2: Additional Columns added to Seal Age dataset

Almost all the pavement related datasets required some manipulation. This primarily involved the reduction of the broader datasets to the same geographical extents and in some cases the addition of some fields to make manipulation and querying easier. Where subjective data was added this was often the result of a lengthy process of evaluation.

It is important to note that the data contained in many of the parent systems is imperfect, in some cases of low quality or incomplete and for this reason a high degree of subjective assessment, inspection and local knowledge of the network is required for the development of appropriate priorities. In the majority of cases the data is captured in one traffic lane only and has been assumed to be similar for adjacent untested lanes. This assumption may not be universally valid and hence further detailed analysis is required of sections that involve such lanes.

5.2.3 Review and Evaluation of Information

It is vital to review and evaluate the data to be utilised in any project as the outcomes are likely to be incorrect should the data be inappropriate for the proposed usage. If data is deemed unreliable it is vital that the limitations of outcomes of analysis be clearly stated as a minimum. If a wide range of data is to be integrated the best way to manage this must be established so that the final product is unambiguous and clear in its communication of outcomes. For this project given that the individual datasets are accessible using a range of other methods and systems external to the project control is not entirely possible. Metadata does provide a solution where data is accessed from individual systems. However where combinatorial operations are utilised this becomes problematic. For this reason a warning is provided in the form of a statement within the legend of output information stating the following. 'The data displayed on this map is provided as a depiction that may not represent the true physical relationships between features. The depiction is a representation of the source data and requires confirmation by field inspection. Please contact your GIS Officer for further information.'

An assessment was also undertaken of any likely sources of error that may exist in the data so that effects could be understood and taken into account when developing an analysis approach. Metadata provided a valuable source of information in the investigation of this aspect.

5.2.4 Data Creation Processes

This project required examination of a wide range of parameters and data relationships so their effects on the road network and its usage could be established. Some of these areas requiring investigation arose from reports and related departmental initiatives such as Barans' (2004) report which suggested aggregate properties required investigation as a possible source of skid deficiency in the District and North Queensland Regions' approach to meeting the requirements of the Road System Manager framework. In addition to examining these issues an investigation into broader trends and relationships between pavement performance parameters such as seal age verses skid resistance properties, and asphalt verses chip seal was warranted. Firstly, an approach to analyse the data to establish any relationships with accidents was required. It is emphasised that when accidents occur where the road appears to be a factor that they are and have always been investigated promptly.

The North Queensland Regions' Strategic Directions 2004-2005 Policy document identifies Deficient Skid Resistance as element 29 of its strategy to meet the requirements of the Departmental Road System Manager framework. An assessment of wet weather accidents is undertaken as part of this strategy. Wet weather accidents are considered more likely to occur where there is a skid deficiency present. In Mackay District there were several approaches taken to examine the different aspects of the skid resistance / accident relationship.

Two datasets in particular required considerable development and a range of additional information. Both these datasets established relationships between road crash information and the skid deficiency testing and are now discussed.

5.2.4.1 Wet Road Crashes Table

Wet road conditions are considered to be more likely than dry conditions to show skid deficiencies in road pavement as water results in a reduction in the available friction. This dataset was an extraction of data from the Departments RoadCrash 2 system and contained various details of road accidents that occurred between 1 January 2000 and 30 March 2005. It was decided that due to the uncertainty of the nature and amount of additional data required that this base table would be built in Microsoft Excel with the final product being mapped, integrated and analysed in the GIS environment.

1. The table was initially filtered in Excel to remove crashes that occurred in dry weather conditions and sorted so that the severity of crashes were

grouped with the most serious at the top of the table. Unknown and Fog condition accidents were also retained for consideration as they may have occurred in wet conditions. The following factors were then assessed and results recorded in the table;

2. Review all police accident reports of the wet crashes to establish whether skidding was a contributory factor in the accident. The accident reports are sourced through Roadcrash 2. Note also any mention of water on or over road which may indicate a pavement drainage issue;

3. Identify whether the accident had occurred on a possibly skid deficient section or not. This was completed by firstly querying the Wet Crashes dataset using Structured Query Language (SQL) in MapInfo to select those accidents where skidding appeared to be a factor (Figure 5.3) This operation is a typical example of an SQL query used in the delivery of this project.

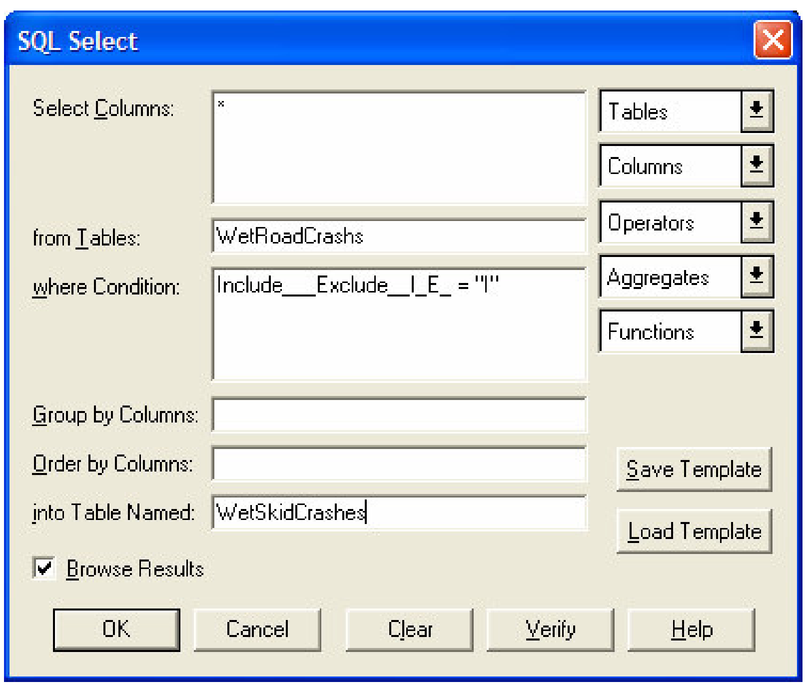


Figure 5.3: Query of WetRoadCrashes dataset

4. An Intersection operation using SQL was then carried out to establish which of these accidents fell on the skid deficient road sections;
5. Identify whether the accident occurred on Asphalt or Chip Seal through examination of the pavement layer information contained within ARMIS;
6. Identify whether the accident occurred where sufficient texture depth existed. This data used the assumption that a minimum surface texture depth of 1 mm was required for chip seals and 0.4 mm was required for asphalt surfaces. It is acknowledged that in the case of high demand asphalt pavements that 0.6 millimetres may be a more appropriate minimum surface texture depth, however for this analysis these AUSTROADS guidelines were adopted as an initial starting point. Where values were close to these levels they were notated in the comments sections of the table;
7. Investigate whether the site was treated post accident through examination of Chartview. By comparing completion dates of jobs against accident dates treatments that have occurred post accident can be identified;
8. View Digital Video Road to establish any visual factors and confirm pavement condition Aspects targeted included evidence of flushing, rutting, cracking, stone loss and pavement deformation.;
9. Comment on any issues identified and whether any initial action may be required. This allows a quick search of those areas that may require a treatment. It includes areas that are already programmed for treatment, which are included as requiring action as they are yet to occur;

10. Identify any apparent accident clusters. Generally a 250 metre radius around intersections was utilised whilst most mid block or non intersection road sections were considered based on homogeneous sections. The majority of mid block sections were less than 500 metres long. This work was carried out primarily in the Excel spreadsheet environment through the use of sorting routines, however was also visually confirmed using the GIS environment. It is acknowledged that this operation may have been carried out solely within the GIS environment using proximity analysis however there was a considerable degree of subjectivity in the assessment and the Excel spreadsheet allowed the result to be delivered within a few seconds. In this case GIS was used to confirm and visualise the analysis carried out in Excel. This analysis included both skid related and non – skid related wet accidents. Each of these clusters is viewed as a priority area for investigation; and
11. This table was subsequently geocoded to allow integration, analysis and display with other datasets.

5.2.4.2 Inspection Priorities Table

The second dataset was constructed as a collation of information from various sources again using the Excel environment. The resultant table was based on an extraction from the skid resistance report supplied to the District. The methodology involved an initial assessment of the skid resistance data. The priority in this process was to establish whether there were any skid related accidents occurring on the possibly skid deficient sections. This assessment used a similar premise to that developed in Northern Regions' Strategic Directions 2004 – 2005 document. Construction of this table involved the following steps;

1. Selection of those sections from the test report where the probability of failure to meet the skid investigatory levels was greater than 30% using Excel;
2. Run the Roadcrash2 TARP crash analysis of the entire District road network spanning the last 5 year period with parameters of 250 metre radius around intersections and 1 kilometre road sections. The outcome of this analysis is a report that ranks locations based on a complex formula that considers the cost of the crashes involved, crash rate at location per vehicles that use the location, and the relative rate that the location has compared with the rest of that road section. The analysis reports in terms of an actual crash rate compared to a critical crash rate. Where the relationship results in a positive value the crash rate at the location is identified as higher than normal. This report was procured in a hard copy format. For the purpose of this analysis these locations were described as blackspots. Those blackspot sections that fall in a possibly skid deficient section are notated in the spreadsheet. The specific locale of the blackspot section within the specific possibly skid deficient section was also identified to aid in prioritisation in an adjacent column of the spreadsheet;
3. Identify any apparent skid related accidents in the possibly skid deficient road sections. This data was obtained from the Wet Road Crash assessment carried out above and notated in the spreadsheet;

4. Determine seal age and notate for each possibly skid deficient section in the spreadsheet. This data was extracted from the Seal Age dataset which contained adjusted dates to match the testing;
5. Using the resultant table from step 1 input additional location data and other fields in the spreadsheet. Fields entered included a local area description, through distance start and length fields. These aid in end user understanding of the individual section and also form part of the reformatting preparation process for MapInfo geocoding;
6. Identify whether each section has adequate or inadequate surface texture depth. As with the wet crashes table this data applied the same assumption of required minimum surface texture depth. The same notation and commenting process used in the wet crashes table was also utilised;
7. Identify and notate any programmed treatments for each of the sections through examination of proposed works programs;
8. Notate comments on these parameters. This includes validation and comments on any of the data described in other columns. For example barely adequate texture depth may be commented;
9. View Digital Video Road to establish any visual factors and confirm pavement condition Aspects targeted included evidence of flushing, rutting, cracking, stone loss and pavement deformation;
10. Prioritise locations based on the following criteria. Obviously all priorities have possibly skid deficient pavement in common;

a. Priority 1.

    i. Includes a Blackspot section which indicates a higher than normal crash rate for that environment; and

    ii. Evidence of 1 or more skid related accidents

b. Priority 2.

    i. Includes areas where EITHER a Blackspot section has been identified or 1 or more skid related accidents have occurred.

c. Priority 3.

    i. Possibly skid deficient areas that do not have a Blackspot section but may have a skid related accident identified that are in the design phase. These areas may also have other pavement deficiencies in addition to possible skid deficiency.

d. Priority 4

    i. Possible skid resistance deficiency was the only significant pavement defect identified at the site. Close monitoring of the site is suggested.

11. Notate reasoning for priorities. This provides a place for validation of initial decisions to be accommodated;

12. Immediately inspect priority 1 sites that have not already been addressed. This process is repeated for all the identified sites in an order of decreasing priority;

13. Report findings with recommended actions;

14. Program remedial works;

15. Monitor performance of treatment solution. It is emphasised that resealing is not necessarily the solution; and
16. This table was also subsequently geocoded to allow further integration, analysis and display with other datasets.

It is acknowledged that several of the steps involved in the construction of these tables may have been carried out by other means however this approach will allow greater ease in querying and smoother data integration.

5.2.5 Geocoding Information

Information was geocoded utilising the 'Nerang Applications' geocoding wizard which forms part of the Road Centreline Tools. This tool utilises the state controlled road network centrelines, road identification number, Tdist and length to produce graphical representations of features on the network. Appendix G contains an example of the AADT dataset being geocoded. Tables were geocoded utilising this tool for all the ARMIS related and derived datasets for this project utilising this tool.

5.2.6 Creating a MapInfo Workspace

Once the various datasets have been collated, and manipulated into an appropriate format and subsequently geocoded against the road centreline the integration of data can commence. This is achieved by the construction of a workspace. A workspace may be likened to a cooking recipe. The workspace tells the computer what ingredients are required, in this case the ingredients are datasets, where those datasets are located, how it wants them displayed, and the order it wants them displayed to produce the desired output. Datasets required for this project include DCDB, road networks, coastline, various road pavement related datasets, DVR, towns, hydrology, and Local Authority Boundary information.

Appendix D provides an image of some of the various datasets that form individual data layers utilised in this project through the use of the MapInfo Layer Control dialog. Additional to the base data layers, various thematic map layers are also present in the above Layer Control image. A thematic map is a layer generated from a dataset based on a particular theme. Appendix E displays the Legend Window from one such thematic layer.

MapInfo provides a full range of zooming, panning and related tools and the user is able to associate additional data to that included in the workspace should they so wish. This flexibility in approach and data integration is the strength of the GIS environment.

5.2.7 Customise the 'Main Roads' Menu

One of the advantages of the Departments 'Nerang Applications' is the ability to develop menus that are accessible to all users in the district. This facilitates the easy development and distribution of pre-built workspaces for commonly used activities and tasks. This approach also enhances accessibility to basic maps for non technical staff usage. Figure 5.4 below shows an example of the Main Roads Menu including the Skid Resistance workspace link.

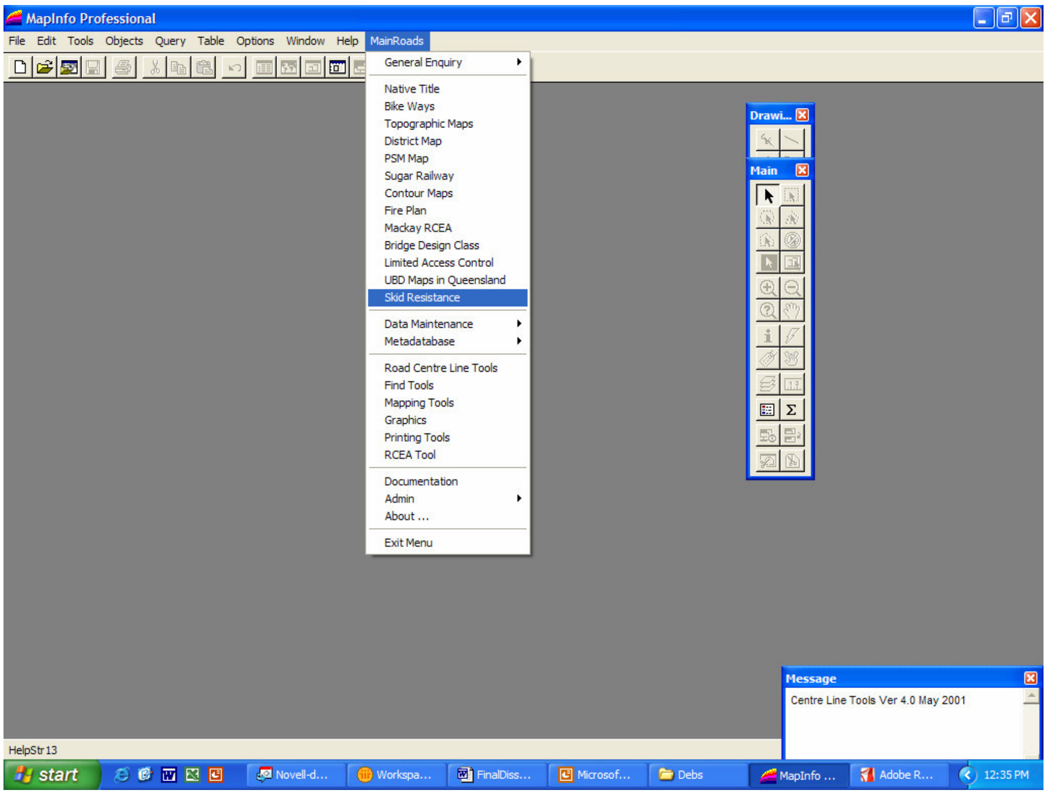


Figure 5.4 Main Roads Menu including Skid Resistance link

Appendix F shows the dialog utilised in setting up the menu link utilising the Main Roads Menu Administration component of the 'Nerang Applications'. Note that this area also allows a variety of other 'Nerang Applications' to be automatically opened when the link on the menu is triggered by the end user. This feature has allowance for any MapBasic application to be automatically run as part of the opening of the workspace and therefore enables non technical end users to access the complete user interface without necessarily having an intimate knowledge of the technology or applications involved.

5.2.8 Layer Control Utility

It is likely to be unclear to a general user what each particular dataset may relate to based on its title. Whilst metadata is utilised to clarify this, an additional way to achieve this is by grouping layers together based on their topic. For example, if all land parcels are grouped together under a group entitled cadastre then the end user does not require a detailed understanding of the individual dataset layer titles that make up this group.

The 'Nerang Applications' include such a layer grouping functionality. The Workspace Layer Control Tool allows a meaningful grouping of similar themed tables. The tool creates a radio button pad which loads with the workspace and allows a toggle on or off display of each group (Figure 5.5). Individual buttons each have an icon that gives a visual cue to the subject they pertain to as well has an attached help string which facilitates a bubble display giving a textural description when the user places the mouse over it.

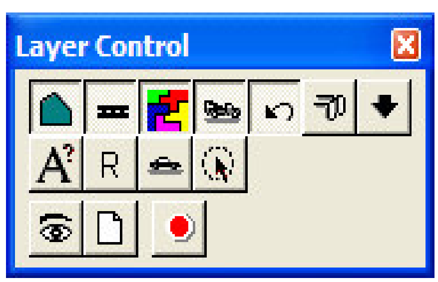


Figure 5.5 Workspace Layer Control

Appendix H contains an image of the layer control tool dialog used to develop the layer control pad for the Skid Resistance workspace.

5.2.9 Representation of Information

Establishment of the best way to display each dataset such that any confusion between differing features is avoided and communication of the significant issues is enhanced is a vital aspect of any GIS project. In this project there was a large amount of information involved that was linearly referenced over the same geographical extents along a network of geographical objects. This presents a significant challenge as the project is dealing with a multi facetted parameter where a wide range of relationships were sought to be investigated and reported.

The approach taken was to utilise a combination of analysis techniques and display options to ensure that communication of desired attributes was clear and effective. This was achieved in the following ways.

1. The use of zoom controlled layering. This means that certain larger datasets are not visible to the end user until a certain zoom level is reached. This allows avoidance of unnecessary clutter that detracts from the depiction of the desired features.
2. The use of Workspace Layer Control. This is a tool that was a departmentally developed as part of the "Nerang Applications". The tool allows the grouping together of similar tables of data under a series of theme based toggle buttons. This allows the user to chose which groups they want displayed without an in depth knowledge of the data tables. Similar buttons have been constructed for likely queries so that the user only need select the appropriate button to gain a visual representation of

the desired dataset or combination of datasets. Each button that forms part of the layer control has a help bubble attached which displays when the mouse is passed over it and describes what feature the button pertains to.

3. Creation of Thematic Maps and Symbology. This project involved many datasets which covered the same approximate extents and this creates challenges in ensuring a meaningful display of the desired attributes. Whilst this could largely be controlled by the workspace layer control there are a lot of cases where combinatorial mapping of features was required. An additional challenge was the large size of the area that the project encompassed which was further complicated by the linear nature of the network along which the features were being mapped. In addition to the workspace layer control the use of colours and line styles to accentuate features of importance was utilised. A variety of analysis techniques were utilised including thematic mapping. Thematic mapping is mapping of a particular theme. Thematic mapping was utilised on most datasets and queries to highlight the key attributes. A legend detailing symbology is naturally also provided to ensure comprehension of the display.

4. Printing Tools. The "Nerang Applications" also include a tool that allows a basic printing layout which title, logo, legend, north point, scale bar, title and footnotes to be created. End users have been instructed in the use of this tool. The Skid Resistance Assessment application is designed for an interactive digital environment rather than a hard copy format. Generally end users will view small sections of the network

individually rather than the entire network. For this project it was not practical to produce a complete map as the features and their relationships would not be viewable at an appropriate scale. Maps can be produced over smaller extents quickly and easily through the use of the mapping tool.

A future enhancement of this approach would be delivered through the ability to create sub menus. The above processes mean that the end user gains a clear understanding of the particular aspect of the project that they are interested in.

5.2.10 Data and Statistical Analysis Outcomes

The focus of this dissertation now shifts to the outcomes realised from the analysis of the tables. Particular focus is given to the relationships established through the wet crashes and inspection priorities tables. Additional associations between various pavement parameters are then discussed.

5.2.10.1 Wet Road Crash Table Analysis and Comments

1. A total of 1998 accidents occurred on the District network between 1 January 2000 and 31 March 2005. This dataset once reduced to those accidents that occurred in wet, foggy or unknown conditions contained 296 accidents. It is acknowledged that this selection may be imperfect as water can be a factor on the roadway due to factors other than rain such as overflow from sprinklers watering grass islands or incorrect

documentation in the police report. In Mackay there are few locations where such irrigation is in place. The assumption was made that the vast majority of relevant accidents will be correctly identified. Of these accidents 47% resulted in property damage only.

2. Of the 296 wet accidents 166 appeared to have a skidding factor. It is emphasised that this number includes accidents that would have still occurred irrespective of the amount of available skid resistance such as accidents involving disobeying traffic lights or driver distraction. These were included because although the driver was considered the primary causation they still had attempted to brake. Factors that resulted in exclusion included non skid accidents involving driver fatigue, driving under the influence (DUI), and other unusual incidents. It is also acknowledged that accidents generally occur due to multiple factors. It is significant that the severity outcomes of an accident may vary depending on the skid resistance available (Oliver, 2002).

3. A selection query of the Wet Road Crashes table within MapInfo was carried out to establish the number of accident reports that mention water on or over the road surface. This resulted in 32 accidents being identified at 25 locations. These sites and in particular those that occurred where there were a cluster of accidents were immediately inspected with remedial action proposed where appropriate. Nine of these sites had been treated since the accident occurred. Interestingly only one of these accident sites was identified as having occurred on a possibly skid deficient pavement. These accidents while significant in terms of safety are a reflection of pavement drainage issues rather than skid issues.

Whilst this was not an initially sought attribute of this project the review process allowed easy identification of such issues as an additional benefit and is an example of the proactive approach to the management of pavement related issues that the District is taking.

4. In the construction of the Wet Crashes dataset it was noted whether the road section had been treated since the accident had occurred. Examination indicated 42 of the 166 skid related accident sites had been treated since the accident. On face value this may seem poor but it is critical to understand that the majority of these accidents did not occur on skid deficient sections of road and as stated above may still have occurred irrespective of available skid resistance. It is also emphasised that many sections are being targeted for treatment in the immediate future and that quite a lot of areas have already been treated under existing maintenance programs. Some areas that have been recently treated through the maintenance program works will not be recorded in databases until the after this project is finished. The 2004 / 2005 reseal programme was not included in the data at the time of this analysis and is known to have treated some areas of concern.
5. The selection of roads based on rainfall and traffic patterns was highly successful in Mackay District. For the 5 years of accident history considered only 3 additional wet condition accidents occurred on road sections that were not tested none of which appeared to be skid related. This compares to 293 wet accidents that occurred over the same period on the test sections of which 166 appeared to have a skidding factor. Only accidents on the test sections will be considered further. It is emphasised

that although 166 accidents appeared to have a skidding component the majority of these would still have occurred irrespective of the skid resistance available at the location although the resultant severity may have been different. The assessment of this fact was largely based on the nature of the accident and the police accident report (eg. Run a red light).

