University of Southern Queensland

Faculty of Engineering and Surveying

INVESTIGATION OF PAVEMENT DESIGN FOR LOW VOLUME RURAL ROADS

A dissertation submitted by

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Abstract

This paper identifies a 'best practice' key criteria for Low Volume Rural Road pavements within Australia. The criteria have been established by comparing and critically evaluating existing practises undertaken by Local Government Authorities.

The evaluation was undertaken after surveying numerous Councils across Australia focusing on their current practises relating to Low Volume Rural Road Pavements. A total of Fourteen Councils have been surveyed from Australia and the responses to the survey form the basis for concluding the results in relation to the Low Volume Rural Road pavements.

Low Volume Rural Road pavements are pavements which cater for traffic volumes up to 200 vehicles per day. The pavement may be formed or unformed depending on its location and serviceability requirements. It may consist of various types of materials and may be sealed or unsealed depending on the situation. Materials and the pavement structure may consist of an earthen / in-situ material, a gravel layer with no seal, a gravel layer with a spray seal or a gravel layer with an asphalt wearing course. No single road pavement is identical to another as many variables influence the pavement structure and performance.

Low Volume Rural Road pavements are presently designed, constructed and maintained with limited regard to reference material and accepted design guidelines. This is as a result of budgetary constraints and a misconception that the processes relating to a Low Volume Rural Road pavement can be undertaken with an ad-hoc approach as the pavement is not a critical asset.

The reference material and guidelines relating to Low Volume Rural Road pavements are easily divided into separate key elements. This enables comparison and critical

evaluation to be undertaken in terms of each element, to conclude an overall 'best practice' for the pavement system in its entirety. Recommendations for further research into some of these design elements are presented due to conflicting information in the publications reviewed or a lack of information.

A 'best practice' key criteria guideline has been concluded. It shares many similarities to some of the existing design guidelines, giving it some merit. Field testing, and practical application is recommended to research its effectiveness.

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Glossary

Annual Average daily Traffic (AADT) and Average Daily Traffic (ADT)	This is the total annual traffic in both directions divided by 365. Hence it is an average 24 hours daily traffic volume. This statistic usually includes motorised and non motorised traffic in rural roads.
Aquaplaning	Occurs when a tyre is completely separated from the road surface by a film of water.
Base	The course of the pavement which supports the surfacing. It may consist of granular, cement or bituminous material which has specific properties. It may comprise more than one layer.
California Bearing Ratio (CBR)	The ratio expressed as a percentage between a test load and an arbitrarily defined standard load. The test load is required to cause a plunger of standard dimension to penetrate at a specified rate into a specifically prepared soil specimen.
Commercial Vehicle	This category comprises the main types of vehicle that damages the pavement. This usually includes; medium trucks (2 axle with twin rear tyres), heavy trucks (greater than 2 axles) and large buses (with greater than about 40 passenger seats).
Controlled or Improved Subgrade	A controlled subgrade layer is material that is located above the lower subgrade.
Course	One or more layers of the same material within a pavement structure.
Design Period	The service life of a particular pavement element before replacement is required. For example; the fatigue life of a concrete or asphalt layer, the terminal rut condition for a subgrade, or the life before excessive oxidation of a bituminous surface layer.
Design Traffic	The number of standard axle load repetitions in one lane that are equivalent in destructive effect, to the total number of repetition of the actual axle using the pavement during the assessment period. The design traffic is given in terms of the equivalent standard axle (ESAs), for subgrade damage and the number of standard axle repetition and the number of standard axle repetition for asphalt and cemented material fatigue.
Equivalent Standard Axle (ESA)	The number of standard axle loads that are equivalent in damaging effective on pavement

	for a given vehicle or axle.
Environmental Factors	Environment factors exclude load-applied stresses but include stresses, strain, change in properties and effects and damage resulting from subgrade volume change, subgrade settlement, and temperature and moisture variation.
Functional Requirements	Requirements that define the service provided to the vehicles using the pavement such as width, radius, grade, cross-fall, roughness, skid resistance, surface texture, delineation, visibility, and flood immunity etc.
Layer	The portion of a pavement course placed and compacted as an entity.
Low Volume Rural Road	A road constructed of earthen or gravel material which is sealed or unsealed which caters for traffic volumes of up to 200 vehicles per day.
Modified Materials	Granular material to which a small amount of stabilising agent have been added to improve their performance (e.g. by reducing plasticity) without causing a significant increase in structural stiffness. Modified materials are considered to behave as unbound material.
Pavement	The portion of the road including shoulder, placed above the subgrade which supports and forms a running surface for vehicular traffic.
Roughness	The roughness of the pavement surface in counts/km as measured by Roughness Meter.
Shoulder	Is a reserved area by the verge of a road.
Standard Axle Repetition	Number of standard axle repetition (or passages of the standard axle) that cause the same amount of damage on the particular pavement material as a single passage of the particular axle group.
Subbase	The portion of pavement between the base and subgrade, it may comprise more than one layer or more than one course.
Subgrade	The prepared formation on which the pavement is constructed.

1 Introduction

The purpose of this report is to describe the investigation undertaken relating to the design, construction, maintenance and environmental impacts of Low Volume Rural Road pavements. From the investigation a number of conclusions are drawn relating to these types of pavements and the practices undertaken in relation to them.

To achieve the aim background information was reviewed with not only an Australian focus but an International focus to ascertain information relating to the current pavement design methods used, the current materials that are used and how construction and maintenance is undertaken on Low Volume Rural Road pavements. This investigation is important as roads are a vital link between communities. This critical infrastructure plays an important part in sustaining the local economy, as well as improving many social aspects and the quality of life of communities. Rural roads are regarded as an import asset in Australia as they provide a transport freight route and allow a connection between areas of interest for society. Since the early 1920's, State Road Authorities (SRA) and Local Councils have been consistently increasing road expenditure to maintain these rural road links to increase performance requirements related to an expanding population. Road freight in Australia has increased dramatically since the 1980's and will continue to increase exponentially into the future. This increase in vehicular traffic and road freight required to service the growing population places significant pressure on the Local, State and National Authorities to design, construct, and maintain all roads to a high standard to allow adequate serviceability and performance.

After reviewing the background information, a survey was produced and applied to a number of Australian Councils located in various states and territories. The survey consisted of numerous multiple choice and short response answer questions to allow the reader to complete the survey within a minimal timeframe. The survey questions were direct in nature requesting information from the respondent regarding the practises that they or their Council undertake in relation to Low Volume Rural Road pavements. The survey responses were analysed to determine the range of practises that are being

undertaken. The survey responses were collectively reviewed to allow for a comparison between each Council and state and also a comparison against the published literature.

The importance and cost of Low Volume Rural Roads makes adequately managing them an onerous task. All roads are an expensive asset. Road pavements in Australia and New Zealand are valued at approximately fifty billion dollars, this relates to approximately one third of total road works infrastructure value. The construction and maintenance works on road pavements in Australia and New Zealand costs approximately three billion dollars per year, or approximately half the total road expenditure (Austroads, 2002). This significant cost highlights the significance of roads in Australia and New Zealand and the benefit gained if improvements and synergies from improving the practises relating to the design, construction, operation, and maintenance of Low Volume Rural Road pavement can be achieved.

