

University of Southern Queensland  
Faculty of Health, Engineering and Sciences

# Asset Condition Monitoring of Gympie Regional Council's Road Network

A dissertation submitted by

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# Abstract

Gympie Regional Council (GRC) spends between \$10M-\$15M on roadworks as part of its annual capital works program. Currently, the selection of projects for these programs relies heavily on customer complaints, councillor requests and feedback from GRCs Construction and Maintenance Branch. GRCs Design Service Division has identified a need for this process to include quantifiable asset condition data, giving the project selection process a consistent and impartial foundation. This project seeks to define a process which will result in the collection of road condition data which can then be used to identify road segments in need of capital works.

Road condition assessments seek to provide an indication of the overall condition of the road by identifying and recording defects in the road pavement and surfacing. As road condition is linked to the age of the asset, road segments found with high defect rates, thus approaching the end of their useful life can be programmed in for capital works. The goal is to provide a reliable long term capital works program to ensure optimal distribution of the available funding.

An analysis of the available literature covering road condition assessments was undertaken. This included nationally recognised best-practice manuals by Austroads, to research papers addressing state of the art data collection techniques. GRCs practices regarding road condition assessment were reviewed. This led to conducting a gap analysis between GRCs existing road inspection procedure and what is currently accepted as best-practice. The above-mentioned research, review and gap analysis provided the platform for the development of draft corporate documents for GRC concerning road condition assessment, including an operational framework.

The framework comprises of an initial assessment phase where the entire sealed road network is screened using road roughness measurement. The roughness data is then used to shortlist a portion of the road network for detailed assessment. There is scope for the detailed assessment phase to be undertaken by GRCs existing inspectors. The framework was developed with a focus on the following findings:

- Quality data must be collected and used; otherwise there will be little confidence in the outputs of the system.

- From a strategic planning standpoint, the condition of a road does not change rapidly. Therefore, frequent inspection cycles are unnecessary and uneconomical.
- The amount of roadworks that can be undertaken is ultimately controlled by the available funding. Therefore, the number of candidate projects is limited by this and the scope of condition inspections should reflect this.

Beyond this project, the next step will be to run a pilot inspection program to test the framework. From there, a process of evaluation and review can be implemented to ensure that GRC benefits from the framework as much as possible.

In conclusion, the establishment of a road condition assessment program for GRC is very much achievable in the short to medium term. This will lead to increased confidence in the outputs of the capital works programming process.

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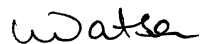
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# Table of Contents

Chapter 1: Introduction .....	1
1.1 Road Condition Assessment for GRC.....	2
1.2 Gympie Regional Council .....	3
1.3 Consequential Effects .....	4
1.4 Ethical Responsibility.....	5
1.5 Project Planning – Methodology, Resource Analysis and Task Timelines.....	6
1.6 Risk Assessment .....	7
Chapter 2: Literature Review .....	10
2.1 Introduction.....	10
2.2 Road Condition Assessments .....	10
2.3 Road Asset Information .....	11
2.2.1 Road Hierarchy .....	11
2.2.2 Road Segmentation .....	11
2.2.3 Road Componentisation.....	12
2.2.4 Useful Life.....	13
2.4 Condition Data Distress Modes.....	15
2.3.1 Roughness.....	15
2.3.2 Deformation .....	16
2.3.3 Cracking.....	17
2.3.4 Wearing Course Defects .....	19
2.3.5 Maintenance Patching.....	21
2.3.6 Strength.....	22
2.5 Condition Data Needs .....	22
2.6 Condition Data Collection .....	24
2.5.1 Defect specific collection methods.....	25

2.7 Condition Assessment Frequency .....	29
2.8 Condition Data Modelling .....	30
2.9 Conclusion .....	30
Chapter 3: Review of Gympie Regional Council’s Road Condition Assessment Practices .....	32
3.1 Organisational Structure .....	32
3.2 Policies and Procedures.....	32
3.3 Road Asset Register.....	34
3.4 Capital Works Prioritisation Process .....	35
3.5 Existing Inspection Regimes.....	36
Chapter 4: Current Best Practice and Gap Analysis.....	38
4.1 Introduction.....	38
4.2 Best Practice .....	38
4.3 Gap Analysis .....	39
4.3.1 Inspection Frequency.....	40
4.3.2 Distress Modes Collected.....	40
Chapter 5: Road Condition Assessment Framework for Gympie Regional Council....	42
5.1 Proposed Framework.....	42
5.1.1 Asset Register and GIS Database .....	43
5.1.2 Initial Assessment Phase (Screening) .....	44
5.1.3 Screening Results using Initial Assessment Results.....	46
5.1.4 Detailed Assessment Phase .....	47
5.1.5 Condition Assessment Results.....	47
5.1.6 Review and Continuous Improvement .....	49
6.0: Conclusion.....	50
6.1 Recommendations/Further Research .....	51
References .....	53



Appendix A: Project Specification.....	57
Appendix B: GRC Work Instruction – Road Inspections.....	58
Appendix C: GRC Enterprise Risk Management Procedure .....	62
Appendix D: GRC Enterprise Risk Assessment Record.....	67
Appendix E: GRC Organisational Structure.....	68
Appendix F: GRC Asset Maintenance Inspection Form (Partial Copy).....	69
Appendix G: GRC Inspection and Prioritisation of Reseals .....	70

## List of Figures

Figure 1: Generic Asset Management Process.....	1
Figure 2: Map of Gympie Regional Council.....	3
Figure 3: Project Gantt Chart.....	8
Figure 4: Example of Road Segmentation.....	12
Figure 5: The components of a roadway.....	13
Figure 6: Remaining useful life of an asset.....	14
Figure 7: Deformation Defects in Flexible Pavements.....	16
Figure 8: Cracking of Flexible Pavements.....	18
Figure 9: Surface Distress of Flexible Pavements.....	20
Figure 10: Information Quality Level Concept.....	23
Figure 11: Current Capital Works Programming Cycle.....	36
Figure 12: Proposed Condition Assessment Framework.....	43
Figure 13: Example of GRC Video Footage.....	46
Figure 14: Example of Imported Condition Data within the Asset Register.....	48
Figure 15: Updated Capital Works Programming Cycle.....	48

## List of Tables

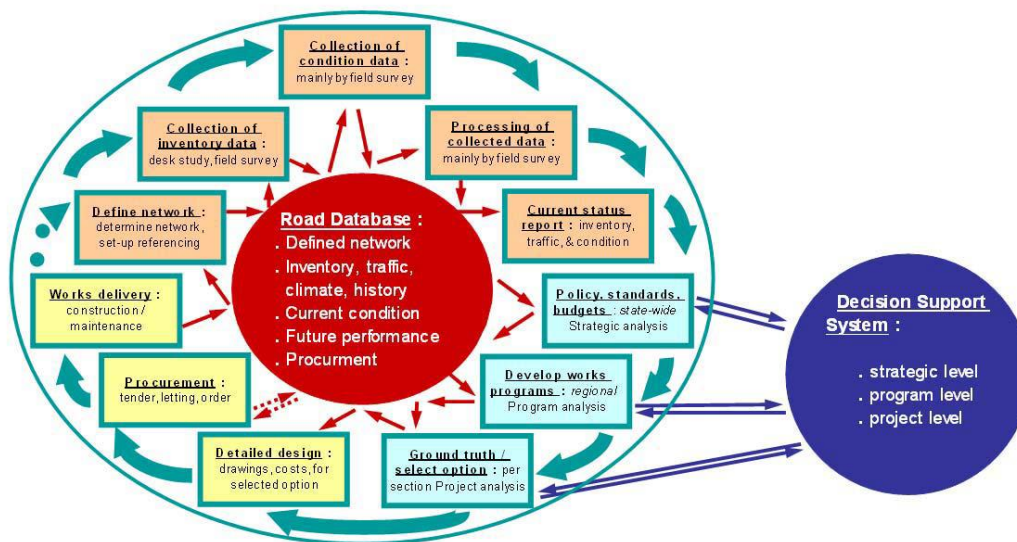
Table 1: Enterprise Risk Assessment Record.....	9
Table 2: Cost/Performance Trade-off Matrix for Data Collection Methods.....	25
Table 3: Detailed Roughness Data Collection Methods.....	26
Table 4: Example of Subjective Roughness Ratings.....	27
Table 5: Summary of Road Network Management Policies and Procedures.....	32
Table 6: Inspection Frequency Gap Analysis.....	40
Table 7: Road Distress Mode Gap Analysis.....	41
Table 8: Roughness Data Output Specification. Adapted from.....	45

## Abbreviations and Acronyms

ARRB	Australian Road Research Board
EA	Engineers Australia
IIMM	International Infrastructure Management Manual
IPWEA	Institute of Public Works Engineers Australasia
GRC	Gympie Regional Council
LATM	Local Area Traffic Management: areas of road that have specially design characteristics to control vehicle speed and movement.
LGAQ	Local Government Association of Queensland
LRRS	Local Roads of Regional Significance. A selection of twenty (20) roads within the Gympie region that are eligible for State Government funding as administered by RRTG.
RRTG	Regional Roads and Transport Group. "A cooperative governance arrangement between the Department of Transport and Main Roads, the Local Government Association of Queensland (LGAQ) and local governments to invest in and regionally manage the Queensland transport network." (TMR 2015)
TMR	Queensland Government Department of Transport and Main Roads
QA	Quality Assurance

## Chapter 1: Introduction

The Australian, state, territory and local Governments expended \$15.8 billion on road related activities during 2008/09 (BITRE 2011). Driving the allocation of this expenditure will be each organisations asset management framework, which “applies a systematic approach of maintaining, upgrading, and operating physical assets cost effectively ... with sound business practices and economic theory” (Bryant & Flintsch 2006, p. 12). In order for the asset management framework to deliver on these objectives, it relies on asset management systems comprising of a decision support tool and a core database (Austroads 2009a, p. 4).



**Figure 1: Generic Asset Management Process**

Source: (Austroads 2009a)

A pavement management system is an example of a decision support tool which analyses road condition data to justify maintenance prioritisation and budget projections (Bryce et al. 2013, p. 149). The quality of the road condition data affects the outputs of the decision support system and, ultimately, the confidence in these systems (Saliminejad & Gharaibeh 2016). Given the vast sums of money expended on road asset management, the confidence in long-term planning outputs is critical. Therefore, the collection of road condition data that is suited to the decision support system used by a road authority is as essential task if the optimisation of the works programming is to be achieved.

## 1.1 Road Condition Assessment for GRC

This project aims to produce a road condition assessment framework for the Gympie Regional Council (GRC) that is economical and purpose-built for the region. The framework aims to deliver quantifiable road condition data that will underpin the systematic allocation of rehabilitation expenditure on GRCs road network. At present, there is very little to no quantifiable condition data used in the project prioritisation process.

“The over-riding obligation on Council in managing the road network is to maintain a focus on asset management and long term financial sustainability. This obligation is embedded in the Local Government Act 2009 and Local Government (Finance, Plans and Reporting) Regulation 2010 and further developed in the state government’s “Financial management (sustainability) Guideline 2011”.” (GRC 2016, p. 4)

By being able to support the distribution of rehabilitation expenditure with impartial condition assessment data, this project will assist GRC in meeting the above obligations as well as managing “the challenge of fiscal austerity that faces governments throughout the world and will beset Australia too for at least another decade” (Evans & Sansom 2015, p. 4).

This project will consider sealed roads, with the following elements being covered in detail:

- A framework for road condition assessments.
- An outline of the procedures for road condition assessments, including:
  - An initial assessment phase
  - The screening of the sealed road network
  - The detailed assessment of the shortlisted road segments
  - Adding the condition assessment results to GRCs asset management software

Some existing activities that will benefit from the outcomes of this project include:

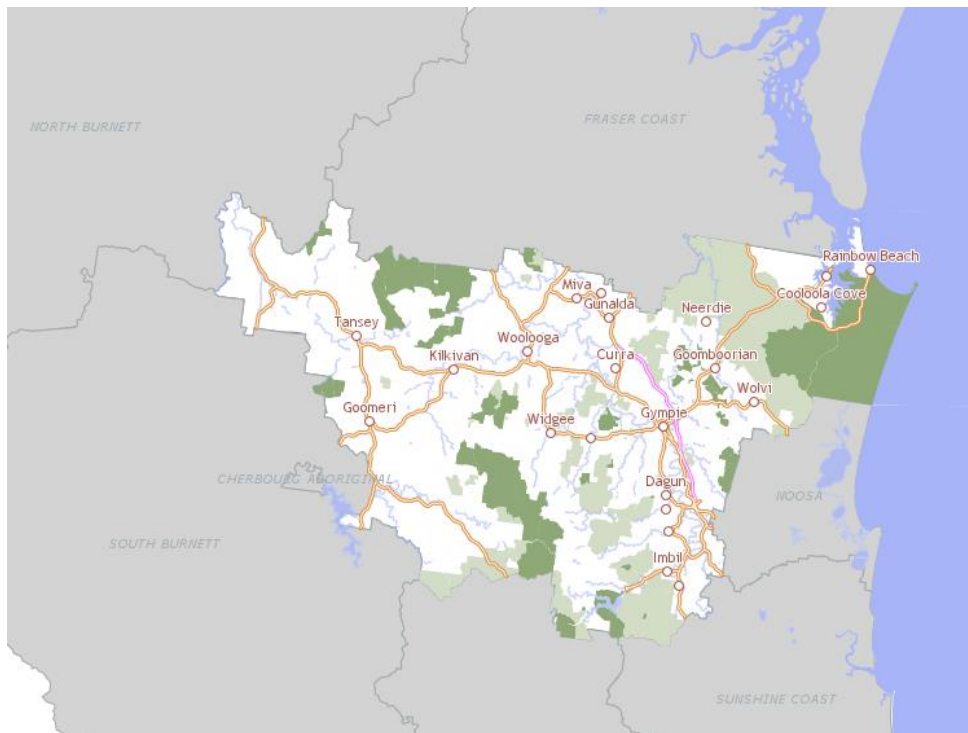
- The streamlining of council’s existing inspection procedures that will allow the incorporation of a road condition monitoring program with minimal extra financial output.

- The project selection process for long-term capital works programming.

A major goal of this project will be to ensure the final framework is logical and presented in a simple manner. This is especially relevant to the road condition assessment procedure as it may be used by a broad range of personnel, not all of which will have a background in the technical aspects of road asset management.

## 1.2 Gympie Regional Council

The Gympie Regional Council is located in the southeast of Queensland. Covering approximately 6,900 square kilometres, the regions road network plays a pivotal role in developing and maintaining the social fabric of the community, helping nearly 50,000 resident's access essential services, goods, employment, schools and so forth.



**Figure 2: Map of Gympie Regional Council**

The aforementioned road network consists of 1230km of sealed roads and 876km of unsealed roads. For the 2015/2016 financial period, GRC spent a combined \$16.5M on maintaining, renewing and rehabilitating this extensive network of roads. The allocation of these funds is guided by the following GRC policies, plans and procedures:

- Asset Management Policy (PRES400)
- Road Network Policy (ESPOL015)
- Road Maintenance Procedure (ISP018)
- Road Plan (Draft)
- Infrastructure Road Asset Maintenance Plan (Draft)
- Inspection and Prioritisation of Reseals (ISP055)

### **1.3 Consequential Effects**

The long term consequential effect of this project will be the improvement in programming of road rehabilitation works leading to optimal value for money on GRCs capital expenditure. In the short to medium term, there will be a number of consequential effects that may have negative impacts on GRC. Listed below are the primary concerns:

#### ***Staffing***

Road condition inspections are currently undertaken by full time GRC employees. This project may identify processes that differ from what is currently being undertaken by these employees. As a result, there may be an effect on the workload of these employees. Whether that effect is a net increase, decrease or nil is yet to be determined. Examples include:

- Reduced workload due to the use of specialised equipment, which may only be available through external contractors
- Reduced workload due to automated measurement and recording
- Increased workload due to more frequent inspection cycles
- Increased workload due to more detailed data collection

#### ***Implementation***

An opportunity exists for the new framework to be implemented incorrectly, especially in its initial stages, due to factors such as:

- Under resourcing
- Resistance to change
- Lack of technical expertise

If this occurs, there may be a drop in the level of service provided by GRC until the new framework is fully understood and functioning. By ensuring the final procedure is logical and presented in a simple manner, the implementation time will be minimised.

### ***Corporate Documents***

The new road condition assessment framework will require the adaption of existing corporate documents or the creation of new documents. For example, the existing work instruction for road inspections (see Appendix B) may require redrafting to include any new methods of inspection.

Due to GRCs quality assurance (QA) procedures, there may a slight delay between the drafting or editing of these documents and their approval for use. In this case, considerations will be made to make available draft versions of the new documents while the QA process is finalised.

## **1.4 Ethical Responsibility**

The Engineers Australia Code of Ethics (2010) states:

“As engineering practitioners, we use our knowledge and skills for the benefit of the community to create engineering solutions for a sustainable future. In doing so, we strive to serve the community ahead of other personal or sectional interests.” (EA 2010)

As mentioned beforehand, a new road condition assessment framework will assist GRC to manage its roads in a more sustainable and impartial manner, effectively satisfying the key concept of the EA Code of Ethics. In addition to this, the GRC Staff Code of Conduct will provide guidance on ethical issues as and if they arise. Two examples of where the above guidelines will influence the project have been listed below.