6. The cluster analysis revealed a total of 23 clusters involving 114 accidents. This analysis included both skid related and non – skid related wet accidents. Each of these clusters is viewed as a priority area for investigation. The inclusion of non - skid related accidents was adopted for this aspect to identify those areas with a high number of crashes in general irrespective of crash rate per vehicle kilometre travelled.
7. A GIS analysis was carried out utilising various queries (two selection queries followed by an intersection query) to determine which of the skid related crashes occurred on the possibly skid deficient sections. This resulted in the finding that 51 of the 166 skid related accidents occurred on possibly skid deficient sections. The possibly skid resistance deficient sections identified by the survey represented a total of 12.9% of the total road length tested. These sections represented 32% of skid related accidents. A higher accident rate on possibly skid resistance deficient sections was an expected finding and supports findings of Oliver (2002) and Baran (2004). This evidence forms a compelling reason to manage skid resistance.
8. Significantly only 26 of the 293 wet accidents occurred on sections where surface texture depth was considered inadequate. Skidding was a factor in 15 of these accidents of which only 3 occurred on possibly skid deficient

sections. Significantly 22 of the 26 accident sites have subsequently been treated or did not appear to be road related. Examination of the severity of the wet road accidents resulted in the breakdown shown in Table 5.1

Severity	Number *	Skidding **	Skidding & Possibly Skid Deficient ***
Fatal	7	2	1
Admitted to Hospital	56	27	8
Medical Treatment	54	35	12
Minor Injury / First Aid	32	15	7
Property Damage Only	140	97	23
Total	293	166	51

* Represents the number of accidents in each severity category that occurred in wet, fog or unknown conditions between 1 January 2000 and 30 March 2005 on the sections tested for skid resistance.

** Represents the number of these wet accidents in each severity category that appear to have a skid component by the nature of the accident, the police report or expected circumstance.

*** Represents the number of these wet and skid implied accidents that occurred on pavement surfaces that recorded skid resistance levels such that they were considered to have a probability of 30% or more of not meeting the relevant investigatory levels in each severity category.

Table 5.1: Wet Accident Severity

Table 5.1 also shows the breakdown of accidents that appeared to have a skidding component and those that have both a skidding component and occurred on a section identified as possibly skid deficient. Only two of the fatal accidents appeared to be skid related and only one of these was on a possibly skid deficient section. Speed and fatigue were cited as likely factors in this particular fatality. Once again it is emphasised that the majority of these accidents including those with an assessed skidding component would still have occurred irrespective of the skid resistance available at the location although the severity outcomes may have been different.

9. Examination of pavement types indicates that 141 of the 293 accidents occurred on asphalt surfaces. In Mackay District asphalt comprises 97 km of the 1758 km. The survey captured all but 400 metres of the asphalt areas in the district. Asphalt is predominantly located in the urban areas in the district and a higher percentage of accidents would naturally be expected due to the significantly higher traffic volumes of these environments and none of these sections had a positive critical crash rate.
10. Investigation shows that 120 of the 293 wet accidents occurred at night or around dawn or dusk. The lower number of accidents at night is possibly a reflection of lower traffic volumes at that time. Further investigation is required to establish whether the relative crash rate at night is higher than in the day time, however this examination was considered beyond the scope of this dissertation.
11. Driver demographics comprised another area of examination. Table 5.2 below shows a breakdown of the license types of the vehicle considered at fault in each of the 293 wet accidents.

License Type	Number
Open	208
Provisional	49
Learner	8
Not licensed in Australia	4
Cancelled / Disqualified	4
Expired	3
Inappropriate Class	1
Not applicable	4
Not known	7
Never Held a License	2
Unlicensed	3

Table 5.2: Driver License Demographics for Wet Accidents

Examination of these demographics indicates that of the 293 wet accidents 57 drivers were Learner or Provisional licence holders which represent 19.45% of the accidents. This compares with state licensing figures that identify the learner / provisional population comprising 252,754 drivers in a total driver population of 2,587,635 or 9.77%. This suggests that the learner / provisional class licence holders may be over represented in wet accidents. Although this may identify a possible problem relating to driver experience there may be several other factors involved which are beyond the scope of this investigation. Significantly many of the police reports examined as part of the accident assessment cited driver inexperience as a contributing factor to the accident

12. Of the 293 wet accidents sites 160 were identified as requiring possible investigation. Many of these suggested investigation sites were already programmed for treatment, identified as part of the previously mentioned clusters, or identified as having other non skid related issues. For example several accidents appeared to be the result of driver fatigue so the required action may relate to investigating whether a fatigue study is warranted for that area.

As can be seen the approach taken has allowed identification of other issues for minimal additional effort. These factors all contribute to a more complete picture of the state of the road network.

5.2.10.2 Inspection Priorities Table Analysis and Comments

1. Although only wet accidents were used in the skid accident analysis portion of this table it is important to note that the Blackspot analysis considers all accidents at the location irrespective of conditions. This allows a clearer prioritisation of sites and allows factors such as social cost of accidents to be taken into consideration. This methodology although basic allows quick identification of areas that need prompt inspection.

2. The initial analysis of the inspection priorities table indicated that there were 52 sections comprising a total of 137.3 km which had a probability of failure to meet the investigatory level of greater than 30%. Table 5.3 shows the number of section in each priority category.

Priority	Number of sites
1	7
2	7
3	9
4	29
Total	52

Table 5.3: Inspection Priorities of Possibly Significantly Deficient sections

As the majority of sites were assessed as priority 4 the only apparent deficiency at the location related to possible skid deficiency and so those sites will be closely monitored. It is possible that some of these sites were the result of errors in the field testing. It is emphasised that all sites identified as possibly skid deficient are inspected with the highest priorities being investigated first. It should be noted that 14 of these 23 higher prioritised sections were already on existing proposed works programs. The majority of the remaining sites are approaching 10 years old and will be incorporated into the normal maintenance program through Scenario Millennium in the immediate future. What is also significant is that in many of the sections that met the 30% probability of failure criteria, the problem area related to one localised section within the section, the specific locale of which was not clear from this initial data. This aspect will be clarified by investigation of the 500 metre interval data which will allow more precise identification of the problem areas in the near future.

5.2.10.3 Other Accident Related Queries

1. A selection of the Wet Crash table was undertaken to reveal accident sites where inadequate texture depth may exist coupled with apparently skid related accidents. This resulted in 15 accident sites being selected of the 166 wet road crashes. Interestingly all of these accidents occurred on chip seals surfaces. The resultant output table from this query was then further interrogated to determine how many of these accident sites were on possibly skid deficient road sections. This query resulted in 9 of the 15 accident sites being identified. It should be noted that further investigation indicates that 4 of these 9 sites had been treated subsequent to the accident.

5.2.11 Investigation of Relationships between Skid Resistance and Pavement Parameters

Whilst the initial data preparation and above analysis of some tables necessarily involved some quite detailed investigation which also identified areas requiring immediate attention a more detailed analysis is required to establish the relationships between the different factors. This environment also allowed a more in depth review of the ancillary data which comprised some of the tables.

The focus was on comparison of the identified possibly skid deficient sections against various individual pavement parameters to establish whether any significant relationships were able to be determined. The relationships investigated are now discussed.

1. <u>Skid deficiency versus Pavement Type.</u> This analysis was based on whether the pavement was an Asphalt or Chip Seal surface. In Mackay

District there is only 97 km of asphalt surfacing of which 96.6 km was tested. A significantly higher percentage of the asphalt was found to be possibly deficient relative to the chip seal surfacing. This correlates with observed state wide trends.

2. <u>Skid Deficiency versus Surface Texture</u>. The basis of this analysis was to establish whether a lack of surface texture depth (macrotexture) was causing skid deficiency. AUSTROADS guidelines were adopted for this assessment with minimum texture depths of 0.4 mm being utilised for asphalt surfaces and 1 mm for chip seals. It is acknowledged that in high demand areas a surface texture depth of 0.6 mm is suggested. Therefore any asphalt section that had a lower depth than 0.6 mm was notated as marginal. Of the 52 high probability of failure sections only 6 exhibited inadequate texture depth. The majority of these sections were over 9 years old and were already programmed for treatment. Essentially this parameter did not appear to be significant as a causation of skid deficiency in this particular circumstance and confirms the initial investigations outlined in the report by Baran (2004) to the District.

3. <u>Skid Deficiency versus Seal Age</u>. The initial assessment provided to the district indicated that the problem appeared most likely to be related to the aggregate. Whilst in service the aggregate is exposed to a variety of factors which over time tend to polish the stone. This polishing results in a decrease in the available skid resistance through the loss of microtexture of the aggregate. Oliver (2002) suggests that pavements over 5 years old may start to show skid deficiencies and should be monitored. The analysis revealed that nearly 88% of the possibly

deficient sections had a seal age greater than 5 years with 85% being older than 6 years old. Approximately 65% of these sections are aged between 6 – 10 years old. Australia has few sources of aggregate with above average Polished Aggregate Friction Value (PAFV). PAFV is a measure of an aggregates resistance to polishing. Whilst the stone used has met the aggregate specification including PAFV pre-service it appears that in some cases the in-service performance does not reflect expectations. Because the possibly deficient sections generally exhibit adequate surface texture (macrotexture), are getting towards the end of their service life and have skid deficiency the likely causation is the loss of microtexture through wear. It is noted that the problem section of the Bruce Highway identified in the initial report has a high percentage of commercial traffic. Heavy commercial traffic has a significant effect on the rate of polishing of aggregates. In the past Mackay District had a policy of resealing the National Highway program every 6 years on chip seals. With the introduction of Scenario Millennium the reseal interval has been extended to 8 years. Perhaps this time span may exceed the usable life of some aggregate materials in use in the District. It is emphasised that the majority of older pavement sections (over the age of 5 years) in the district have NO apparent skid deficiency. Whether this is a function of the particular aggregate used or other factors is not clear and is the subject of further investigation. The analysis tends to indicate that PAFV does not guarantee in service performance but is of some use to rank different aggregates.

4. <u>Skid Deficiency versus Traffic Environment</u>. As discussed in the previous section the nature of the traffic on a road section can have a significant effect on the way that the pavement performs. In general no specific relationships were able to be established between the traffic volumes and the possibly deficient sections however as some sections are subject to a high percentage of heavy loads this area may warrant further investigation. There were some naturally expected relationships such as higher traffic volumes in urban areas which were generally asphalt surfaced.

5. <u>Skid Deficiency versus Roughness.</u> Roughness is a measure of the longitudinal profile of a road surface and is reported against the International Roughness Index (IRI). Roughness is significant not only through its effect on the friction available to vehicles but also because it can affect the results of the skid testing. Generally higher roughness will result in decreased skid resistance due to lesser contact area at the tyre / pavement interface. A trigger of 120 counts per 100 metre road section was utilised to identify sections of high roughness. Approximately 10% of the significantly possibly skid deficient sections had a high roughness count. Significantly these sections were also aged and were already programmed for treatment based on various pavement parameters.

6. <u>Skid Deficiency versus Speed Environment.</u> The speed environment is taken into account when assessing skid deficiency through the application of the appropriate investigatory level. However this assessment does not take into account sections of roadway that may be under advisory speed signage such as range sections. This is a possible source of error as the

wrong investigatory level may be used. It is also important to note that as speed increases the macrotexture of the road becomes more important in the provision of skid resistance. This parameter was utilised to confirm that the correct investigatory levels had been used. Several sections were identified where the levels used may be inappropriate.

Obviously once the desktop analysis is complete field inspection and further engineering input is required. A skid resistance investigation form is under development which documents the entire assessment process from the findings of the desktop analysis, through field inspection, through to treatments. This form can be stored electronically and hot linked to the appropriate road section in the workspace. Digital photos may also be attached in this manner. The draft form may be seen in Appendix J of this paper. It is also significant to note that mitigations for possibly skid deficient sections may include treatments other than resealing such as changes to speed zones.

5.2.12 Field Inspection and Verification

As with all database systems the outputs are only as good in quality as the inputs. As it is acknowledged that the data quality of many of the datasets involved is variable a field inspection and verification is required to be undertaken to establish the validity of the priorities and trends identified by the system. Some of this verification can be completed at the desktop by consulting with technical experts and via the use of tools such as DVR. Priority areas can then be targeted for field inspection with a determination of whether what the system is advising as a problem is a real problem. The inspector utilises outputs from the system to focus investigation on those particular aspects that resulted in the priority. The field inspection is documented on a proforma word document which may be hot linked to the relevant road section using the graphics tool. A copy of a skid resistance field inspection form is shown in Appendix J.

5.2.13 Graphics Tools

The Graphics tool allows the user to associate photographs, documents, images and reports with a particular location. This tool was very helpful for various aspects of this project. The field inspection report on a particular section of roadway can be hot linked in this way to the relevant section of roadway. When the icon is clicked by the user an appropriate window will be opened with the desired information within the workspace environment. This facilitates enhanced communication and the ability for the end user to gain access regarding the road section from the one source. An example of the Graphic tool interface is shown in Figure 5.6

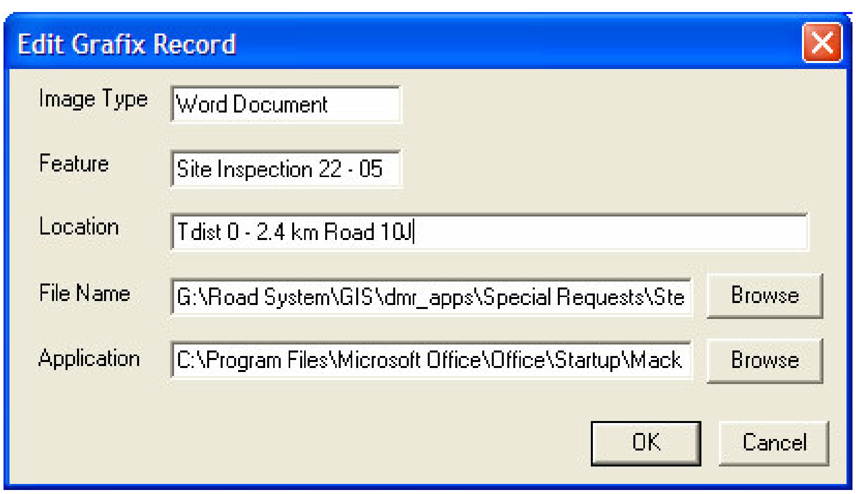


Figure 5.6: Graphics Tool Data Entry Interface

5.2.14 Information Outputs and Reporting

Due to the large extents in terms of area that the project covers a flexible approach is required that allows the end user to target the area of interest for their specific need. One application available to end users as part of the 'Nerang Applications' is the Print Tool. This allows the end user to interactively generate a map product which includes a Title, Subtitle, Scale, North Point, Departmental Logo, Disclaimers, Legends, Overview Map, Footnotes, Author and Date suitable for communicating the information to clients.

A wide range of map displays are available within the system. A commonly used methodology was the use of thematic maps. Thematic maps are simply maps that display a particular theme or subject. For example the colour coding of road crash data based on the severity of the crash. Thematic displays can be used to enhance communication of a particular issue to the end user via shaping or colouring of the subject objects. In the case of many of the thematic displays needed for this project the queries and symbology have been carried out and are assigned to a unique button in the Layer Control Toolbar. A press of the appropriate button will result in the desired analysis being displayed. Thematic maps were also utilised in this project to integrate data by the displaying of an object based on its compliance with two or more features. This is known as bi-variate and multi variate thematic mapping respectively. A key feature of the GIS solution to for this project is that the nature of output and analysis available is virtually open ended once the data is in the GIS environment this is an extremely advantageous feature of this approach.

5.2.15 Testing the System

The final stage of development was the testing of the workspace. This encompassed a series of activities and tests which included;

- Ensuring all menus and toolbars worked correctly and efficiently
- All reports entered through the graphics tool could be accessed. These reports may also contain photographs
- All queries worked and produced accurate results

The system testing did not result in any problems in the operation of the workspace.

5.3 Conclusions

- The management of skid resistance and other related data is a complex activity which is ideally suited to computer based approach. The provision of a complete outcome and management of skid resistance to meet departmental objectives is achievable through utilisation of computers systems. However, the data utilised for the project is of variable quality and as such a purely desktop solution is not achievable.
- The use of the linear referencing of data along road centrelines available through GIS is an efficient and effective way to bring the various datasets required for analysis of skid resistance into a single environment.

- The workspace and associated methodologies developed within this GIS based system will provide a useful decision support tool for the prioritisation and management of skid resistance in Mackay District.
- A variety of additional MapInfo based departmentally developed tools were utilised in the system to ensure a user friendly interface. These tools are known as the Nerang Applications. This project primarily made use of the road centreline, workspace layer control, hotlink and printing tools that form a part of this group of applications. Care was taken with symbology and the development of thematic maps to develop outputs that could be clearly understood by the end user.
- The system was tested to ensure that all menus, radio buttons, hotlinks and tools worked properly. This testing also included verification that the pre built queries returned the correct answers.
- The environment allows the data to be associated with other information. This information may be drawn internally from actions such as thematic maps or queries or be added from an external source. Alternatively the data may also be exported from this system and associated with another application. The power of data integration is a key feature that is of great benefit to this project and enables decisions to be made based on a detailed analysis. The nature of outputs and analysis available is open ended once the data is in the GIS environment and this is a strong advantage of this approach.

CHAPTER 6 CONCLUSIONS & DISCUSSIONS

6.1 Introduction

Main Roads recognises the importance of the provision of adequate infrastructure to support the road transport needs of Queensland. The Department recognises the significance of skid resistance as a factor in evaluating the performance of the road network. Skid resistance is one of many inputs used to enable the Department to manage the network in an effective manner which facilitates the delivery of a safe network for the people of Queensland. Maintenance of the road network is an expensive aspect of the Departments' activities. As available funding is limited it is vital that the Department is proactive in its approach to ensure that the funds spent on the network result in realisation of maximum benefits. The Department achieves this by:

- Collecting and updating road asset data;

- Development of effective policies, guidelines and frameworks that address all key issues;
- Formulation of works programs that meet the asset management vision; and
- Integration of asset management and departmental strategies to enable a cohesive and uniform solution to problems.

The effective management of the road network has gained a stronger focus in the Department due to increased demands placed on funding resulting from the growth in usage, heavier and increased amounts of freight, ageing of the road infrastructure, and greater user expectations. The funding and resource limitations of this environment mean that appropriate prioritisation of projects is vital in achieving the goal of delivering an adequate level of service to the people of Queensland.

Through regular development and review of asset information against standards and policies the Department is able to readily identify any potential shortcomings, deficiencies or sections requiring remedial action in an effective manner. Issues identified are then prioritised utilising the developed standards so that a suitable and achievable approach to the treatments may be carried out. An outcome of this prioritisation process is the development of a series of actions that will form the core of future work programs designed to meet and deliver the asset maintenance vision.

The current strategies and methodologies adopted by the Department form a strong framework through which the delivery of effective asset management can be achieved. Ideally, as much of the data considered is stored electronically it is logical that a computer based approach be taken. Through its ability as a spatial data integrator and manager GIS is an ideal environment to examine asset information. The use of such a tool enhances communication and provides risk based outcomes to facilitate delivery of Departmental objectives.

6.2 Benefits

The developed system allows users to view, interrogate, and prioritise sections of the road network whilst applying consideration of the effects of a wide range of asset data with minimal GIS knowledge. This approach should lead to better decision making processes that lead to informed management of the road network.

Benefits of the approach taken to evaluate the skid resistance data include

- Establishment of a defensible set of priorities utilising a variety of parameters that ensure a more complete picture of the network to be established
- Enhanced communication and comprehension of the factors that affect the usage and safety of the road network
- Establishment of a methodology that allows consistent investigation and prioritisation of skid resistance on the network

- Integration and collation of a wide range of asset information into a single environment.
- A wide range of other analysis is able to be carried out for other additional purposes. This value adds to the usability of the system and allows further investigation to be carried out. Establishment of relationships between datasets can be viewed and assessed interactively by the end user.
- A wide range of flexible graphical and tabular reporting formats are available.
- Hot Links to other information such as reports, videos and pictures facilitate further integration and understanding of issues. This ability also allows the system to be used as a central index for all skid related information.

6.3 Future Directions

The methodologies and management principles developed in this project create a viable tool through which the District can proactively deal with skid resistance. Such a system provides a framework that supports the delivery of road safety objectives through efficient, effective and informed asset management decisions and practices. As with all database systems the outcomes generated are only as good as the quality, relevance and availability of the information input.

Future developments of the system are likely to include the development of a querying interface for end users which will facilitate the combinatorial analysis of all pavement related datasets. This will allow detailed analysis of the factors and relationships affecting not only skid resistance but also other pavement related issues across the district. Another aspect of system development is the likely automation of some of the manual processes used to construct the base tables that were created in this project.

A continued and ongoing field capture program of skid resistance information is planned with the proposed frequency of testing dependant on the risk profile of the road section. All road sections within Mackay district will be captured towards the end of this year.

Continued investigation into pavement performance of different aggregates and surfaces is a key focus of the Department. Once the second round of testing is complete the data will be analysed to establish trial sections of different ages of possibly problem aggregates. These sections will then be subject to more intensive testing. This work should lead to a greater understanding of the likely useful service life of different aggregate / pavement combinations in different environment. Another benefit of this approach will be the monitoring and evaluation of effectiveness of the various mitigation methods used.

The additional testing will also allow confirmation of perceived trends identified in this project. Further development will occur in terms of a uniform approach via the development and adoption of a Regional and District policy for the testing, investigation and management of skid resistance. Management of skid resistance will remain a part of the Districts' proactive approach to asset management and is recognised as a key factor in the delivery of a safe road network.

6.4 Conclusions

The objectives of the project were realised through the successful development of;

- A GIS database system developed for analysis of skid resistance (addressing Objectives 1,2,4,& 5);
- An investigative methodology utilising statistical methods to analyse skid resistance (addressing Objective 2,3 & 4); and
- Investigations into the underlying relationships between skid resistance and other pavement parameters (addressing additional aim).

Other conclusions include;

- Skid resistance is affected by a wide variety of factors that require detailed analysis to establish causes and determine appropriate remedial solutions.
- The majority of possibly skid deficient surfaces identified are approaching the end of their design life and were already included in treatment programs in Mackay District as a result of other mechanisms.
- It is emphasised that although the majority of road sections identified as having possible skid deficiency were older than 6 years the majority of old pavements on the network have adequate skid resistance.