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2 Background Information

The design, construction, and maintenance of Low Volume Rural Road pavements vary depending on their geographic location, service requirements, functionality and the level of funding provided. The processes, methods, and materials used to construct Low Volume Rural Road pavements in Australia is vastly different to the processes, methods and materials used in other locations, such as less economically developed countries, due to a number of variables including funding, service requirements and availability of material. Rural roads make up a large portion of roads within Australia, thus investigation in developing technologies relating to rural road pavements is becoming increasingly important. The performance of Low Volume Rural Road pavements is largely dependent on the quality of available materials, the local environmental conditions, maintenance policies, resources and funds.

Low Volume Rural Road's differ from major arterial roads and highways in countless ways. The most obvious differentiation is that traffic volumes are much higher on a major arterial road than a rural road. Because of the increased reliability required for a major road a greater level of funding for research and development is provided to investigate the planning, design, and construction of major sealed arterial roads. A rural road is just as important but due to its classification and functionality much less development and research capital has been invested in the planning, design and construction guidelines for rural roads especially Low Volume Rural Roads.

The varying nature of Low Volume Rural Road pavements results in minimal design criteria set and enforced for:

- horizontal and vertical geometry,
- drainage requirements and immunity,
- type of materials,
- minimum thickness of material layers,
- cross sectional width including lane widths, shoulder widths,
- verge requirements,
- site widening

- maximum and minimum cross falls,
- aquaplaning requirements, and
- line marking and signage.

The criterion that is documented relates to rural roads and not Low Volume Rural Roads. This makes it difficult to apply a reliable criterion to a Low Volume Rural Road, as the classification and functionality of these types of roads are diverse. The guidelines are not authoritative to the functional requirements of Low Volume Rural Roads and design exceptions and variations are common for Low Volume Rural Roads, unlike the more controlled and regimented major arterial roads.

A Low Volume Rural Road pavement is often designed and constructed using local knowledge and available materials. Depending on the classification of the Low Volume Rural Road the standard of the final asset achieved during the design and construction of the pavement will vary. The design and construction of a Low Volume Rural Road pavement incorporates the same basic principals as a major sealed pavement, however the use of the in-situ soils as the subgrade or wearing course and the use of locally available materials in the sub-base and wearing course occurs to reduce costs. Although Low Volume Rural Road pavements are less travelled than a highway, Low Volume Rural Roads still need to meet adequate standards and provide a safe environment for the motorists commuting on them. Generally, local controlling authorities do not enforce stringent design and construction criteria due to the perception that Low Volume Rural Roads are not critical for the continuing functionality of the local road network. As a result less emphasis is focused on achieving the desired outcomes of a Low Volume Rural Road pavement.

The construction of a Low Volume Rural Road pavement is generally undertaken using machinery that is readily available with the use of local materials. Limited testing is undertaken during the construction compared to a major arterial road which directly affects the design life and performance of the newly constructed pavement. In less economically developed countries materials used in the pavement of a Low Volume Rural Road vary. Stones, cobbles, and clay pavers are common materials that are

substituted into the Low Volume Rural Road pavements to provide a traversable surface at a reduced cost. In Australia materials used consists of gravels and granular materials or the in-situ material which is compacted with the use of machinery to achieve an acceptable pavement structure. Figure 2-1 below is an example of a typical unsealed Low Volume Rural Road in Australia.

Figure 2-1: Typical unsealed Low Volume Rural Road

Published literature exists on the design, development, construction and maintenance of rural roads; however specifications and guidelines directly relating to Low Volume Rural Road pavements are limited. Compared to a National Highway, Arterial Road, or Residential Street a Low Volume Rural Road has a wide classification and varying functionality, and as a result the reference documentation is open to interpretation. There is no set standard which is consistently adhered to for the pavement design for a Low Volume Rural Road at a National, State or Local level. A Rural Road can be classified as low volume, high volume, sealed, unsealed, divided, undivided, single lane and two lane. The pavement design for the road varies accordingly for all of the above classifications.

A Low Volume Rural Road has many purposes, often the primary purpose of this type of road is to provide access. Across Australia and the world, Low Volume Rural Roads and pavements are common assets which provide a service often taken for granted by the road users. They can be sealed roads which connect townships, unsealed roads

which provide an access between farm lands, or to points of interest. A Low Volume Rural Road can connect local farmers and industry, it can be a transport route for heavy vehicles between communities and it can form an access to social and / or recreational areas. According to Bullen (2000), 'Low-cost, low-volume roads remain an essential part of the Australian road infrastructure because of the vast areas to be linked together for the good of the nation'. This highlights the importance Rural Roads and Low Volume Rural Roads play in the Australian landscape. Rural roads and Low Volume Rural Road's can help reduce poverty. A Low Volume Rural Road provides an access point reducing isolation of communities and allows for a reduction in poverty as the villagers have access to services and places of interest to suit their needs. The Ministry of Rural Development in India (2007) identifies the effect of deprivation is due to lack of rural road access, and as a result millions of villagers are suffering tragic isolation and prolonged deprivation, noting how a functional Low Volume Rural Road can benefit and positively impact local communities both socially and economically.

2.1 Low Volume Rural Road Classification

There are approximately 3,200,000 miles (5,100,000 km) of rural roads in the United States. A rough estimate places some 2,000,000 (3,000,000 km) of these in a low – volume category, as noted by Oglesby (1984).

A wide variety of definitions are used for a Low Volume Rural Road. Published literature gives varying values of average daily traffic to define a low volume road. The following definitions apply to low volume roads which results in the average annual daily traffic varying:

- Based on the traffic volume criterion, a low volume road is one that carries less than X vehicles per day (vpd). Each road agency must pick it's own appropriate number.

- Based on American Association of State Highway and Transportation Officials (AASHTO) definitions, a low volume road is one that serves primarily for land access.

- From an administrative perspective, a low volume road is any road administered by a local road agency in most circumstances.

Categorising a Low Volume Rural Road varies throughout the world, the average annual daily traffic volume (AADT) of 400 is recommended by the New York State Legislative Commission on Rural Resources (2005), this commission also classifies low volume roads based on their functionality and a breakdown of volumes to 50 vehicles per day. Similarly the Rural Roads Technical Manual of Afghanistan (2009) divides Low Volume Rural Roads into secondary and tertiary classifications with a secondary Low Volume Rural Road carrying a maximum of AADT volume of 2000 vehicles compared to an AADT of 400 vehicles for a tertiary rated Low Volume Rural Road. The World Bank (2001) specifies the cut off for Low Volume Rural Roads at 200 vehicles per day. Libo and Schelling (2000) notes that the majority of rural roads in developing countries carry traffic of less than 50 motorised four wheeled vehicles per day (vpd). Hall (2000) states low-volume roads typically carry less than 500 vehicles per day. Petts, Cook and Salter (2008) indicate that Low Volume Rural Roads have a cut off of less than 400 (vpd). The Queensland Department of Main Roads (2009) doesn't directly identify AADT for a Low Volume Rural Road; they specify suitable pavements for a range based on equivalent standard axles (ESA's). For permanent pavements the breakdown is less than 10 ESA, 10 to 100 ESA and 100 to 1000 ESA, so a Low Volume Rural Road has the potential to be classified in all three ranges.