- As noted previously, there is a chance the existing staffing level of road inspections will change. If that situation arises, any recommendations must be suitably justified and must not be influenced by personnel within GRC that may have a conflict of interest on these matters.



- The task of road condition assessment has developed beyond visual inspection methods. There have been technical advancements in this field which have led to the development of purpose built equipment. Whilst this equipment would appear to be an improvement on visual methods, matters such as sustainability must be considered. Will it be sustainable to assess GRCs network entirely using this type of equipment? This, and similar, questions will need be considered from both ethical and operational aspects.

## **1.5 Project Planning - Methodology, Resource Analysis and Task Timelines**

This project has been broken up into five (5) main components. Each component has been described below and is represented on the projects Gantt Chart (see Figure 3) with an estimated timeline. As the project develops, the Gantt Chart will be used to estimate the projects progress in line with the risks identified in subsection 1.6 Risk Assessment.

1. Undertake a review of information on the practice of road condition monitoring, including:
  - current best practice guidelines
  - predictive modelling of future road conditions
  - assessable modes of distress of a road
  - techniques to assess and/or measure the modes of distress
  - the accuracy of measurement required for the particular distress modes

The publications for review are available as hard copies within GRCs engineering library or are freely available on the internet.

2. Review the current road condition monitoring practices employed by GRC. This will involve meeting with staff from:
  - GRCs Construction and Maintenance Branch that are currently employed to undertake and manage road condition inspections.
  - GRCs Design Services Branch that administer its asset management software.

All of GRCs current policies, procedures and plans are available via the internal intranet. GRCs asset management software has been made available for the length of this project.

3. Conduct a gap analysis between GRCs road condition monitoring practices and the current best practice guidelines.
4. Develop an asset condition monitoring framework for GRCs sealed road network. Detail the individual components of the framework, including:
  - An initial assessment phase
  - The screening of the sealed road network
  - The detailed assessment of the shortlisted road segments
  - Adding the condition assessment results to GRCs asset management software

## 1.6 Risk Assessment

With regard to exposure to health and safety risks, this project will have a minimal exposure to any safety hazards. As the sponsor of this project, GRC has a work instruction in place for the collection of road condition data (See Appendix B) which includes risk assessments for personnel undertaking visual inspections. This document will be reviewed as part of this project; however its risk analysis component is applicable.

The project will however be exposed to enterprise hazards. These mainly concern production losses for GRC due to complications such as:

- Change in scope mid-project, leading to time delays
- Reduced quality to meet time deadlines
- Limited availability of skilled personnel, appropriate plant and/or suitable contractors to carry out the results of the project

All enterprise hazards encountered by GRC must be dealt with in accordance to GRCs Enterprise Risk Management Procedure (See Appendix C). Table 1 (see Appendix D) summarises the risk attributed to the above hazards as per GRCs procedure. As illustrated in Table 1, the risk level of the identified hazards is acceptable, provided the projects progress is monitored closely. The Project Gantt Chart shown in Figure 3 will assist with this process.

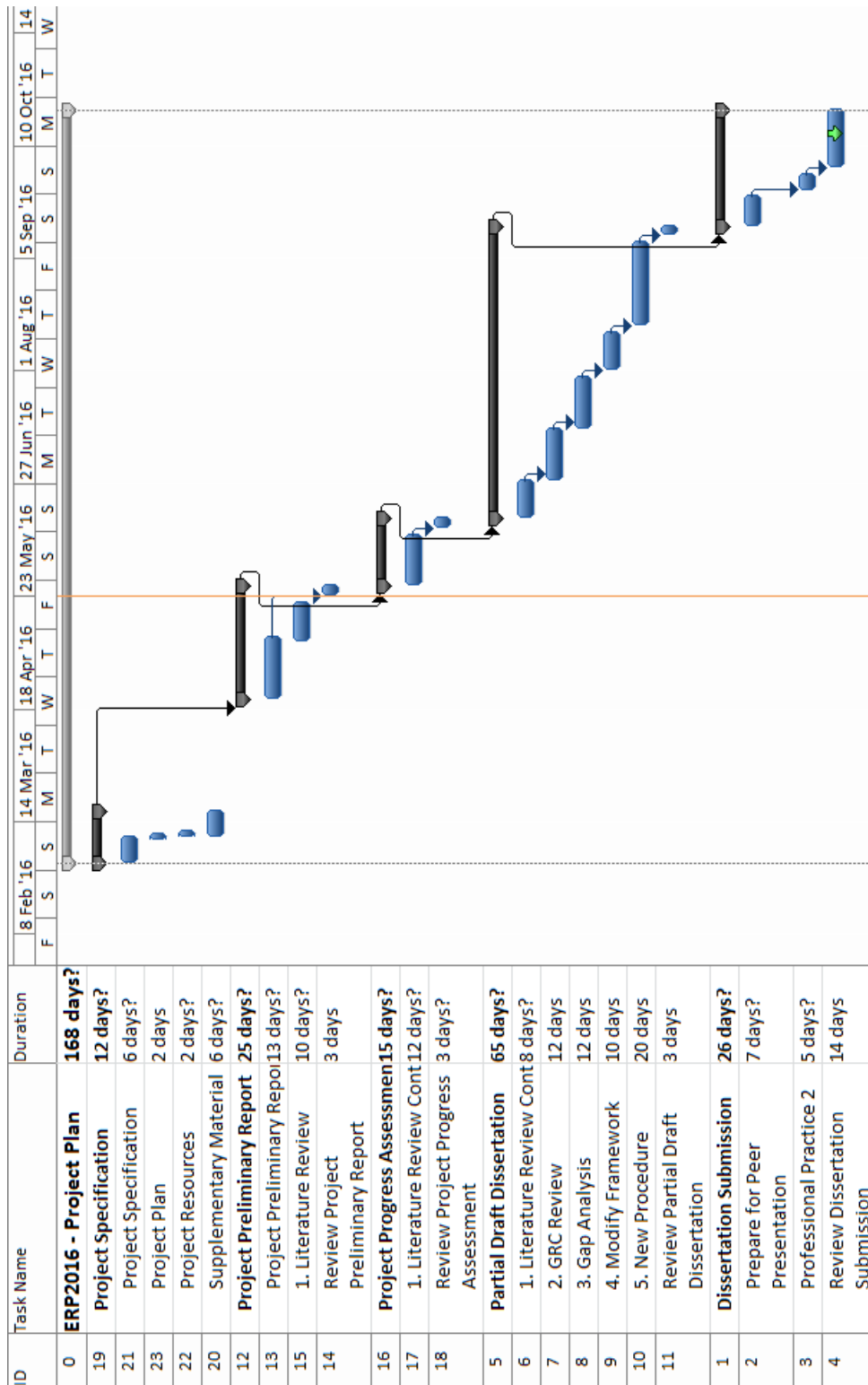


Figure 3: Project Gantt Chart

Table 1: Enterprise Risk Assessment Record

Possible Hazard	Likelihood of Occurrence	Enterprise Consequences	Inherent Risk Level	Potential Controls	New Risk
Reduced quality to meet time deadlines	3. Possible (Maybe, less than 50/50 chance)	D. Minor (Sustained minor non-compliance)	Medium	Reduce risk level by limiting scope of project to ensure project outcome is of sufficient quality. New consequence rating E. Insignificant.	Low
Change in scope mid-project, leading to time delays	4. Unlikely (Low probability of occurrence)	C. Moderate (Delayed 1 year)	Medium	Accept risk level but closely monitor progress of project against project plan.	
Limited availability of skilled personnel, appropriate plant and/or suitable contractors to carry out the results of the project	4. Unlikely (Low probability of occurrence)	C. Moderate (Delayed 1 year)	Medium	Accept inherent risk level but as project nears completion, reassess likelihood of occurrence and implement controls if necessary	

## Chapter 2: Literature Review

### 2.1 Introduction

There is a vast array of guidelines, manuals and research papers that address the management of roads. These publications have been produced by state or national road authorities (i.e. TMR), road and transport associations (i.e. Austroads, IPWEA), public or private companies (i.e. ARRB), and by sponsored or independent researchers. This literature review will examine road condition assessments through the following topics:

- Road condition assessments
- Road asset information
- Condition data distress modes
- Condition data needs
- Condition data collection
- Condition assessment frequency
- Condition data modelling

### 2.2 Road Condition Assessments

IPWEA and NAMS (2011, p. 2|72) state that asset condition is a measure of the asset's physical integrity. Austroads (2009c, p. 13) supports this view, relating condition data to the description of the transient physical properties of the asset. Provided the asset in question is a roadway, road condition assessment involves the systematic collection and processing of pavement condition data (AASHTO 2012; Koch et al. 2015).

The objective of a road condition assessment "is to provide sufficient information on asset condition to assist informed strategic asset planning" IPWEA (2015, p. 4). The pivotal role that condition data plays in the decision making process, and the effect its quality has on these decision was widely recognized throughout the literature (Ruotoistenmäki, Seppälä & Kanto 2006; Saliminejad & Gharaibeh 2016; Sun & Gu 2011).

Despite the obvious advantages of undertaking road condition assessment, IPWEA (2015, p. 3) cites that there are inconsistent approaches to its implementation. This

leads to various forms of data collection, making aggregation and regional benchmarking impractical.

## **2.3 Road Asset Information**

The road itself “must serve two basic functions – it must perform as an engineering structure and at the same time meet functional requirements” (Austroads 2009d, p. 4). In order to properly manage a road to meet these functions, the road must be defined on several different levels.

### **2.2.1 Road Hierarchy**

The first level of differentiation is described as the road hierarchy or classification. Austroads (2009e, p. 11) defines a road hierarchy as the grading of roads according to increasing (or decreasing) importance of traffic task/function or importance in the logistics chain. An example of a road hierarchy as developed by Eppell, McClurg and Bunker (2001, p. 7) has been provided below.

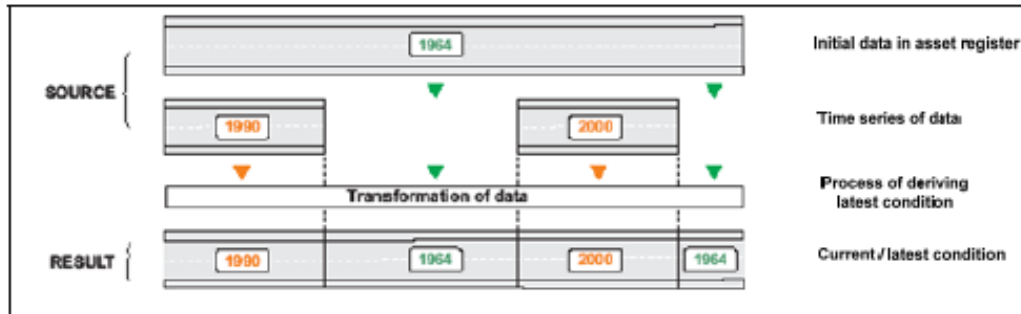
“The four functional categories in level 2 of the hierarchy are defined as:-

- arterial roads – to carry long distance through traffic external to specific areas;
- sub arterial roads – to carry through traffic between specific areas and arterial roads on a supporting role to the latter;
- collector streets – to provide connectivity between the environmental cells and the traffic carrying road and serve property access; and
- local streets – to provide direct property access.”

### **2.2.2 Road Segmentation**

The next level of division involves segmenting the road. IPWEA (2015, p. 2) summarises that segments are used to represent uniform lengths of road with important characteristic similarities being pavement type, width and age. “Generally segments need to be long enough to form an on-site project and short enough so

that the data describing the length accurately portrays the characteristics of the segment in the analysis" (Austroads 2009f, p. 20).



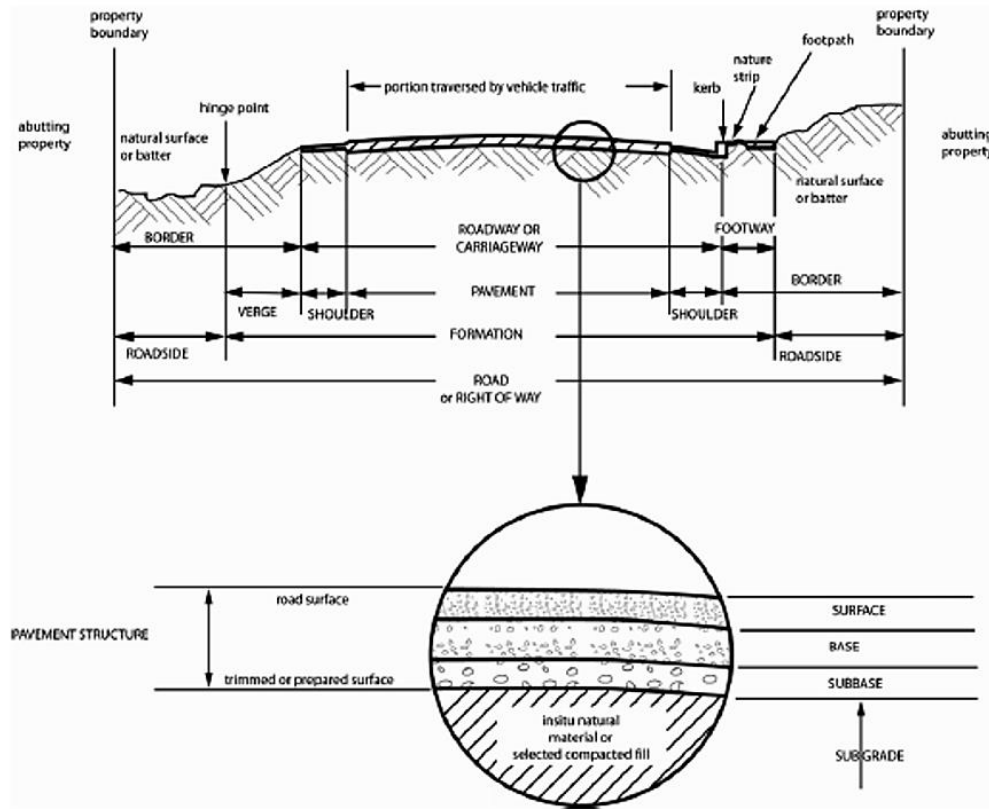
**Figure 4: Example of Road Segmentation**

Source: (Austroads 2009c, p. 19)

### 2.2.3 Road Componentisation

Finally, the road is broken down into components "having independent physical or functional identity and having specific attributes such as different life expectancy, maintenance regimes, risk or criticality (Austroads 2009g, p. 20). An example of the componentisation of a road is shown in Figure 5. As also highlighted in Figure 5, the pavement component of a road can be broken down further to include the following sub-components as according to Austroads (2009d, pp. 7-8):

- Wearing surface: a spray seal, asphalt or concrete surface course employed to provide a safe and functional riding surface whilst protecting the underlying pavement courses from moisture ingress.
- Base and Subbase: the load carrying courses of pavement generally constructed using unbound granular materials, but can also be asphalt, concrete or stabilised granular materials.
- Subgrade: the prepared surface of the in-situ material on which the pavement is constructed.



**Figure 5: The components of a roadway**

Source: (Austroads 2009d, p. 5)

As previously mentioned, the importance of identifying asset components is to recognise the difference in life expectancy, or useful life, between these components.

#### 2.2.4 Useful Life

IPWEA (2015, p. 21) states that “actual useful life is the point when intervention to renew the asset component occurs, taking into account the organisations affordable service levels”. Austroads (2009g, p. 22) provides a similar, yet more succinct definition: “the useful life is the period over which the asset (component) is expected to provide services to an entity”. Condition ratings are used to determine the remaining useful life (RUL) of an asset (Jordan & Cook 2013, p. 4), however converting these indicators to remaining useful life and overall useful life is a significant difficulty and a source of major variation in practice (Jeff Roorda and Associates 2006, p. 6). This difficulty arises due to the lack of reliable data to



validate the results of the mechanistic models upon which estimates of remaining life are based (Austroads 2003). The concept of useful life is displayed in Figure 6.