- Resealing may not be the solution if the cause of the skid deficiency is lack of adequate microtexture in the local aggregate source.
- Failure to manage road condition states adequately may result in exposure to litigation.
- The data analysed in this project appears to support the hypothesis that the problem in the district is aggregate related, however further testing is required.
- It is likely that the extension of seal life may have resulted in in-situ polishing of the aggregate which has contributed to a loss in microtexture and therefore decrease in skid resistance available.
- It had been expected that aggregates meeting the departmental specification would resist polishing adequately for the extended lifespan however this appears to indicate that PAFV is of value for ranking aggregates but does not necessarily give an indication of likely in service performance
- GIS provided advantages over other approaches through integration, analysis, presentation, and enhanced communication of relevant data.
- The evaluation process has the additional benefits of allowing a proactive management through the identification of other issues that may have otherwise been overlooked.
- Skid deficiency is useful as an additional input into the prioritisation of works and is essential to the delivery of a safe road network.
- The results of skid resistance testing are useful to identify and prioritise areas that require further investigation.

- A level less than the investigatory level does not necessarily mean that there is any problem with the section of pavement.
- As with many pavement parameters the diligent application of technical knowledge, standards and field inspection are required to arrive at an appropriate management strategy for the particular case being considered.
- Efficient and effective skid resistance management is essential to ensure that an appropriate level of road safety is provided to the travelling public and the methodology provided by this project is a viable way to deliver this objective.

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Appendix A - Project Specifications

The University of Southern Queensland
Faculty of Engineering and Surveying

ENG 4111/2 Research Project
PROJECT SPECIFICATION

FOR: **STEPHEN JOHN CLAGUE**

TOPIC: Investigation of Relationships between Skid Resistant Deficient Pavements and Aggregate by GIS and Statistical Analysis.

SUPERVISOR: Dr Sunil Bhaskaran, Co – Supervisor Mr. Robert Perna

PROJECT AIMS:

1. To establish relationships between identified sections of pavement with deficient skid resistance and aggregate properties on the State Controlled Road Network of the Mackay District of the Department of Main Roads.

2. To develop an information system utilizing Geographic Information Systems (GIS) that facilitates analysis and visualization of these relationships.

PROGRAMME: **Issue A, 20th March 2005**

1. Prepare draft proposal (3-4 pages) with abstract, introduction and literature review (Harvard referencing system), methodology, study area, data sources, availability, copy rights, data analysis, and anticipated results and a clear and practical project time line **by 26 November 2004**
2. Detailed assessment and study of data sources **by end December 2004**
3. Literature Review **by end December 2004**
4. Appropriate use of advanced statistical modelling to establish relationships **by end of April 2005**
5. Spatio-temporal Mapping of the data **by end of June 2005**
6. Start writing thesis by July, 2005. **First draft in** to supervisor **by end August, 2005**

If time permits:

AGREED:

__________ (Student) _____________ (Supervisor) _________ (Co-Supervisor)
___/___/___ ___/___/___ ___/___/___

Appendix B - Skid Deficiency Spreadsheet

District	Road	Class	Intervention Speed	Lane	Section	Chainage	Length	F60 Mean	SD	C of V	Sp Mean	SD	C of V	Site Cat.	Base F60	Speed Zone	Tolerable F60	10% Lowest F60
8	10F	**NH**	80	1	A	149.4 - 150.0	0.6	**0.48**	0.03	6.3%	145	102	70%	G	0.25	110	**0.29**	**0.44**
8	10F	**NH**	80	1	B	150.0 - 151.2	1.2	**0.28**	0.07	25.0%	44	15	34%	G	0.25	110	**0.39**	**0.19**
8	10F	**NH**	80	1	C	151.2 - 154.0	2.8	**0.44**	0.10	22.7%	60	51	85%	G	0.25	110	**0.35**	**0.31**
8	10F	**NH**	80	1	D	154.0 - 156.0	2.0	**0.38**	0.06	15.8%	89	41	46%	G	0.25	110	**0.31**	**0.30**
8	10F	**NH**	80	1	E	156.0 - 158.8	2.8	**0.41**	0.08	19.5%	54	47	87%	G	0.25	110	**0.36**	**0.31**
8	10F	**NH**	80	1	F	158.8 - 159.4	0.6	**0.35**	0.07	20.0%	56	10	18%	G	0.25	110	**0.36**	**0.26**
8	10F	**NH**	80	1	G	159.4 - 161.5	2.1	**0.49**	0.10	20.4%	57	23	40%	G	0.25	110	**0.36**	**0.36**
8	10F	**NH**	80	1	H	161.5 - 163.6	2.1	**0.39**	0.03	7.7%	93	22	24%	G	0.25	110	**0.31**	**0.35**
8	10F	**NH**	80	1	I	163.6 - 165.1	1.5	**0.45**	0.07	15.6%	63	27	43%	G	0.25	110	**0.34**	**0.36**
8	10F	**NH**	80	1	J	165.1 - 167.8	2.7	**0.37**	0.09	24.3%	42	15	36%	G	0.25	110	**0.40**	**0.25**
8	10F	**NH**	80	1	K	167.8 - 168.5	0.7	**0.45**	0.07	15.6%	48	21	44%	G	0.25	110	**0.38**	**0.36**
8	10F	**NH**	80	1	L	168.5 - 171.5	3.0	**0.31**	0.08	25.8%	43	23	53%	G	0.25	110	**0.40**	**0.21**
8	10F	**NH**	80	1	M	171.5 - 173.6	2.1	**0.44**	0.07	15.9%	39	18	46%	G	0.25	110	**0.42**	**0.35**
8	10F	**NH**	80	1	N	173.6 - 174.5	0.9	**0.20**	0.07	35.0%	32	11	34%	G	0.25	110	**0.47**	**0.11**
8	10F	**NH**	80	1	O	174.5 - 177.4	2.9	**0.39**	0.07	17.9%	61	38	62%	G	0.25	110	**0.35**	**0.30**
8	10F	**NH**	80	1	P	177.4 - 177.8	0.4	**0.31**	0.04	12.9%	77	41	53%	G	0.25	110	**0.32**	**0.26**
8	10G	**NH**	80	1	A	0.0 - 3.6	3.6	**0.29**	0.09	31.0%	64	33	52%	G	0.25	110	**0.34**	**0.17**
8	10G	**NH**	80	1	B	3.6 - 6.3	2.7	**0.38**	0.06	15.8%	61	22	36%	G	0.25	110	**0.35**	**0.30**
8	10G	**NH**	80	1	C	6.3 - 7.5	1.2	**0.31**	0.12	38.7%	58	25	43%	G	0.25	110	**0.35**	**0.16**

8	10G	**NH**	80	1	D	7.5 - 8.9	1.4	**0.40**	0.08	20.0%	78	33	42%	G	0.25	110	**0.32**	**0.30**
8	10G	**NH**	80	1	E	8.9 - 10.3	1.4	**0.27**	0.04	14.8%	42	13	31%	G	0.25	110	**0.40**	**0.22**
8	10G	**NH**	80	1	F	10.3 - 16.9	6.6	**0.36**	0.10	27.8%	65	31	48%	G	0.25	110	**0.34**	**0.23**
8	10G	**NH**	80	1	G	16.9 - 26.5	9.6	**0.30**	0.09	30.0%	49	20	41%	G	0.25	110	**0.38**	**0.18**
8	10G	**NH**	80	1	H	26.5 - 27.2	0.7	**0.23**	0.03	13.0%	42	11	26%	G	0.25	110	**0.40**	**0.19**
8	10G	**NH**	80	1	I	27.2 - 31.4	4.2	**0.33**	0.11	33.3%	54	19	35%	G	0.25	110	**0.36**	**0.19**
8	10G	**NH**	80	1	J	31.4 - 34.3	2.9	**0.33**	0.10	30.3%	47	13	28%	G	0.25	110	**0.38**	**0.20**
8	10G	**NH**	80	1	K	34.3 - 37.8	3.5	**0.32**	0.07	21.9%	58	31	53%	G	0.25	110	**0.35**	**0.23**
8	10G	**NH**	80	1	L	37.8 - 39.6	1.8	**0.21**	0.05	23.8%	47	15	32%	G	0.25	110	**0.38**	**0.15**
8	10G	**NH**	80	1	M	39.6 - 40.7	1.1	**0.44**	0.08	18.2%	64	26	41%	G	0.25	110	**0.34**	**0.34**
8	10G	**NH**	80	1	N	40.7 - 41.3	0.6	**0.23**	0.10	43.5%	46	17	37%	G	0.25	110	**0.39**	**0.10**
8	10G	**NH**	80	1	O	41.3 - 49.1	7.8	**0.48**	0.05	10.4%	106	48	45%	G	0.25	110	**0.30**	**0.42**
8	10G	**NH**	80	1	P	49.1 - 55.0	5.9	**0.42**	0.06	14.3%	110	60	55%	G	0.25	110	**0.30**	**0.34**
8	10G	**NH**	60	1	Q	55.0 - 57.9	2.9	**0.47**	0.09	19.1%	85	38	45%	G	0.25	80	**0.25**	**0.35**
8	10G	**NH**	80	1	R	57.9 - 61.6	3.7	**0.40**	0.02	5.0%	104	51	49%	G	0.25	100	**0.30**	**0.37**
8	10G	**NH**	80	1	S	61.6 - 65.1	3.5	**0.42**	0.03	7.1%	114	70	61%	G	0.25	100	**0.30**	**0.38**
8	10G	**NH**	80	1	T	65.1 - 72.5	7.4	**0.43**	0.06	14.0%	95	57	60%	G	0.25	100	**0.31**	**0.35**
8	10G	**NH**	80	1	U	72.5 - 74.0	1.5	**0.37**	0.09	24.3%	102	56	55%	G	0.25	100	**0.30**	**0.25**
8	10G	**NH**	80	1	V	74.0 - 78.5	4.5	**0.45**	0.03	6.7%	100	45	45%	G	0.25	100	**0.31**	**0.41**
8	10G	**NH**	80	1	W	78.5 - 82.7	4.2	**0.48**	0.06	12.5%	98	47	48%	G	0.25	100	**0.31**	**0.40**
8	10G	**NH**	80	1	X	82.7 - 88.6	5.9	**0.43**	0.04	9.3%	120	53	44%	G	0.25	100	**0.30**	**0.38**
8	10G	**NH**	80	1	Y	88.6 - 91.0	2.4	**0.46**	0.04	8.7%	108	38	35%	G	0.25	100	**0.30**	**0.41**
8	10G	**NH**	80	1	Z	91.0 - 91.5	0.5	**0.34**	0.03	8.8%	112	54	48%	G	0.25	100	**0.30**	**0.30**
8	10G	**NH**	80	1	AA	91.5 - 97.9	6.4	**0.45**	0.05	11.1%	123	49	40%	G	0.25	100	**0.29**	**0.39**
8	10G	**NH**	60	1	BB	97.9 - 99.0	1.1	**0.37**	0.03	8.1%	122	48	39%	I	0.30	60-80	**0.30**	**0.33**
8	10G	**NH**	80	1	CC	99.0 - 102.3	3.3	**0.43**	0.04	9.3%	100	57	57%	G	0.25	100	**0.31**	**0.38**
8	10G	**NH**	80	1	DD	102.3 - 105.7	3.4	**0.41**	0.02	4.9%	113	67	59%	G	0.25	100	**0.30**	**0.38**
8	10G	**NH**	80	1	EE	105.7 - 107.1	1.4	**0.37**	0.02	5.4%	99	44	44%	G	0.25	100	**0.31**	**0.34**
8	10G	**NH**	80	1	FF	107.1 - 108.0	0.9	**0.47**	0.04	8.5%	104	63	61%	G	0.25	100	**0.30**	**0.42**
8	10G	**NH**	80	1	GG	108.0 - 116.0	8.0	**0.52**	0.05	9.6%	104	55	53%	G	0.25	100	**0.30**	**0.46**
8	10G	**NH**	60	1	HH1	116.0 - 117.7	1.7	**0.32**	0.04	12.5%	101	47	47%	G	0.25	100	**0.25**	**0.27**
8	10G	**NH**	60	1	HH2	117.7 - 118.2	0.5	**0.29**	0.02	6.9%	81	22	27%	G	0.25	80	**0.25**	**0.26**
8	10G	**NH**	60	1	HH3	118.2 - 119.5	1.3	**0.24**	0.06	25.0%	95	55	58%	I	0.30	70	**0.30**	**0.16**
8	10G	**NH**	60	1	HH4	119.5 - 119.9	0.4	**0.27**	0.02	7.4%	122	65	53%	I	0.30	60	**0.30**	**0.24**
8	10G	**NH**	50	1	HH5	119.9 - 121.0	1.1	**0.23**	0.07	30.4%	77	41	53%	D	0.35	50	**0.31**	**0.14**

8	10G	**NH**	60	1	HH6	121.0 - 121.4	0.4	**0.22**	0.02	9.1%	94	28	30%	I	0.30	60	**0.30**	**0.19**
8	10G	**NH**	60	1	HH7	121.4 - 121.7	0.3	**0.27**	0.02	7.4%	142	27	19%	G	0.25	80	**0.25**	**0.24**
8	10G	**NH**	80	1	HH8	121.7 - 123.0	1.3	**0.29**	0.03	10.3%	97	33	34%	G	0.25	100	**0.31**	**0.25**
8	10G	**NH**	80	1	II	123.0 - 130.0	7.0	**0.38**	0.06	15.8%	103	42	41%	G	0.25	100	**0.30**	**0.30**
8	10G	**NH**	80	1	JJ1	130.0 - 131.6	1.6	**0.52**	0.06	11.5%	120	62	52%	G	0.25	100	**0.30**	**0.44**
8	10G	**NH**	60	1	JJ2	131.6 - 133.0	1.4	**0.48**	0.04	8.3%	113	48	42%	I	0.30	80	**0.30**	**0.43**
8	10G	**NH**	80	1	KK	133.0 - 141.3	8.3	**0.37**	0.05	13.5%	103	60	58%	G	0.25	100	**0.30**	**0.31**
8	10G	**NH**	80	1	LL	141.3 - 146.5	5.2	**0.42**	0.04	9.5%	108	40	37%	G	0.25	100	**0.30**	**0.37**
8	10G	**NH**	70	1	MM	146.5 - 148.2	1.7	**0.34**	0.04	11.8%	122	44	36%	G	0.25	90	**0.27**	**0.29**
8	10G	**NH**	70	1	NN1	148.2 - 149.8	1.6	**0.28**	0.02	7.1%	124	46	37%	G	0.25	90	**0.27**	**0.25**
8	10G	**NH**	60	1	NN2	149.8 - 151.1	1.3	**0.31**	0.02	6.5%	103	40	39%	G	0.25	80	**0.25**	**0.28**
8	10G	**NH**	60	1	NN3	151.1 - 151.6	0.5	**0.32**	0.01	3.1%	99	29	29%	I	0.30	80	**0.30**	**0.31**
8	10G	**NH**	60	1	NN4	151.6 - 152.0	0.4	**0.30**	0.02	6.7%	107	28	26%	I	0.30	60	**0.30**	**0.27**
8	10G	**NH**	60	1	OO	152.0 - 156.0	4.0	**0.25**	0.03	12.0%	88	46	52%	D	0.35	60	**0.35**	**0.21**
8	10H	**NH**	60	1	A1	0.0 - 0.2	0.2	**0.26**	0.03	11.5%	74	6	8%	I	0.30	60	**0.30**	**0.22**
8	10H	**NH**	60	1	A2	0.2 - 0.4	0.2	**0.28**	0.02	7.1%	69	27	39%	G	0.25	80	**0.25**	**0.25**
8	10H	**NH**	60	1	B1	0.4 - 2.0	1.6	**0.38**	0.02	5.3%	95	36	38%	G	0.25	80	**0.25**	**0.35**
8	10H	**NH**	60	1	B2	2.0 - 2.4	0.4	**0.29**	0.06	20.7%	70	22	31%	D	0.35	80	**0.35**	**0.21**
8	10H	**NH**	60	1	B3	2.4 - 4.7	2.3	**0.37**	0.03	8.1%	83	19	23%	I	0.30	80	**0.30**	**0.33**
8	10H	**NH**	60	1	C1	4.7 - 5.1	0.4	**0.45**	0.03	6.7%	99	29	29%	I	0.30	80	**0.30**	**0.41**
8	10H	**NH**	80	1	C2	5.1 - 6.1	1.0	**0.42**	0.03	7.1%	97	35	36%	G	0.25	100	**0.31**	**0.38**
8	10H	**NH**	80	1	D	6.1 - 9.4	3.3	**0.36**	0.04	11.1%	106	30	28%	G	0.25	100	**0.30**	**0.31**
8	10H	**NH**	60	1	E1	9.4 - 10.2	0.8	**0.44**	0.03	6.8%	108	63	58%	I	0.30	80	**0.30**	**0.40**
8	10H	**NH**	80	1	E2	10.2 - 10.7	0.5	**0.45**	0.02	4.4%	97	44	45%	G	0.25	100	**0.31**	**0.42**
8	10H	**NH**	80	1	F	10.7 - 12.5	1.8	**0.37**	0.02	5.4%	118	53	45%	G	0.25	100	**0.30**	**0.34**
8	10H	**NH**	80	1	G	12.5 - 13.5	1.0	**0.40**	0.06	15.0%	123	46	37%	G	0.25	100	**0.29**	**0.32**
8	10H	**NH**	80	1	H	13.5 - 16.4	2.9	**0.35**	0.03	8.6%	106	36	34%	G	0.25	100	**0.30**	**0.31**
8	10H	**NH**	80	1	I	16.4 - 19.7	3.3	**0.44**	0.07	15.9%	81	44	54%	G	0.25	100	**0.32**	**0.35**
8	10H	**NH**	80	1	J	19.7 - 21.2	1.5	**0.38**	0.05	13.2%	108	62	57%	G	0.25	100	**0.30**	**0.32**
8	10H	**NH**	80	1	K	21.2 - 27.4	6.2	**0.33**	0.05	15.2%	96	52	54%	G	0.25	100	**0.31**	**0.27**
8	10H	**NH**	80	1	L	27.4 - 31.7	4.3	**0.47**	0.05	10.6%	102	46	45%	G	0.25	100	**0.30**	**0.41**
8	10H	**NH**	60	1	M1	31.7 - 32.7	1.0	**0.45**	0.04	8.9%	68	35	51%	G	0.25	80	**0.25**	**0.40**
8	10H	**NH**	80	1	M2	32.7 - 39.5	6.8	**0.41**	0.04	9.8%	112	46	41%	G	0.25	100	**0.30**	**0.36**
8	10H	**NH**	80	1	N	39.5 - 40.4	0.9	**0.46**	0.03	6.5%	86	25	29%	G	0.25	100	**0.32**	**0.42**
8	10H	**NH**	80	1	O	40.4 - 43.8	3.4	**0.39**	0.03	7.7%	120	52	43%	G	0.25	100	**0.30**	**0.35**

8	10H	**NH**	80	1	P	43.8 - 44.9	1.1	**0.32**	0.05	15.6%	95	60	63%	G	0.25	100	**0.31**	**0.26**
8	10H	**NH**	80	1	Q	44.9 - 46.5	1.6	**0.37**	0.02	5.4%	91	57	63%	G	0.25	100	**0.31**	**0.34**
8	10H	**NH**	80	1	R	46.5 - 52.5	6.0	**0.41**	0.05	12.2%	102	47	46%	G	0.25	100	**0.30**	**0.35**
8	10H	**NH**	80	1	S	52.5 - 54.5	2.0	**0.38**	0.05	13.2%	120	71	59%	G	0.25	100	**0.30**	**0.32**
8	10H	**NH**	80	1	T	54.5 - 58.8	4.3	**0.42**	0.02	4.8%	124	53	43%	G	0.25	100	**0.29**	**0.39**
8	10H	**NH**	80	1	U	58.8 - 66.6	7.8	**0.50**	0.02	4.0%	114	35	31%	G	0.25	100	**0.30**	**0.47**
8	10H	**NH**	80	1	V	66.6 - 71.0	4.4	**0.45**	0.05	11.1%	103	42	41%	G	0.25	100	**0.30**	**0.39**
8	10H	**NH**	80	1	W	71.0 - 73.9	2.9	**0.48**	0.03	6.3%	92	41	45%	G	0.25	100	**0.31**	**0.44**
8	10H	**NH**	80	1	X	73.9 - 75.5	1.6	**0.38**	0.06	15.8%	106	60	57%	G	0.25	100	**0.30**	**0.30**
8	10H	**NH**	80	1	Y	75.5 - 83.4	7.9	**0.43**	0.05	11.6%	95	50	53%	G	0.25	100	**0.31**	**0.37**
8	10H	**NH**	80	1	Z1	83.4 - 84.8	1.4	**0.47**	0.05	10.6%	102	49	48%	G	0.25	100	**0.30**	**0.41**
8	10H	**NH**	60	1	Z2	84.8 - 85.8	1.0	**0.46**	0.05	10.9%	82	37	45%	I	0.30	80	**0.30**	**0.40**
8	10H	**NH**	80	1	Z3	85.8 - 95.5	9.7	**0.47**	0.06	12.8%	104	44	42%	G	0.25	100	**0.30**	**0.39**
8	10H	**NH**	80	1	AA	95.5 - 97.5	2.0	**0.42**	0.05	11.9%	101	37	37%	G	0.25	100	**0.30**	**0.36**
8	10H	**NH**	80	1	BB	97.5 - 101.1	3.6	**0.49**	0.03	6.1%	107	45	42%	G	0.25	100	**0.30**	**0.45**
8	10H	**NH**	80	1	CC	101.1 - 106.5	5.4	**0.43**	0.04	9.3%	102	59	58%	G	0.25	100	**0.30**	**0.38**
8	10H	**NH**	80	1	DD	106.5 - 112.6	6.1	**0.39**	0.04	10.3%	95	44	46%	G	0.25	100	**0.31**	**0.34**
8	10H	**NH**	80	1	EE	112.6 - 113.7	1.1	**0.48**	0.02	4.2%	90	27	30%	G	0.25	100	**0.31**	**0.45**
8	10H	**NH**	80	1	FF	113.7 - 118.5	4.8	**0.42**	0.04	9.5%	104	43	41%	G	0.25	100	**0.30**	**0.37**
8	10H	**NH**	80	1	GG	118.5 - 121.7	3.2	**0.40**	0.04	10.0%	101	39	39%	G	0.25	100	**0.30**	**0.35**
8	10H	**NH**	60	1	HH	121.7 - 122.3	0.6	**0.34**	0.03	8.8%	109	29	27%	G	0.25	60-80	**0.25**	**0.30**
8	10H	**NH**	60	1	II	122.3 - 123.6	1.3	**0.25**	0.03	12.0%	99	34	I	G	0.30	60	**0.30**	**0.21**
8	10J	**NH**	60	1	A	0.0 - 0.9	0.9	**0.30**	0.03	10.0%	104	42	40%	I	0.30	60	**0.30**	**0.26**
8	10J	**NH**	60	1	B	0.9 - 1.6	0.7	**0.33**	0.01	3.0%	79	37	47%	G	0.25	80	**0.25**	**0.32**
8	10J	**NH**	60	1	C	1.6 - 1.9	0.3	**0.43**	0.01	2.3%	73	32	44%	G	0.25	80	**0.25**	**0.42**
8	10J	**NH**	80	1	D	1.9 - 2.5	0.6	**0.50**	0.06	12.0%	71	25	35%	G	0.25	100	**0.33**	**0.42**
8	10J	**NH**	80	1	E	2.5 - 4.5	2.0	**0.42**	0.04	9.5%	73	24	33%	G	0.25	100	**0.33**	**0.37**
8	10J	**NH**	80	1	F	4.5 - 7.9	3.4	**0.39**	0.03	7.7%	79	31	39%	G	0.25	100	**0.32**	**0.35**
8	10J	**NH**	80	1	G	7.9 - 8.8	0.9	**0.34**	0.04	11.8%	132	73	55%	G	0.25	100	**0.29**	**0.29**
8	10J	**NH**	80	1	H	8.8 - 11.3	2.5	**0.47**	0.03	6.4%	90	36	40%	G	0.25	100	**0.31**	**0.43**
8	10J	**NH**	80	1	I	11.3 - 13.0	1.7	**0.40**	0.06	15.0%	84	43	51%	G	0.25	100	**0.32**	**0.32**
8	10J	**NH**	80	1	J	13.0 - 21.4	8.4	**0.50**	0.04	8.0%	103	51	50%	G	0.25	100	**0.30**	**0.45**
8	10J	**NH**	80	1	K	21.4 - 23.1	1.7	**0.43**	0.06	14.0%	99	32	32%	G	0.25	100	**0.31**	**0.35**
8	10J	**NH**	80	1	L	23.1 - 31.3	8.2	**0.46**	0.04	8.7%	104	46	44%	G	0.25	100	**0.30**	**0.41**
8	33A	**SH**	80	1	A	100.9 - 102.0	1.1	**0.37**	0.04	10.8%	91	49	54%	G	0.25	100	**0.31**	**0.32**