For the purpose of this project a Low Volume Rural Road will be classified as a road with a maximum (AADT) of 200 vehicles.

2.2 Pavement

A road pavement must serve two basics functions – it must perform as an engineered structure and at the same time meet functional requirements. In terms of structural requirements, materials of sufficient quality must withstand the various loads applied to it by heavy vehicles. In terms of functional performance, the pavement must have a good riding quality and finish to ensure comfortable travel for the road user and, a surface having adequate drainage, skid resistance, reflectivity and line markings to ensure safe travel if the pavement is surfaced. The surface must also be capable of resisting both vertical and horizontal surface stresses in order to maintain its integrity. If the surface is comprised or cracked, then ride comfort is affected and water can enter the

underlying base layers. The pavement must also be capable of withstanding environmental loads, including oxidation of bituminous binders. Inherent in these demands is the need to ensure that construction and maintenance practices are adequate and suitable for the demand to be placed upon the pavement, (Austroads, 2003).

2.3 Sealed and Unsealed Pavements

Unsealed and sealed pavements are located across the entire globe. Australia has about 800,000 km of roads, and of this length about two-thirds are unsealed whilst New Zealand has about 92,700 km of roads of which about half are unsealed, (Austroads, 2009). Countries with a large geographical coverage have more unsealed roads than densely populated countries. This is a result of population spread and the need for a transport route to all locations. Unsealed rural roads are generally always classified as a Low Volume Rural Road; this is as a result of the low serviceability they provide. Table 2-1 below shows the percentage of sealed and unsealed road pavements in selected countries. This table highlights the lengths of unpaved roads compared to paved road throughout various countries.

Table 2-1 Unpaved Roads in Selected Countries

Country	Road Length	Percentage of unpaved roads in total length
Australia (1999 est.)	Total: 811,603 km Paved: 314,090 km Unpaved: 497,513 km	61.3
Bangladesh (1999)	Total: 207,486 km Paved: 19,773 km Unpaved: 187,713 km	90.4
Brazil (2000)	Total: 1,724,929 km Paved: 94,871 km Unpaved: 1,630,058 km	94.5

China (2002 est.)	Total: 1,765,222 km Paved: 395,410 km Unpaved: 1,369,812 km	77.6
Mexico (1999 est.)	Total: 329,532 km Paved: 108,087 km Unpaved: 221,445 km	67.0
South Africa (2002)	Total: 275,971 km Paved: 57,568 km Unpaved: 218,403 km	79.1
United States of America (2003)	Total: 6,393,603 km Paved: 4,180,053 km Unpaved: 2,213,550 km	34.6
India (1999)	Total: 2,525,989 km Paved: 1,448,655 km Unpaved: 1,077,334 km	42.6

(Source: CIA World Fact Book, 2005)

2.4 Low Volume Rural Road Pavement Types

Construction and commissioning of new Low Volume Rural Road pavements within Australia is rapidly reducing as more emphasis is placed on maintaining existing Low Volume Rural Road pavements and upgrading these pavements, rather than constructing new pavements. With population growth and the geographical urban sprawl that is occurring many existing rural roads are being upgraded to urban roads, industrial roads or arterial roads.

The Technical Guidelines for Agricultural and Rural Roads (1998) state 'there are three categories of roads, namely black topped, gravelled and dirt (earthen)'. A Low Volume Rural Road may first exist as an unformed track. This track is a clearing that allows a passage for vehicles to pass. No imported pavement material exists on the track; it is just the existing material / in-situ earth that forms the pavement. After such time that the serviceability of the unformed track is no longer adequate the track will be formed, and levelled to provide a greater level of serviceability. Once the track has been formed there are three basic stages of development that may be undertaken on the track. The first stage or lifespan of the track is where the formation consists of in-situ material. The formed track primary purpose is to provide a delineated access which forms a safe trafficable route. A formed track results in clearing of vegetation, and a graded geometry to allow vehicles to transverse it. As traffic volumes increase or the formed track ends its life span a gravel pavement would be laid above the subgrade (in-situ material) to provide a greater level of serviceability. The gravel layer would be specified to function under the required traffic loadings and conditions. As traffic volumes further increase or a higher level of serviceability is required, a seal would be installed to again improve the pavements structure under the increased load conditions, and provided a safer passage. Once the traffic volumes increase to a point where the seal doesn't provide adequate serviceability the Low Volume Rural Road would generally be reclassified and a new full depth pavement would be installed to suit the upgraded classification of the road. Such classifications in the road hierarchy are urban road, collector or sub arterial route. Figure 2-2 below shows an example of a sealed Low Volume Rural Road providing a high level of serviceability in undulating topography.

Figure 2-2: Low Volume Sealed Rural Road

This type of Low Volume Rural Road would be considered to be catering for traffic volumes close to the maximum AADT allowable for a Low Volume Rural Road. Low Volume Rural Road's are sealed and line marked only if there is a considerable safety risk or social need for the road to offer a high degree of serviceability and driveability.

The designation of a proposed Low Volume Rural Road pavement to be sealed or unsealed is determined by Council, or the authority that controls the road. This decision will be made by the relevant authority based on the predicted traffic volumes, the type of traffic that will use the road and the roads location with respect to the Shire's road hierarchy and network. The classification given to the Low Volume Rural Road will also constitute what pavement materials are used in the road construction. Petts, Cook and Salter (2008) note that when classifying a Rural Road various factors must be considered such as Road Standards, Road Environment, Environmentally Optimised Design, Surface & Paving Options, Whole Life Costing, Materials, Specifications and Supervision, and Maintenance. This highlights the multitude of elements that effect and contribute to the functionality of a Low Volume Rural Road pavement.

Henning, Kadar, and Bennett (2006) highlight that 'four types of engineered and un-engineered unsealed roads can be distinguished, namely unformed roads, formed roads, gravelled roads and sealed roads'. A Low Volume Rural Road pavement can be split into two distinct types, formed and unformed, after this distinction the pavement can be categorised into four main sub types.

An unformed pavement is where the pavement wearing surface is not levelled and the pavement consists of natural earthen in-situ material. The road is primarily a route where a track provides an access from one point to another. A formed pavement is where a clear track is formed and the user is able to derive that the road is safe to be traversed. Figure 2-3 below shows the breakdown for classifying Low Volume Rural Road pavements, incorporating the classifications made by The Technical Guidelines for Agricultural and Rural Roads (1998) and Henning, Kadar, and Bennett (2006).