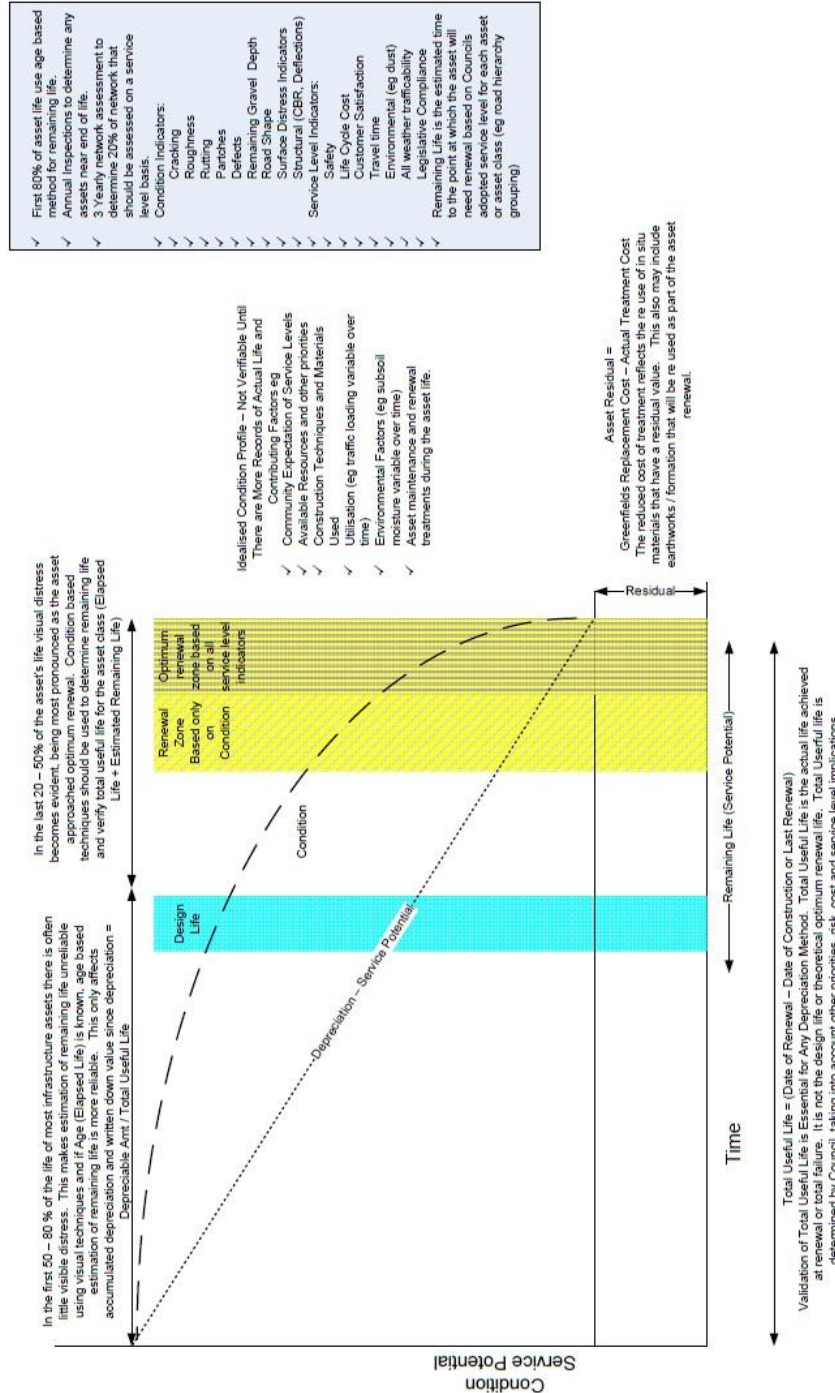


Figure 6: Remaining useful life of an asset

Source: (Jeff Roorda and Associates 2006)

## 2.4 Condition Data Distress Modes

As the asset approaches intervention level, typically the last 20-50% of its useful life, the asset develops visual distresses (Jeff Roorda and Associates 2006, p. 25). These distresses result from a process of deterioration under the effects of both traffic and environmental conditions (Mubaraki 2013, p. 239). These concepts are best summarised by Figure 6, displaying the link between useful life and asset deterioration. The remainder of this section will be dedicated to the different distress modes of a sealed road pavement.

### 2.3.1 Roughness

Austrroads (2007b, p. 4) defines roughness as “a condition parameter which characterises deviations from the intended longitudinal profile of a road surface with characteristic dimensions that affect vehicle dynamics (and hence road user costs), ride quality and dynamic pavement loading”. Jordan and Cook (2013, p. 14) simplifies roughness “to the measurement of the unevenness of a road surface”. Whilst the definitions encountered through the literature vary in terminology, there is consensus among the literature to its usefulness in measuring pavement condition, leading Hunt (2002) to find that “roughness is the most widely used pavement condition indicator, as it is affordable data to capture, it reflects the road user's costs and is widely accepted as the most relevant measure of pavement behaviour”.

The preferred method of reporting road roughness is via the International Roughness Index (IRI). “Initiated by the World Bank in 1986, the IRI is a profile-based statistic which is used around the world as a cost-effective index for gathering and comparing pavement smoothness” (King 2014, p. 27). “IRI roughness results are usually reported in ... meters per kilometre (m/km) on an increasing, boundless scale ... Therefore, a perfectly smooth pavement (which is generally considered to be impossible to achieve) would have an IRI of 0” (AASHTO 2012, pp. 4-14).

“NAASRA roughness counts (NRM) which were an older method of determining roughness” (King 2014, p. 23) have been superseded by IRI measurements. These ratings can be converted to IRI using conversion tables available in Austrroads (2007b) and IPWEA (2015) manuals.

### 2.3.2 Deformation

Roadway deformation comes in many different forms and results from a variety of sources including: “inadequate support from the subgrade; inadequate pavement thickness; poor compaction of the base; inadequate strength or stability in the surfacing or base” (VicRoads 2009, p. 17). Figure 7 provides a visual guide to these defects.

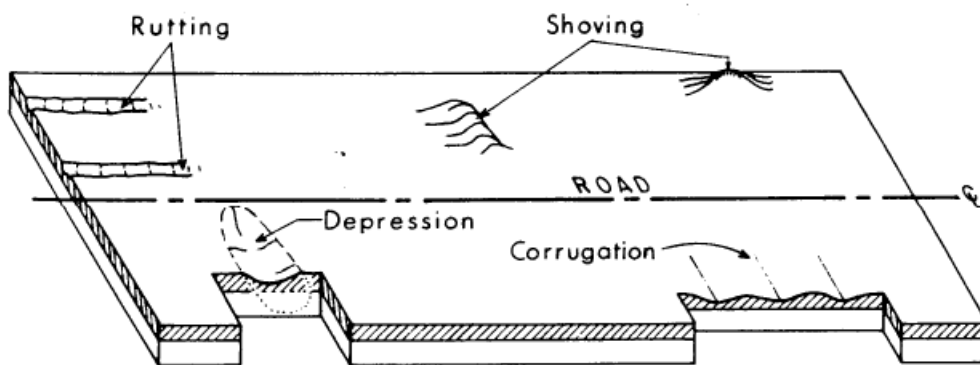


Figure 7: Deformation Defects in Flexible Pavements

Source: (Austroads 2008b, p. 34)

#### **Rutting**

Rutting is the longitudinal deformation or depression of the wheel paths in a road pavement (Austroads 2007a, p. 4; TMR 2012, pp. 2-32). It is an important defect to monitor as:

- “Rutting is an indicator of inadequate strength and stiffness of the pavement or subgrade
- Ruts interfere with surface drainage and can cause aquaplaning in wet weather” (Jordan & Cook 2013, p. 16)

Rutting data should be collected in the outer wheel path of the lane, with the extent of the rutting to be categorised depending on its depth and length (Austroads 2007a, p. 6). The depths to be recorded vary depending on the literature and will ultimately depend on the expected service level of the road.

#### **Shoving**

Shoving is the bulging and horizontal deformation of the roadway (IPWEA 2015; VicRoads 2009). It is the result of a shear failure in the pavement (Austroads 2007a,

p. 20) and generally occurs in areas of the road subject to heavy braking or acceleration (VicRoads 2009, p. 17), for example intersections or sharp curves.

### ***Depression***

A depression is “a localised areas within a pavement with elevations lower than the surrounding area” (Austroads 2007a; VicRoads 2009). Depressions arise in a pavement primarily due to the variable settlement of an underlying subgrade (IPWEA 2015; VicRoads 2009).

### ***Corrugations***

Corrugations (or megatexture) are closely spaced transverse undulations with wavelengths of less than 2 metres (IPWEA 2015; VicRoads 2009), creating a directional instability in the vehicle as it navigates the defect (Jones & Paige-Green 2000, p. 43). Corrugations, similar to shoving, form primarily in locations of high shear stress.

### **2.3.3 Cracking**

A crack is an unplanned break or discontinuity in the integrity of the pavement surface, usually a narrow opening or partial fracture (Austroads 2006b; VicRoads 2009). The origin of cracks can be differentiated by their shapes, configurations, movement under traffic loads and level of road deformation. (Jordan & Cook 2013, p. 8). The different cracking types are best illustrated in Figure 8. Cracking has many detrimental effects, including the loss of waterproofing and load spreading ability that usually leads to accelerated deterioration of the pavement condition (VicRoads 2009, p. 11).

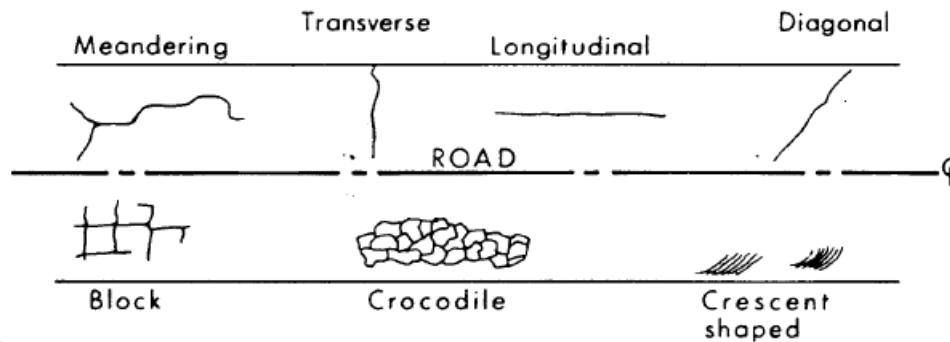


Figure 8: Cracking of Flexible Pavements

Source: (Austroads 2008b, p. 34)

### ***Block Cracking***

Block cracking is identified by a series of interconnected cracks forming a series of rectangular block shapes. The common causes of block cracking include shrinkage of an underlying cement treated pavement layer, ageing of the bitumen surface or reflection from underlying joints (Austroads 2006b; IPWEA 2015; VicRoads 2009).

### ***Crocodile Cracking***

Crocodile cracking “consists of interconnected or interlaced cracks forming a series of small polygons resembling crocodile hide” (Austroads 2006b, p. 45). The presence of crocodile cracking usually signifies that the surfacing has reached the end of its design life (IPWEA 2015, p. 54). These cracks usually results from inadequate pavement thickness; low stiffness/strength base; brittle base or wearing course (e.g. cemented, aged); or fatigue cracking in brittle (aged) asphalt wearing course. (Austroads 2006b; IPWEA 2015; VicRoads 2009).

### ***Transverse Cracking, Diagonal Cracking and Meandering Cracking***

These crack types are identified as an unconnected crack running transversely, diagonally or irregularly (meandering) across the pavement (IPWEA 2015; VicRoads 2009). These isolated cracks can develop due to reflection of a shrinkage crack or joint from an underlying cemented base, settlement associated with an underground service or structure or the intrusion of tree roots into or under the pavement layers (IPWEA 2015; VicRoads 2009).

### ***Longitudinal Cracking***

Longitudinal cracking runs longitudinally along the pavement and does not exhibit strongly developed transverse branches. (Austroads 2006b, p. 45). This cracking type is often a precursor to wheel path rutting (IPWEA 2015, p. 62). When found in isolation, longitudinal cracking represents:

- Reflection of a shrinkage crack or joint in an underlying base;
- Poorly constructed paving lane joint in asphalt surfacing;
- Daily temperature cycles, or asphalt hardening;
- Displacement of joint at pavement widening.

But if a series of these cracks is present, the causes can differ to include:

- Volume change of expansive clay subgrade, due to moisture;
- Cyclical weakening of pavement edge;
- Differential settlement between cut and fill. (Austroads 2006b; IPWEA 2015; VicRoads 2009)

### ***Crescent Shaped Cracking***

Austroads (2006b, p. 37) defines crescent shaped cracking as closely spaced half-moon shaped cracking that is commonly associated with shoving in asphalt wearing courses. The list of possible causes of crescent shaped cracking provided by VicRoads (2009, p. 11) includes:

- Poor bond between wearing course and underlying layers;
- Low strength base course;
- Thin wearing courses;
- High stresses due to braking and acceleration movements.

#### **2.3.4 Wearing Course Defects**

Wearing course defects cover a range of distress modes as displayed in Figure 9. The development of these defects has a “significant influence on the serviceability of a pavement surfacing, especially with regard to skid resistance and ride quality” (VicRoads 2009, p. 16). Depending on the type of in-situ wearing course (either sprayed seal or asphalt), the modes of deterioration may be quite different (VicRoads 2009, p. 9).

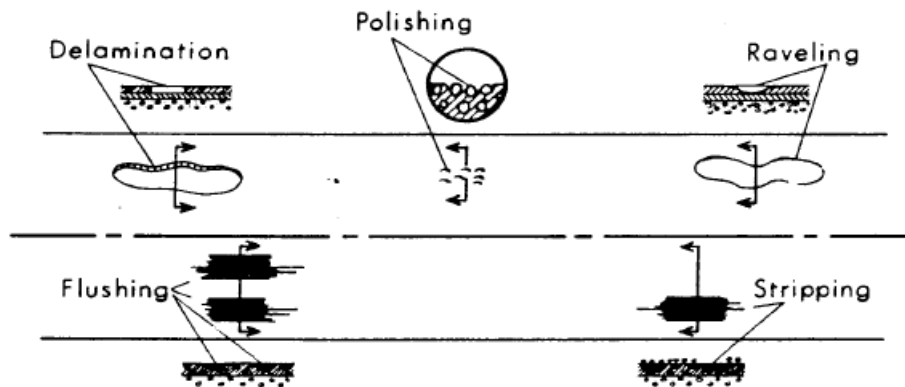


Figure 9: Surface Distress of Flexible Pavements

Source: (Austroads 2008b, p. 35)

### ***Delamination***

Austroads (2008b); IPWEA (2015); VicRoads (2009) define delamination as the loss of a discrete area of seal or asphalt to the full depth of the wearing course layer. Delamination occurs due to the loss of adhesion between the wearing course and lower pavement layers as a result of:

- Inadequate preparation of the lower pavement layers
- Water seepage between pavement layers
- Weak and loose layer of pavement immediately underneath the seal
- Adhesion of the binder to vehicle tyres
- Inadequate thickness of wearing course layer.

### ***Stripping***

Stripping is defined as the loss of aggregate from a seal leaving the binder exposed to direct tyre contact (Austroads 2008b; IPWEA 2015). This defect usually occurs only in sprayed seals and is due to:

- Loss of adhesion of the binder (and its ability to retain aggregate)
- Bitumen binder hardening with age due to oxidation
- Insufficient binder application rate
- Mechanical dislodgment by traffic (IPWEA 2015; Jordan & Cook 2013; VicRoads 2009)

***Ravelling***

The progressive disintegration of the pavement surface by the loss of both binder and aggregate is defined as ravelling according to Austroads (2008b) and IPWEA (2015). The causes to ravelling include:

- Hardening and oxidation of the binder
- Poor asphalt mix design
- Poor construction quality (i.e. lack of compaction, binder contamination) (Austroads 2008b; IPWEA 2015; VicRoads 2009)

***Flushing***

Austroads (2008b); IPWEA (2015) define flushing as an excess of binder on the surface of the pavement. Flushing is often the result of:

- Inappropriate binder application rate either because of poor design or poor spraying practice
- Sealing over an already flushed surface, sealing over patches, which have not had sufficient time to strengthen (routine maintenance should precede a reseal by at least two months),
- Using excessive cutter in the binder.
- Stone penetration into the granular base, hence flushing may be indicative of a base with inadequate strength or compaction

***Polishing***

Austroads (2008b); IPWEA (2015) define polishing as the smoothing and rounding of the upper surface of a sealing aggregate. It commonly occurs in the wheel tracks and is caused by:

- Inadequate durability of the selected surface aggregate
- The use of naturally smooth aggregates.

**2.3.5 Maintenance Patching**

The extent of maintenance patching provides a reasonable indication of the pavement performance with regard to strength and the effect of moisture passing through the surfacing into the pavement (Austroads 2008b; VicRoads 2009). Austroads (2008b); IPWEA (2015); VicRoads (2009) provide the following



definitions and causes of maintenance patching defects, which includes potholing, patching and edge defects.

### ***Potholing***

Potholing is defined as a steep-sided or bowl-shaped cavity extending into the layers below the wearing course. Potholing can occur due to:

- Failure of the wearing course, resulting in moisture ingress
- Low quality or disintegration of base course pavement material
- Pickup of bitumen wearing surface in sprayed seals caused by binder adhesion to tyres.

### ***Patches***

Patches are repaired sections of pavement. They are usually employed to:

- Repair surface defects as identified in this section
- Correct a deficiency in the pavement

### ***Edge break/drop-off***

Edge defects occur along the interface between a sealed roadway and an unsealed shoulder. As the unsealed shoulder deteriorates and leaves the sealed edge unsupported (usually a result of inadequate seal width exposing the shoulder to higher traffic loads or erosion from surface water flows,), the seal edge breaks and recedes towards the road centre line.