8	33A	**SH**	80	1	B	102.0 - 103.8	1.8	**0.44**	0.04	9.1%	101	75	74%	G	0.25	100	**0.30**	**0.39**
8	33A	**SH**	80	1	C	103.8 - 104.1	0.3	**0.29**	0.01	3.4%	91	17	19%	G	0.25	100	**0.31**	**0.28**
8	33A	**SH**	80	1	D	104.1 - 108.9	4.8	**0.43**	0.07	16.3%	99	42	42%	G	0.25	100	**0.31**	**0.34**
8	33A	**SH**	80	1	E	108.9 - 109.3	0.4	**0.24**	0.06	25.0%	112	71	63%	G	0.25	100	**0.30**	**0.16**
8	33A	**SH**	80	1	F	109.3 - 111.3	2.0	**0.39**	0.08	20.5%	99	49	49%	G	0.25	100	**0.31**	**0.29**
8	33A	**SH**	80	1	G	111.3 - 114.7	3.4	**0.48**	0.07	14.6%	100	50	50%	G	0.25	100	**0.31**	**0.39**
8	33A	**SH**	80	1	H	114.7 - 125.0	10.3	**0.44**	0.09	20.5%	91	55	60%	G	0.25	100	**0.31**	**0.32**
8	33A	**SH**	80	1	I	125.0 - 125.7	0.7	**0.30**	0.10	33.3%	54	23	43%	G	0.25	100	**0.36**	**0.17**
8	33A	**SH**	80	1	J	125.7 - 127.6	1.9	**0.38**	0.04	10.5%	103	45	44%	G	0.25	100	**0.30**	**0.33**
8	33A	**SH**	80	1	K	127.6 - 128.5	0.9	**0.26**	0.05	19.2%	78	34	44%	G	0.25	100	**0.32**	**0.20**
8	33A	**SH**	80	1	L	128.5 - 130.3	1.8	**0.42**	0.05	11.9%	106	76	72%	G	0.25	100	**0.30**	**0.36**
8	33A	**SH**	80	1	M	130.3 - 136.8	6.5	**0.46**	0.07	15.2%	103	66	64%	G	0.25	100	**0.30**	**0.37**
8	33A	**SH**	80	1	N	136.8 - 144.8	8.0	**0.49**	0.04	8.2%	128	59	46%	G	0.25	100	**0.29**	**0.44**
8	33A	**SH**	80	1	O	144.8 - 145.5	0.7	**0.39**	0.05	12.8%	100	34	34%	G	0.25	100	**0.31**	**0.33**
8	33A	**SH**	80	1	P	145.5 - 148.9	3.4	**0.47**	0.05	10.6%	104	49	47%	G	0.25	100	**0.30**	**0.41**
8	33A	**SH**	80	1	Q	148.9 - 150.5	1.6	**0.54**	0.06	11.1%	132	65	49%	G	0.25	100	**0.29**	**0.46**
8	33A	**SH**	80	1	R	150.5 - 153.2	2.7	**0.43**	0.05	11.6%	129	59	46%	G	0.25	100	**0.29**	**0.37**
8	33A	**SH**	80	1	S	153.2 - 157.5	4.3	**0.46**	0.04	8.7%	167	82	49%	G	0.25	100	**0.28**	**0.41**
8	33A	**SH**	80	1	T	157.5 - 163.4	5.9	**0.43**	0.08	18.6%	119	76	64%	G	0.25	100	**0.30**	**0.33**
8	33A	**SH**	80	1	U	163.4 - 168.8	5.4	**0.50**	0.03	6.0%	155	58	37%	G	0.25	100	**0.28**	**0.46**
8	33A	**SH**	80	1	V	168.8 - 177.1	8.3	**0.43**	0.06	14.0%	123	79	64%	G	0.25	100	**0.29**	**0.35**
8	33B	**SH**	80	1	A	0.0 - 1.4	1.4	**0.38**	0.04	10.5%	150	71	47%	G	0.25	100	**0.29**	**0.33**
8	33B	**SH**	80	1	B	1.4 - 6.0	4.6	**0.47**	0.04	8.5%	148	66	45%	G	0.25	100	**0.29**	**0.42**
8	33B	**SH**	80	1	A	44.9 - 45.3	0.4	**0.39**	0.03	7.7%	144	46	32%	G	0.25	100	**0.29**	**0.35**
8	33B	**SH**	80	1	B	45.3 - 47.4	2.1	**0.32**	0.03	9.4%	102	21	21%	G	0.25	100	**0.30**	**0.28**
8	33B	**SH**	80	1	C	47.4 - 49.6	2.2	**0.34**	0.02	5.9%	148	88	59%	G	0.25	100	**0.29**	**0.31**
8	33B	**SH**	80	1	D	49.6 - 51.0	1.4	**0.38**	0.06	15.8%	94	62	66%	G	0.25	100	**0.31**	**0.30**
8	33B	**SH**	80	1	E	51.0 - 52.9	1.9	**0.32**	0.04	12.5%	90	32	36%	G	0.25	100	**0.31**	**0.27**
8	33B	**SH**	80	1	F	52.9 - 57.0	4.1	**0.44**	0.04	9.1%	98	50	51%	G	0.25	100	**0.31**	**0.39**
8	33B	**SH**	80	1	G	57.0 - 61.8	4.8	**0.47**	0.05	10.6%	109	44	40%	G	0.25	100	**0.30**	**0.41**
8	33B	**SH**	70	1	H1	61.8 - 62.4	0.6	**0.37**	0.02	5.4%	64	11	17%	G	0.25	80-100	**0.29**	**0.34**
8	33B	**SH**	60	1	H2	62.4 - 63.6	1.2	**0.26**	0.05	19.2%	113	85	75%	G	0.25	60	**0.25**	**0.20**
8	33B	**SH**	60	1	H3	63.6 - 64.7	1.1	**0.31**	0.11	35.5%	90	54	60%	G	0.25	80	**0.25**	**0.17**
8	33B	**SH**	80	1	I	64.7 - 67.0	2.3	**0.37**	0.08	21.6%	82	39	48%	G	0.25	100	**0.32**	**0.27**

8	33B	**SH**	80	1	J	67.0 - 73.0	6.0	**0.48**	0.05	10.4%	140	65	46%	G	0.25	100	**0.29**	**0.42**
8	33B	**SH**	80	1	K1	73.0 - 76.2	3.2	**0.45**	0.03	6.7%	142	55	39%	G	0.25	100	**0.29**	**0.41**
8	33B	**SH**	60	1	K2	76.2 - 76.7	0.5	**0.46**	0.03	6.5%	86	20	23%	G	0.25	80	**0.25**	**0.42**
8	33B	**SH**	60	1	L	76.7 - 78.0	1.3	**0.36**	0.03	8.3%	96	39	41%	G	0.25	60	**0.25**	**0.32**
8	33B	**SH**	60	1	M1	78.0 - 79.3	1.3	**0.27**	0.06	22.2%	87	39	45%	I	0.30	60	**0.30**	**0.19**
8	33B	**SH**	60	1	M2	79.3 - 80.2	0.9	**0.26**	0.06	23.1%	62	22	35%	G	0.25	80	**0.25**	**0.18**
8	33B	**SH**	80	1	N	80.2 - 81.2	1.0	**0.41**	0.05	12.2%	94	42	45%	G	0.25	100	**0.31**	**0.35**
8	33B	**SH**	70	1	O1	81.2 - 86.5	5.3	**0.34**	0.05	14.7%	99	56	57%	G	0.25	80-100	**0.28**	**0.28**
8	33B	**SH**	60	1	O2	86.5 - 87.3	0.8	**0.35**	0.03	8.6%	89	25	28%	G	0.25	70	**0.25**	**0.31**
8	33B	**SH**	60	1	O3	87.3 - 87.8	0.5	**0.33**	0.01	3.0%	69	5	7%	I	0.30	60	**0.30**	**0.32**
8	512	**MR**	80	2	A	67.1 - 68.4	1.3	**0.46**	0.03	6.5%	147	48	33%	G	0.25	100	**0.29**	**0.42**
8	512	**MR**	80	2	B	68.4 - 69.7	1.3	**0.45**	0.08	17.8%	79	50	63%	G	0.25	100	**0.32**	**0.35**
8	512	**MR**	80	2	C	69.7 - 70.5	0.8	**0.34**	0.08	23.5%	34	8	24%	G	0.25	100	**0.45**	**0.24**
8	512	**MR**	80	2	D	70.5 - 71.2	0.7	**0.52**	0.08	15.4%	45	22	49%	G	0.25	100	**0.39**	**0.42**
8	512	**MR**	80	2	E	71.2 - 71.6	0.4	**0.37**	0.01	2.7%	78	50	64%	G	0.25	100	**0.32**	**0.36**
8	512	**MR**	80	2	F	71.6 - 73.7	2.1	**0.50**	0.05	10.0%	139	90	65%	G	0.25	100	**0.29**	**0.44**
8	512	**MR**	80	2	G	73.7 - 74.8	1.1	**0.43**	0.06	14.0%	149	117	79%	G	0.25	100	**0.29**	**0.35**
8	512	**MR**	80	2	H	74.8 - 75.2	0.4	**0.55**	0.01	1.8%	94	10	11%	G	0.25	100	**0.31**	**0.54**
8	512	**MR**	80	2	I	75.2 - 75.8	0.6	**0.36**	0.04	11.1%	61	29	48%	G	0.25	100	**0.35**	**0.31**
8	512	**MR**	80	2	J	75.8 - 79.2	3.4	**0.46**	0.07	15.2%	71	50	70%	G	0.25	100	**0.33**	**0.37**
8	512	**MR**	80	2	K	79.2 - 80.2	1.0	**0.54**	0.07	13.0%	100	89	89%	G	0.25	100	**0.31**	**0.45**
8	512	**MR**	80	2	L	80.2 - 81.3	1.1	**0.38**	0.07	18.4%	96	64	67%	G	0.25	100	**0.31**	**0.29**
8	512	**MR**	80	2	M	81.3 - 83.4	2.1	**0.49**	0.09	18.4%	100	58	58%	G	0.25	100	**0.31**	**0.37**
8	512	**MR**	80	1	A	188.0 - 188.5	0.5	**0.25**	0.05	20.0%	51	21	41%	G	0.25	100	**0.37**	**0.19**
8	512	**MR**	80	1	B	188.5 - 190.4	1.9	**0.38**	0.05	13.2%	79	42	53%	G	0.25	100	**0.32**	**0.32**
8	512	**MR**	80	1	C	190.4 - 195.1	4.7	**0.42**	0.06	14.3%	97	67	69%	G	0.25	100	**0.31**	**0.34**
8	512	**MR**	80	1	D	195.1 - 195.4	0.3	**0.37**	0.05	13.5%	89	44	49%	G	0.25	100	**0.31**	**0.31**
8	512	**MR**	80	1	E	195.4 - 198.3	2.9	**0.40**	0.04	10.0%	95	40	42%	G	0.25	100	**0.31**	**0.35**
8	512	**MR**	80	1	F	198.3 - 199.0	0.7	**0.33**	0.06	18.2%	68	27	40%	G	0.25	100	**0.34**	**0.25**
8	512	**MR**	80	1	G	199.0 - 201.3	2.3	**0.37**	0.07	18.9%	116	73	63%	G	0.25	100	**0.30**	**0.28**
8	512	**MR**	80	1	H	201.3 - 202.0	0.7	**0.30**	0.05	16.7%	79	27	34%	G	0.25	100	**0.32**	**0.24**
8	512	**MR**	80	1	I	202.0 - 203.5	1.5	**0.40**	0.07	17.5%	109	87	80%	G	0.25	100	**0.30**	**0.31**
8	512	**MR**	80	1	J	203.5 - 204.1	0.6	**0.39**	0.08	20.5%	102	103	101%	G	0.25	100	**0.30**	**0.29**
8	512	**MR**	80	1	K	204.1 - 204.8	0.7	**0.53**	0.06	11.3%	55	18	33%	G	0.25	100	**0.36**	**0.45**

8	512	**MR**	80	1	L	204.8 - 206.1	1.3	**0.41**	0.05	12.2%	98	36	37%	G	0.25	100	**0.31**	**0.35**
8	512	**MR**	80	1	M	206.1 - 207.5	1.4	**0.51**	0.10	19.6%	84	43	51%	G	0.25	100	**0.32**	**0.38**
8	512	**MR**	80	1	N	207.5 - 209.0	1.5	**0.40**	0.06	15.0%	71	34	48%	G	0.25	100	**0.33**	**0.32**
8	512	**MR**	80	1	O	209.0 - 211.7	2.7	**0.47**	0.06	12.8%	113	63	56%	G	0.25	100	**0.30**	**0.39**
8	512	**MR**	80	1	P	211.7 - 213.1	1.4	**0.37**	0.04	10.8%	71	30	42%	G	0.25	100	**0.33**	**0.32**
8	512	**MR**	80	1	Q	213.1 - 215.0	1.9	**0.51**	0.08	15.7%	78	37	47%	G	0.25	100	**0.32**	**0.41**
8	512	**MR**	80	1	R	215.0 - 216.2	1.2	**0.47**	0.06	12.8%	102	85	83%	G	0.25	100	**0.30**	**0.39**
8	512	**MR**	80	1	S	216.2 - 217.2	1.0	**0.34**	0.06	17.6%	43	22	51%	G	0.25	100	**0.40**	**0.26**
8	512	**MR**	80	1	T	217.2 - 219.0	1.8	**0.52**	0.09	17.3%	113	75	66%	G	0.25	100	**0.30**	**0.40**
8	512	**MR**	80	1	U	219.0 - 220.9	1.9	**0.47**	0.07	14.9%	98	59	60%	G	0.25	100	**0.31**	**0.38**
8	512	**MR**	80	1	V	220.9 - 221.9	1.0	**0.52**	0.07	13.5%	126	76	60%	G	0.25	100	**0.29**	**0.43**
8	512	**MR**	80	1	W	221.9 - 222.6	0.7	**0.40**	0.04	10.0%	146	75	51%	G	0.25	100	**0.29**	**0.35**
8	512	**MR**	80	1	X	222.6 - 223.8	1.2	**0.49**	0.03	6.1%	105	80	76%	G	0.25	100	**0.30**	**0.45**
8	512	**MR**	80	1	Y	223.8 - 226.9	3.1	**0.42**	0.11	26.2%	129	101	78%	G	0.25	100	**0.29**	**0.28**
8	512	**MR**	80	1	Z	226.9 - 229.5	2.6	**0.23**	0.05	21.7%	71	39	55%	I	0.30	100	**0.40**	**0.17**
8	512	**MR**	80	1	AA	229.5 - 230.7	1.2	**0.38**	0.04	10.5%	82	39	48%	G	0.25	100	**0.32**	**0.33**
8	512	**MR**	80	1	BB	230.7 - 232.3	1.6	**0.43**	0.03	7.0%	98	51	52%	G	0.25	100	**0.31**	**0.39**
8	512	**MR**	80	1	CC	232.3 - 234.6	2.3	**0.35**	0.05	14.3%	111	70	63%	G	0.25	100	**0.30**	**0.29**
8	512	**MR**	80	1	DD	234.6 - 235.1	0.5	**0.26**	0.04	15.4%	96	53	55%	G	0.25	100	**0.31**	**0.21**
8	512	**MR**	80	1	EE	235.1 - 237.5	2.4	**0.37**	0.06	16.2%	95	46	48%	G	0.25	100	**0.31**	**0.29**
8	512	**MR**	80	1	FF	237.5 - 238.0	0.5	**0.41**	0.12	29.3%	147	91	62%	G	0.25	100	**0.29**	**0.26**
8	512	**MR**	80	1	GG1	238.0 - 240.3	2.3	**0.38**	0.04	10.5%	104	59	57%	G	0.25	100	**0.30**	**0.33**
8	512	**MR**	60	1	GG2	240.3 - 240.5	0.2	**0.38**	0.01	2.6%	89	6	7%	G	0.25	80	**0.25**	**0.37**
8	512	**MR**	60	1	HH	240.5 - 241.8	1.3	**0.28**	0.04	14.3%	93	45	48%	G	0.25	60	**0.25**	**0.23**
8	512	**MR**	50	1	II	241.8 - 242.4	0.6	**0.23**	0.04	17.4%	71	13	18%	I	0.30	50	**0.26**	**0.18**
8	516	**MR**	80	1	A	0.0 - 0.7	0.7	**0.33**	0.04	12.1%	52	13	25%	G	0.25	100	**0.37**	**0.28**
8	516	**MR**	80	1	B	0.7 - 5.0	4.3	**0.40**	0.04	10.0%	73	39	53%	G	0.25	100	**0.33**	**0.35**
8	516	**MR**	70	1	C	5.0 - 8.6	3.6	**0.42**	0.04	9.5%	118	55	47%	G	0.25	80-100	**0.27**	**0.37**
8	516	**MR**	80	1	D	8.6 - 11.0	2.4	**0.50**	0.06	12.0%	95	58	61%	G	0.25	100	**0.31**	**0.42**
8	516	**MR**	80	1	E1	11.0 - 11.7	0.7	**0.39**	0.05	12.8%	122	46	38%	G	0.25	100	**0.29**	**0.33**
8	516	**MR**	60	1	E2	11.7 - 12.2	0.5	**0.38**	0.10	26.3%	80	38	48%	I	0.30	60	**0.30**	**0.25**
8	516	**MR**	60	1	E3	12.2 - 12.6	0.4	**0.42**	0.01	2.4%	84	12	14%	G	0.25	80	**0.25**	**0.41**
8	517	**MR**	60	1	A	0.0 - 0.5	0.5	**0.33**	0.04	12.1%	169	110	65%	G	0.25	80	**0.25**	**0.28**
8	517	**MR**	60	1	B	0.5 - 1.7	1.2	**0.42**	0.03	7.1%	94	67	71%	G	0.25	80	**0.25**	**0.38**

8	517	**MR**	60	1	C	1.7 - 2.3	0.6	**0.38**	0.04	10.5%	81	49	60%	G	0.25	80	**0.25**	**0.33**
8	517	**MR**	80	1	D	2.3 - 5.9	3.6	**0.44**	0.06	13.6%	129	73	57%	G	0.25	100	**0.29**	**0.36**
8	517	**MR**	80	1	E	5.9 - 7.1	1.2	**0.38**	0.07	18.4%	88	30	34%	G	0.25	100	**0.31**	**0.29**
8	517	**MR**	80	1	F	7.1 - 10.5	3.4	**0.51**	0.07	13.7%	143	67	47%	G	0.25	100	**0.29**	**0.42**
8	517	**MR**	80	1	G	10.5 - 17.5	7.0	**0.43**	0.07	16.3%	109	78	72%	G	0.25	100	**0.30**	**0.34**
8	517	**MR**	80	1	H	17.5 - 18.0	0.5	**0.50**	0.08	16.0%	90	93	103%	G	0.25	100	**0.31**	**0.40**
8	517	**MR**	80	1	I	18.0 - 21.8	3.8	**0.47**	0.08	17.0%	106	73	69%	G	0.25	100	**0.30**	**0.37**
8	517	**MR**	80	1	J	21.8 - 25.5	3.7	**0.43**	0.06	14.0%	114	86	75%	G	0.25	100	**0.30**	**0.35**
8	517	**MR**	60	1	K	25.5 - 26.3	0.8	**0.42**	0.08	19.0%	86	70	81%	G	0.25	80	**0.25**	**0.32**
8	518	**MR**	60	1	A	0.0 - 0.3	0.3	**0.28**	0.03	10.7%	66	10	15%	G	0.25	80	**0.25**	**0.24**
8	518	**MR**	80	1	B	0.3 - 1.6	1.3	**0.37**	0.02	5.4%	127	57	45%	G	0.25	100	**0.29**	**0.34**
8	518	**MR**	80	1	C	1.6 - 3.2	1.6	**0.46**	0.04	8.7%	101	60	59%	G	0.25	100	**0.30**	**0.41**
8	518	**MR**	80	1	D	3.2 - 5.2	2.0	**0.52**	0.03	5.8%	113	56	50%	G	0.25	100	**0.30**	**0.48**
8	518	**MR**	80	1	E	5.2 - 5.8	0.6	**0.46**	0.03	6.5%	96	61	64%	G	0.25	100	**0.31**	**0.42**
8	518	**MR**	80	1	F	5.8 - 10.4	4.6	**0.36**	0.06	16.7%	92	63	68%	G	0.25	100	**0.31**	**0.28**
8	530	**MR**	60	1	A	0.0 - 1.0	1.0	**0.33**	0.01	3.0%	90	21	23%	G	0.25	60	**0.25**	**0.32**
8	530	**MR**	60	1	B1	1.0 - 1.8	0.8	**0.28**	0.08	28.6%	128	90	70%	I	0.30	60	**0.30**	**0.18**
8	530	**MR**	40	1	B2	1.8 - 2.2	0.4	**0.30**	0.04	13.3%	93	44	47%	I	0.30	40	**0.24**	**0.25**
8	530	**MR**	60	1	B3	2.2 - 2.5	0.3	**0.29**	0.05	17.2%	118	99	84%	G	0.30	40	**0.30**	**0.23**
8	530	**MR**	60	1	C	2.5 - 3.0	0.5	**0.27**	0.02	7.4%	73	27	37%	G	0.25	60	**0.25**	**0.24**
8	530	**MR**	60	1	D	3.0 - 3.8	0.8	**0.37**	0.04	10.8%	37	11	30%	G	0.25	80	**0.25**	**0.32**
8	530	**MR**	60	1	E	3.8 - 4.3	0.5	**0.31**	0.02	6.5%	59	34	58%	G	0.25	60	**0.25**	**0.28**
8	531	**MR**	60	1	A	0.0 - 0.4	0.4	**0.30**	0.03	10.0%	67	20	30%	I	0.30	70	**0.30**	**0.26**
8	531	**MR**	60	1	B	0.4 - 1.9	1.5	**0.33**	0.02	6.1%	85	15	18%	I	0.30	70	**0.30**	**0.30**
8	531	**MR**	60	1	C	1.9 - 3.5	1.6	**0.22**	0.05	22.7%	65	52	80%	I	0.30	60	**0.30**	**0.16**
8	532	**MR**	80	1	A	0.0 - 0.5	0.5	**0.26**	0.03	11.5%	95	33	35%	G	0.25	100	**0.31**	**0.22**
8	532	**MR**	80	1	B	0.5 - 3.2	2.7	**0.35**	0.03	8.6%	121	70	58%	G	0.25	100	**0.29**	**0.31**
8	532	**MR**	60	1	C1	3.2 - 4.1	0.9	**0.42**	0.02	4.8%	105	39	37%	G	0.25	80	**0.25**	**0.39**
8	532	**MR**	70	1	C2	4.1 - 5.6	1.5	**0.45**	0.03	6.7%	105	42	40%	G	0.25	90	**0.27**	**0.41**
8	532	**MR**	60	1	D1	5.6 - 6.3	0.7	**0.37**	0.02	5.4%	110	42	38%	I	0.30	70	**0.30**	**0.34**
8	532	**MR**	80	1	D2	6.3 - 9.5	3.2	**0.37**	0.05	13.5%	111	53	48%	G	0.25	100	**0.30**	**0.31**
8	532	**MR**	80	1	E1	9.5 - 14.8	5.3	**0.35**	0.03	8.6%	107	57	53%	G	0.25	100	**0.30**	**0.31**
8	532	**MR**	60	1	E2	14.8 - 16.0	1.2	**0.35**	0.03	8.6%	84	30	36%	I	0.30	60	**0.30**	**0.31**
8	532	**MR**	60	1	F	16.0 - 18.1	2.1	**0.26**	0.04	15.4%	88	30	34%	I	0.30	60	**0.30**	**0.21**
8	532	**MR**	80	1	G	18.1 - 20.2	2.1	**0.37**	0.02	5.4%	140	71	51%	G	0.25	100	**0.29**	**0.34**