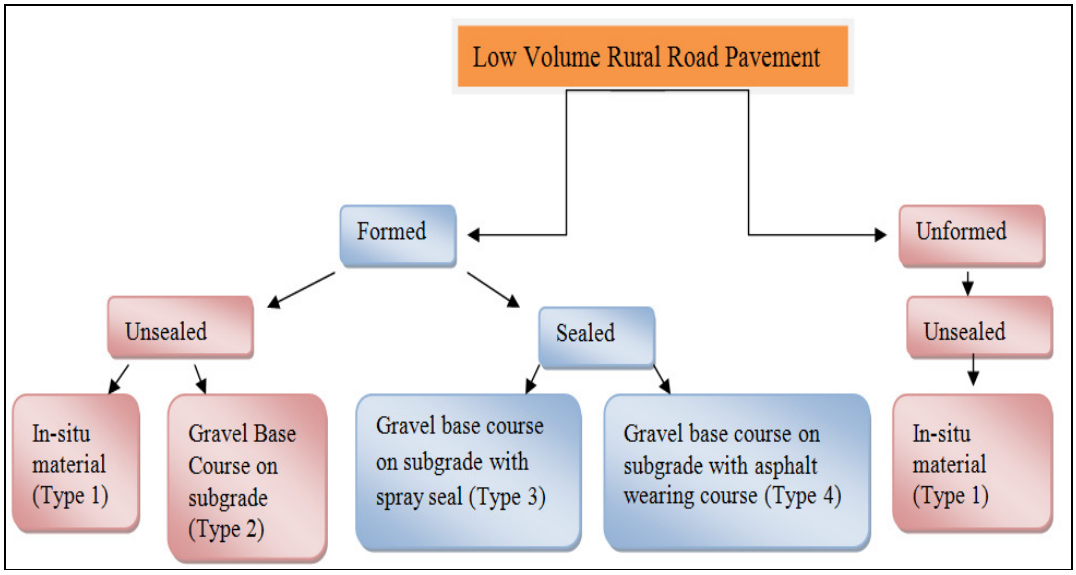

Figure 2-3: Flowchart for classifying Low Volume Rural Road's

The subtype classifications relate to the pavement properties and the serviceability that the road provides. A rural road pavement can be formed using the existing site material, in-situ material (Type 1), a gravel base course on top of an in-situ subgrade with no seal (Type 2), a gravel pavement with a spray seal (Type 3), or a gravel pavement with an asphalt wearing course (Type 4). The above mentioned types of typical rural road pavements occur based on the location of the road, the funds provided to service and maintain them, the volume of traffic that uses the road, and the level of serviceability the road is to provide. The higher the level of service the road is to provide the more in depth the pavement design and construction methods are.

Type 1 and 2 pavements are classified as unsealed pavements, this type of pavement is generally always classified as a Low Volume Rural Road pavement as the predicted traffic volumes are low and the serviceability provided by the pavement is also low. Type 3 and 4 pavements have a seal which reduces rutting and dust. Sealed rural roads provide a higher level of serviceability and increase the design life of the pavement however they are more costly to construct and repair if the pavement surface deteriorates. Type 3 pavements are common for Low Volume Rural Road's that have a high AADT or serviceability requirement. Type 4 pavements are the least utilised

pavement type for a Low Volume Rural Road as they provide a high level of serviceability and are costly to construct. This type of pavement - subgrade, base course and wearing course is more suited to urban environments and higher trafficable roadways. This type of pavement structurally mirrors the pavements used most commonly in urban environments. Type 4 pavements are only briefly discussed in this report.

Investigation into the pavement design guidelines for all four types of pavements results in a pavement design being required for rural pavements with an imported granular material only, no pavement design is undertaken for a Type 1 pavement, as the existing material remains in place.

2.4.1 Type 1 - Pavements

Type 1 pavements are always associated with Low Volume Rural Road's; they are an unsealed surface with a pavement consisting of natural materials. The existing material may be profiled and compacted to form a roadway or it can be left in place, and function as the wearing course of the pavement. This type of pavement is cheap to construct and is designed and constructed to minimal standards as the existing material is formed to match the existing topography. The importing of gravel is not required. Maintenance of the pavement surface is regularly required as a result of surface deterioration such as rutting, potholes and deformation. Type 1 pavements provide the least amount of serviceability and reliability of any Low Volume Rural Road pavement types, however in service they can provide a reliable service if traffic volumes are low, and routine maintenance is undertaken. Material grading, drainage, and geometric requirements are not generally investigated in association with the design and construction of this type of pavement. An in-situ material is not suited to undulating topography with high seasonal rainfall, due to scour and erosion problems. Figure 2-4 indicates an in-situ Type 1 pavement in central Australia.

Figure 2-4: In-situ Low Volume Rural Road pavement (Type 1)

2.4.2 Type 2 – Pavements

A gravel base course material provides a more reliable and driveable surface compared to an in-situ material. The gravel base course provides a structure which distributes loads from the traffic evenly to the subgrade improving the pavement performance. The gravel layers interlock and assist the road surface in maintaining its desired formation as the gravel is compacted and graded, improving the cohesiveness and strength properties. Type 2 pavements consist of a single or multiple gravel layers of material with a nominal thickness constructed on a prepared subgrade layer. This type of pavement is common where the AADT volumes warrant a smoother and more reliable surface then provided by an in-situ material pavement. Greater consideration into the design and construction of a Type 2 pavement is required however this is directly related to the increased construction, operation and pavement cost. This type of pavement is used in a Low Volume Rural Road environment and is not suitable to urban road pavements. Research by Petts, Cook and Salter (2008) suggests that gravel materials in a Low Volume Rural Road may not be appropriate in certain instances. For example in situations where the gravel quality is poor, compaction and thickness cannot be assured, haul distances are long eg, >10km, where rainfall is very high, where adequate maintenance cannot be provided and where the subgrade is weak or soaked. Also where the quality of construction can not be guaranteed gravel materials may not be appropriate.

2.4.3 Type 3 – Pavements

Type 3 pavements consist of a subgrade layer, base course layer and a seal. The pavement is the same as Type 2 pavement with the addition of a spray sealed bituminous coat applied to the gravel to smooth the finished surface of the pavement and provide additional strength to the wearing course. This pavement is applied to Low Volume Rural Road's and Rural Roads. The seal protects the granular material within the base course from wearing and deteriorating. Drainage, material grading and application rates are considered in conjunction with a Type 3 pavement.

2.4.4 Type 4 - Pavements

Type 4 pavements are generally not associated with Low Volume Rural Road's, unless the Low Volume Rural Road is required to provide a high level of serviceability. Type 4 pavements consist of an engineered pavement structure with a subgrade layer, base course layer or subbase layer and an asphalt wearing course layer. This type of pavement treatment is more commonly applied to urban environments.

2.5 Geometry

The geometry of the road affects the functionality of the road pavement. Various pavements are not suitable in certain situations. The road geometry standards are just as important as pavement design standards. In Australia, Austroads have published a Rural Road Design Manual which addresses preferential design standards for the geometry of rural roads. Ideally Low Volume Rural Road's should be designed in accordance with these guidelines. A typical cross section of a Low Volume Rural Road as recommended by Austroads is shown below in Figure 2-5.