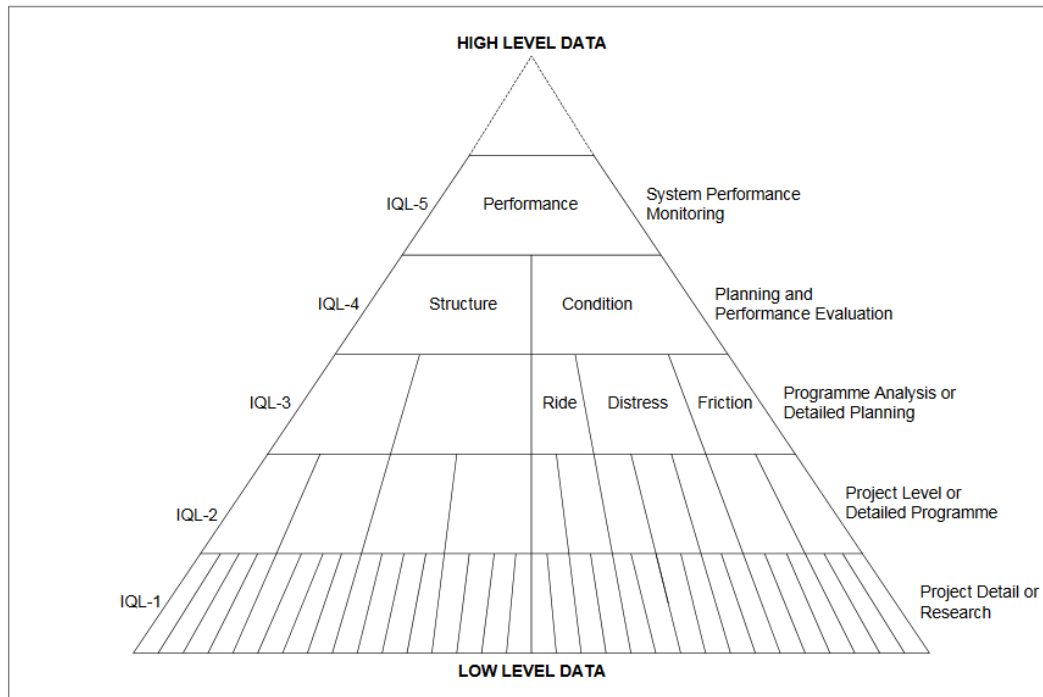
## **2.3.6 Strength**

Austrroads (2008a) considers pavement strength an important characteristic when defining the general condition of a road. It is defined as “the ability of a pavement structure to carry a cumulative repeated heavy axle loading before the pavement shows unacceptable signs of structural and surface distress which seriously compromise its function” (Austrroads 2008a, p. 1).

## **2.5 Condition Data Needs**

Given the extensive list of the aforementioned distress modes, the literature agrees that the collection of all of these defects is unnecessary and in fact “excessive data collection is ... one of the top five reasons road management systems are abandoned” (Bennett, Solminihac & Chamorro 2006, p. 1). There is consensus that

the data to be collected should match the business process that it will be supporting (Austroads 2009a; Bryant & Flintsch 2006; IPWEA 2015). The business process referred to will generally rely on one of five (5) different information quality levels, depending on where the business process sits in the organisations hierarchy (Austroads 2009c, p. 20). These information quality levels, or IQLs, are best summarised in Figure 10.



**Figure 10: Information Quality Level Concept**

**Source: (Bennett & Paterson 2000, p. 37)**

Austroads (2009c, p. 21) explains that “IQL-1 and IQL-2 data is typically collected by large road agencies including maintenance contractors responsible for performance (or outcome) based contracts, whilst IQL-3 data is sufficient for smaller, rural agencies”.

Given the above discussion, the following principles provided by Bennett, Solminihac and Chamorro (2006, p. 1) are best applied to data collection activities:

- “Collect only the data you need;
- Collect data to the lowest level of detail sufficient to make appropriate decisions; and,
- Collect data only when they are needed.”

The data that has been collected also needs to be validated and checked for repeatability and bias.

## 2.6 Condition Data Collection

The techniques of assessment of condition data covered by the literature generally fall into the following categories:

- Manual
- Semi-automated
- Fully automated

“In general for network purposes, a higher level of automation in the methodology may be expected to offer benefits over manual methods in improved personnel safety, more rapid and cost effective data collection, better reporting and planning capabilities, and the production of higher quality data in terms of repeatability” (Austroads 2006b, p. 10). Whilst automated methods may be most suited to large scale data capture, the following section will still look into all the available categories of data collection.

### ***Manual surveys***

Manual surveys are generally visual assessments of the road conditions conducted by an inspector who views the pavement through the windshield of a vehicle or as they walk the pavement (AASHTO 2012, pp. 4-21). Distresses are generally recorded on predefined forms, but there is an increasing trend to enter the survey results directly into computers or hand-held devices (Pierce, McGovern & Zimmerman 2013, p. 14). This method does allow very detailed data collection, but is very labour intensive and it does require more time per asset than automated or semi-automated methods (Bryant & Flintsch 2006, p. 24). As a result, fully automated and semi-automated technologies have gained wide acceptance in pavement condition data collection, however manual surveys are still used by many highway agencies (Pierce, McGovern & Zimmerman 2013, p. 15).

### ***Fully-automated surveys***

Automated surveys typically incorporate the use of specially fitted out vehicles for collecting pavement and roadway features at normal speed through lasers, high-speed cameras, and computers (Attoh-Okine & Adarkwa 2013; Pierce, McGovern &

Zimmerman 2013). The captured data is then automatically processed, either in real-time or post-processed, using a suite of computer applications depending on the defect to be measured (AASHTO 2012, pp. 4-23). The newest data collection equipment has achieved high automation and accuracy and is capable of very fast, comprehensive data collection (Bryant & Flintsch 2006, p. 25). However, fully integrated equipment is expensive and it must be updated regularly to take advantage of new technology (AASHTO 2012; Attoh-Okine & Adarkwa 2013).

### ***Semi-automated surveys***

Semi-automated surveys involve similar equipment as the completely automated method but with a lesser degree of automation (Bryant & Flintsch 2006, p. 25). The data processing stage is carried out by a human who views the automatically captured data and determines a condition rating (AASHTO 2012, pp. 4-24). It is very popular within transportation agencies and yields comprehensive and accurate data collection when properly implemented (Bryant & Flintsch 2006, p. 25).

#### **2.5.1 Defect specific collection methods**

The following sub-section will look into the available methods to collect specific condition defect types. Bennett, Solminihac and Chamorro (2006, p. 4) provides an overview of the available collection methods for a selection of defect types in Table 2.

**Table 2: Cost/Performance Trade-off Matrix for Data Collection Methods**

		Operational Performance				
Scale		1 (Low performance)	2	3	4	5 (High performance)
Equipment Global Cost	1 (High cost)			<ul style="list-style-type: none"> <li>Skid Resistance Dynamic - Vehicle</li> </ul>	<ul style="list-style-type: none"> <li>Imaging for Surface Distress</li> </ul>	
	2			<ul style="list-style-type: none"> <li>Ground Penetrating Radar - Dynamic</li> <li>FWD - Trailer</li> </ul>	<ul style="list-style-type: none"> <li>Macrotecture - Dynamic High Speed</li> <li>Precision INU for Geometry</li> <li>Roughness - Class I (Laser)</li> </ul>	
	3			<ul style="list-style-type: none"> <li>Deflection Beams</li> <li>FWD - Portable</li> <li>Ground Penetrating Radar - Static</li> <li>Skid Resistance - Dynamic Trailer</li> </ul>	<ul style="list-style-type: none"> <li>GPS with INU</li> <li>Macrotecture - Dynamic Low Speed</li> <li>Rut Depth Profilers</li> <li>Roughness - Class II</li> </ul>	
	4		<ul style="list-style-type: none"> <li>Roughness-Class IV</li> </ul>	<ul style="list-style-type: none"> <li>Roughness - Class I (Manual)</li> <li>Skid Resistance - Static</li> </ul>	<ul style="list-style-type: none"> <li>Video Logging</li> <li>Roughness - Class III</li> </ul>	<ul style="list-style-type: none"> <li>GPS</li> </ul>
	5 (Low cost)			<ul style="list-style-type: none"> <li>Macrotecture - Static</li> </ul>		<ul style="list-style-type: none"> <li>Digital DMI</li> </ul>

“As a general rule, if an agency has budgetary restrictions, equipment selected for pavement data collection should be located in the right bottom boxes shaded in the matrix (cost ranging between 3 to 5 and operational performance from 3 to 5)” (Bennett, Solminihac & Chamorro 2006, p. 3).

### ***Roughness***

Austrroads (2007b, p. 7) provides a detailed overview of roughness collection methods in Table 3.

**Table 3: Detailed Roughness Data Collection Methods**

**Source: (Austrroads 2007b)**

Class	Description	Examples of equipment
Class 1 Precision profilers	This class is the highest accuracy for roughness measuring devices. The profile is measured as a series of closely spaced accurate elevation points in the wheelpath. Equipment in this class can be divided in two broad groups, those using laser technology and manually operated equipment.	Laser profilers: non-contact lightweight profiling devices and portable laser profilers Manually operated devices: e.g. rod and level, TRL beam, Face Dipstick/ROMDAS z-250, ARRB Walking Profiler.
Class 2 Other profilometer methods	This class considers dynamic profile measuring methods that determine profile elevations by either elevation data or summarising statistics calculated from elevation data. Accuracy of these devices is dependent on the technology used, being less accurate than Class 1.	APL profilometer, profilographs (e.g. California, Rainhart), optical profilers, and inertial profilers (GMR).
Class 3 IRI estimates from correlation equations	Class 3 equipment includes mechanical or electronic devices that indirectly evaluate pavement profiles. Measures obtained using these devices require calibration through correlations with standardised roughness values.	NAASRA Roughness Meter, Roadmaster, ROMDAS, ARRB Roughometer, TRL Bump Integrator, rolling straightedge.
Class 4 Subjective ratings/uncalibrated measures	Subjective ratings are produced by either riding over the section or conducting a visual inspection.	Key code rating systems, visual inspections, ride over section.

Austrroads (2007b) provides further discussion on roughness collection, recommending that Class 1 devices be used wherever possible as Class 2 devices are not readily available, and Class 3 devices depend on vehicle suspension characteristics which increase the chance of inaccurate results, especially if several vehicles are used.

Recent research into the use of smart phone devices to collect roughness measurements indicates that they are able to collect data that can be used to detect the quality and irregularities of the road surface (Alessandroni et al. 2014; Perttunen et al. 2011).

Where automated methods of roughness data collection are not available, subjective ratings can provide a useful indication of roughness, as demonstrated by Table 4.

**Table 4: Example of Subjective Roughness Ratings**

Source: (Jordan &amp; Cook 2013, p. 15)

Condition	Description	Rural and High Speed Urban	Low Speed Urban
1	Excellent	Very smooth ride Comfortable/safe driving speed > 100 km/hr	Very smooth riding surface. New or resurfaced road.
2	Good	Some minor bumps encountered Comfortable/safe driving speed >80 <100 km/hr	Smooth riding surface. Constructed or reconstructed within the last five years.
3	Fair	Constant small up and down and/or sideways movement, but reasonably comfortable driving - Comfortable/safe driving speed >60 <80 km/hr	A relatively smooth ride but surface or pavement deterioration is starting to impact on ride quality
4	Poor	Constant small up and down and/or sideways movement. Can feel very rough in trucks. Modern cars suspension makes car driving bearable, but with low comfort - Comfortable/safe driving speed >40 <60 km/hr	A rough riding surface caused by cracking, pavement distress or patching. The defects can be felt while driving.
4.5	Very Poor	Uncomfortable driveability experiencing severe up/down and/or sideways movement. Drivers must maintain good control of steering and reduce speed in some circumstances. - Comfortable/safe driving speed <40 km/hr	A very uncomfortable riding surface caused by extensive cracking, pavement distress or patching. Defects have reached the stage that they are severely impacting the ride quality.

***Deformation***

Deformation defects are primarily collected via automated methods as it is not feasible to measure deformation manually at a network level (Austroads 2007a, p. 10). "By 2003, all Austroads Member Authorities were using laser profilometers" (Austroads 2007a, p. 11) to measure rutting. An alternative automated method of collection is the use of 3D point cloud data to identify depressions (Koch et al. 2015, p. 206). The most viable manual method for measuring and reporting pavement surface rutting involves the use of a physical straight edge (Austroads 2007a, p. 10) and measuring the height difference between the straight edge and the distressed pavement.

***Cracking***

Austroads (2006b) provides an extensive overview of the available methods of crack detection, which have been summarised below:

- Manual: this method is suitable only for sampling type investigations. It has an advantage in that it can detect fine crack sizes, however it is associated with high subjectivity, high costs and slow progress.
- Windshield: this method is limited in the size of crack identification, with only wide cracks being readily identifiable. It is much faster than the manual method, however the results will still be highly subjective with low repeatability.
- Video capture, manual review: again, this method is susceptible to high levels of subjectivity. Depending on the quality of the video, crack size detection will vary. As the video is recorded, it does allow for auditing of the survey results at a later date. It also presents a much safer environment for the rater to work in.
- Fully automated: this method provides an objective assessment of cracks, resulting in a high level of repeatability. As it utilises a specially design vehicle to undertake the survey, it does have a high associated costs. The upside is that the survey can be undertaken within the traffic stream and processed in real time. Depending on the quality of the devices optics, crack seize detection will vary, however it has the potential to identify cracks down to 1mm wide.

### ***Wearing Course Defects and Maintenance Patching***

Visual condition inspections of surface defect criteria can be carried out with a reasonable degree of accuracy, providing an appropriate rating score for each (Jordan & Cook 2013, p. 10). These defect types are easily noticeable and aren't subject to minimum defect sizes like cracking.

Many of the automated methods for pavement distress detection are based on the assumption that distress pixels are darker than the background (Koch et al. 2015, p. 205). This would allow for a number of these defect types to be identified automatically via an optical processing device.

The loss of skid resistance (a product of wearing course defects) cannot be quantified visually and therefore relies on equipment specially designed to measure skid resistance (i.e. SCRIM – Sideways force Coefficient Routine Investigation Machine) (VicRoads 2009, p. 16)

### ***Strength***

Austrroads (2008a) states that pavement strength is most commonly determined using the measurement of pavement deflection under a standard test load. The main devices used to test this according to Austrroads (2008a) are:

- Benkelman Beam – tests at discrete points, suitable only for small networks due to its relatively slow rate of testing
- Deflectograph – conducts almost continuous testing at a constant speed of 3 to 4 km/h
- Falling Weight Deflectometer or Heavy Weight Deflectometer (HWD) – discrete test points.

## **2.7 Condition Assessment Frequency**

When considering how often to undertake road condition assessments, there was consensus among the literature that the survey frequency should be based on the available budget, resources and need for the data (AASHTO 2012; Austrroads 2007b; Bryant & Flintsch 2006; IPWEA 2015). However, there was a range of differing opinions when specifying a particular survey interval. IPWEA (2015, p. 26) and VicRoads (2009, p. 22) both recommended adopting a rolling survey program, but couldn't agree to a frequency with IPWEA suggesting a survey frequency of 1-2



years for high function roads and 2-3 years for lower function roads, whilst VicRoads suggested 1-3 years regardless of road function. Austroads (2009a) consistently recommended a frequency between 1-5 years depending on road function. Jeff Roorda and Associates (2006, p. 19), via a survey of Victorian Local Governments, found that they carried out condition assessment every 3-5 years.

## 2.8 Condition Data Modelling

The accurate prediction of pavement performance (or deterioration), and its impact on road agency and road user costs, significantly improves asset management processes and long-term infrastructure planning (Austroads 2009b; Mubarak 2013). Whilst the benefits of modelling are obvious, "there are considerable difficulties in modelling deterioration and despite ongoing worldwide research, exhaustive analytical models are not yet a practical option for modelling (Austroads 2003, p. 21). However, through the continual collection of road condition data, a trend can be established and extrapolated to predict deterioration (Austroads 2003, 2007b). Without adequate data though, the road deterioration cannot be quantified or evaluated accurately, and the planning decisions tend to become short term (Mubarak 2013, p. 240).

## 2.9 Conclusion

The literature review explored many aspects pertaining to road condition assessment including the defects encountered, the techniques of measurement and the type of data that needs to be collected.

There is a definite consistency to the content in the literature when considering the individual components of condition assessment, suggesting that the theoretical aspect of condition assessment is well developed. However, the overriding sentiment encountered throughout the literature is best summarised by IPWEA (2015, p. 4):

"Practitioners need to employ the best practices appropriate to the organisation size and capacity that will provide the most suitable and cost effective, decision making process."

Phrases like "... limited to budget constraints" and "... as funding permits" are frequently used throughout the literature. It suggests that road condition

assessment is still yet to command enough authority to drive sufficient budget allocations in road authorities. This lack of authority stems from an inconsistent and haphazard implementation of condition assessment practices, often leading “many local governments and data collection contractors to develop their own condition data collection manuals” (Jordan & Cook 2013, p. 4). This results in a lack of consistent outcomes when applying road condition assessments, which in turn fails to provide road authorities with sufficient evidence to support their claims for increased funding for condition assessment.

More guidance is needed from state and national road authorities that links the roads function and traffic carrying capacity to the collection and assessment of specific road condition parameters.