8	532	**MR**	80	1	H	20.2 - 24.9	4.7	**0.46**	0.02	4.3%	118	46	39%	G	0.25	100	**0.30**	**0.43**
8	532	**MR**	60	1	I	24.9 - 26.2	1.3	**0.39**	0.03	7.7%	105	57	54%	I	0.30	60-80	**0.30**	**0.35**
8	532	**MR**	60	1	J	26.2 - 27.1	0.9	**0.45**	0.06	13.3%	121	64	53%	G	0.25	80	**0.25**	**0.37**
8	532	**MR**	80	1	K	27.1 - 30.6	3.5	**0.50**	0.03	6.0%	114	44	39%	G	0.25	100	**0.30**	**0.46**
8	532	**MR**	80	1	L1	30.6 - 38.9	8.3	**0.46**	0.09	19.6%	112	64	57%	G	0.25	100	**0.30**	**0.34**
8	532	**MR**	60	1	L2	38.9 - 40.9	2.0	**0.41**	0.04	9.8%	122	48	39%	I	0.30	60-80	**0.30**	**0.36**
8	532	**MR**	70	1	L3	40.9 - 41.5	0.6	**0.41**	0.12	29.3%	87	59	68%	G	0.25	80-100	**0.28**	**0.26**
8	532	**MR**	80	1	M	41.5 - 42.5	1.0	**0.53**	0.09	17.0%	67	35	52%	G	0.25	100	**0.34**	**0.41**
8	532	**MR**	60	1	N	42.5 - 43.3	0.8	**0.26**	0.07	26.9%	61	25	41%	I	0.30	60-80	**0.30**	**0.17**
8	532	**MR**	80	1	O1	43.3 - 50.5	7.2	**0.35**	0.05	14.3%	102	54	53%	G	0.25	100	**0.30**	**0.29**
8	532	**MR**	60	1	O2	50.5 - 50.9	0.4	**0.33**	0.04	12.1%	152	53	35%	G	0.25	80	**0.25**	**0.28**
8	532	**MR**	60	1	O3	50.9 - 52.0	1.1	**0.34**	0.03	8.8%	104	52	50%	I	0.30	60	**0.30**	**0.30**
8	532	**MR**	80	1	P	52.0 - 58.0	6.0	**0.41**	0.06	14.6%	85	41	48%	I	0.30	100	**0.38**	**0.33**
8	532	**MR**	80	1	Q1	58.0 - 62.5	4.5	**0.47**	0.07	14.9%	88	54	61%	I	0.30	100	**0.38**	**0.38**
8	532	**MR**	70	1	Q2	62.5 - 65.5	3.0	**0.43**	0.06	14.0%	91	70	77%	I	0.30	80-100	**0.33**	**0.35**
8	532	**MR**	80	1	R	65.5 - 66.8	1.3	**0.32**	0.03	9.4%	82	25	30%	I	0.30	100	**0.38**	**0.28**
8	532	**MR**	80	1	S	66.8 - 68.8	2.0	**0.20**	0.07	35.0%	50	24	48%	I	0.30	100	**0.45**	**0.11**
8	532	**MR**	80	1	T	68.8 - 69.9	1.1	**0.28**	0.06	21.4%	62	23	37%	I	0.30	100	**0.41**	**0.20**
8	533	**MR**	60	1	A	0.0 - 0.5	0.5	**0.28**	0.02	7.1%	93	15	16%	I	0.30	60	**0.30**	**0.25**
8	533	**MR**	80	1	B	0.5 - 4.9	4.4	**0.36**	0.04	11.1%	113	62	55%	G	0.25	100	**0.30**	**0.31**
8	533	**MR**	80	1	C	4.9 - 5.5	0.6	**0.28**	0.04	14.3%	64	37	58%	G	0.25	100	**0.34**	**0.23**
8	533	**MR**	80	1	D	5.5 - 6.0	0.5	**0.38**	0.02	5.3%	87	32	37%	G	0.25	100	**0.31**	**0.35**
8	533	**MR**	80	1	E	6.0 - 6.5	0.5	**0.31**	0.05	16.1%	82	28	34%	G	0.25	100	**0.32**	**0.25**
8	533	**MR**	80	1	F	6.5 - 9.5	3.0	**0.41**	0.08	19.5%	91	47	52%	G	0.25	100	**0.31**	**0.31**
8	533	**MR**	80	1	G	9.5 - 9.8	0.3	**0.31**	0.02	6.5%	172	74	43%	G	0.25	100	**0.28**	**0.28**
8	533	**MR**	60	1	H	9.8 - 10.5	0.7	**0.40**	0.02	5.0%	128	53	41%	G	0.25	80	**0.25**	**0.37**
8	533	**MR**	60	1	I	10.5 - 11.3	0.8	**0.33**	0.03	9.1%	74	19	26%	I	0.30	60	**0.30**	**0.29**
8	533	**MR**	80	1	J	11.3 - 12.1	0.8	**0.38**	0.03	7.9%	93	40	43%	G	0.25	100	**0.31**	**0.34**
8	533	**MR**	80	1	K	12.1 - 13.4	1.3	**0.48**	0.05	10.4%	95	49	52%	G	0.25	100	**0.31**	**0.42**
8	533	**MR**	80	1	L	13.4 - 14.5	1.1	**0.33**	0.11	33.3%	84	32	38%	G	0.25	100	**0.32**	**0.19**
8	533	**MR**	80	1	M	14.5 - 15.3	0.8	**0.44**	0.03	6.8%	83	11	13%	G	0.25	100	**0.32**	**0.40**
8	533	**MR**	60	1	N	15.3 - 15.7	0.4	**0.23**	0.05	21.7%	65	36	55%	I	0.30	60-80	**0.30**	**0.17**
8	534	**MR**	60	1	A	0.0 - 0.5	0.5	**0.23**	0.09	39.1%	57	39	68%	G	0.25	60	**0.25**	**0.11**

8	534	**MR**	80	1	B	0.5 - 4.3	3.8	**0.44**	0.05	11.4%	105	49	47%	G	0.25	100	**0.30**	**0.38**
8	534	**MR**	80	1	C	4.3 - 4.9	0.6	**0.32**	0.04	12.5%	53	28	53%	G	0.25	100	**0.36**	**0.27**
8	534	**MR**	80	1	D	4.9 - 6.4	1.5	**0.42**	0.03	7.1%	92	69	75%	G	0.25	100	**0.31**	**0.38**
8	534	**MR**	80	1	E	6.4 - 8.6	2.2	**0.46**	0.05	10.9%	117	51	44%	G	0.25	100	**0.30**	**0.40**
8	534	**MR**		1	F	8.6 - 12.2												
8	534	**MR**	80	1	G	12.2 - 12.7	0.5	**0.43**	0.03	7.0%	85	31	36%	G	0.25	100	**0.32**	**0.39**
8	534	**MR**	80	1	H	12.7 - 16.8	4.1	**0.54**	0.08	14.8%	96	46	48%	G	0.25	100	**0.31**	**0.44**
8	534	**MR**	80	1	I	16.8 - 17.1	0.3	**0.30**	0.02	6.7%	81	39	48%	G	0.25	100	**0.32**	**0.27**
8	534	**MR**	80	1	J	17.1 - 18.4	1.3	**0.45**	0.05	11.1%	90	51	57%	G	0.25	100	**0.31**	**0.39**
8	534	**MR**	80	1	K	18.4 - 18.7	0.3	**0.20**	0.03	15.0%	55	13	24%	G	0.25	100	**0.36**	**0.16**
8	534	**MR**	80	1	L	18.7 - 23.0	4.3	**0.40**	0.06	15.0%	90	44	49%	G	0.25	100	**0.31**	**0.32**
8	535	**MR**	60	1	A	0.0 - 0.5	0.5	**0.29**	0.06	20.7%	94	38	40%	G	0.25	60	**0.25**	**0.21**
8	535	**MR**	70	1	B	0.5 - 1.6	1.1	**0.38**	0.03	7.9%	116	39	34%	G	0.25	80-100	**0.27**	**0.34**
8	535	**MR**	80	1	C	1.6 - 3.5	1.9	**0.43**	0.02	4.7%	137	65	47%	G	0.25	100	**0.29**	**0.40**
8	535	**MR**	70	1	D	3.5 - 5.0	1.5	**0.46**	0.03	6.5%	122	62	51%	G	0.25	80-100	**0.27**	**0.42**
8	535	**MR**	60	1	E	5.0 - 5.5	0.5	**0.36**	0.03	8.3%	81	13	16%	G	0.25	80	**0.25**	**0.32**
8	535	**MR**	80	1	F	5.5 - 8.4	2.9	**0.39**	0.05	12.8%	91	70	77%	G	0.25	100	**0.31**	**0.33**
8	535	**MR**	80	1	G	8.4 - 8.8	0.4	**0.30**	0.03	10.0%	75	51	68%	G	0.25	100	**0.33**	**0.26**
8	536	**MR**	60	1	A	0.0 - 0.2	0.2	**0.27**	0.01	3.7%	122	58	48%	G	0.25	80	**0.25**	**0.26**
8	536	**MR**	80	1	B	0.2 - 0.8	0.6	**0.28**	0.02	7.1%	100	56	56%	G	0.25	100	**0.31**	**0.25**
8	536	**MR**	80	1	C	0.8 - 1.2	0.4	**0.37**	0.02	5.4%	45	5	11%	G	0.25	100	**0.39**	**0.34**
8	536	**MR**	80	1	D	1.2 - 1.8	0.6	**0.27**	0.06	22.2%	42	23	55%	G	0.25	100	**0.40**	**0.19**
8	536	**MR**	80	1	E	1.8 - 3.8	2.0	**0.39**	0.06	15.4%	63	39	62%	G	0.25	100	**0.34**	**0.31**
8	536	**MR**	80	1	F	3.8 - 6.8	3.0	**0.36**	0.08	22.2%	69	60	87%	G	0.25	100	**0.33**	**0.26**
8	536	**MR**	80	1	G	6.8 - 7.9	1.1	**0.37**	0.03	8.1%	70	34	49%	G	0.25	100	**0.33**	**0.33**
8	536	**MR**	80	1	H	7.9 - 9.5	1.6	**0.47**	0.06	12.8%	101	64	63%	G	0.25	100	**0.30**	**0.39**
8	536	**MR**	80	1	I	9.5 - 15.2	5.7	**0.40**	0.04	10.0%	88	61	69%	G	0.25	100	**0.31**	**0.35**
8	536	**MR**	80	1	J	15.2 - 20.8	5.6	**0.35**	0.06	17.1%	56	26	46%	G	0.25	100	**0.36**	**0.27**
8	536	**MR**	80	1	K	20.8 - 23.1	2.3	**0.40**	0.06	15.0%	63	37	59%	G	0.25	100	**0.34**	**0.32**
8	536	**MR**	80	1	L	23.1 - 23.5	0.4	**0.28**	0.09	32.1%	71	48	68%	G	0.25	100	**0.33**	**0.16**
8	536	**MR**	80	1	M	23.5 - 28.6	5.1	**0.48**	0.04	8.3%	104	57	55%	G	0.25	100	**0.30**	**0.43**
8	536	**MR**	80	1	N	28.6 - 32.5	3.9	**0.44**	0.12	27.3%	82	67	82%	G	0.25	100	**0.32**	**0.29**
8	536	**MR**	80	1	O	32.8 - 38.3	5.5	**0.35**	0.09	25.7%	77	59	77%	G	0.25	100	**0.32**	**0.23**

8	851	MR	60	1	A1	0.0 - 0.3	0.3	0.23	0.06	26.1%	148	137	93%	G	0.25	60	0.25	0.15
8	851	MR	80	1	A2	0.3 - 1.7	1.4	0.30	0.03	10.0%	103	59	57%	G	0.25	100	0.30	0.26
8	851	MR	80	1	B	1.7 - 5.4	3.7	0.38	0.02	5.3%	101	46	46%	G	0.25	100	0.30	0.35
8	851	MR	80	1	C	5.4 - 12.6	7.2	0.37	0.03	8.1%	109	63	58%	G	0.25	100	0.30	0.33
8	851	MR	80	1	D	12.6 - 17.2	4.6	0.34	0.03	8.8%	96	40	42%	G	0.25	100	0.31	0.30
8	851	MR	70	1	E1	17.2 - 17.5	0.3	0.32	0.01	3.1%	71	8	11%	G	0.25	90	0.29	0.31
8	851	MR	60	1	E2	17.5 - 19.3	1.8	0.29	0.04	13.8%	72	21	29%	I	0.30	70	0.30	0.24
8	851	MR	60	1	F	19.3 - 22.8	3.5	0.31	0.03	9.7%	70	26	37%	I	0.30	60	0.30	0.27
8	851	MR	50	1	G	22.8 - 24.0	1.2	0.24	0.04	16.7%	61	18	30%	I	0.30	50	0.25	0.19
8	851	MR	60	1	H	24.0 - 25.4	1.4	0.31	0.03	9.7%	93	27	29%	G	0.25	70	0.25	0.27
8	851	MR	60	1	I	25.4 - 26.6	1.2	0.36	0.03	8.3%	114	59	52%	G	0.25	80	0.25	0.32
8	851	MR	80	1	J1	26.6 - 28.3	1.7	0.36	0.03	8.3%	62	31	50%	G	0.25	100	0.35	0.32
8	851	MR	80	1	J2	28.3 - 30.6	2.3	0.40	0.03	7.5%	90	46	51%	G	0.25	100	0.31	0.36
8	851	MR	60	1	K	30.6 - 31.2	0.6	0.32	0.10	31.3%	93	48	52%	G	0.25	80	0.25	0.19
8	851	MR	60	1	L	31.2 - 33.7	2.5	0.30	0.07	23.3%	67	40	60%	G	0.25	60	0.25	0.21
8	852	MR	60	1	A1	0.0 - 0.5	0.5	0.50	0.05	10.0%	80	10	13%	G	0.25	60	0.25	0.44
8	852	MR	60	1	A2	0.5 - 1.8	1.3	0.43	0.03	7.0%	110	38	35%	G	0.25	60	0.25	0.39
8	852	MR	80	1	B	1.8 - 2.2	0.4	0.31	0.02	6.5%	90	23	26%	G	0.25	100	0.31	0.28
8	852	MR	80	1	C	2.2 - 3.5	1.3	0.38	0.02	5.3%	104	43	41%	G	0.25	100	0.30	0.35
8	852	MR	80	1	D	3.5 - 8.3	4.8	0.44	0.05	11.4%	89	36	40%	G	0.25	100	0.31	0.38
8	852	MR	70	1	E	8.3 - 11.6	3.3	0.55	0.03	5.5%	123	40	33%	G	0.25	80-100	0.27	0.51
8	852	MR	60	1	F	11.6 - 14.1	2.5	0.51	0.06	11.8%	111	50	45%	G	0.25	60	0.25	0.43
8	854	MR	80	1	A	0.0 - 0.7	0.7	0.33	0.05	15.2%	61	39	64%	G	0.25	100	0.35	0.27
8	854	MR	80	1	B	0.7 - 1.6	0.9	0.44	0.04	9.1%	113	45	40%	G	0.25	100	0.30	0.39
8	854	MR	80	1	C	1.6 - 1.8	0.2	0.27	0.02	7.4%	42	10	24%	G	0.25	100	0.40	0.24
8	854	MR	80	1	D	1.8 - 5.1	3.3	0.42	0.04	9.5%	115	84	73%	G	0.25	100	0.30	0.37
8	854	MR	80	1	E	5.1 - 7.7	2.6	0.50	0.04	8.0%	102	60	59%	G	0.25	100	0.30	0.45
8	855	MR	60	1	A	0.0 - 0.7	0.7	0.37	0.04	10.8%	76	23	30%	I	0.30	70	0.30	0.32
8	855	MR	80	1	B	0.7 - 3.3	2.6	0.44	0.06	13.6%	90	47	52%	I	0.30	100	0.37	0.36
8	855	MR	80	1	C	3.3 - 4.6	1.3	0.38	0.06	15.8%	92	75	82%	G	0.25	100	0.31	0.30
8	855	MR	80	1	D	4.6 - 7.0	2.4	0.51	0.06	11.8%	93	32	34%	G	0.25	100	0.31	0.43
8	855	MR	80	1	E	7.0 - 8.5	1.5	0.35	0.07	20.0%	69	41	59%	G	0.25	100	0.33	0.26
8	855	MR	80	1	F	8.5 - 9.2	0.7	0.48	0.05	10.4%	97	27	28%	G	0.25	100	0.31	0.42
8	855	MR	80	1	G	9.2 - 11.8	2.6	0.38	0.08	21.1%	110	82	75%	G	0.25	100	0.30	0.28

8	855	**MR**	80	1	H	11.8 - 12.9	1.1	**0.32**	0.03	9.4%	112	47	42%	G	0.25	100	**0.30**	**0.28**
8	855	**MR**	80	1	I	12.9 - 13.7	0.8	**0.40**	0.07	17.5%	115	104	90%	G	0.25	100	**0.30**	**0.31**
8	855	**MR**	80	1	J	13.7 - 20.4	6.7	**0.42**	0.07	16.7%	101	75	74%	G	0.25	100	**0.30**	**0.33**
8	855	**MR**	70	1	K1	20.4 - 22.5	2.1	**0.38**	0.05	13.2%	91	60	66%	G	0.25	100	**0.28**	**0.32**
8	855	**MR**	60	1	K2	22.5 - 23.1	0.6	**0.38**	0.02	5.3%	89	34	38%	I	0.30	60-80	**0.30**	**0.35**
8	855	**MR**	60	1	L	23.1 - 23.4	0.3	**0.23**	0.04	17.4%	46	7	15%	I	0.30	60	**0.30**	**0.18**
8	856	**MR**	60	1	A	0.0 - 0.7	0.7	**0.25**	0.07	28.0%	64	20	31%	I	0.30	60	**0.30**	**0.16**
8	856	**MR**	60	1	B1	0.7 - 1.5	0.8	**0.35**	0.02	5.7%	100	38	38%	G	0.25	60	**0.25**	**0.32**
8	856	**MR**	60	1	B2	1.5 - 2.7	1.2	**0.34**	0.04	11.8%	85	27	32%	G	0.25	80	**0.25**	**0.29**
8	856	**MR**	60	1	C	2.7 - 4.3	1.6	**0.39**	0.03	7.7%	84	33	39%	G	0.25	80	**0.25**	**0.35**
8	856	**MR**	60	1	D	4.3 - 7.6	3.3	**0.32**	0.05	15.6%	94	43	46%	I	0.30	60	**0.30**	**0.26**
8	856	**MR**	70	1	E1	7.6 - 9.0	1.4	**0.40**	0.02	5.0%	117	27	23%	G	0.25	90	**0.27**	**0.37**
8	856	**MR**	60	1	E2	9.0 - 10.2	1.2	**0.37**	0.02	5.4%	105	37	35%	G	0.25	80	**0.25**	**0.34**
8	856	**MR**	60	1	E3	10.2 - 10.8	0.6	**0.38**	0.04	10.5%	83	23	28%	G	0.25	60	**0.25**	**0.33**
8	857	**MR**	60	1	A	0.0 - 0.4	0.4	**0.31**	0.01	3.2%	125	49	39%	I	0.30	60	**0.30**	**0.30**
8	857	**MR**	60	1	B	0.4 - 0.7	0.3	**0.22**	0.02	9.1%	55	17	31%	I	0.30	60	**0.30**	**0.19**
8	857	**MR**	60	1	C	0.7 - 0.9	0.2	**0.30**	0.01	3.3%	92	8	9%	I	0.30	60	**0.30**	**0.29**
8	857	**MR**	60	1	D	0.9 - 1.9	1.0	**0.22**	0.03	13.6%	61	12	20%	I	0.30	60	**0.30**	**0.18**
8	857	**MR**	60	1	E	1.9 - 3.0	1.1	**0.30**	0.02	6.7%	83	20	24%	I	0.30	60	**0.30**	**0.27**
8	857	**MR**	60	1	F	3.0 - 3.3	0.3	**0.21**	0.04	19.0%	52	19	37%	I	0.30	60	**0.30**	**0.16**
8	857	**MR**	60	1	G	3.3 - 4.3	1.0	**0.31**	0.02	6.5%	89	19	21%	G	0.25	80	**0.25**	**0.28**
8	857	**MR**	60	1	H	4.3 - 5.7	1.4	**0.40**	0.03	7.5%	92	20	22%	G	0.25	80	**0.25**	**0.36**
8	857	**MR**	60	1	I	5.7 - 6.2	0.5	**0.32**	0.03	9.4%	106	46	43%	G	0.25	80	**0.25**	**0.28**
8	857	**MR**	80	1	J	6.2 - 7.4	1.2	**0.43**	0.05	11.6%	98	35	36%	G	0.25	100	**0.31**	**0.37**
8	857	**MR**	60	1	K	7.4 - 7.8	0.4	**0.43**	0.01	2.3%	145	52	36%	G	0.25	80	**0.25**	**0.42**
8	857	**MR**	60	1	L	7.8 - 8.5	0.7	**0.36**	0.02	5.6%	122	39	32%	I	0.30	60	**0.30**	**0.33**
8	857	**MR**	60	1	M	8.5 - 9.6	1.1	**0.40**	0.04	10.0%	91	51	56%	I	0.30	60	**0.30**	**0.35**
8	857	**MR**	60	1	N	9.6 - 10.3	0.7	**0.28**	0.07	25.0%	69	31	45%	I	0.30	60	**0.30**	**0.19**
8	857	**MR**	60	1	O	10.3 - 11.0	0.7	**0.37**	0.04	10.8%	115	75	65%	I	0.30	60	**0.30**	**0.32**
8	857	**MR**	60	1	P	11.0 - 12.1	1.1	**0.42**	0.04	9.5%	101	57	56%	I	0.30	60	**0.30**	**0.37**
8	5126	**SR**	60	1	A	0.0 - 0.4	0.4	**0.32**	0.04	12.5%	105	55	52%	I	0.30	60-80	**0.30**	**0.27**
8	5126	**SR**	80	1	B	0.4 - 0.7	0.3	**0.26**	0.02	7.7%	98	21	21%	G	0.25	100	**0.31**	**0.23**
8	5126	**SR**	80	1	C	0.7 - 2.0	1.3	**0.41**	0.05	12.2%	97	50	52%	G	0.25	100	**0.31**	**0.35**
8	5126	**SR**	80	1	D	2.0 - 2.5	0.5	**0.57**	0.12	21.1%	97	50	52%	G	0.25	100	**0.31**	**0.42**
8	5126	**SR**	80	1	E	2.5 - 3.5	1.0	**0.48**	0.07	14.6%	118	88	75%	G	0.25	100	**0.30**	**0.39**