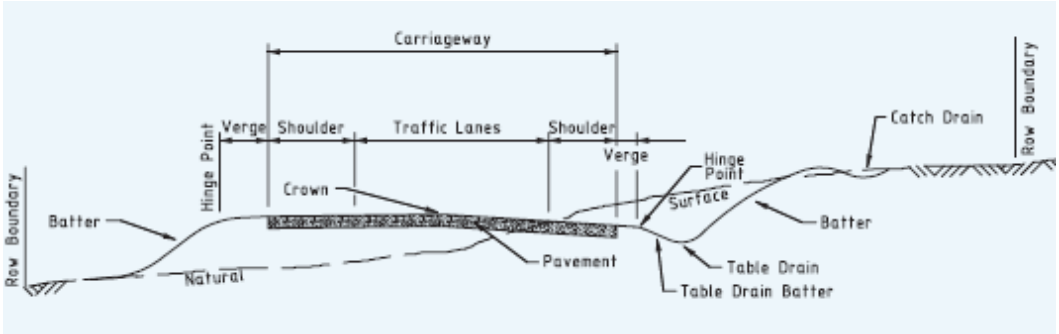

Figure 2-5: Typical Low Volume Rural Road Cross Section

Due to a wide classification of a Low Volume Rural Road, guidelines' relating to the geometrical standards and pavement standards compliance with the prescribed standards is often not achieved. Austroads publications indicate preferred geometric requirements which are outlined in Table 2-2 to 2-4 below. The minimum desirable lane width for a Low Volume Rural Road is 3.5m. These geometric guidelines are appropriate as they improve the serviceability of the Low Volume Rural Road.

Table 2-2 Recommended Cross Section requirements for Design Traffic

Element	**Design AADT**				
	1-150	**150-500**	**500-1000**	**1000-3000**	**>3000**
Traffic Lanes	3.5 (1 x 3.5)	6.2 (2 x 3.1)	6.2-7.0 (2 x 3.1/3.5)	7.0 (2 x 3.5)	7.0 (2 x 3.5)
Total Shoulder	2.0	1.5	1.5	2.0	2.5
Shoulder Seal	0.5	0.5	0.5	1.0	1.5

Table 2-3 Material Crossfalls

Type of Pavement	**Crossfall (%)**
Earth, Loam	5
Gravel, Water bound Macadam	4
Bituminous Sprayed Seal	3
Bituminous Concrete (asphalt)	2.5-3
Portland Cement Concrete	2-3

Table 2-4 Operating Speed VS Grade

Operating Speed (km/hr)	Terrain		
	Flat	**Rolling**	**Mountainous**
60	6-8	7-9	9-10
80	4-6	5-7	7-9
100	3-5	4-6	6-8
120	3-5	4-6	-
130	3-5	4-6	-

For unsealed surfaces the above value should be reduced by 1%.

The above design tables are commonly not applied to Low Volume Rural Road's, due to funding or other factors. As a result the pavements likelihood to fail is increased with the sub standard road geometry, reducing the pavements design life. The Ministry of Rural Development, (2007) states 'there is a misconception that Rural Roads being the lowest category of roads need no elaborate design and engineering.' Giummarra (n.d) highlights that the main causes of accidents are poor road geometry, low cost facilities and inadequate maintenance, and changing road surface conditions. These factors can be directly controlled by the asset owner. Asset owners often assume for a Low Volume Rural Road standards are not required to be achieved. An example of how road geometry impacts the pavement design approach adopted is where in-situ pavements are constructed on flat topography and existing in-situ pavements are not adopted for a situation where undulating topography and increased speed limits are required. This is because an in-situ pavement is prone to degradation and deterioration more quickly, increasing the safety risk to the road users. Sealed pavements are required on steep or undulating topography to allow for safer travel.

According to the Ministry of Rural Development (2007) the following principles should govern in the design of Low Volume Rural roads:

- Rural Roads are low volume facilities basically serving as an access function. The design speed and level of service expected are low. The design standards should be in harmony with such expectations.

- Geometric standards, particularly gradients, are difficult to change later, and hence should be selected carefully with the future requirements in view.

- The initial cost is an important consideration. Many roads particularly through routes will in due course carry fairly substantial traffic but it is preferable to optimise costs by stage construction in tune with traffic growth.

- A design period of 10 years is considered adequate, with rehabilitation being planned based on road condition.

- Durable and permanent assets need to be aimed at through adequate provision for drainage and protection works, and

- The maintenance of assets must receive careful attention as a policy and should not be capitalised into richer than required standards.

3 Pavement Considerations and Materials

A pavement can be classified as two distinct types a flexible pavement or a rigid pavement. Flexible pavements are used extensively for Low Volume Rural Road's as rigid pavements are constructed of concrete and are expensive to apply to the vast lengths of rural roads.

3.1 Rigid Pavements

Rigid concrete pavements are rarely associated with the design or construction of a Low Volume Rural Road pavement as a result of their construction difficulty, cost ineffectiveness and material availability. However, a rigid pavement may be considered in the design of a Low Volume Rural Road for a causeway crossing where a functional solution is required irrespective of cost. The construction cost of installing a rigid pavement for long lengths along a Low Volume Rural Road far exceeds the benefit of the structural strength and resulting design life of the pavement.

3.2 Flexible Pavements

Flexible pavements are the most commonly adopted pavement provided for a Low Volume Rural Road. There are various types of flexible pavements. The commonly used flexible pavements for Low Volume Rural Roads are detailed below.

3.2.1 Unbound Granular Pavements

For Low Volume Rural Road's the unbound granular pavements would consist of locally sourced gravel if possible, installed on top of an in-situ material forming the subgrade layer. A single layer of material would be installed on top of the subgrade to function as the base course and wearing course combined. Where a higher serviceability is required for the Low Volume Rural Road a bituminous surface treatment would be applied to the surface of the granular material.

‘Unbound granular pavements with thin bituminous surfacing form the bulk of the rural pavement network, including National highways. As a result, the volume of traffic, and traffic loads, can vary enormously and this needs to be taken into account in the selection of the most appropriate base and subbase materials’, (Austroads, 2009).

The Australian Pavement Research group Report No. 21 (APRG 1998) provides pavement thickness design curves based on ESA’s for constructing both sealed and unsealed roads of low structural integrity with granular materials. The design chart is based on the fact that there is only an 80% chance the pavement will last the required design life. The design chart is shown in Figure 3-1 below. The chart recommends regardless of the subgrade strength and resulting Californian Bearing Ratio (CBR) the minimum gravel base layer thickness of any pavement should be 100mm.