## Chapter 3: Review of Gympie Regional Council's Road Condition Assessment Practices

Gympie Regional Council does not have a formally developed asset condition monitoring process for its road network. This project was undertaken with the intention that its outcomes will be adopted by GRC. "This will ultimately result in a review of the existing Asset Management Plan to include long term predictive modelling of pavement renewal needs" (GRC 2016, p. 16). The following chapter will cover the

### 3.1 Organisational Structure

When considering GRCs daily operating practices, an important to aspect to consider is its existing Organisational Structure (HRI052). HRI052 (see Appendix E) provides a concise overview of the GRCs organisational structure. The key feature to absorb when addressing the management of GRCs road network is that:

"Infrastructure Services Construction and Maintenance Branch operates as council's preferred contractor for delivery of construction, maintenance and operation activities. Engineering Services general role is that of the asset owner and provider of capital works." (GRC 2015, p. 4)

### 3.2 Policies and Procedures

GRC has adopted a large number of policies and procedures to ensure a consistent approach to its road network management practices. These corporate documents are listed below in Table 5 and are available on GRCs intranet.

**Table 5: Summary of Road Network Management Policies and Procedures**

Source: (GRC 2016, pp. 42-3)

Policy Title	Ref No.	Summary
<b>Strategic planning and program development</b>		
Road Network Policy	ESPOL-015	Policy addresses council's

		commitments and obligations for managing risks on roads within available budgets.
Asset Management Policy	PRES400	Council's over-arching policy for asset management, including roads.
Road asset and condition data collection	TBA	Proposed policy - Describes the type of information collected and the frequencies.
Construction of Roads on Road Reserve	ISP-017	Documents Council's position with respect to taking responsibility for maintenance of roads that are not currently Council maintained.
Classification of Roads	PRW-019	Describes how roads are classified as "maintained", "maintained to 4WD standard" or "unmaintained".
Road Hierarchy	ESDP-005	Defines Council's adopted road hierarchy.
Inspection and Prioritisation of Reseals	IS-P-055	Procedure for inspecting roads and carparks to determine priorities for resurfacing.
Bridge inspection, maintenance and renewal	TBA	Proposed policy/procedure documents the bridge inspection, analysis and maintenance frequencies and procedures.

<b>Road construction and maintenance</b>		
Capital Works Process	ESDP-202	Flowchart for road project delivery from preconstruction to finalisation.
Road Maintenance	ISP-018	Describes the risk-based approach

		which is followed by Council for inspecting and maintaining roads
Standards and Procedures for New Roads Not Associated with a Development	TBA	Draft policy Defines the minimum standards that Council will consider when a property owner/s wishes to upgrade an existing track in a road reserve (or construct a new road in road reserve) which is not associated with a development application.
Development Standards	Planning Scheme Policy 1	Part of the Planning Scheme. Describes the standards for roadworks associated with a development application.
Land Acquisition for Road Projects	TBA	Draft policy Describes how compensation is determined for the acquisition of land for roadworks and the preferred acquisition process.
Upgrading of Gravel Roads with Bitumen Seals	ISP-016	Allows Council to apply bitumen seals to sections of gravel road where landowners agree to fund the works.
Signs and line marking	TBA	Proposed policy/procedure Defines how signs and linemarking are inspected and priorities determined for upgrades and new installations.

### 3.3 Road Asset Register

The road asset register is administered by the Assets Section within GRCs Design Services Branch. It is the data repository for all the road data held by GRC, which includes the road inventory and road valuation data. The asset management software that contains the road asset register was recently upgraded. At present, the

adopted road asset register still resides in the existing software as the data migration process continues.

The inventory data held in the asset register is guided by the following document:

- Classification of Roads (PRW-019)
- Road Hierarchy (ESDP-005)
- Standard Measurement Calculations (addresses road componentisation)
- Capital Works Process (ESDP202)
- As Constructed Data Flow Process (ESDP206)
- Request for Asset Component Survey (ESDF205)

These documents ensure that consistent inventory data is entered into the system. At present, there isn't a procedure which addresses the segmentation of the road asset.

The valuation data holds the expected and remaining useful life data of the road assets. Current practice at GRC has the following expected life for the given components:

- Bitumen spray seal – 20 years
- Asphalt Concrete seal – 35 years
- Granular Pavement – 80 years

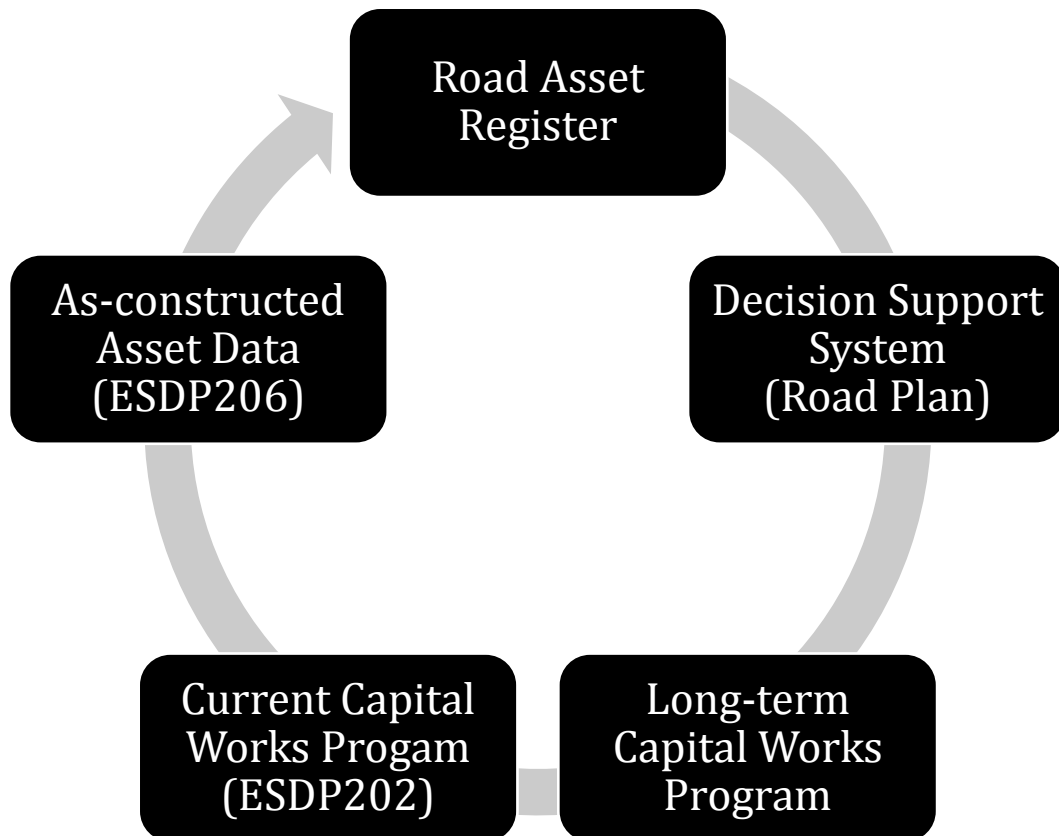
### **3.4 Capital Works Prioritisation Process**

At present, the selection of projects for future Capital Works Programs is guided by the draft Road Plan. It documents the process of project selection whereby a number of sources are interrogated for a list of candidate projects. These sources include:

- Customer complaints
- Councillor requests
- Feedback provided by GRCs Construction and Maintenance Branch

“Relatively simple benchmarks (known as “minimum tolerable standards”) are used to identify the most urgent group of candidate projects which, based on industry standards and local experience, are considered essential works in the short to medium term” (GRC 2016, p. 11).

A process map has been developed to represent the current capital works cycle. Please note that ESDP202 relates to the carrying out a project in the current capital works program.



**Figure 11: Current Capital Works Programming Cycle**

Capital expenditure on unsealed roads is controlled by GRCs Construction and Maintenance Branch. Therefore, road condition assessment of unsealed roads will not be covered by this project.

### 3.5 Existing Inspection Regimes

Despite not having a road condition monitoring process in place, GRCs Construction and Maintenance Branch has two separate inspection programs in operation. The closest existing procedure to a road condition assessment is the Inspection and Prioritisation of Reseals Procedure (ISP055). ISP055 (see Appendix G) outlines a three yearly manual inspection process for the development of GRCs reseal program. It is a visual, windshield inspection process that uses a 1-5 rating scale,

where a rating 1 would indicate the seal is in very poor condition and a rating 5 is in very good condition. Each rating increment is defined by a short description. The results of these inspections are stored in a database managed by the Construction and Maintenance Branch.

“Asset maintenance inspections, separate from asset condition inspections(GRC 2015, p. 6) are undertaken on a quarterly basis over GRCs entire road network. It is an entirely manual inspection process that involves the recording of a predefined set of road defects (see Appendix F). Again, it is predominantly a visual, windshield style inspection method. As this inspection is more generalised than ISP055, it does contain a greater list of defects to record, with each defect given a short description to classify its severity. The inspection results are recorded on-site, using a laptop computer to enter the data into a spreadsheet template. The spreadsheets are analysed by the Construction and Maintenance Branch, with the resulting data used exclusively for short to medium term maintenance planning.



## Chapter 4: Current Best Practice and Gap Analysis

### 4.1 Introduction

This chapter will be used to review current best practices in the field of road condition assessments and then conduct a gap analysis to GRCs current condition assessments practices as identified in Chapter 3: Review of Gympie Regional Council's Road Condition Assessment Practices. The review will focus on the key components of road condition assessment as identified by the literature. A benchmark for these components will then be ascertained and used in the gap analysis.

### 4.2 Best Practice

A survey conducted by Austroads (2002, p. 9) found that only 55% of rural Australian council's collected road condition data, as compared to 92% of urban council's. According to Jordan and Cook (2013, p. 4), this large disparity exists because: there isn't an appropriately recognised standard for carrying out road surface and pavement condition assessments; and the current methods of road condition assessment are too intensive for rural local governments.

In response to comments similar to those made above by Jordan and Cook, IPWEA released a practice note (PN 9) for the visual assessment of road pavements. "The primary purpose of the Practice Note is to develop consistency in the collection and interpretation of data carried out by visual inspection" (IPWEA 2016, p. 1). This guide addresses visual condition assessments of both sealed and unsealed roads via two different inspection regimes. The basic level of investigation, or core approach, involves estimating the condition across the whole of the road segment. The advanced approach involves measuring the condition over a 50m gauging length within the road segment, which is then adopted as representative for the whole segment. The advanced approach is based on the RoCond90 method developed by the RTA.

Austroads, through Part 5 of its Guide to Asset Management (AGAM05), seeks to "promote a framework and consistency of approach for the collection, storage,

analysis and reporting of pavement performance related road condition data” (Austroads 2009a, p. 1). Whilst this part addresses both visual and automated condition assessment methods of sealed roads, the majority of the discussion is dedicated to automated measuring methods. As alluded to by South West RRTG above, the methods employed by this guide may be too intensive for local governments, especially those with limited resources.

VicRoads Technical Bulletin 50 Guide to Surface Inspection Rating for Pavements Surfaced with Sprayed Seals and Asphalt (SIR) is “a tool to uniformly assess the existing condition and estimate the remaining service life of sprayed seals and asphalt wearing surfaces” (VicRoads 2009, p. 7). This guide is similar in application to the IPWEA PN 9 in that it is a visual inspection regime. As it is the adopted procedure for a State Road Authority, it was included as the intermediary best practice standard between the two previously mentioned methods.

### **4.3 Gap Analysis**

The above publications will form the basis of the gap analysis between GRCs existing practices and the current best practice in road condition assessments.

For the purpose of this exercise, the GRCs road asset maintenance inspections and reseal inspections will be used as the base comparison. Whilst these inspections are not identified as ‘condition assessments’, this gap analysis may reveal pre-existing practices that can be directly utilised by the new condition assessment process. If this happens to be the case, it presents an opportunity to form a base dataset of condition information that could be used to supplement the data collected by the new framework.

Given the findings of the literature review, it is obvious that there isn't a single best practice approach for road condition assessment. It depends heavily on the level of funding available, the type of roads to be surveyed and the existing asset management capability of the organisation. For this reason, the gap analysis was limited to components that were relatively consistent in light of the aforementioned constraints. In the end, two components were selected for the gap analysis:

- inspection frequency, and
- distress modes recorded.

### 4.3.1 Inspection Frequency

Inspection frequency is an important component of the road condition assessment process. Given the expected life of the particular components of the road asset, inspections must be undertaken frequently enough to provide sufficient data to predict the degradation of the asset.

The gap analysis for inspection frequencies showed that the triennial inspection frequency as undertaken by ISP055 is comparable to current best practice. The results comparison is shown below in Table 6.

**Table 6: Inspection Frequency Gap Analysis**

Road Function	IPWEA PN 9	AGAM05	VicRoads SIR	GRC ISP055	GRC Asset Maintenance Inspection
All			1-3 years	3 yearly	3 monthly
Higher Function	1-2 years	1-3 years			
Lower Function	2-3 years	3-5 years			

### 4.3.2 Distress Modes Collected

The range of distress modes collected is extensive, as are the methods that they can be collected. As mentioned in the introductory paragraphs, the method of collection is one aspect of condition assessment that relies heavily on the funding available to the organisation. Some of the distress modes included in this gap analysis are very resource intensive to collect and would be more suited to project specific investigations (these items have been highlighted in the Table 7).

The gap analysis for distress mode collection highlighted a short coming in GRCs existing inspection process when compared current best practice. The results are shown below in Table 7.

Table 7: Road Distress Mode Gap Analysis

Sealed Road Defect	IPWEA PN9	AGAM05	VicRoads TB 50	GRC ISP055	GRC Asset Maintenance Inspection
Roughness	✓	✓	✗	✗	✗
Rutting	✓	✓	✓	✗	✓
Shoving	✓	✗	✓	✗	✓
Depression and Heave	✓	✗	✓	✗	✗
Corrugations	✓	✗	✓	✗	✗
Block Cracking	✓	✓	✓	✗	✗
Crocodile Cracking	✓	✓	✓	✗	✓
Transverse Cracking	✓	✓	✓	✗	✗
Diagonal Cracking	✓	✗	✓	✗	✗
Meandering Cracking	✓	✗	✓	✗	✗
Longitudinal Cracking	✓	✓	✓	✗	✗
Crescent Shaped Cracking		✗	✓	✗	✗
Edge Break	✓	✗	✓	✗	✓
Edge Drop-off	✓	✗	✓	✗	✓
Delamination	✓	✗	✓	✓	✗
Stripping of Sprayed Seals	✓	✗	✓	✓	✓
Ravelling	✓	✗	✓	✗	✗
Flushing	✓	✗	✓	✓	✓
Potholing	✓	✗	✓	✓	✓
Patches	✓	✗	✓	✗	✗
Polishing*	✓	✗	✗	✗	✗
Strength*	✗	✓	✗	✗	✗
Skid Resistance*	✗	✓	✗	✗	✗
Texture*	✗	✓	✓	✗	✗
Binder Oxidation*	✗	✗	✗	✗	✗

\* distress modes more suited to collection at project specific level.

## Chapter 5: Road Condition Assessment Framework for Gympie Regional Council

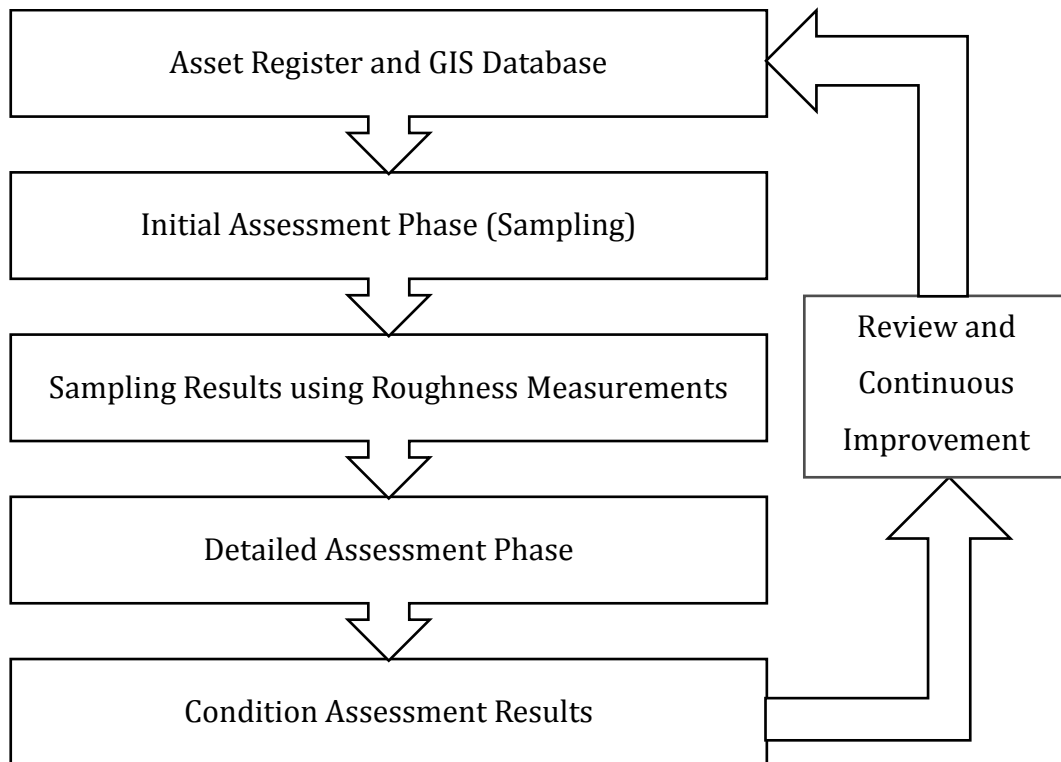
The main objective of this project is to produce a framework for road condition assessments which Gympie Regional Council can adopt and implement. As such, the following chapter will outline the proposed framework, the individual elements (procedures) of the framework, the proposed operational responsibilities and an updated capital works process as originally defined in Chapter 3: Review of Gympie Regional Council's Road Condition Assessment Practices.