8	5302	**SR**	60	1	A1	0.0 - 0.4	0.4	**0.33**	0.03	9.1%	75	32	43%	I	0.30	60	**0.30**	**0.29**
8	5302	**SR**	60	1	A2	0.4 - 1.3	0.9	**0.34**	0.03	8.8%	77	25	32%	G	0.25	80	**0.25**	**0.30**
8	5302	**SR**	60	1	B	1.3 - 1.8	0.5	**0.28**	0.05	17.9%	75	40	53%	G	0.25	60	**0.25**	**0.22**
8	5302	**SR**	80	1	C	1.8 - 2.9	1.1	**0.40**	0.05	12.5%	94	49	52%	G	0.25	100	**0.31**	**0.34**
8	5302	**SR**	80	1	D	2.9 - 3.5	0.6	**0.29**	0.03	10.3%	72	27	38%	G	0.25	100	**0.33**	**0.25**
8	5302	**SR**	80	1	E	3.5 - 9.1	5.6	**0.48**	0.06	12.5%	92	40	43%	G	0.25	100	**0.31**	**0.40**
8	5302	**SR**	80	1	F	9.1 - 10.9	1.8	**0.43**	0.06	14.0%	68	39	57%	G	0.25	100	**0.34**	**0.35**
8	5302	**SR**	80	1	G	10.9 - 13.2	2.3	**0.50**	0.10	20.0%	106	68	64%	G	0.25	100	**0.30**	**0.37**
8	5302	**SR**	80	1	H	13.2 - 13.6	0.4	**0.33**	0.07	21.2%	70	37	53%	G	0.25	100	**0.33**	**0.24**
8	5302	**SR**	80	1	I	13.6 - 17.3	3.7	**0.51**	0.06	11.8%	107	59	55%	G	0.25	100	**0.30**	**0.43**
8	5302	**SR**	80	1	J	17.3 - 18.1	0.8	**0.46**	0.06	13.0%	120	24	20%	G	0.25	100	**0.30**	**0.38**
8	5302	**SR**	80	1	K	18.1 - 19.0	0.9	**0.39**	0.05	12.8%	69	27	39%	G	0.25	100	**0.33**	**0.33**
8	5302	**SR**	80	1	L	19.0 - 22.0	3.0	**0.46**	0.08	17.4%	78	52	67%	G	0.25	100	**0.32**	**0.36**
8	5302	**SR**		1	M	22.0 - 23.0												
8	5302	**SR**	80	1	N	23.0 - 24.3	1.3	**0.48**	0.06	12.5%	102	90	88%	G	0.25	100	**0.30**	**0.40**
8	5302	**SR**	60	1	O	24.3 - 24.1	0.1	**0.28**	0.02	7.1%	46	10	22%	G	0.25	80	**0.25**	**0.25**
8	5323	**SR**	60	1	A1	0.0 - 0.4	0.4	**0.24**	0.05	20.8%	58	18	31%	I	0.30	60	**0.30**	**0.18**
8	5323	**SR**	60	1	A2	0.4 - 0.8	0.4	**0.35**	0.04	11.4%	133	70	53%	I	0.30	60	**0.30**	**0.30**
8	5323	**SR**	80	1	B	0.8 - 1.9	1.1	**0.35**	0.02	5.7%	83	34	41%	G	0.25	100	**0.32**	**0.32**
8	5323	**SR**	80	1	C	1.9 - 3.0	1.1	**0.44**	0.04	9.1%	100	45	45%	G	0.25	100	**0.31**	**0.39**
8	5323	**SR**	80	1	D	3.0 - 3.4	0.4	**0.56**	0.02	3.6%	89	43	48%	G	0.25	100	**0.31**	**0.53**
8	5323	**SR**	80	1	E	3.4 - 5.6	2.2	**0.52**	0.05	9.6%	105	48	46%	G	0.25	100	**0.30**	**0.46**
8	5323	**SR**	80	1	F	5.6 - 6.9	1.3	**0.48**	0.06	12.5%	99	49	49%	G	0.25	100	**0.31**	**0.40**
8	5323	**SR**	80	1	G	6.9 - 8.8	1.9	**0.38**	0.06	15.8%	100	48	48%	G	0.25	100	**0.31**	**0.30**
8	5323	**SR**	80	1	H	8.8 -- 11.3	2.5	**0.48**	0.05	10.4%	119	68	57%	G	0.25	100	**0.30**	**0.42**
8	5323	**SR**	80	1	I	11.3 - 13.3	2.0	**0.45**	0.06	13.3%	89	67	75%	G	0.25	100	**0.31**	**0.37**
8	5323	**SR**		1	J	13.3 - 14.2												
8	5323	**SR**	80	1	K	14.2 - 14.4	0.2	**0.43**	0.01	2.3%	83	12	14%	G	0.25	100	**0.32**	**0.42**
8	5323	**SR**		1	L	14.4 - 15.3												
8	5323	**SR**	80	1	M	15.3 - 17.6	2.3	**0.47**	0.07	14.9%	107	37	35%	G	0.25	100	**0.30**	**0.38**
8	5324	**SR**	60	1	A	0.0 - 0.9	0.9	**0.40**	0.06	15.0%	76	19	25%	I	0.30	60	**0.30**	**0.32**
8	5324	**SR**	60	1	B	0.9 - 1.3	0.4	**0.39**	0.02	5.1%	70	20	29%	I	0.30	80	**0.30**	**0.36**
8	5324	**SR**	80	1	C	1.3 - 3.0	1.7	**0.44**	0.04	9.1%	81	26	32%	I	0.30	100	**0.38**	**0.39**
8	5324	**SR**	80	1	D	3.0 - 4.4	1.4	**0.52**	0.04	7.7%	98	39	40%	I	0.30	100	**0.37**	**0.47**
8	5324	**SR**	80	1	E	4.4 - 5.0	0.6	**0.46**	0.03	6.5%	99	24	24%	I	0.30	100	**0.37**	**0.42**

8	5324	**SR**	50	1	F	5.0 - 5.5	0.5	**0.38**	0.05	13.2%	64	34	53%	I	0.30	50	**0.26**	**0.32**
8	5324	**SR**	60	1	G	5.5 - 6.0	0.5	**0.44**	0.05	11.4%	86	37	43%	I	0.30	80	**0.30**	**0.38**
8	5324	**SR**	80	1	H	6.0 - 7.4	1.4	**0.47**	0.05	10.6%	101	28	28%	I	0.30	100	**0.37**	**0.41**
8	5332	**SR**	60	1	A	0.0 - 0.6	0.6	**0.33**	0.06	18.2%	55	28	51%	I	0.30	60	**0.30**	**0.25**
8	5332	**SR**	80	1	B	0.6 - 2.9	2.3	**0.47**	0.04	8.5%	108	55	51%	G	0.25	100	**0.30**	**0.42**
8	5332	**SR**	80	1	C	2.9 - 3.8	0.9	**0.36**	0.05	13.9%	72	38	53%	G	0.25	100	**0.33**	**0.30**
8	5342	**SR**	80	1	A	0.0 - 0.6	0.6	**0.37**	0.04	10.8%	58	16	28%	G	0.25	100	**0.35**	**0.32**
8	5342	**SR**	80	1	B	0.6 - 4.8	4.2	**0.44**	0.05	11.4%	86	48	56%	G	0.25	100	**0.32**	**0.38**
8	5342	**SR**	80	1	C	4.8 - 5.1	0.3	**0.36**	0.02	5.6%	69	18	26%	G	0.25	100	**0.33**	**0.33**
8	5382	**SR**	60	1	A	0.0 - 0.3	0.3	**0.24**	0.02	8.3%	56	10	18%	I	0.30	60	**0.30**	**0.21**
8	5382	**SR**	40	1	B1	0.3 - 1.0	0.7	**0.18**	0.03	16.7%	55	18	33%	I	0.30	40	**0.21**	**0.14**
8	5382	**SR**	60	1	B2	1.0 - 2.5	1.5	**0.23**	0.04	17.4%	57	22	39%	I	0.30	60	**0.30**	**0.18**
8	5382	**SR**	60	1	C	2.5 - 3.5	1.0	**0.31**	0.03	9.7%	82	50	61%	G	0.25	80	**0.25**	**0.27**
8	5382	**SR**	80	1	D	3.5 - 5.5	2.0	**0.42**	0.03	7.1%	118	61	52%	G	0.25	100	**0.30**	**0.38**
8	5382	**SR**	80	1	E	5.5 - 15.6	10.1	**0.45**	0.05	11.1%	92	48	52%	G	0.25	100	**0.31**	**0.39**
8	5382	**SR**	80	1	F	15.6 - 17.7	2.1	**0.41**	0.06	14.6%	91	49	54%	G	0.25	100	**0.31**	**0.33**
8	5382	**SR**	80	1	G1	17.7 - 23.3	5.6	**0.54**	0.05	9.3%	95	60	63%	G	0.25	100	**0.31**	**0.48**
8	5382	**SR**	60	1	G2	23.3 - 24.1	0.8	**0.50**	0.05	10.0%	96	16	17%	G	0.25	80	**0.25**	**0.44**
8	5382	**SR**	60	1	H	24.1 - 24.6	0.5	**0.41**	0.07	17.1%	69	43	62%	G	0.25	80	**0.25**	**0.32**
8	8501	**SR**	80	1	A	0.0 - 0.2	0.2	**0.29**	0.02	6.9%	95	13	14%	I	0.30	100	**0.37**	**0.26**
8	8501	**SR**	80	1	B	0.2 - 0.9	0.7	**0.46**	0.03	6.5%	106	60	57%	G	0.25	100	**0.30**	**0.42**
8	8501	**SR**	80	1	C	0.9 - 6.3	5.4	**0.49**	0.05	10.2%	101	51	50%	G	0.25	100	**0.30**	**0.43**
8	8501	**SR**	80	1	D	6.3 - 11.8	5.5	**0.40**	0.05	12.5%	97	48	49%	G	0.25	100	**0.31**	**0.34**
8	8501	**SR**	80	1	E	11.8 - 12.3	0.5	**0.34**	0.03	8.8%	78	19	24%	G	0.25	100	**0.32**	**0.30**
8	8501	**SR**		1	F	12.3 - 13.1												
8	8501	**SR**	80	1	G	13.1 - 14.2	1.1	**0.28**	0.06	21.4%	90	44	49%	G	0.25	100	**0.31**	**0.20**
8	8506	**SR**	80	1	A	0.0 - 3.4	3.4	**0.39**	0.04	10.3%	111	32	29%	G	0.25	100	**0.30**	**0.34**
8	8506	**SR**	60	1	B	3.4 - 4.3	0.9	**0.34**	0.03	8.8%	92	30	33%	G	0.25	60	**0.25**	**0.30**
8	8506	**SR**	60	1	C	4.3 - 4.6	0.3	**0.36**	0.03	8.3%	153	14	9%	G	0.25	80	**0.25**	**0.32**
8	8506	**SR**	80	1	D	4.6 - 6.4	1.8	**0.48**	0.03	6.3%	112	49	44%	G	0.25	100	**0.30**	**0.44**
8	8506	**SR**	80	1	E	6.4 - 7.1	0.7	**0.30**	0.03	10.0%	43	29	67%	I	0.30	100	**0.48**	**0.26**
8	8506	**SR**	80	1	F	7.1 - 9.0	1.9	**0.48**	0.03	6.3%	101	27	27%	G	0.25	100	**0.30**	**0.44**
8	8506	**SR**	80	1	G	9.0 - 10.0	1.0	**0.40**	0.03	7.5%	106	27	25%	G	0.25	100	**0.30**	**0.36**
8	8509	**SR**	60	1	A	0.0 - 0.2	0.2	**0.24**	0.04	16.7%	51	2	4%	G	0.25	60	**0.25**	**0.19**

8	8509	**SR**	60	1	B	0.2 - 1.9	1.7	**0.37**	0.05	13.5%	96	52	54%	G	0.25	60	**0.25**	**0.31**
8	8509	**SR**	60	1	C	1.9 - 2.5	0.6	**0.44**	0.02	4.5%	101	59	58%	G	0.25	80	**0.25**	**0.41**
8	8509	**SR**	80	1	D	2.5 - 3.5	1.0	**0.37**	0.06	16.2%	164	104	63%	G	0.25	100	**0.28**	**0.29**
8	8509	**SR**	80	1	E	3.5 - 6.5	3.0	**0.42**	0.05	11.9%	121	60	50%	G	0.25	100	**0.29**	**0.36**
8	8509	**SR**	80	1	F	6.5 - 7.2	0.7	**0.53**	0.08	15.1%	110	74	67%	G	0.25	100	**0.30**	**0.43**
8	8509	**SR**	80	1	G	7.2 - 9.4	2.2	**0.43**	0.07	16.3%	128	64	50%	G	0.25	100	**0.29**	**0.34**
8	8509	**SR**	80	1	H	9.4 - 11.8	2.2	**0.51**	0.08	15.7%	117	88	75%	G	0.25	100	**0.30**	**0.41**
8	8509	**SR**	60	1	I	11.8 - 12.2	0.4	**0.49**	0.10	20.4%	107	67	63%	G	0.25	80	**0.25**	**0.36**
8	8509	**SR**	60	1	J	12.2 - 12.7	0.5	**0.48**	0.08	16.7%	75	32	43%	G	0.25	60	**0.25**	**0.38**
8	8509	**SR**	50	1	K	12.7 - 13.1	0.4	**0.33**	0.12	36.4%	64	36	56%	I	0.30	50	**0.26**	**0.18**
8	8554	**SR**		1	A	0.0 - 0.2												
8	8554	**SR**	80	1	B	0.2 - 0.7	0.5	**0.46**	0.07	15.2%	130	41	32%	G	0.25	100	**0.29**	**0.37**
8	8554	**SR**		1	C	0.7 - 3.8												
8	8554	**SR**	80	1	D	3.8 - 4.2	0.4	**0.35**	0.02	5.7%	44	13	30%	G	0.25	100	**0.39**	**0.32**
8	8554	**SR**	80	1	E	4.2 - 6.3	2.1	**0.51**	0.05	9.8%	78	38	49%	G	0.25	100	**0.32**	**0.45**
8	8554	**SR**	80	1	F	6.3 - 7.0	0.7	**0.42**	0.01	2.4%	45	26	58%	G	0.25	100	**0.39**	**0.41**
8	8554	**SR**	80	1	G	7.0 - 8.7	1.7	**0.47**	0.03	6.4%	97	55	57%	G	0.25	100	**0.31**	**0.43**
8	8554	**SR**	60	1	H	8.7 - 9.2	0.5	**0.42**	0.02	4.8%	101	71	70%	G	0.25	80	**0.25**	**0.39**
8	8554	**SR**	60	1	I	9.2 - 9.8	0.6	**0.40**	0.02	5.0%	100	24	24%	G	0.25	60	**0.25**	**0.37**
8	8554	**SR**	60	1	J	9.8 - 10.3	0.5	**0.29**	0.03	10.3%	131	61	47%	I	0.30	60	**0.30**	**0.25**
8	8554	**SR**	60	1	K	10.3 - 10.7	0.4	**0.42**	0.03	7.1%	124	43	35%	G	0.25	60	**0.25**	**0.38**
8	8554	**SR**	80	1	L	10.7 - 11.3	0.6	**0.30**	0.08	26.7%	74	49	66%	G	0.25	100	**0.33**	**0.20**
8	8565	**SR**	60	1	A	0.0 - 0.5	0.5	**0.45**	0.07	15.6%	85	21	25%	G	0.25	60	**0.25**	**0.36**
8	8565	**SR**	60	1	B	0.5 - 1.7	1.2	**0.49**	0.03	6.1%	142	44	31%	G	0.25	80	**0.25**	**0.45**
8	8565	**SR**	60	1	C	1.7 - 2.3	0.6	**0.39**	0.01	2.6%	118	26	22%	G	0.25	80	**0.25**	**0.38**
8	8565	**SR**	60	1	D	2.3 - 2.7	0.4	**0.29**	0.08	27.6%	83	29	35%	I	0.30	80	**0.30**	**0.19**
8	8565	**SR**	60	1	E	2.7 - 3.0	0.3	**0.43**	0.01	2.3%	107	17	16%	G	0.25	80	**0.25**	**0.42**
8	8565	**SR**	60	1	F	3.0 - 3.5	0.5	**0.40**	0.01	2.5%	125	55	44%	G	0.25	60	**0.25**	**0.39**
8	8565	**SR**	60	1	G	3.5 - 3.9	0.4	**0.33**	0.03	9.1%	94	24	26%	G	0.25	60	**0.25**	**0.29**
8	8565	**SR**	50	1	H	3.9 - 4.6	0.7	**0.34**	0.05	14.7%	84	39	46%	I	0.30	50	**0.27**	**0.28**

Unsealed
Roadworks

Appendix C - Metadata

DIGITAL CADASTRAL DATA BASE

Dataset

ANZLIC Identifier: ANZQL0053000003

Title : Digital Cadastral Data Base (DCDB)

Custodian

Custodian: Department of Natural Resources and Mines (NR&M)

Jurisdiction : Queensland

Description

Abstract : The DCDB is the spatial representation of the property boundaries and the related property descriptions of Queensland. The DCDB provides the map base for systems dealing with land and land related information and provides data in order to generate hard copy map products. The DCDB is a fundamental reference layer for spatial information systems in Queensland.

Search Words: LAND
LAND Cadastral
BOUNDARY Administrative

Geographic Extent Name : gds_redcliffe_u.qif

Geographic Extent polygon: Extent Window

-27.20 153.11, -27.20 153.11, -27.23 153.11, -27.23 153.11, -27.20 153.11

Data Currency

Beginning Date: June 1983

Ending Date: Current

Data Status

Progress: Complete

Maintenance and Update Frequency: Daily

Access

Stored Data Format: The DCDB is stored in a relational data base format managed by an INGRES RDBMS Version II 2.0/0001 on a SUN E880 server using a SunOS 5.8 operating system. The DCDB data is accessed using a three tier client / server application for viewing or the extraction of QIF data or the production of hardcopy mapping. Available Format Types:

- **DIGITAL - QIF Grid / Geographic co-ordinate values - ASCII**
- **DIGITAL - ArcInfo / ArcView**
- **DIGITAL - Autocad DXF / DWG**
- **DIGITAL - MicroStation DGN**
- **DIGITAL - MapInfo**
- **NON DIGITAL - Plotted maps**
- **NON DIGITAL - Printouts**
- **NON DIGITAL - Reports**

The digital DCDB data is extracted in an interchange format, QIF (Queensland Interchange Format). This specification provides the digital data in a flat ASCII file format suitable for translation to proprietary systems. The specification is available as an NR&M QA document PBD/801/206 ver. 3.2. The QIF data can be provided in either datum, AGD84 or GDA94. The data is available in any of the standard co-ordinate systems below:-

- **grid co-ordinates (Eastings and Northings) in metres using the Australian Map Grid 1984 (AGD84) co-ordinate set;**

- **Geographical co-ordinates (Latitude and Longitudes) in decimal degrees using the Australian Geodetic Datum 1984 (AGD84) co-ordinate set;**
- **grid co-ordinates (Eastings and Northings) in metres using the Map Grid Australia (GDA94) co-ordinate set;**
- **Geographical co-ordinates (Latitude and Longitudes) in decimal degrees using the Geocentric Datum of Australia 1994 (GDA84) co-ordinate set.**

The DCDB is available already translated in a variety of specialist formats:

- **ArcInfo / ArcView**
- **Autocad DXF / DWG**
- **MapInfo**
- **MicroStation DGN**

The DCDB data is available in hard copy output on standard mapping format by scale or geographic window from the Departments' Basic Land Information Network (BLIN) application.

Access Constraints:

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DCDB digital data is supplied to clients under specific licence agreements. Licensed clients of DCDB data are divided into three categories, distribution and value adding, ongoing and once off users. The digital data is costed on a per parcel basis relative to the terms of supply. Enquiries regarding the costs should be directed to the Principal Cartographer, DCDB Data Supply, Geographic Data Services, on (07) 3896 3162.

<u>Data Quality</u>

Lineage: The DCDB was captured by digitising the best available cadastral mapping at a variety of scale and map accuracy. These mapping scales ranged from Standard 1:2500 to 1:250000, Provisional 1:2500 to 1:253400 and mapping such as Parish, Locality, Environ and Town maps. At the initial capture, existing control identified from the Survey Control Database, standard cadastral and topographic mapping, photogrammetric and orthophoto compilations and this control was used as part of the digitising process. Additional control was requested if

necessary. The DCDB is continuously updated by inputting metes and bounds descriptions from registered plans of subdivision and from any attribute updates from government gazettes and other administrative notifications. Selected areas of the DCDB are being upgraded for an improved positional accuracy, this is an ongoing process affected on a data or cost sharing basis with the user. The geodetic datum for the DCDB is GDA94. In October 2000, the datum of DCDB was converted from AGD84 values. A distortion model based on a Queensland grid was used in the transformation process for the conversion of the DCDB co-ordinate values from AGD84 to GDA94.