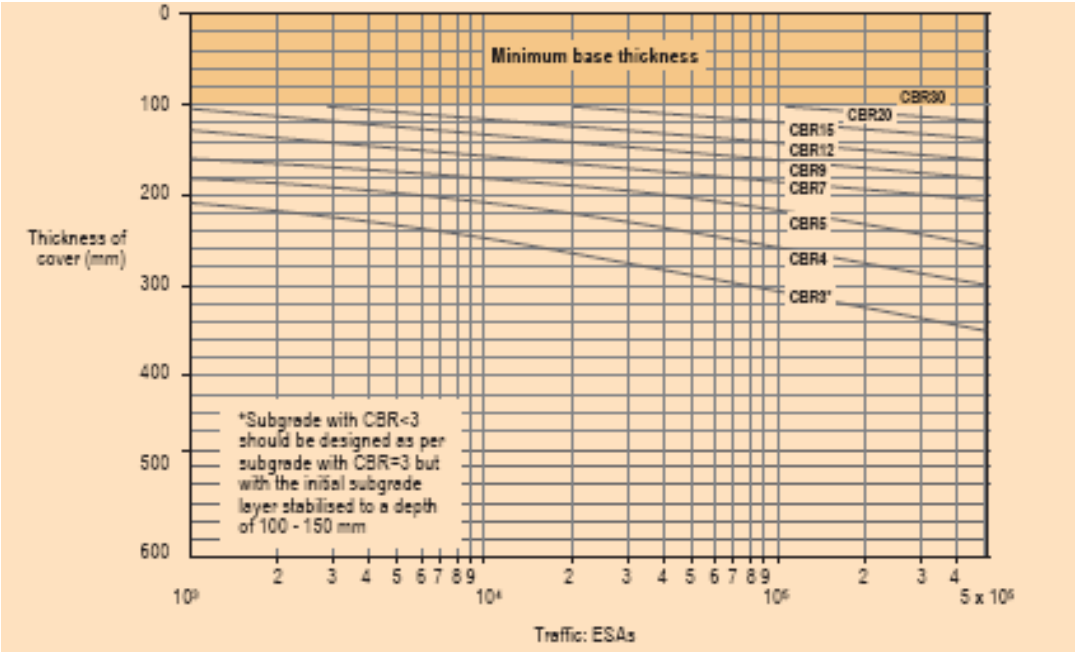

Figure 3-1: 80% Confidence Design Chart for Granular Pavements

(Source: Australian Pavement Research Group Report No. 21 (APRG 1998))

3.2.2 Stabilised Pavements

Stabilised pavements provide additional strength and durability to the pavement structure. An increasing emphasis has been placed on the use of stabilised pavement

materials in recent years. Siddique and Rajbongshi (2005) state 'through the use of stabilising agents, low quality materials can be economically upgraded to the extent that they may be effectively utilised in the pavement structure'. This is an important principle that allows for low cost materials to be modified to function as necessary as part of a pavement structure. Stabilised pavement materials are generally incorporated into the pavement structure as base courses and subbases.

Common properties which can be improved with the addition of stabilising agents are strength, volume stability, abrasion resistance, permeability, and durability. Common methods of stabilisation are granular stabilisation, lime stabilisation, cement stabilisation, bituminous stabilisation using emulsions, the use of geotextiles, and chemical stabilisation. The two most common stabilisation methods used for Low Volume Rural Road's pavements are lime and cement. The cost to stabilise granular material with these two materials is more cost effective than alternative methods.

For areas with very soft or expansive subgrades and in-situ materials such as clay or peat, deformation to a thin gravel layer would occur under load; this would increase the construction and maintenance costs while reducing the design life of the pavement. In such situations a thick gravel base or stabilisation of the subgrade would be investigated to increase the structural capacity of the subgrade, with the addition of materials such as Portland cement or lime. The stabilised subgrade allows for a thinner granular pavement to be installed providing a more durable pavement, where the potential for deterioration is reduced as the subgrades structural integrity has increased. Lime stabilisation is common, however for each material type there is an optimum lime content similar to moisture content with compaction. Where excessive quantities of lime are added to a gravel material the pavement will be adversely affected. Cement added to the base course for additional structural integrity can cause maintenance concerns. Cement stabilised materials are not as workable as lime stabilised materials resulting in construction and maintenance processes being more onerous for cement stabilised materials.

Maintenance considerations should be made with the modification by stabilisation on unsealed Low Volume Rural Road pavements. The wearing course for an unsealed pavement is the part of the pavement structure that is generally stabilised. The wearing course of the pavement is the surface which is routinely graded and reshaped which can be problematic when stabilisation agents are used.

Climatic conditions should be considered when stabilisation is considered, the conditions have an effect on the choice of the stabilisation adopted; therefore irrespective of cost the selection of the stabilisation agent is reduced. In Australia particular care must be taken when using stabilisation techniques in hot arid areas and cold wet regions.

The Ministry of Rural Development (2006) highlights in many less economically developed countries or where there is a skill shortage many lower cost technologies like soil stabilisation is not used due to a lack of appropriate mechanical devices. Such shortcomings must be removed by appropriate developments or to provide access to machineries and plant to allow for implementation of cost effective pavement alternatives.

3.2.2.1 Mechanical Stabilisation

Mechanical stabilisation is suitable where local materials with suitable grading and plasticity are unable to be sourced, by mixing two or more local materials the required plasticity and particle size distribution may be achieved. For a Low Volume Rural Road pavement this mixing is undertaken on site prior to the compaction and placement of the material. A commonly used mechanical stabilisation is the blending of granular material void of fines with a locally sourced sandy clay material to improve the strength, constructability, compaction and imperviousness of the final product.

3.2.2.2 Geotextiles

Geotextiles are an expensive stabilisation method which improves the structural integrity of the pavement exponentially. Where the subgrade consists of expansive clays or is unstable, geotextiles and geosynthetic matting can be used to provide structural

capacity. Vischer (2003) notes that there are numerous problems associated with geotextiles and their application within the pavement. The use of geotextile must be carefully considered prior to installation to ensure it will be beneficial and fit for its intended purpose. A geotextile is a propriety product composing of a woven or unwoven fabric material which provides a separation layer. The most common use of a geotextile as a stabilising agent is in areas with poor subgrade conditions or contaminated land. The geotextile separates the material layers for example the subbase and subgrade which stops fines from the subgrade leaching up into the pavement layers and also prevents deformation of the subbase from subsidence into the subgrade. Geotextiles used over soft soils increases the pavements load spread across the pavement layers and into the subgrade which improves pavement performance and provides additional structural reinforcement. Extensive subgrade distress cannot be solved by a geotextile application. The use of geotextiles in conjunction with a Low Volume Rural Road pavement is limited due to the increased cost for this type of treatment.

3.2.3 Bituminous Surface Treatments

Depending on the traffic volumes and the functionality required for the Low Volume Rural Road a bituminous surface treatment may be investigated as part of the design to improve the ride ability and serviceability of the road. A seal coat or chip seal is where a thin layer of bituminous material / emulsion is sprayed on to the gravel surface, capping the gravel course and improving the surface finish of the road. A chip seal involves spraying rapid setting emulsified asphalt onto the road surface, followed immediately by the placement of a single layer of clean, crushed gravel particles. A rubber-tired compactor (roller) is used to press the stones into the asphalt before the emulsion is able to set. Chip sealing is also used to enhance skid resistance on a slippery or undulating road. Bituminous surfacing is currently tightly specified in Australia in comparison with other countries, which indicates that certain areas of relaxation are possible. These are mostly in relation to the grading and aggregate hardness. It is has been proven that the use of modified bitumen with marginal aggregates results in lower whole of life costs for surfacing when co-ordinated and implemented correctly.

An asphalt layer may also be installed where the Low Volume Rural Road is of high importance / classification, however asphalt as a wearing course in Australia on a Low Volume Rural Road is rare but has been found to be economical overseas in certain circumstances. An asphalt layer consists a mixture of gravel aggregate and bitumen forming a black viscous material which is hot mixed together and installed above the gravel base course, this aggregate and bitumen is embedded together will the use of a roller to provide a smooth consistent surface finish.

Bitumen can also be stabilised to help the retardation of moisture absorption of the pavement. Waterproofing the pavement is advantageous however due to the high content of bitumen that is required unless the road requires a high serviceability the application of a bitumen wearing course to granular pavement on a Low Volume Rural Road is generally uneconomical.