### 5.1 Proposed Framework

The purpose of this framework is to define how Gympie Regional Council will undertake the condition assessment of its sealed road network. The major elements of the framework have been identified through an extensive literature review, a review of GRCs existing practices and a gap analysis to current best practice. The intention is that the framework will remain relatively constant with the individual procedures being updated as part of an ongoing continuous improvement process as "business drivers and available condition assessment technologies will change" (IPWEA & NAMS 2011, p. 2|73).

This framework will become an integral part of the Road Plan, assisting with project selection for future capital works programs. It specifically applies to the condition of the road surface and pavement. As the demand for condition data for other roadway components arises (such as kerb and channel, footpaths etc.), this framework has the potential to be transferable.

The proposed framework will be undertaken as part of a three year rolling inspection program, similar to that of the existing ISP055, and identified as current best practice in the gap analysis. Austroads (2007b, p. 26) supports this frequency, citing that "annual surveys are not expected to show measurable changes" and that "intervals of two to three years would appear to be a more practical and cost-effective approach". The remaining components of the framework are best summarised in Figure 12.



**Figure 12: Proposed Condition Assessment Framework**

The framework comprises of six elements, with each element discussed in depth in the following sections.

### 5.1.1 Asset Register and GIS Database

The asset register will play a vital role in the overall implementation of the condition assessment process. At several stages throughout the process, it will be required to import, export and sort certain data fields. Given the frequent interaction with the asset register, it will be imperative that the data being accessed is relevant, coherent, accurate, current, interpretable and accessible (Austroads 2009c, pp. 7-8).

Wherever road segment data is required, a spreadsheet should be exported from the road asset register containing the following data of all of GRCs sealed roads:

- Asset ID
- Segment/Group Name
- Locality
- Asset Name
- Segment Number

- Start Chainage
- End Chainage
- Segment Length
- Change Type

A template for the export can be developed in the asset management software as it is important that the spreadsheet format is maintained throughout the assessment process to allow for simple import and export operations.

The GIS database will have little input in the initial implementation of the framework. It is envisaged that as the procedures develop over time, the importance of geo-referencing road asset data will increase and therefore the interaction with the GIS database will also increase.

### **5.1.2 Initial Assessment Phase (Screening)**

The initial assessment phase involves screening the entire sealed road network to highlight roads that are approaching the end of their useful lives. This will be determined by capturing the roughness of the sealed road segments. The roughness measurements will be undertaken once and will indicate the commencement of the three year rolling inspection program. Roughness is the most suitable condition data to serve this purpose as acknowledged by Austroads (2007b, p. 14):

“A key application of roughness data is to allow a network manager to screen an entire network and separate those lengths of road whose condition warrants further investigation from the larger portion of the network which does not.”

Not only will roughness allow for the screening of the road network, it will also provide a reliable condition dataset for customers. Research by Blom, Marco and Guthrie (2015, p. 31) indicates that road smoothness is a frequent and a critical concern of customers. The initial assessment phase will deliver this data, opening the door to greater customer understanding of the decision making processes.

Further to this endorsement from Austroads, “pavement roughness is a decisive criterion of deterioration” (Papageorgiou & Mouratidis 2015, p. 244). There is also a clear link between increased IRI values and vehicular accident rates (King 2014, p. 34).

The method of roughness data collection is to be determined by GRC upon consideration of matters such as funding availability. Regardless of the method of capture, the roughness data will need to be collected in a manner that will satisfy Table 8.

**Table 8: Roughness Data Output Specification. Adapted from**

**Source: (Austroads 2015, p. 7)**

Attribute	Description
Measure	Lane IRI <sub>qc</sub>
Measure description	Roughness for a lane is reported in terms of the International Roughness Index (IRI) – the average of the results of the application of a computer model of a standard 'quarter-car' to the measured longitudinal road profile of each wheel path.
Measure components	Lane: Collected in estimated most heavily trafficked lane (one direction only) Algorithm (if applicable): Quarter-car algorithm
Units	m/km
Record precision	Two decimal places
Recording segment length	100m
Survey date	Year of collection
Data collection specification	Austroads Specification AGAM/S001, Specification for Pavement Roughness Measurement with an Inertial Laser Profilometer Austroads Test Method AGAM/T001, Pavement Roughness Measurement with an Inertial Laser Profilometer Austroads Test Method AGAM/T002, Validation of an Inertial Laser Profilometer for Measuring Pavement Roughness (Reference Device Method) Austroads Test Method AGAM/T003, Validation of an Inertial Laser Profilometer for Measuring Pavement Roughness (Loop Method) Austroads Test Method AGAM/T004, Pavement Roughness Repeatability and Bias Checks for an Inertial Laser Profilometer Austroads Test Method AGAM/T005 Distance Measurement Validation of Road Condition Monitoring Vehicles OR A method as approved by the Gympie Regional Council
Location referencing	As provided by Road Asset Register for Initial Assessment Phase AND Longitudinal chainage OR GPS coordinates



To clarify the measure components of Table 8, it is appropriate to record roughness in one lane in one direction only, and assume similar roughness in the other lane for a typical two-lane two-way roads (Austroads 2007b, p. 26).

Along with the roughness data, the initial assessment phase will involve the capture of video footage of the road. The video setup will be paired with a DMI for linear referencing of the road segments. It will be used to validate sections of road that show outlier roughness values.



Figure 13: Example of GRC Video Footage

### 5.1.3 Screening Results using Initial Assessment Results

The roughness data will be imported into GRCs asset management software, with the roughness data to align with the predefined road segments. The asset register will then produce a report (in .csv format) that sorts the road segments according to the measured roughness values in descending order. The roughest 25 percent of the entire sealed network will then make up the shortlist that is subject to a detailed investigation.

#### *Justification of screening value*

A review of past capital works programs found that GRC averaged approximately 65km of capital works on roads per year (2013/14  $\approx$  41km, 2014/15  $\approx$  59km, 2015/16  $\approx$  80km). Considering a three-year capital works program (to match the cycle of the rolling inspection program), 195km of road may be subject to capital works. Allowing a further 50% contingency as it is long-range planning, 300km of road should be considered for capital works during the three-year program period. At present, this equates to 25% of the sealed road network.

***Exceptions to network screening***

Roughness data collected at low speeds (less than 25km/h) or for less than 50m will be misleading (Austroads 2007b, p. 32). Intersections, short road segments and LATM controlled town centres will therefore require visual inspections for condition assessment.

**5.1.4 Detailed Assessment Phase**

The detailed assessment phase will subject those road segments highlighted in the screening phase to a visual inspection in accordance with IPWEA Practice Note Nine (core approach). The guide was developed “to provide direction and national consistency in the process of carrying out condition and performance assessment for road pavement assets” (IPWEA 2015, p. viii). Heeding the warnings from the literature review, the core approach was selected so as not to overwhelm the still developing road asset register and risk the assessment process being abandoned due to an unsustainable amount of data collection. The core approach will allow a manageable build-up of condition data that “will ultimately lead to a more advanced asset management process” (IPWEA 2015, p. 6).

By adopting a visual assessment process, it will also allow GRC to utilise its existing staff base with extensive experience in visual inspections. This will also allow for the visual inspection of those segments identified in Exceptions to network screening. Condition assessments will be recorded electronically, utilising a similar format to that currently utilised by the asset maintenance inspectors (see Appendix F: GRC Asset Maintenance Inspection Form (Partial Copy)). The updated format for collection will need to match a predefined order to allow for a straight forward import process into the road asset register.

**5.1.5 Condition Assessment Results**

The recorded condition data will be imported into GRCs asset management software straight from the inspection spreadsheet, with the data to align with the predefined road segments. Once imported, the condition data will populate the relevant field in the asset register, as shown in Figure 14.

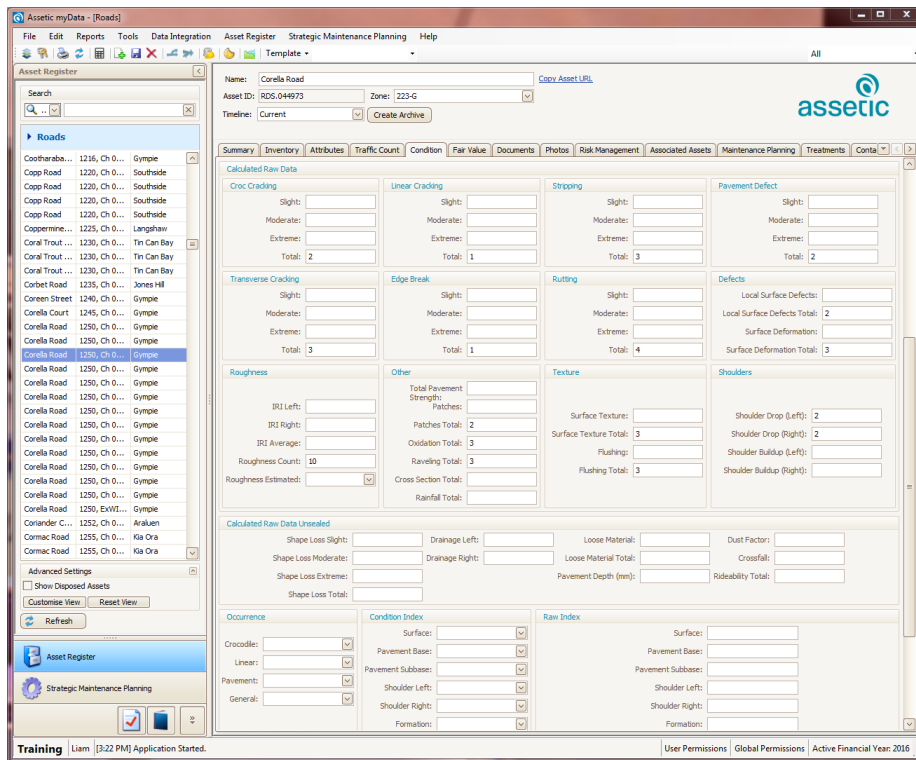


Figure 14: Example of Imported Condition Data within the Asset Register

From this point, the data can be used as required to supplement the Road Plan, as illustrated in the Updated Capital Works Programming Cycle.

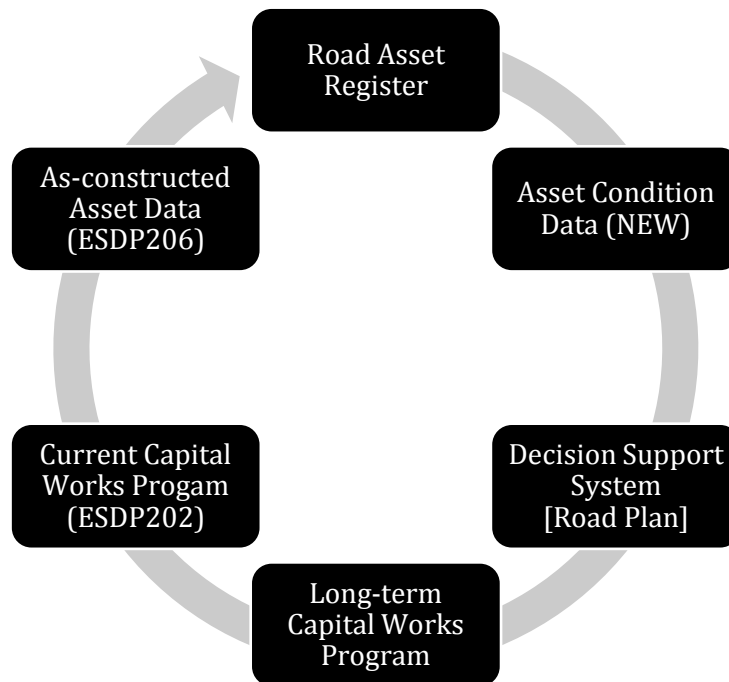


Figure 15: Updated Capital Works Programming Cycle

### **5.1.6 Review and Continuous Improvement**

This component of the framework will be critical in the long-term success of condition assessments. As previously mentioned, the framework has been set up at the core or basic level of asset management. This was done purposely to ensure that the condition assessment process had room to develop as GRC became more accustomed to the framework. Items that would be considered include:

- Monitoring the developments in state-of-the-art data collection techniques
- Incorporating asset component age into the screening process along with roughness.
- Aligning maintenance and capital works activities with the specific road segment to allow better capture of the actual age of the component.

Further items that could be considered are included in 6.1 Recommendations/Further Research.

## 6.0: Conclusion

The driving factor behind this project is to aid in the capital works prioritisation process for GRC by providing a framework that will ultimately deliver a quantifiable base of road condition data. In order to develop this framework, a literature review was undertaken.

The review examined literature covering the road condition assessments, seeking information on road defects, defect collection methods, assessment frequency and condition data needs. It unearthed a broad range of information, including the suitability of utilising road roughness measurement as a screening tool. Ultimately though, the review did reveal a gap in the literature when it comes to definitive recommendations on the extent of condition data to record and how often to record it.

A review of GRCs existing practices followed the literature review. It looked into several aspects including the existing road asset register and the existing inspection regimes. The most notable items identified in the review were:

- the lack of a road segmentation procedure in the road asset register, and
- the lack on integration of existing inspection results and the asset register.

This internal review provided the foundation for a gap analysis to current best practice. The gap analysis confirmed that the frequency of the existing reseal inspection program was satisfactory; however, it did identify a shortfall in the scope of road defects collected and the method of collection.

The new framework was developed after considering all the above matters, with the aim to produce a process that is economical and purpose-built for the region. The framework utilises an over-arching condition data (roughness) to screen the network. The shortlisted roads produced from the screening process can then be assessed in detail using the existing inspection personnel employed by GRC, who have experience undertaking visual inspections and have an intimate knowledge of the regions road network.

## 6.1 Recommendations/Further Research

The following recommendations have been identified to assist with the implementation of the proposed framework. They are in no particular order.

1. Undertake a pilot inspection program to test the framework. The pilot program will be useful to determine the type of roughness measuring device to use. It is suggested that an inertial laser profilometer (class 1) and a smartphone (class 4) roughness application (RoadBump, or similar) be field tested and the results compared prior to selecting which tool to use.
2. Develop and implement a road segmentation procedure for the asset register. The effectiveness of condition data can be greatly reduced by excessively long segments.
3. Development and implement a check that ensures the most current as-constructed data has been integrated into the asset register prior to starting the condition assessment cycle.
4. Review the frequency of asset maintenance inspections. If the frequency of these inspections could be justifiably increased to half yearly (see Austroads (2006a, p. 34) for further information), it could allow the incorporation of the detailed condition assessment phase with only a minimal increase in work load.
5. Implement the framework methodically. Diving into the framework and collecting condition data en masse could result in poor data being collected. This will increase the probability of misguided funding allocations, therefore reducing the trust in the condition assessment process. In the worst case, this could lead to abandonment of the entire process.
6. Unsealed roads have been identified as fundamentally different in funding application and maintenance operations to sealed roads. Therefore, a separate framework will be required.
7. Make the video footage captured in the initial assessment phase available to whole of Council either by linking the corporate GIS application or through a network location.
8. The framework will be the responsibility of the Manager – Assets Section. It is envisaged that the majority of the work will need to be incorporated into

the Design Services Branch budget, with only the detailed assessment phase being undertaken by the Construction and Maintenance Branch.

## References

AASHTO 2012, 'Pavement Condition Assessment', in *Pavement Management Guide (2nd Edition)*, American Association of State Highway and Transportation Officials (AASHTO), ch 4.

Alessandrini, G, Klopfenstein, LC, Delpriori, S, Dromedari, M, Luchetti, G, Paolini, BD, Seraghiti, A, Lattanzi, E, Freschi, V, Carini, A & Bogliolo, A 2014, 'SmartRoadSense: Collaborative Road Surface Condition Monitoring', in *UBICOMM 2014: The Eighth International Conference on Mobile Ubiquitous Computing, Systems, Services and Technologies: Proceedings of the UBIKOMM 2014: The Eighth International Conference on Mobile Ubiquitous Computing, Systems, Services and Technologies* IARIA.

Attoh-Okine, N & Adarkwa, O 2013, *Pavement Condition Surveys - Overview of Current Practices*, Delaware Center for Transportation, USA.

Austrroads 2002, *Heavy Vehicle Loading of Low Trafficked Roads: Part 1 - Strategic Framework for Reviewing Expenditure*, Austrroads Inc., Sydney, NSW.

Austrroads 2003, *Remaining Life of Road Infrastructure Assets: An Overview*, Austrroads Inc., Sydney, NSW.

Austrroads 2006a, *Guide to Asset Management Part 1: Introduction to Asset Management*, Austrroads Inc., Sydney, NSW.

Austrroads 2006b, *Guide to Asset Management Part 5E: Cracking*, Austrroads Inc., Sydney, NSW.

Austrroads 2007a, *Guide to Asset Management Part 5C: Rutting*, Austrroads Inc., Sydney, NSW.