Positional Accuracy:

Positional accuracy values have been allocated all parcels in the DCDB. This value reflects 'maximum error' status of the parcel and has been derived from the capture process or assigned as the DCDB data has been upgraded. For this QIF extraction, the 'maximum error' of parcels range from: 0.10m to 0.10m.

The data is sourced from: B&D plot controlled

It has been established that the positional accuracy of the DCDB should include a finite value representing the 'maximum error' based on the source map type, the scale and a digitising value component. The calculated values linked to the source map scale is the root mean square error results of the precision of digitising and source map accuracy. Accuracy value have been applied to upgraded parcels, these values were determined at the time of upgrade and are dependent on the upgrade process. The values are expressed in metres at a 95% confidence level.

Attribute Accuracy:

The attributes in the DCDB are acquired from a number of sources within the Department. The attributes describe a range of characteristics about each land parcel such as property description, area, tenure, linestyle etc. Each polygon in the DCDB has a unique identifier called a segment-parcel number. The following attributes are attached to each polygon in the DCDB based on the polygon centroid which is the segment-parcel number

Accuracy code	**Centroid value**	**Coverage code**
Excluded area value	**Feature name**	**Linestyle code**
Local Government code	**Locality code**	**Locality name**
Lot area value	**Lot number**	**Maximum error value**
Parcel indicator code	**Parcel type code**	**Parcel number**
Parcel corner value	**Parcel count value**	**Parish code**
Plan number	**Segment number**	**Surveyed indicator**
Tenure code	**Update number**	**Update type code**

Most attributes were validated after the initial capture of the DCDB and are updated as part of the maintenance process. The validation process consisted of the visual inspection/comparison of hard copy output compared to the departmental cadastral working maps and update plans. There are several system validation procedures in the maintenance process and these are run at a required frequency. The QIF data routine also provides a validation report on a data extract. The attributes of Locality and Parish have not been fully validated. A program for the capture of Locality data is in progress. As this locality data becomes available it will be reflected in the

database. As other departmental datasets of lot/plan data, (ie ATS, QVAS, CISP, TAS etc), become available they are matched to each other to improve the reliability of the Departments' databases. The estimated accuracy of the attribute information is 98%, this is exclusive of locality and parish information.

Logical consistency:

The current DCDB can be considered as a seamless map of the State and consists of base cadastral parcels, strata level parcels (secondary interests), volumetric and easement parcels. Base parcels are contiguous with surrounding base parcels. The graphic package and the routines that extract and reload update data to the database has a tolerance of 2mm on the ground. This tolerance may become significant in some proprietary systems and therefore an allowance will be necessary.

Completeness:

The DCDB data has been investigated for completeness by visual inspection of validation plots compared to the cadastral working maps and update plans. The update process for new graphics subdivisional data entered into the DCDB includes an extraction of a hard copy output after the update data is loaded back to the database for the data validation. When digital data is extracted from the DCDB in QIF, the extract routine provides a report on the completeness of the data extracted. If the data indicated errors then subsequent corrective action is taken before the data is re-extracted. Easements are being input as new plans of subdivision are updated in the database. The historical easements are being captured as a project. This capture over the whole of the State is not yet complete. Volumetric plans are being input as new plans of subdivision are updated in the database.

Contact Information

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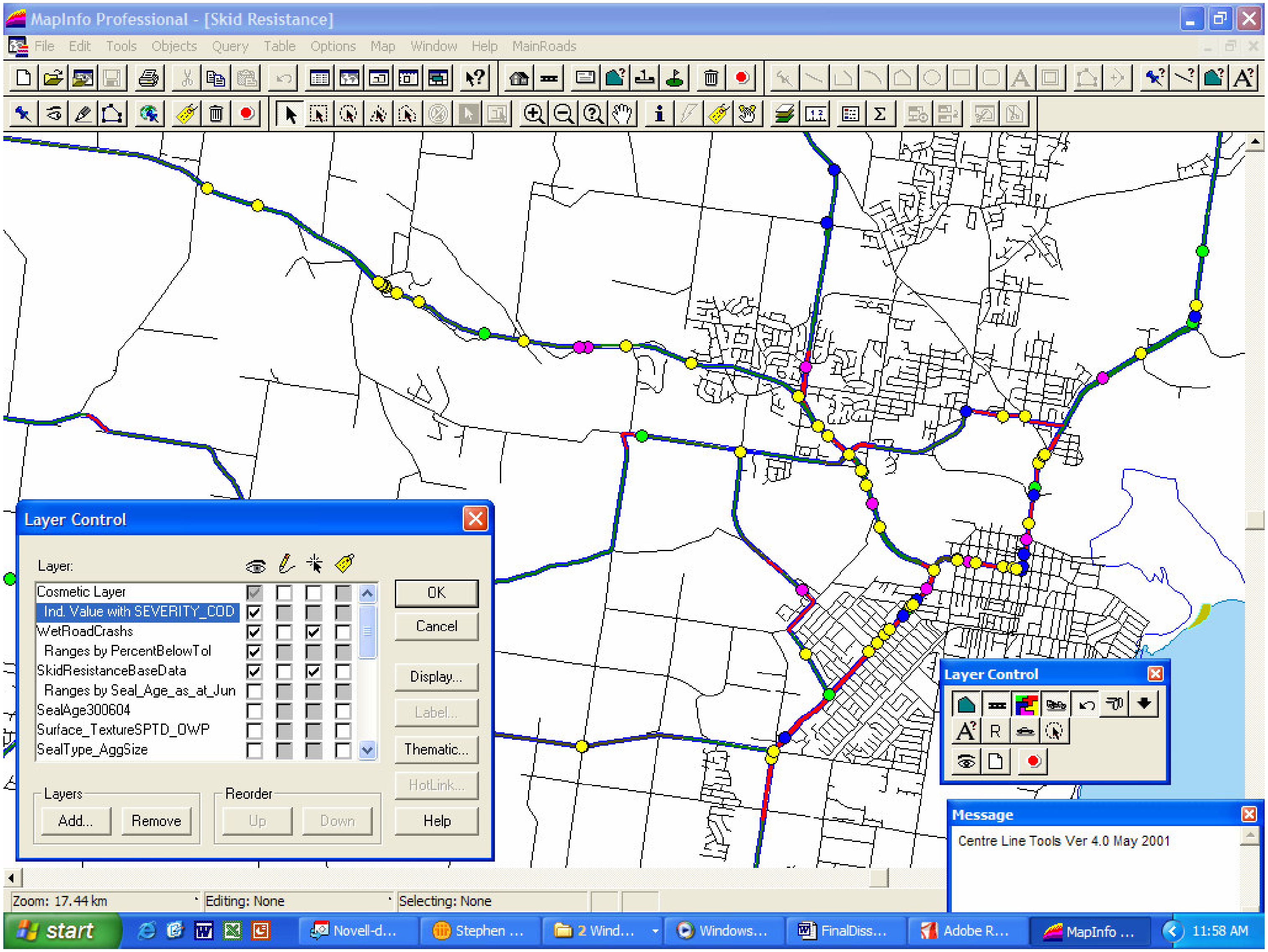
Metadata Date

Metadata Date: 15/05/2005

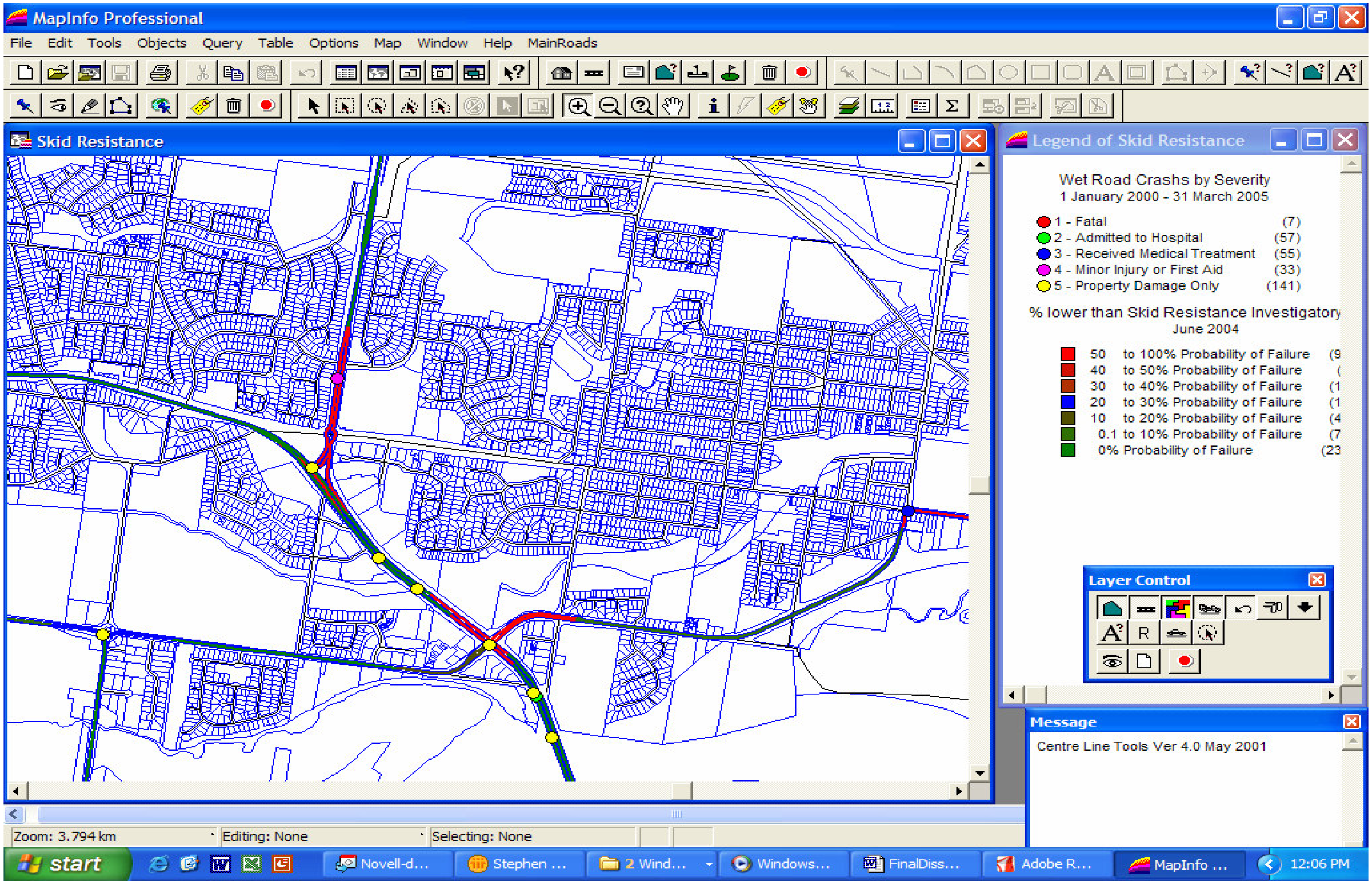
Additional Metadata

Additional Metadata: Further information about the supply of the DCDB in specific digital formats is available from the Principal Cartographer, DCDB Data Supply, Geographic Data Services, on (07) 3896 3162 or Email datasupply@dnr.qld.gov.au.

Appendix D Sample Workspace


MapInfo Professional - [Skid Resistance]
File Edit Tools Objects Query Table Options Map Window Help MainRoads
Layer Control
Layer:
Cosmetic Layer
Ind. Value with SEVERITY_COD
WetRoadCrashs
Ranges by PercentBelowTol
SkidResistanceBaseData
Ranges by Seal_Age_as_at_Jun
SealAge300604
Surface_TextureSPTD_OWP
SealType_AggSize
OK
Cancel
Display...
Label...
Thematic...
HotLink...
Help
Layers
Add...
Remove
Reorder
Up
Down
Layer Control
Message
Centre Line Tools Ver 4.0 May 2001
Zoom: 17.44 km
Editing: None
Selecting: None
start
11:58 AM

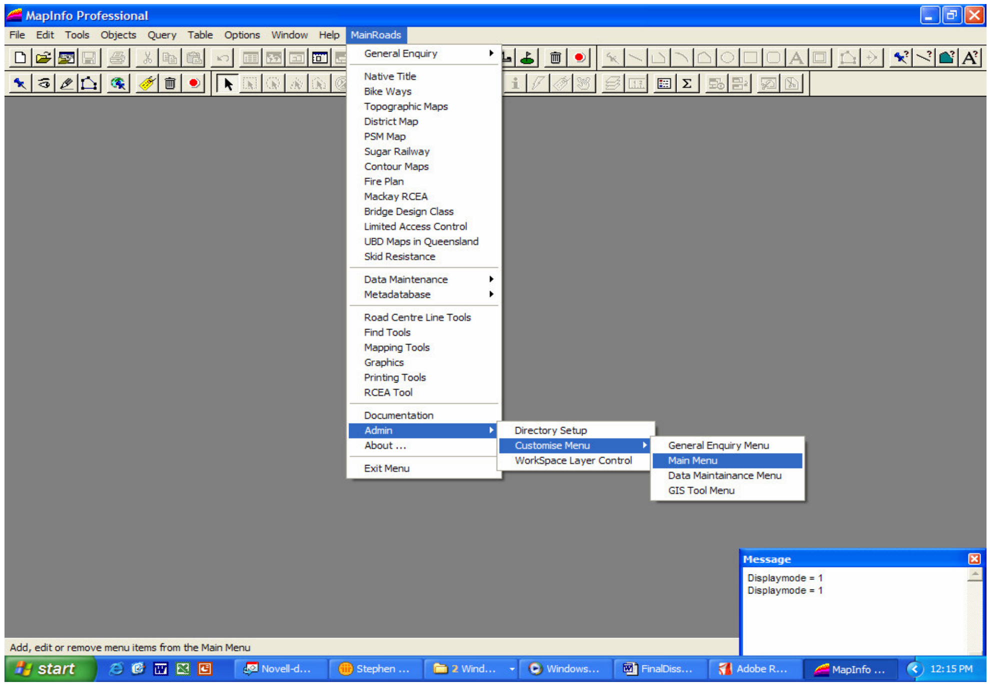
Appendix E Sample Thematic Output



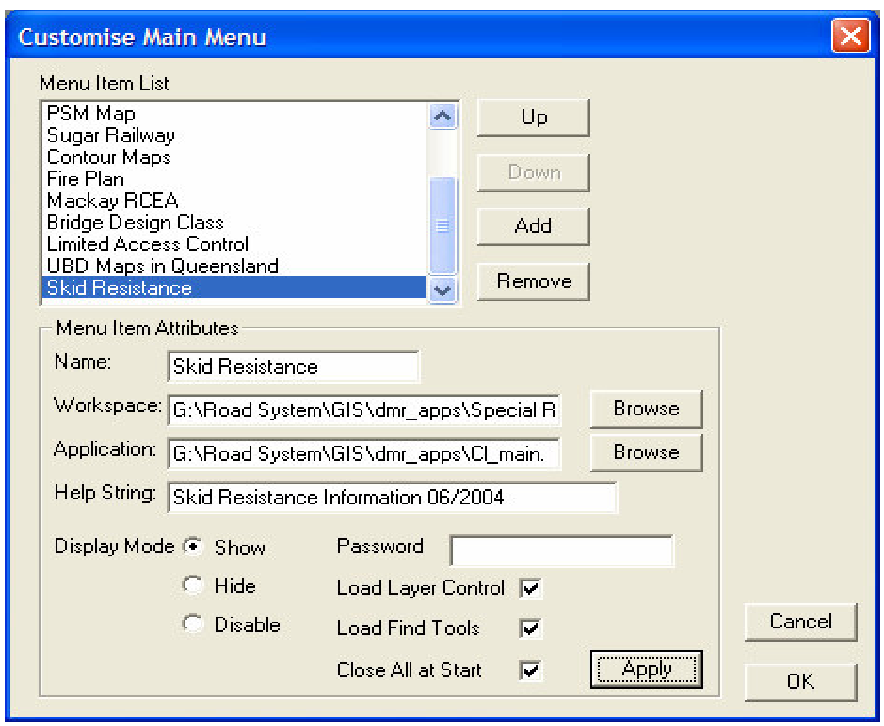
Sample Thematic Map Showing Percentage Probability of Failure to meet Investigatory Levels on Road Sections

& Thematic Map of Wet Road Crashes based on Severity

Appendix F Main Menu Customisation

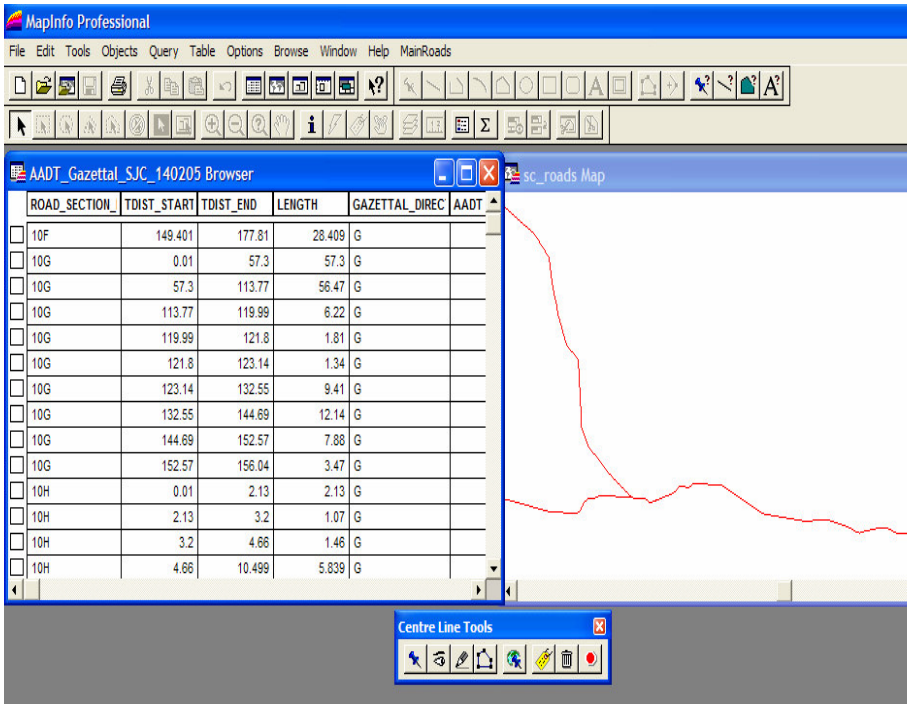


Accessing the Customise Menu Option

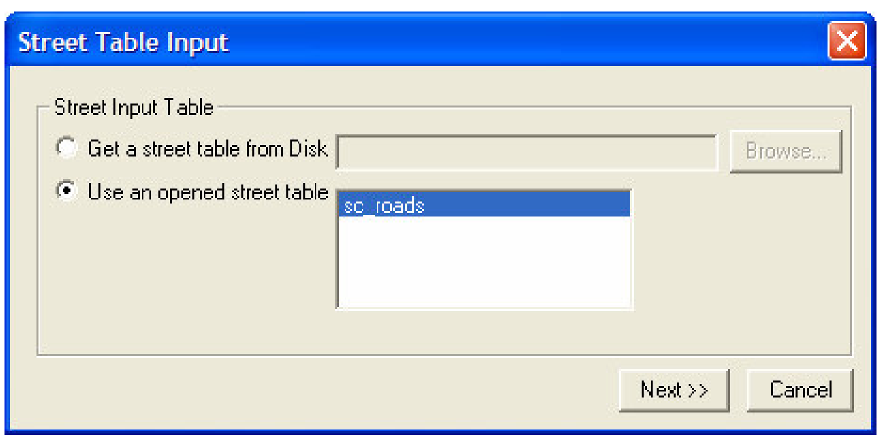


Customising the Menu

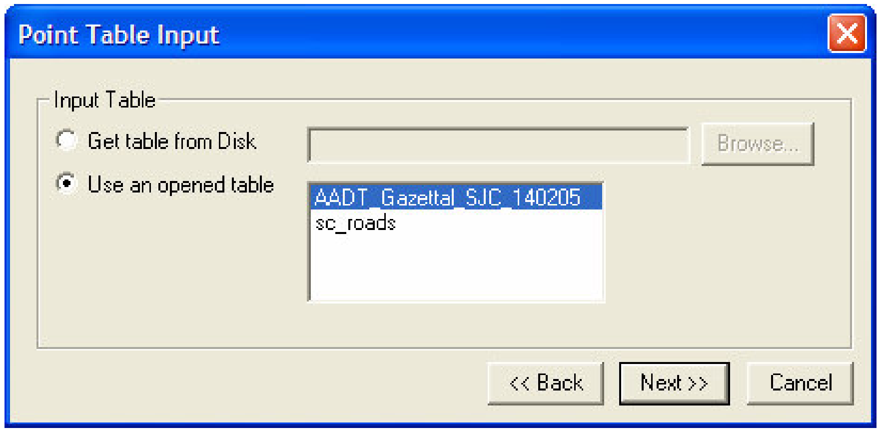
Appendix G Geocoding



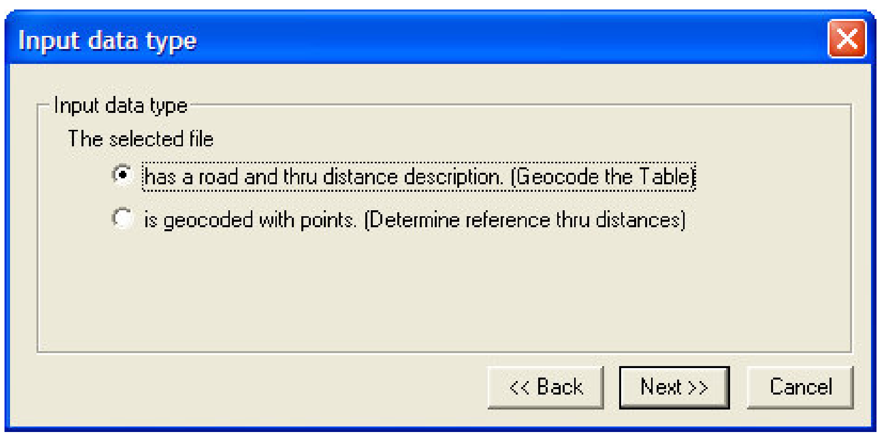
Step 1 – Open Table to be Geocoded as a browser in MapInfo and then run the Centreline Tools application