The National Rural Roads Development Agency (2005) explains that in 'Karnataka they had used plastic blended bitumen on the roads which was proving to be very effective'. For surface treatments in India it is suggested that sealing of gravel roads should be attempted with appropriate technologies to reduce life cycle costs and be environmentally friendly.

3.3 Other Pavements and Surfaces

In locations where material sources may be limited other suitable materials are used to assist in achieving the structural makeup of a Low Volume Rural Road pavement. In economically challenged countries or isolated areas clay bricks and pavers are examples of the various materials that have been used in a road formation.

3.4 Traffic Volumes

Traffic volumes are the determining factor when designing a pavement for a rural road. Along with the subgrade strength the traffic volumes which are not as deterministic as the CBR values dictate the depth of pavement required. The higher the volume of

traffic, the greater the serviceability required from the pavement. Increased volumes mean that material properties and thicknesses are changed to suit the operating conditions of the pavement.

The Queensland Department of Main Roads Pavement Design Manual sets out designs for pavement thickness based on the average equivalent standard axle (ESA) on the design lane. Based on this classification the manual states what material properties should be achieved. This relates to spray sealed pavements only. Below is a summary of Main Roads classification of acceptable spray sealed rural roads surfacing relating to their predicted traffic volume.

Table 3-1 Pavement Type Application – Queensland Main Roads

Type	**Location**	**Average daily ESA in design lane in year of opening**		
		<10	**10 to < 100**	**100 to < 1000**
Permanent	Rural	SG(D) AG(C)	SG(C) AG(C)	SG(B) AG(A-C)
Abbreviation	Pavement Properties			
AG(C) AG(A-C)	Asphalt over granular pavement. AG(A-C) can be any standard that suits the circumstances, including budget and whole of-life costing.			
SG(B) SG(C) SG(D)	Spray sealed granular pavement			

As seen in Table 3-1 numerous pavement types can be specified for numerous traffic numbers and conditions.

The deterioration of a pavement is not highly impacted on by light vehicles. Heavy vehicles, commercial vehicles with dual axles, and overloaded vehicles have a greater impact on the design life of a pavement. The (ESA) pavement design method with the use of empirical charts is commonly used throughout Australia. It requires traffic counts to be undertaken, and a ratio of light to heavy vehicles to be determined. The design life of the pavement must also be specified. Once the above criteria has been specified a range of pavement thickness can be determined based the on the CBR value of the

subgrade. The range is analysed to result in the most economical pavement design. This method is the prescribed method in the Austroads manual which forms the National guidelines for Australia and New Zealand.

3.5 Materials

The selection of the correct material for the construction of a Low Volume Rural Road pavement is critical. The more onerous the selection process for the material and the appropriateness of the material selected the higher quality the resulting pavement will be. Low Volume Rural Road pavement materials are often sourced on site or locally for Type 2, 3 and 4 pavements. The material used for a Type 1 pavement is the natural onsite material or earth. In rural regions it is common that natural gravels or rocks are sourced from local deposits to provide materials for the construction of sealed and unsealed roads. The locality and identification of these materials is carried out by qualified experienced personnel such as geotechnical engineers. Examples of such materials are steam gravel, ridge gravel, and granitic sands found in transported deposits and residual deposits.

Recognition that a Low Volume Rural Road is essentially low cost road, the specifications for pavement materials for various thicknesses and layers should be as economical as possible, but still consistent with the traffic expected to use the road and the climatic conditions to allow the formation to be able to function as desired. Local materials which are cheaper, easy to source and involve minimum haulage should be used to the maximum extent feasible for Low Volume Rural Road pavements. The Ministry of Public Works and Transport (2008) state that 'the Low Volume Rural Roads principles require that as much use as possible should be made of locally available materials and the least use of more expensive high quality pavement materials, particularly where these have to be hauled long distances'. The use of locally available materials in Low Volume Rural Roads can result in significant cost savings. However, associated with the cost saving is an increased risk of distress or failure. Thin pavement structures which make the maximum use of the in-situ and local materials can provide satisfactory performance provided the drainage and construction quality is well controlled. Emery, Cocks and Keeley (2007) identify that many materials have been

used that do not meet conventional selection criteria but still give satisfactory performance. Their choice is based on locally developed selection criteria, non-standard testing, and attention to construction technique. Any unsatisfactory undertaking of these processes results in a sub standard pavement.

Hockly (n.d.) found that revising the methodology of the pavement design and construction methods delivered outcomes of strong durable pavement with good size aggregate and greater efficiencies and significant cost savings were achieved. This highlights the need for an appropriate analysis on the pavement design and materials to be undertaken to deliver desirable outcomes.

3.5.1 Wearing Course

The selection of the wearing course material is an important process in the pavement design of a Low Volume Rural Road. The selected material should have cohesive properties to bind the wearing course together. The material should have low permeability, a high skid resistance, a resistance to rutting and scouring and good load distribution properties.

To assist during the construction and maintenance of the road pavement the surface material should allow for easy compaction and grading. The determining factor when selecting a material is the particle size distribution (PSD), as it indicates the fractions that pass through various sieve sizes which is an indication of how the material may behave and perform. For a wearing course the percentage passing through a sieve should be 100% for a 26.5mm sieve, allowing for ease of construction. This sieve size may be reduced to 20mm without largely affecting the quality of the final product in areas where gravel is not easily sourced or readily available.

A soil consisting of a well graded gravel sand mixture with a limited amount of clay fines is the most desirable material for an unsealed wearing course surface on a Low Volume Rural Road. The material makeup allows the particles to bind together providing a smooth riding surface which is easy to construct and maintain, is durable,

resistant to rutting and scour and has less permeability compared to other gravel materials.

Different types of materials other than gravels may be used for surface dressing and wearing courses of pavements. Third world countries and economically disadvantaged societies often use local stones, clay and brick pavers as surface dressings. Lebo and Schelling (2000) highlight the potential uses of various types of materials and identify situations and conditions were the types of materials are acceptable. Refer to Appendix B for details.

In the selection of a pavement wearing course, the determination of sealing the road is dictated by the controlling authority and the level of service that the road is to provide. Archondo-Callao (1999) identifies under certain circumstances, 'paving of unpaved roads may be economically justified'. By paving an unpaved road there are many benefits both physical and social, and consideration into the surface finish of the road is a key component to the overall functioning of the roadway. International Road Federation (2009) notes that 'commercial additives can contribute to reduced gravel loss, but traditional construction using thin bituminous seals has a lower whole life cost'.

3.5.2 Base Course

The base is the main 'load carrying' course within the pavement. 'An unbound base course is composed of materials which are granular or mechanically stabilised or treated with binders to improve properties other than strength (e.g. plasticity). An unbound base course therefore behaves under load as if its component parts were not bound together although significant mechanical interlock can occur. In the majority of cases an unbound granular base course is provided under a sprayed seal surfacing', (Austroads, 2009).

The specification requirements for base course materials on Low Volume Rural Road's are broader than sealed roads, because of the vast types of materials that are used. The

basic principles that need to be achieved are particle size distribution, shape of the material, plasticity of the material, and the aggregate hardness. The above mentioned properties influence the behaviour of the material more than any other property.