Austrroads 2007b, *Guide to Asset Management Part 5B: Roughness*, Austrroads Inc., Sydney, NSW.

Austrroads 2008a, *Guide to Asset Management Part 5D: Strength*, Austrroads Inc., Sydney, NSW.

Austrroads 2008b, *Guide to Pavement Technology Part 5: Pavement Evaluation and Treatment Design*, Austrroads Inc., Sydney, NSW.

Austrroads 2009a, *Guide to Asset Management Part 5: Pavement Performance*, Austrroads Inc., Sydney, NSW.

Austrroads 2009b, *Guide to Asset Management Part 5H: Performance Modelling*, Austrroads Inc., Sydney, NSW.



Austrroads, 2009c, *Guide to Asset Management Part 5A: Inventory*. Austrroads Inc., Sydney, NSW.

Austrroads 2009d, *Guide to Pavement Technology Part 1: Introduction to Pavement Technology*, Austrroads Inc., Sydney, NSW.

Austrroads 2009e, *Guide to Asset Management Part 2: Community and Stakeholder Requirements*, Austrroads Inc., Sydney, NSW.

Austrroads 2009f, *Guide to Asset Management Part 4: Program Development and Implementation*, Austrroads Inc., Sydney, NSW.

Austrroads 2009g, *Guide to Asset Management Part 8: Assets Valuation and Audit*, Austrroads Inc., Sydney, NSW.

Austrroads 2015, *A Common Data Output Specification for Texture, Cracking, Strength and Skid Resistance*, Austrroads, Sydney, NSW.

Bennett, C & Paterson, W 2000, *A guide to the calibration and adaption of HDM-4*, World Roads Association (PIARC), Paris, France.

Bennett, CR, Solminihac, Hd & Chamorro, A 2006, *Transport Note No. 30: Data Collection Technologies for Road Management*, The World Bank, Washington, USA.

BITRE 2011, *Public road-related expenditure and revenue in Australia*, Information Sheet 40, BITRE, Canberra.

Blom, CM, Marco, LD & Guthrie, PM 2015, 'Customer perceptions of road infrastructure surface conditions', *Infrastructure Asset Management*, vol. 2, no. 1, pp. 23-38.

Bryant, J & Flintsch, G 2006, *Asset Management Data Collection for Supporting Decision Processes*, U.S. Department of Transportation, USA.

Bryce, JM, Hosten, AM, Priddy, LP, Flintsch, GW, Izeppi, EdL & Nelson, WO 2013, 'Using Pavment Management to Support Maintenance and Engineering Policy Decisions for Small and Mid-Sized Municipalities', *Public Works Management & Policy*, vol. 19, pp. 148-63.

EA 2010, *Code of Ethics*, Engineers Australia, ACT.

Epell, V, McClurg, BA & Bunker, JM 2001, 'A four level road hierarchy for network planning and management'.

Evans, M & Sansom, G 2015, *A Federation for Communities and Places: Australia in a Century of Local Governance*, Draft, Local Government Professionals Australia.

GRC 2015, *Construction and Maintenance Branch Business Plan*, Version 1, Queensland, Discussion Paper.

GRC 2016, *Road Plan*, Draft, Queensland.

Hunt, PD 2002, *Analysis of Roughness Deterioration of Bitumen Sealed Unbound Granular Pavements for use in Road Asset Management Modelling*, Queensland University of Technology, Australia, Master's Thesis.

IPWEA 2015, *Condition Assessment and Asset Performance Guidelines Practice Note 9 - Road Pavement Assets*, IPWEA, Sydney, NSW.

IPWEA 2016, *Condition Assessment and Asset Performance Guidelines Practice Note 9.1 - How to: Assess Road Pavement Condition*, IPWEA, Sydney, NSW.

IPWEA & NAMS 2011, *International Infrastructure Management Manual*, NAMS Limited, Wellington, N.Z.

Jeff Roorda and Associates 2006, *Guidelines for Measuring and Reporting the Condition of Road Assets*, Local Government Victoria, Melbourne, Vic.

Jones, D & Paige-Green, P 2000, *Draft TMH12 Pavement Management Systems: Standard Visual Assessment Manual for Unsealed Roads*, CSIR Transportek, South Africa.

Jordan, G & Cook, G 2013, *Road Condition Assessment Manual*, South West RRTG, Queensland.

King, B-A 2014, 'The effect of road roughness on traffic speed and road safety', University of Southern Queensland, Toowoomba, Qld.

Koch, C, Georgieva, K, Kasireddy, V, Akinci, B & Fieguth, P 2015, 'A review on computer vision based defect detection and condition assessment of concrete and asphalt civil infrastructure', *Advanced Engineering Informatics*, vol. 29, no. 2, pp. 196-210.

Mubaraki, M 2013, 'Proposed integrated road surface management system for small municipalities', *Proceedings of the Institution of Civil Engineers - Municipal Engineer*, vol. 166, no. 4, pp. 239-49.

Papageorgiou, G & Mouratidis, A 2015, 'Defining threshold values for pavement surface characteristics', *Proceedings of the Institution of Civil Engineers - Transport*, vol. 168, no. 3, pp. 223-30.

Perttunen, M, Mazhelis, O, Cong, F, Kauppila, M, Leppänen, T, Kantola, J, Collin, J, Pirttikangas, S, Haverinen, J, Ristaniemi, T & Riekkii, J 2011, 'Distributed Road

Surface Condition Monitoring Using Mobile Phones', in C-H Hsu, et al. (eds), *Ubiquitous Intelligence and Computing: 8th International Conference, UIC 2011, Banff, Canada, September 2-4, 2011. Proceedings*, Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 64-78.

Pierce, LM, McGovern, G & Zimmerman, KA 2013, *Practical Guide for Quality Management of Pavement Condition Data Collection*, U.S. Department of Transportation, Federal Highway Administration, Washington DC, USA.

Ruotoistenmäki, A, Seppälä, T & Kanto, A 2006, 'Comparison of Modeling and Measurement Accuracy of Road Condition Data', *Journal of Transportation Engineering*, vol. 132, no. 9, pp. 715-21.

Saliminejad, S & Gharaibeh, NG 2016, 'Proximity-Based Outlier Detection Method for Roadway Infrastructure Condition Data', *Journal of Computing in Civil Engineering*, vol. 30, no. 1, p. 04015001.

Sun, L & Gu, W 2011, 'Pavement Condition Assessment Using Fuzzy Logic Theory and Analytic Hierarchy Process', *Journal of Transportation Engineering*, vol. 137, no. 9, pp. 648-55.

TMR 2012, *Pavement Rehabilitation Manual*, Brisbane, QLD.

TMR 2015, *The Roads and Transport Alliance*, Queensland Government.

VicRoads 2009, *Technical Bulletin 50: Guide to Surface Inspection Rating*, VicRoads, Victoria.

## Appendix A: Project Specification

### ENG4111/4112 Research Project

#### Project Specification

For: Liam Douglas Watson

Title: Asset Condition Monitoring of Gympie Regional Council's Road Network

Major: Civil Engineering

Supervisor: Dr Nateque Mahmood

Sponsorship: Gympie Regional Council

Enrolment: ENG4111 Semester 1, 2016 (External Study)  
ENG4112 Semester 2, 2016 (External Study)

Project Aim: This project aims to produce a road condition monitoring procedure for Gympie Regional Council that is economical, purpose-built for the region and provides quantifiable data that will act as the foundation for determining roadway rehabilitation for future capital works expenditure.

#### Programme: Issue B, 11 March 2016

1. Undertake research of information on the practice of road condition monitoring, including current best practice guidelines, predictive modelling of future road conditions, assessable road conditions, techniques to assess and/or measure the road conditions and the accuracy of measurement required for particular road conditions.
2. Undertake research on the current road condition monitoring practices at Gympie Regional Council, including the predictive modelling component of Council's asset management software.
3. Conduct a gap analysis between Gympie Regional Council's road condition monitoring practices and current best practice guidelines.
4. Modify Gympie Regional Council's road condition monitoring framework.
5. Develop a new asset condition monitoring procedure in line with the modified framework for Gympie Regional Council's road network. The procedure will capture data that can be utilised by the predictive modelling component of Council's asset management software.
6. Present the findings to a peer group and submit the dissertation in the required written format.

*If time permits:*

7. Trial the new asset condition monitoring procedure on a sample group of roads within the Gympie Region.

# Appendix B: GRC Work Instruction - Road Inspections



INFRASTRUCTURE

## **WORK INSTRUCTION ROAD INSPECTIONS**

<b>Council Details</b>	Gympie Regional Council Address: 242 Mary St, Gympie QLD 4570 Phone: 1300 307 800 ABN: 91 269 530 353
<b>Work Location:</b>	
<b>SCOPE OF WORK:</b>	This describes the work methods to be employed in the Road Inspections
<b>This Instruction is to be used in conjunction with the following Documents:</b> (Where Required)	<input type="checkbox"/> Safe Work Method Statement WHSWMS040 <input type="checkbox"/> Daily Prestart Meetings WDF010 <input type="checkbox"/> Traffic Management Plan and Risk Assessment WDF336
<b>PPE: SPECIFIC TYPE</b> (e.g. Riggers Gloves or Cartridge Respirator)	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/>
<b>OTHER:</b>	.....
<b>Plant</b>	Light vehicle or utility fitted with flashing amber beacons and displaying a "Road Inspection Unit" sign made from an approved retro – reflective material
<b>Materials</b>	
<b>Particular Planning Points</b>	
<b>Abbreviations</b>	JM – Job Manager, CQR - Contractors Quality Representative, S - Supervisor, LH Leading Hand, PPE – Personal Protective Equipment, MT – Material Testers
<b>Hazards:</b>	<input type="checkbox"/> Noise <input type="checkbox"/> Falls, Slips, Trips <input type="checkbox"/> Chemicals <input type="checkbox"/> Electricity <input type="checkbox"/> Heat <input type="checkbox"/> Airborne Contaminants <input type="checkbox"/> Physical/Verbal Assault <input type="checkbox"/> Hazardous Manual Task <input type="checkbox"/> Heat Stress <input type="checkbox"/> Other: _____

**Approval by Authorised Person**

Print Name \_\_\_\_\_ Signature \_\_\_\_\_ Position \_\_\_\_\_ Date \_\_\_\_/\_\_\_\_/\_\_\_\_ Employee No. \_\_\_\_\_

ISWI9004

Page 1 of 4

Work Instruction – Road Inspections

Reviewed: 1/5/13

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INFRASTRUCTURE

Road Inspections

Work Process Being Assessed:



STEP NO. / I.D.NO.	JOB STEP List the steps required to perform the task and the sequence they are to be carried out in.	POTENTIAL HAZARD Against each step list the potential risk/hazards that could cause injury/damage when the task step is performed	REQUIRED HAZARD CONTROL For each hazard identified, list the control measures required to eliminate or minimize the risk of injury	RISK LEVEL After Controls	RESPONSIBILITY Nominate the person who will be required to put the control measures in place
1.	Select area or group of the road network to be inspected	- High traffic volumes - High posted speed	- If possible conduct inspections at times of reduced traffic flow - Drive vehicle to conditions – reduce speed where possible	Unlikely Moderate M6	Inspector
2.	Ensure vehicle and equipment are fit for conducting the inspections	Signage missing or lights on vehicle not working	Ensure pre-use inspection is conducted on the vehicle. Flashing beacons are fitted and operating and road inspection unit signage is displayed. If defects are detected, tag out vehicle "OUT OF SERVICE" and inform supervisor and workshop	Unlikely Minor L7	Inspector
3.	Travel road/s to be inspected	- Vehicle collision - Loss of control of vehicle due to speed driven during inspections	- Obey road rules at all times - Travel at a reduced speed where necessary to conduct inspections, ensuring at all times - Slow down only when traffic has passed and its safe to do so - Always have your flashing beacons on when driving at reduced speeds	Unlikely Moderate M6	Inspector
4.	Alighting vehicle to conduct further inspections	- Struck by vehicle - Slips, trips and falls	- Park off road where possible - Ensure safety foot wear and high visibility vest are worn whilst outside the vehicle - Walk only where there is sure footing	Unlikely Moderate M6	Inspector


ISWI9004

Page 2 of 4

Work Instruction – Road Inspections

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		INFRASTRUCTURE			
		LIST OTHER HAZARDS AS IDENTIFIED DURING THE WORK	CONTROLS	RISK LEVEL After Controls	RESPONSIBILITY
JOB STEPS					

ISW19004

Page 3 of 4

Work Instruction – Road Inspections

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INFRASTRUCTURE

Instructions For Use  
1. Document procedure

2. Identify Hazards

3. Implement Safety controls

4. Complete work

5. Supervisor forwards procedure to Director/Manager.

6. Director/Manager signs and authorises procedure to be placed on Intranet. (Forward to Document Controller)

Risk Assessment Calculator

**A** Assess the likelihood and consequences from the hazards or risks

Likelihood	Consequences					
	Insignificant No injury, minor property damage	Minor First Aid minor injury, minor property damage	Major Medical attention, minor injury, minor property damage	Catastrophic Death, Severe injury, major property damage		
Almost certain to occur at some time	H-5	H-4	E-3	E-2	E-1	E-1
Likely to occur at some time	M-6	H-5	H-4	E-3	E-2	E-2
Possible to occur at some time	L-7	M-6	H-5	E-4	E-3	E-3
Unlikely to occur at some time	L-8	L-7	M-6	H-5	E-4	E-4
Very unlikely to occur at some time	L-9	L-8	M-7	H-6	E-5	E-5

The hierarchy of control must be considered when controlling risks. Refer to Risk Management WHS-P-001.

**Level 1**  
ELIMINATE – Can the process or plant be eliminated completely?

**Level 2**  
SUBSTITUTE – Can the process or plant be replaced with a safer one?

**Level 3**  
ISOLATE – Can the process or person be isolated from the plant?

**Level 4**  
ENGINEER – Can the process be redesigned?

**Level 5**  
ADMINISTRATION – Can we limit exposure to the risk – job rotation, work procedure, training.

**Level 6**  
PPE- Can we use Personal Protective Equipment?

In Consultation with the following Staff:

<b>Signature</b>	Date	Name	Employee No
	Date:	Name:	Employee No:
	Date:	Name:	Employee No:
	Date:	Name:	Employee No:
	Date:	Name:	Employee No:
Other	Date:	Name:	Employee No:
Approved by Supervisor:	Date:	Name:	Employee No:
Director/Manager: <b>Compulsory</b> (Forward to Document Controller)	Date:	Name:	Employee No:

ISW9004

Page 4 of 4

Work Instruction – Road Inspections

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# Appendix C: GRC Enterprise Risk Management Procedure



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## ENTERPRISE RISK MANAGEMENT

### Purpose

To provide a method that allows risks (other than safety) within Gympie Regional Council to be identified, assessed and effectively controlled so as to minimise or eliminate potential losses/harm to the organisation, consistent with Council's Risk Management Framework ([OCI201](#)) and Policy ([OCPOL200](#)).

### Scope

This procedure applies to all personnel of Gympie Regional Council which includes contractors and volunteers, who, in the process of planning or conducting work, are required to identify, assess and control a potential risk situation. Hazards to workforce safety are assessed and managed as per WHS Risk Management ([WHSP001](#)).

### References

Introduction to Risk Management Training ([OCT201](#))  
Local Government Act 2009  
Local Government Regulation 2012  
AS/NZS ISO 31000-2009 Risk Management

### Definitions

**Hazard / Issue** – a source of potential harm or a situation with the potential to cause loss, an unwanted event.

**Risk – Effect of uncertainty on objectives.** A chance that an event will occur in a workplace that will result in loss to an organisation. Risk level is measured in terms of consequences and likelihood.

**Inherent Risk** - the risk level before any control measure is put in place.

**Residual Risk** - the risk level considering the existing controls

**Risk Assessment** – The process used to think about what can go wrong and deciding if enough has been done to control it. A risk assessment is a proactive risk management tool to control losses such as injuries, near misses, property damage and other business losses. It must be documented.

**Consequence** - is the outcome of an event being a loss, injury, disadvantage, or a gain. It is the range of possible outcomes associated with an event. (effect)

**Likelihood** - is a qualitative description of probability, chance or frequency. (uncertainty) It can also be quantitative.

### Responsibilities

All personnel are responsible for enterprise risk management and conducting assessments consistent with this procedure as a normal part of the work process.

Managers / Co-ordinators are also responsible for ensuring assessments are provided to the Systems & Risk Management Coordinator and reporting on high and extreme residual risks to the directors.

CEO and the Directors are responsible for promoting enterprise risk management and ensuring the Risk Management Plan ([OCMP200](#)) reflects the current status of council's strategic risks.

### Enterprise Risk Management Process

There are several basic steps in the risk management process. These are:

Communicate and consultation

Establish the context

Risk assessment      identify hazards / issues / risks  
   analyse and assess

   identify control measures to prevent or minimise the level of risks

Implement any required additional control measures

Monitor and review

OCP201

Page 1 of 5

Reviewed: 05/11/13

### Enterprise Risk Management Procedure

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Communicate and Consultation

An essential part of the enterprise risk management process is to develop and implement an effective framework to communicate and consult with all relevant stakeholders, internal and external as appropriate, at each stage of the risk management process and concerning the process as a whole. Nominated "Risk Champions" play an important role in this process.