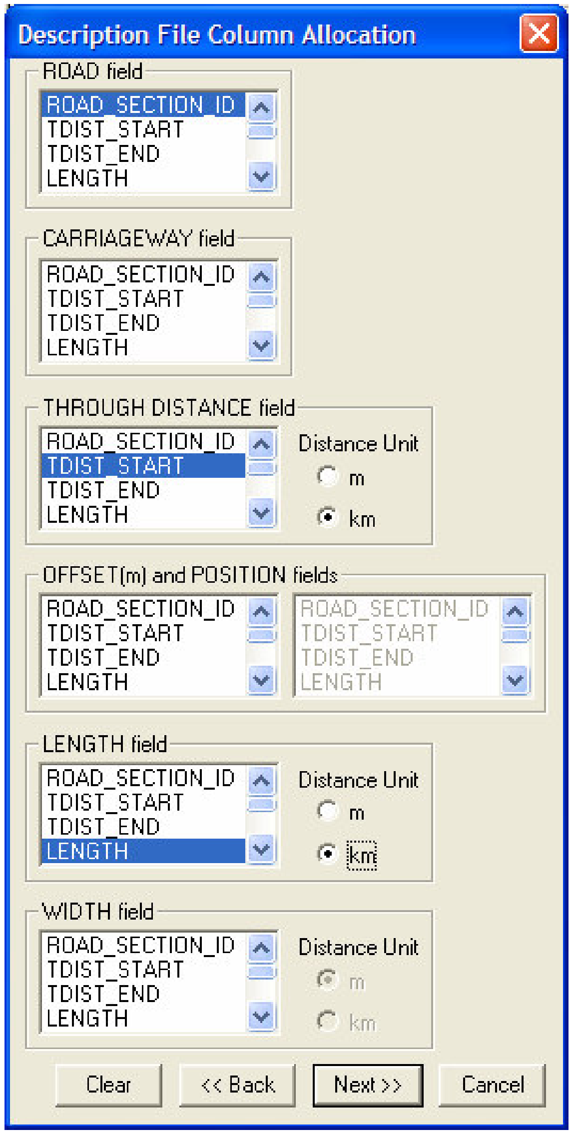
Step 2 – Click the 'Thru distance Wizard' and Select the road dataset to map data against



Step 3 - Select the dataset to be mapped

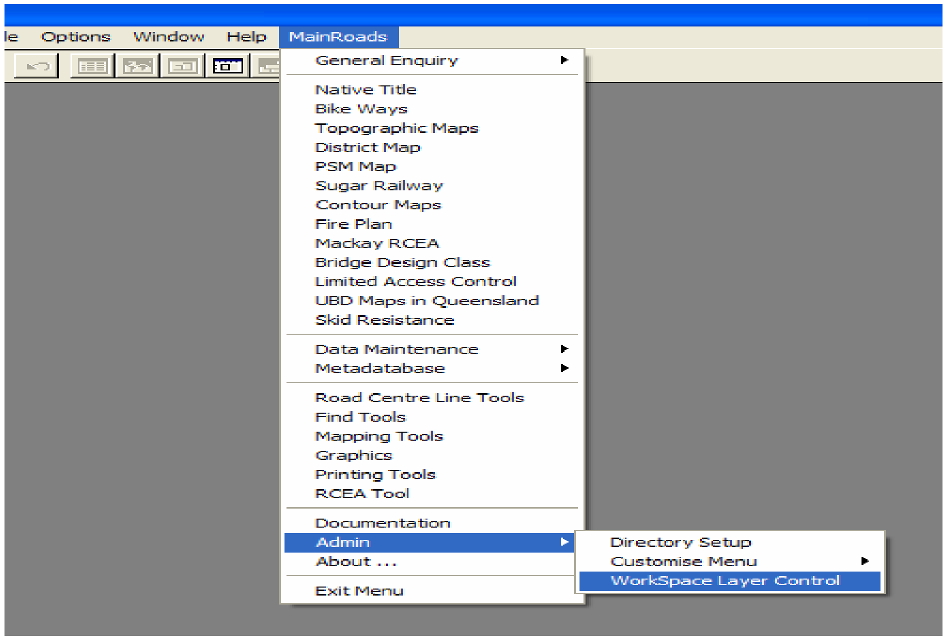


Step 4 – Choose data type

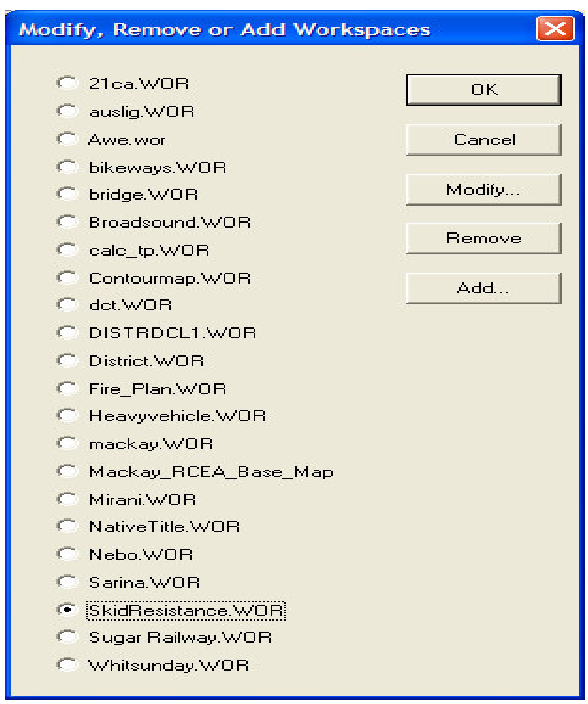


Step 5 – Identify the fields in the dataset that will enable production of the graphical object. The table is geocoded when the next key is pressed.

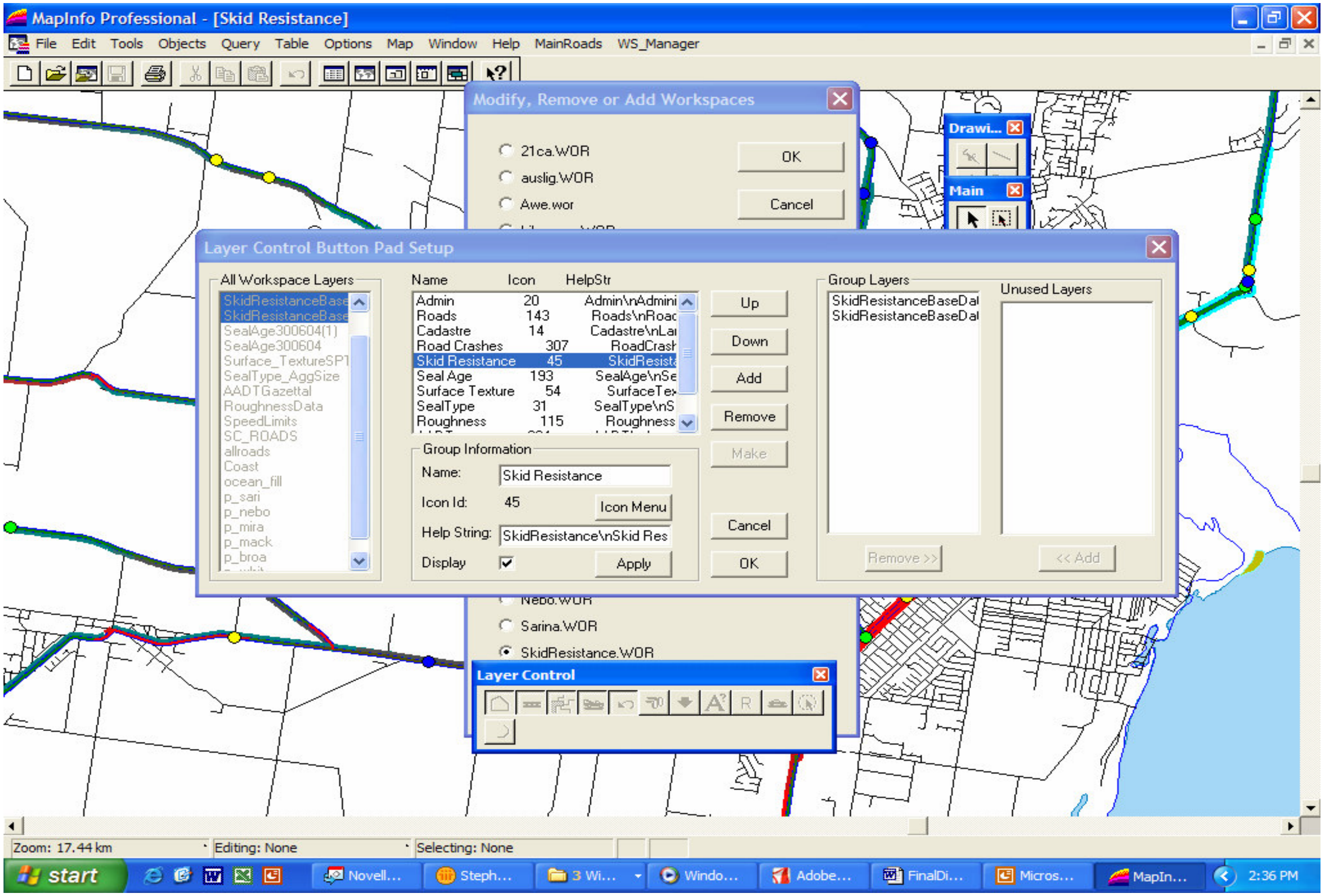
Appendix H Layer Tool Customisation



Select the workspace Layer Control Application



Select the Skid Resistance Workspace and Select Modify (initially this would be Add)



This Dialog allows the customisation of the layer control to be carried out.

Appendix I ARMIS Database snapshots

ROAD_SECTION_ID	TDIST_START	TDIST_END	LENGTH	GAZETTAL_DIRECTION	AADT	AADT_YEAR	GROWTH_PC_1YR	GROWTH_PC_5YR	GROWTH_F
10F	149.401	177.810	28.409	G	974	2003	2.31	2.8	
10G	0.010	57.300	57.300	G	1009	2003	1.2	1.54	
10G	57.300	113.770	56.470	G	1396	2003	3.41	3.17	
10G	113.770	119.990	6.220	G	1726	2003	3.23	2.47	
10G	119.990	121.800	1.810	G	5078	2003	-0.22	-16.02	
10G	121.800	123.140	1.340	G	3227	2003	1.67	3.48	
10G	123.140	132.550	9.410	G	2927	2003	11.46	6.69	
10G	132.550	144.690	12.140	G	4016	2003	3.37	1.28	
10G	144.690	152.570	7.880	G	6363	2003	1.58	1.81	
10G	152.570	156.040	3.470	G	15608	2003	17.66	9.6	
10H	0.010	2.130	2.130	G	13347	2003	-4.57	1.32	
10H	2.130	3.200	1.070	G	12257	2003	5.98	4.47	
10H	3.200	4.660	1.460	G	5141	2003	5.2	7.9	
10H	4.660	10.499	5.839	G	3815	2003	-23.08	1.35	
10H	10.499	20.119	9.620	G	2959	2003	6.36	8.38	
10H	20.119	53.910	33.791	G	1752	2003	4.72	4.63	
10H	53.910	101.580	47.670	G	1488	2003	-0.2	3.32	
10H	101.580	123.430	21.850	G	1881	2003	1.4	1.65	
10J	0.010	1.289	1.289	G	3986	2003	-7.04	1.95	
10J	1.289	12.679	11.390	G	1332	2003	-0.37	1.98	
10J	12.679	31.130	18.451	G	1213	2003	0.75	0.28	
33A	100.900	127.055	26.155	G	730	2003	17.74	6.71	
33A	127.055	148.350	21.295	G	727	2003	9.82	7.7	
33A	148.350	162.570	14.220	G	898	2003	-6.94	23.98	
33A	162.570	177.090	14.520	G	952	2003	31.49	17.38	
33B	0.010	6.000	6.000	G	1088	2003	10.91	12.94	
33B	44.900	52.885	7.985	G	1088	2003	10.91	12.94	
33B	52.885	62.070	9.185	G	1318	2003	10.39	68.42	

Snapshot of a section of Traffic Data

ROAD_SECTION_ID	DISTRICT_ID	CARRIAGEWAY_CODE	LANE_CODE	TDIST_START	TDIST_END	Length	AUSTROADS_ROUGHNESS_COUNT	CALEND
10F	8	1	1	149.4	149.5	0.1	106	
10F	8	1	1	149.5	149.6	0.1	101	
10F	8	1	1	149.6	149.7	0.1	95	
10F	8	1	1	149.7	149.8	0.1	87	
10F	8	1	1	149.8	149.9	0.1	88	
10F	8	1	1	149.9	150	0.1	87	
10F	8	1	1	150	150.1	0.1	100	
10F	8	1	1	150.1	150.2	0.1	107	
10F	8	1	1	150.2	150.3	0.1	94	
10F	8	1	1	150.3	150.4	0.1	72	
10F	8	1	1	150.4	150.5	0.1	100	
10F	8	1	1	150.5	150.6	0.1	103	
10F	8	1	1	150.6	150.7	0.1	74	
10F	8	1	1	150.7	150.8	0.1	71	
10F	8	1	1	150.8	150.9	0.1	93	
10F	8	1	1	150.9	151	0.1	102	
10F	8	1	1	151	151.1	0.1	98	
10F	8	1	1	151.1	151.2	0.1	109	
10F	8	1	1	151.2	151.3	0.1	120	
10F	8	1	1	151.3	151.4	0.1	87	
10F	8	1	1	151.4	151.5	0.1	83	
10F	8	1	1	151.5	151.6	0.1	89	
10F	8	1	1	151.6	151.7	0.1	81	
10F	8	1	1	151.7	151.8	0.1	61	
10F	8	1	1	151.8	151.9	0.1	56	
10F	8	1	1	151.9	152	0.1	56	

Snapshot of a section of Roughness data

LAYER_DEPTH	LAYER_DATE	LAYER_TYPE_NAME	LAYER_CATEGORY_NAME	SEAL_AGE as at Dec-04	Seal Age as at Jun 04	Treatment
10	16-NOV-92	Bitumen Spray Seal	Spray Seal	12.2	11.6	
16	28-OCT-02	PMB Spray Seal	Spray Seal	2.3	1.7	
16	28-OCT-02	PMB Spray Seal	Spray Seal	2.3	1.7	
16	28-OCT-02	PMB Spray Seal	Spray Seal	2.3	1.7	
10	28-OCT-02	PMB Spray Seal	Spray Seal	2.3	1.7	
16	28-OCT-02	PMB Spray Seal	Spray Seal	2.3	1.7	
10	28-OCT-02	PMB Spray Seal	Spray Seal	2.3	1.7	
16	28-OCT-02	PMB Spray Seal	Spray Seal	2.3	1.7	
10	28-OCT-02	PMB Spray Seal	Spray Seal	2.3	1.7	
10	28-OCT-02	PMB Spray Seal	Spray Seal	2.3	1.7	
10	28-OCT-02	PMB Spray Seal	Spray Seal	2.3	1.7	
10	10-OCT-95	Bitumen Spray Seal	Spray Seal	9.3	8.7	
350	01-JAN-80	Jointed Reinforced Cement Concrete	Cement Concrete	25.1	24.5	
10	10-OCT-95	Bitumen Spray Seal	Spray Seal	9.3	8.7	
10	09-MAR-04	PMB Spray Seal	Spray Seal	0.9	0.3	
10	10-OCT-95	Bitumen Spray Seal	Spray Seal	9.3	8.7	
10	10-OCT-95	Bitumen Spray Seal	Spray Seal	9.3	8.7	
10	10-OCT-95	Bitumen Spray Seal	Spray Seal	9.3	8.7	
10	10-OCT-95	Bitumen Spray Seal	Spray Seal	9.3	8.7	
10	10-OCT-95	Bitumen Spray Seal	Spray Seal	9.3	8.7	
10	10-OCT-95	Bitumen Spray Seal	Spray Seal	9.3	8.7	
10	10-OCT-95	Bitumen Spray Seal	Spray Seal	9.3	8.7	
10	09-MAR-04	PMB Spray Seal	Spray Seal	0.9	0.3	

Snapshot of section of Seal Age Data

ROAD_SECTION_ID	CARRIAGEWAY_CODE	START	END	LENGTH	LAYER_NUMBER	LAYER_TYPE	LAYER_DEPTH	LAYER_DATE	LAYER_TYPE_NAM
10F	1	149.4	149.45	0.05	1	K1	10	16-NOV-92	Bitumen Spray Seal
10F	1	149.45	149.455	0.005	1	K2	16	28-OCT-02	PMB Spray Seal
10F	1	149.455	149.485	0.03	1	K2	16	28-OCT-02	PMB Spray Seal
10F	1	149.485	149.75	0.265	1	K2	16	28-OCT-02	PMB Spray Seal
10F	1	149.75	150.05	0.3	1	K2	10	28-OCT-02	PMB Spray Seal
10F	1	150.05	150.35	0.3	1	K2	16	28-OCT-02	PMB Spray Seal
10F	1	150.35	150.65	0.3	1	K2	10	28-OCT-02	PMB Spray Seal
10F	1	150.65	150.95	0.3	1	K2	16	28-OCT-02	PMB Spray Seal
10F	1	150.95	151.15	0.2	1	K2	10	28-OCT-02	PMB Spray Seal
10F	1	151.15	151.45	0.3	1	K2	10	28-OCT-02	PMB Spray Seal
10F	1	151.45	151.535	0.085	1	K2	10	28-OCT-02	PMB Spray Seal
10F	1	151.535	158.654	7.119	1	K1	10	10-OCT-95	Bitumen Spray Seal
10F	1	158.654	158.726	0.072	1	E2	350	01-JAN-80	Jointed Reinforced C Concrete
10F	1	158.726	162.535	3.809	1	K1	10	10-OCT-95	Bitumen Spray Seal
10F	1	162.535	162.565	0.03	1	K2	10	09-MAR-04	PMB Spray Seal
10F	1	162.565	165.346	2.781	1	K1	10	10-OCT-95	Bitumen Spray Seal
10F	1	165.346	165.367	0.021	1	K1	10	10-OCT-95	Bitumen Spray Seal
10F	1	165.367	167.086	1.719	1	K1	10	10-OCT-95	Bitumen Spray Seal
10F	1	167.086	167.106	0.02	1	K1	10	10-OCT-95	Bitumen Spray Seal
10F	1	167.106	168.218	1.112	1	K1	10	10-OCT-95	Bitumen Spray Seal
10F	1	168.218	168.251	0.033	1	K1	10	10-OCT-95	Bitumen Spray Seal
10F	1	168.251	170.15	1.899	1	K1	10	10-OCT-95	Bitumen Spray Seal
10F	1	170.15	170.21	0.06	1	K2	10	09-MAR-04	PMB Spray Seal

Snapshot of section of Seal Type and Aggregate Size data

ROAD_SECTION_ID	CARRIAGEWAY_CODE	TDIST_START	TDIST_END	LENGTH	SPEED_LIMIT
10F	1	149.4	177.81	28.41	110
10G	1	0.1	28.22	28.22	110
10G	1	28.22	56.74	28.52	100
10G	1	56.74	57.61	0.87	80
10G	1	57.61	97.92	40.31	100
10G	1	97.92	98.43	0.51	80
10G	1	98.43	99.05	0.62	60
10G	1	99.05	99.56	0.51	80
10G	1	99.56	118.15	18.59	100
10G	1	118.15	118.595	0.445	80
10G	1	118.595	119.935	1.34	70
10G	1	119.935	120.385	0.45	60
10G	1	120.385	120.55	0.165	50
10G	2	120.55	121.27	0.72	50
10G	1	121.27	121.415	0.145	50
10G	1	121.415	121.845	0.43	60
10G	1	121.845	122.145	0.3	80
10G	1	122.145	132.07	9.925	100
10G	1	132.07	132.97	0.9	80
10G	1	132.97	145.89	12.92	100
10G	1	145.89	150.275	4.385	90
10G	1	150.275	151.53	1.255	80

Snapshot of Section of the Speed Limit data

RSECT_ID	LCODE_ID	CCODE_ID	TDIST_START	TDIST_END	LENGTH	SPTD_OWP	SPTD_BWP	SPTD_IWP	RATE_DATE
10F	1	1	149.4	149.5	0.1	3.27	4.15		05-MAY-04
10F	1	1	149.5	149.6	0.1	3.73	4.69		05-MAY-04
10F	1	1	149.6	149.7	0.1	3.42	4.46		05-MAY-04
10F	1	1	149.7	149.8	0.1	2.72	3.32		05-MAY-04
10F	1	1	149.8	149.9	0.1	2.54	2.69		05-MAY-04
10F	1	1	149.9	150	0.1	2.9	3.29		05-MAY-04
10F	1	1	150	150.1	0.1	3.05	4.26		05-MAY-04
10F	1	1	150.1	150.2	0.1	3.69	4.62		05-MAY-04
10F	1	1	150.2	150.3	0.1	3.54	4.06		05-MAY-04
10F	1	1	150.3	150.4	0.1	2.64	3.22		05-MAY-04
10F	1	1	150.4	150.5	0.1	2.24	2.71		05-MAY-04
10F	1	1	150.5	150.6	0.1	2.81	3.64		05-MAY-04
10F	1	1	150.6	150.7	0.1	3.91	4.77		05-MAY-04
10F	1	1	150.7	150.8	0.1	4.41	5.26		05-MAY-04
10F	1	1	150.8	150.9	0.1	3.89	4.67		05-MAY-04
10F	1	1	150.9	151	0.1	2.84	3.34		05-MAY-04
10F	1	1	151	151.1	0.1	2.34	2.85		05-MAY-04
10F	1	1	151.1	151.2	0.1	2.32	2.81		05-MAY-04
10F	1	1	151.2	151.3	0.1	2.29	2.74		05-MAY-04
10F	1	1	151.3	151.4	0.1	2.1	2.68		05-MAY-04
10F	1	1	151.4	151.45	0.05	1.85	2.51		05-MAY-04
10F	1	1	151.45	151.5	0.05	1.85	2.51		05-MAY-04
10F	1	1	151.5	151.6	0.1	1.73	2.49		05-MAY-04
10F	1	1	151.6	151.7	0.1	1.61	2.3		05-MAY-04

Snapshot of section of Surface Texture Depth Data

Appendix J Skid Resistance Field Inspection

Skid Resistance Investigation Form

Locality

Road Name Road Number

Tdist Start Tdist End

Geometry: Straight____________________ Curved______________________

Intersection ________________ Open_______________________

Vertical Grade______________ Superelevation________________

Aggregate Size

Inspected by: Date:

Factors Triggering Inspection

Skid Resistance ____________________ Seal Age___________________

Roughness ____________________ Rutting____________________

Accidents ____________________ Drainage___________________

Surface Texture ____________________ Blackspot__________________

Cracking ____________________ Deformation________________

Public Complaint ____________________

Other (Specify)

Comments

Field Observations

Pavement Condition

Flushed___________Hungry___________Fair______________Good_____________

Site Characteristics

Lighting is	Inadequate / Adequate / Not Applicable
Visibility is	Inadequate / Adequate
Delineation	Inadequate / Adequate
Longitudinal Drainage is	Inadequate / Needs Maintenance / Adequate
Cross Pavement Drainage is	Inadequate / Adequate
Advanced Signage is	Not Present / Present
Signage Condition is	Poor / Fair / Good

Possible Mitigations

Speed Zone	________________	Signage	________________
Reseal	________________	Surface Treatment	________________
Line Marking	________________	Re-profile	________________
Pavement Drainage	________________		

Other (Specify)

Comments

Recommendations

Action Required

Action Taken Date