Establish the Context

Establish the criteria against which risks will be evaluated, the risk appetite of the organisation and corrective actions for different risks.

*Risk Tolerance / Appetite*

Gympie Regional Council acknowledges that some level of risk is evident when undertaking necessary work and activities. Whenever and wherever, practical personnel must reduce risk to a medium or low level. The Executive Management Team may decide that some high level risks will be tolerated where a benefit exists and some documented controls are in place. Extreme level risks are not acceptable and will not be tolerated, except in extraordinary circumstances and only with the specific prior approval of the CEO, or the relevant director, and where some control is in place.

*Risk Transference*

Gympie Regional Council also acknowledges that not all risks are or can be effectively controlled and therefore maintains numerous insurance policies. It is noted that insurance only covers in pre-defined situations and that all costs associated with an event are generally not recoverable through insurance.

*Emergency Preparedness, Business Continuity and Disaster Recovery*

In addition to specific controls for identified risks, Council routinely considers its emergency preparedness, develops Business Continuity Plans and plans for Disaster Recovery.

*Risk Management Plans*

Specific Risks Management Plans are required for extreme and high risks. These include the action required, the person accountable and the timeframe for implementation and reporting requirements.

Identify Hazards / Issues / Risks

Identification can be undertaken systematically, using a number of different tools, such as pre-developed checklists, consideration of "impediments to success", "energy out of control", Input / Output Model, Cause and Effect assessments, FMECA (failure modes effect criticality analysis) and historical / records review. Identification can also be undertaken for simple subjects by "brainstorming" alone.

Identification is done at both strategic and operational levels of council.

Identification needs to be thorough, as an issue not identified, cannot be managed. Team identification is best, and if this cannot be undertaken, the identification is subjected to peer review.

Issues are recorded on Enterprise Risk Assessment Record Template [OCF200](#) or similar.



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**Analyse and Assess the Level of Risk (effect of uncertainty on objectives)**

Look at the likelihood that loss, damage or injury (consequences) would occur as a result of the identified hazard and decide on the risk level using the IAC Risk Process.



- For each issue previously identified determine the likelihood of an incident occurring. This ranges from:
  - 1. Almost Certain** Expected to occur at least once per year
  - 2. Likely** Will probably occur about once per year
  - 3. Possible** Might occur at some time (1/10yrs)
  - 4. Unlikely** Not anticipated this decade
  - 5. Rare** May occur in exceptional circumstances
- Also for each issue previously identified determine the consequences that may result from the incident occurring (using the following descriptions as a guide).
  - Recurrent Risks**
    - Expected to occur at least once per year
    - Will probably occur about once per year
    - Might occur at some time (1/10yrs)
    - Not anticipated this decade
    - May occur in exceptional circumstances
  - Single Events**
    - Expected to occur during project/activity
    - Probable, greater than 50/50 chance
    - Maybe, less than 50/50 chance
    - Low probability of occurrence
    - Negligible, close to zero probability

Enterprise Consequences					
Likelihood	E	D	C	B	A
1.	M-11	H-16	H-20	E-23	E-25
2.	M-7	M-12	H-17	H-21	E-24
3.	L-4	M-8	H-15	H-18	H-22
4.	L-2	L-5	M-9	M-13	H-19
5.	L-1	L-3	M-6	M-10	H-14

	Assets / Financial damage	Lost production / higher costs	Personnel	Environment	Reputation / Compliance
<b>A Catastrophic</b>	major damage \$M1-10M >\$10M	completion delayed 5yrs	Persistent staff issues disrupt delivery of essential services	significant, irreparable damage	
<b>B Major</b>	major damage \$M1-10M	cost increase \$1M-10M	average retention time 18 months	significant repairable damage	official misconduct / prosecution
<b>C Moderate</b>	medium damage \$50K-1M	delayed 1 yr or cost increase \$50K-1M	50% of employees mildly stressed / dissatisfied	moderate damage / unsatisfactory EPA audit	persistent harassment, investigations, conflict of interest
<b>D Minor</b>	low-medium damage \$3K-50K	cost increase \$1K-50K	30% of employees mildly stressed / dissatisfied	minor damage	sustained minor legal non-compliance
<b>E Insignificant</b>	none or low damage <\$3K	completion delayed 3mths	10% of employees mildly stressed / dissatisfied	insignificant damage	late / limited compliance

- Apply the determined likelihood and consequence on the risk matrix and record the risk level – "Extreme", "High", "Medium" or "Low" (inherent risk) (Recorded on OCF200 or similar)
- After deciding how to control the risk (see below), conduct a risk assessment again and make notation of this risk score (residual risk)

Page 3 of 5

Enterprise Risk Management Procedure

OCF201

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**Note:** Always conduct an assessment of risk before any control measures are implemented (inherent risk) and a risk assessment after the control measures are implemented as this will identify if the control measures are effective in reducing risks (residual risk).

#### Identify Control Measures - Making Consistent Decisions

1. Council aims for a consistent approach to risk. For an issue and a determined level of risk, the options are:
  - **Acceptance** – the risk level is acceptable to the organisation
  - **Reduction** – the current risk level is not acceptable and needs to be reduced
  - **Elimination** – the risk level is not acceptable and cannot be effectively reduced, then the issue must be eliminated
  - **Transference** – the effective solution to the risk level is insurance or other means of transference.
2. When determining a mitigation (reduction) strategy "controls" are to contain elements of "Prevention", "Monitoring" (auditing / inspection / reporting) and "Contingency". The Hierarchy of Control may also be useful:
 

<b>Elimination</b>	Eliminate the issue, event, work process, material, or hazardous situation completely.
<b>Substitution</b>	Alter the circumstances, replace the work process, material, or situation with a different one (with less chance of loss).
<b>Isolation</b>	Isolate the organisation from the issue, event, process, material, or damaging situation.
<b>Engineering</b>	Design or re-design the event, material or work environment.
<b>Administration</b>	Limit the exposure to risk issue by job rotation, following a safe work procedure and/or providing adequate training.

**Note:** A control measures effectiveness ranges from the most effective method (elimination of the risk) to the least effective method (reporting / complaints handling).

3. When selecting the control to be implemented always consider short term control measures (temporary option) and long term control measures (permanent option); and
4. When deciding on the control measures to be implemented, consideration must also be given to the costs associated with the potential losses, in comparison with the costs associated with the control measures.

Record control measures on Enterprise Risk Assessment Record Template (OCF200) or similar.

Based on the **residual risk level** additional control measures may be needed.

- **Extreme** Immediate action required
  - Develop Specific Management Plan for immediate implementation to address extreme risks ([OCF201](#))
  - Immediately advise the directors and CEO in writing
  - As directed, allocate actions and budget for implementation
  - Monitor implementation
  - Separately report progress to directors weekly
- **High**
  - Develop specific plan for implementation to address high risks
  - Allocate actions and budget for implementation
  - Monitor implementation
  - Report progress to directors monthly
- **Medium**
  - Implement any agreed additional controls
  - Monitor implementation
  - Report quarterly
- **Low**
  - Accept and monitor

OCP201

Page 4 of 5

Reviewed: 05/11/13

Enterprise Risk Management Procedure

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Implementing Control Measures

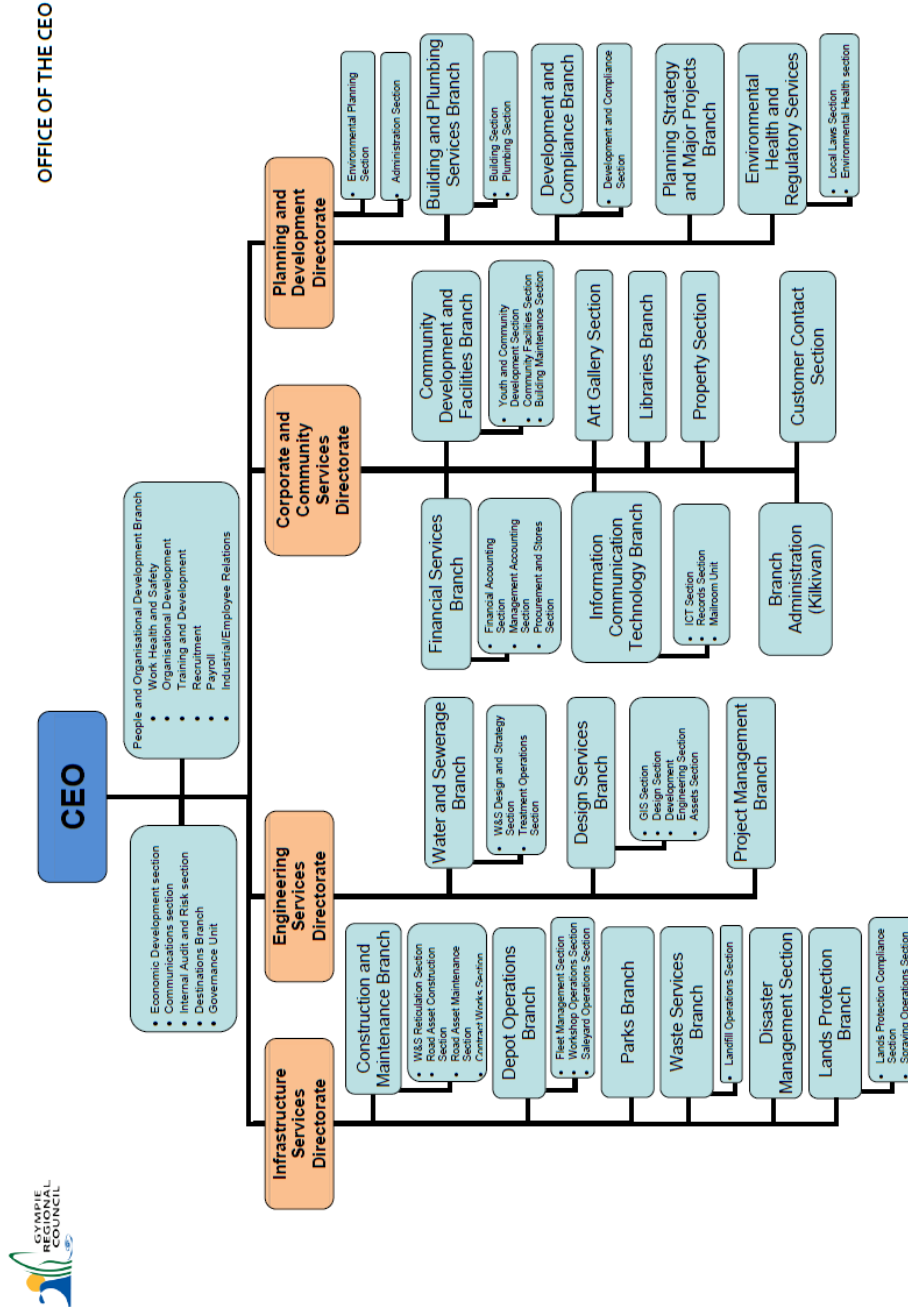
1. When implementing control measures identified from the risk assessments all persons that may be affected need to be informed of these measures;
2. Consideration needs to be given to training, compiling or reviewing work procedures, regular supervision of staff to ensure the control methods are used and educating the workforce on the risk management process; and
3. Documenting the process is extremely important; this can be achieved by completing the Enterprise Risk Assessment Record Template (OCF200), Key Enterprise Risk Summary (OCF201), rectification action plan ([WHSF 110](#)) or writing specific file notes / project notes / reports.
4. Forward risks to the Systems & Risk Management Coordinator.

Monitoring and Review

The effectiveness of risk management is determined by regular monitoring. This includes a constant programme of risk assessments, leading to review of (and additions to) the risk register ([OCI202](#)), regular review of the council's risk profile, appetite (tolerance) for risk and adequacy of insurance cover and regular monitoring of Specific Risk Management Plans (aimed at reducing extreme risks) to ensure implementation.



# Appendix E: GRC Organisational Structure



Reviewed: 10/03/14

Organisational Structure Information (whole of structure)  
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HR1052

## Appendix F: GRC Asset Maintenance Inspection Form (Partial Copy)

<b>Sealed Survey Inspection</b>	
Type of Inspection	Description of Hazard
<b>Shoulder Drop Off</b>	Small >5m long and <15mm deep
	Moderate <5m long and 15 - 50mm deep
	Moderate >4m long and 15 - 50mm deep, or <5m but >50mm deep
	Heavy >5m long and >50mm deep
	Gravel Required (tonne)
	Chainage
Other Comments (e.g. drainage works required while in area etc)	
<b>Edge Break</b>	Small >5m long and <15mm deep
	Moderate <5m long and 15 - 50mm deep
	Moderate >4m long and 15 - 50mm deep, or <5m but >50mm deep
	Heavy >5m long and >50mm deep
<b>Potholes</b>	Small <100mm diameter and <50mm deep
	Moderate 100 - 200mm diameter and 50 - 100mm deep
	Large 200 - 300mm diameter and >100mm deep
	Extreme >300mm diameter and >100mm deep
<b>Shoving/Failures</b>	Area <1.5m <sup>2</sup> and depth 15 - 50mm
	Area <1.5m <sup>2</sup> and depth >50mm, or area >1.5 <sup>2</sup> and depth 15 - 100mm
	Area >1.5 <sup>2</sup> and depth >100mm
<b>Rutting</b>	Moderate <4m long and 15 - 50mm deep
	Moderate >4m long and 15 - 50mm deep, or <4m but >50mm deep
	Heavy >4m long and >50mm deep
<b>Bitumen Surface</b>	Small area <10m <sup>2</sup> of flushing / bleeding
	Large area >10m <sup>2</sup> of flushing / bleeding and area is stripping
	Small area <10m <sup>2</sup> of crocodile cracking
	Large area >10m <sup>2</sup> of crocodile cracking
<b>Obstructions and Substances on Road</b>	Small sized object <100mm (e.g. loose screenings)
	Medium sized object 100 - 200mm
	Large sized object >200mm
<b>Spilled Materials on Road</b>	Spills of fine granular materials
	Small spills of oil, wet clay or other slippery substance
	Large spills of oil, wet clay or other slippery substance
<b>Signage and Roadside Furniture</b>	Warning Signage in poor condition or missing
	Regulatory/Hazard Signage in poor condition or missing
	Comments (e.g. type of sign missing, type of furniture damaged)
<b>Guide Posts</b>	Guide posts missing/damaged (not urgent)
	Guide posts missing/damaged (urgent)
<b>Vegetation</b>	Grass / weeds in gutters or traffic islands
	Vegetation regrowth spraying required
	Roadside slashing required
	Side arm slashing required
	Heavy vegetation encroaching on to the roadway
	Heavy vegetation restricting visibility
Hazardous trees requiring removal	



# Appendix G: GRC Inspection and Prioritisation of Reseals



## INFRASTRUCTURE SERVICES

### INSPECTION & PRIORITISATION OF RESEALS

#### 1. PURPOSE

The purpose of this procedure is to document the system for inspection of sealed roads, footpaths and carparks and set priorities to develop a reseal programme.

#### 2. SCOPE

This procedure applies to all Gympie Regional Council maintained sealed roads, carparks, footpaths and other sealed areas.

#### 3. RESPONSIBILITIES

##### 3.1 General Manager – Construction and Maintenance.

The General Manager Construction and Maintenance shall establish and maintain a system for ensuring inspections are completed.

##### 3.2 Technical Officer – Capital Works

The Technical Officer Capital Works carries out inspections.

From information gathered, the Technical Officer, Road Asset Maintenance Manager and the Road Asset Construction Manager shall prepare an annual reseal program based on priorities from the inspections and funds allocated to the reseal program. Liaise with the Design Branch in development of the program. This program is presented to the General Manager Construction and Maintenance for his endorsement.

##### 3.3 Road Asset Construction Manager

The Road Asset Construction Manager is responsible for ensuring that the endorsed reseal program is delivered.

#### 4.0 PROCEDURE

##### 4.1 General

Inspections shall be carried out on sealed Council facilities at least every 3 years. Information on Councils reseal condition spreadsheet is reviewed and updated as necessary. The priority rating shall be determined using the following criteria:

- Rating 1
- Extremely Urgent. Requires inclusion in the immediate program.
  - Road surface badly stripped. Little or no screenings
  - 20% of pavement showing through seal



## INFRASTRUCTURE SERVICES

### Rating 2

- Urgent. Requires inclusion in program
- Severe stripping. Top layer of screenings missing
- Bottom layer of screenings sparse
- Small areas of pavement showing through seal

### Rating 3

- Moderate. Should be included in program if funds permit
- Flush surface
- Moderate loss of top layer of screenings
- Seal approaching 10 years in age

### Rating 4

- Fair. Monitor. Does not warrant inclusion in a current program
- Surface has good adhesion qualities
- Minor wear of surface layer
- No immediate action required.

### Rating 5

- Good – relatively new. Monitor
- No wear evident
- No action required.

5.2 Spray rates for bitumen surfaces to be determined in accordance with the current AAPA sprayed seal design guide

## 8. REFERENCES

<a href="#">ISW1060</a>	Sprayed Bituminous Surfacing
<a href="#">ISW1122</a>	Surface Correction with Asphalt
<a href="#">ISW1126</a>	Surface Sweeping