The particle size distribution is important because it indicates how the material will interlock and achieve the required strength properties. The particle size distribution also controls how permeable the pavement will be, if the source material is all large rounded gravel the resulting base course will be permeable and not suitable. See Section 3.5.1 and Figure 3-2.

The shape of the gravel affects the interlocking ability of the gravel and impacts on the constructability of the material. The desirable shape of gravel used in the base course material is cubical with jagged edges. Smooth well round gravels and flat flaky gravels do not interlock well and are problematic to construction and maintenance processes as they are hard to compact and grade. Angular stones with sharp edges are also not desired as they can be hard to compact and they affect the driveability of the surface; sharp edges protruding from the pavement have the potential to damage vehicle tyres.

Well graded gravels consisting of smaller fines within the material provide the most cohesive pavement structure. The fine particles assist in interlocking the pavement and when the pavement is subjected to wet conditions the structure is not undermined, this cohesive strength helps hold the pavement together in dry conditions. This effect relates to the plasticity of the material. The plasticity of the pavement is an important property as a pavements ability to maintain its shape under wetting and drying conditions improves the pavements durability and reduces the future life cycle costs and maintenance costs.

The gravel on a Low Volume Rural Road is subjected to various loads and the aggregate hardness is a gavel property to ensure it will not breakdown, decompose under construction, or under the load conditions in service. If the base course is acting as a

wearing course, e.g. unsealed pavement, the aggregate strength must be such that it will not breakdown under exposed conditions and loadings.

For a Low Volume Rural Road pavement generally a higher emphasis is placed on material availability rather than the material properties. For the classification of materials and the particle size distribution of the materials, under load conditions and where their applications are suitable is shown in Figure 3-2 below.

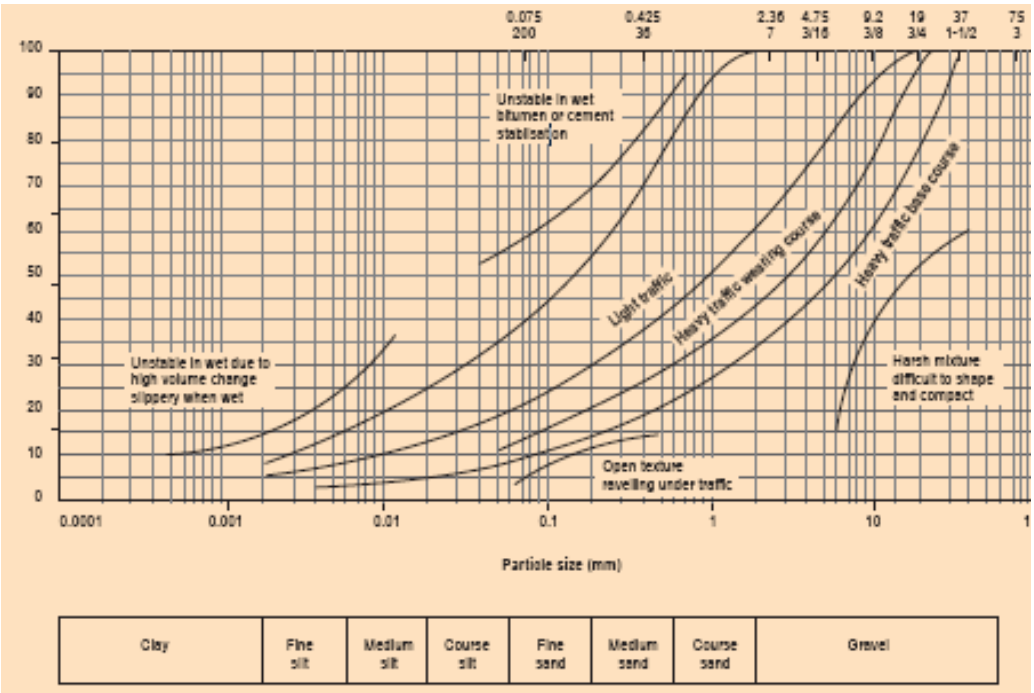

Figure 3-2: Properties of Mechanically Stable Gradings

(Source: Wooltorton (1947))

As noted by Emery, Cocks and Keeley (2007), many countries have locally available granular materials which are an important source for the base course and subbase in the construction of flexible pavements. This integration of local materials can be achieved by understanding the materials properties and using graphs such as the above to determine the materials appropriateness for the situation.

3.5.3 Subgrade

The subgrade material is the in-situ material that the pavement base or subbase is constructed on. The subgrade material is a critical part of the pavement layers as the strength of the subgrade determines the thickness required for the preceding gravel layers. The Ministry of Public Works and Transport (2008) state 'the minimum sub-base strength requirement for LVRR roads is a soaked strength of CBR of 25%'. This is to ensure that the subgrade has adequate strength to support the proceeding pavement structure.

Rural roads are often built on minimally prepared subgrade, which can lead to subgrade failure resulting in fatigue cracking and depression. Special attention should be paid to questionable subgrade areas and nearby fill embankments than may erode causing an edge depression or failure. For this reason adequate subgrade testing must be undertaken during the design and construction of the pavement to ensure that maintenance is minimised throughout the design life of the pavement.

3.6 Recycled Materials

With the environmental considerations in modern society and the need to reduce landfill and waste, numerous recycled materials have been identified and utilised as substitute materials for use in the implementation of Low Volume Rural Road pavements with success. Vedula (2005) states that 'conventional methods and specifications tend to recommend technology and materials, however difficult and distance away they may be, which normally results in higher cost of construction'. This mindset needs to be challenged by developing processes to allow alternative materials to be used in Low Volume Rural Road pavements. With innovative design many low cost materials could be incorporated into Low Volume Rural Road pavements.

Natural aggregate is a limited resource and it is becoming more difficult to source and transport the aggregate as required. Heng, et al., (n.d.) discusses the idea of using roads as a "linear landfill" is not universally attractive because of the concern that undesirable materials may end up in the recycled aggregate that may compromise the quality of the

road pavement but this may be an option for future road pavements with further investigation into suitable materials.

This innovative and forward thinking is highlighted by the Ministry of Rural Development (2006) identifies that low cost marginal and industrial waste materials may be promoted for rural road construction. This authority (Ministry of Rural Development) has taken the necessary steps to start to develop relevant design guidelines and specifications to allow appropriate waste materials to be used in applicable situations in the future within the road pavement. This will reduce landfill if these technologies are viable.

The use of recycled materials has occurred for numerous years. Stones, rocks and used pavers have been used extensively in Low Volume Rural Road pavements. The Ministry of Rural Rehabilitation and Development, Afghanistan (2009) notes 'packed stone paving is an example of a recycled material and consists of a layer (typically 200 – 300mm thick) of large broken stone pieces, tightly packed together and wedged in place with smaller stone chips rammed by hand into the joints using hammers and steel rods. The remaining voids are filled with sand. The hand packed stone is normally bedded on a thin layer of sand/gravel. For use by heavy traffic, the layer should be compacted with a vibrating or heavy non-vibrating roller. An edge restraint or kerb constructed (for example) of large or mortared stones improves durability.

Full depth pavement reclamation is an example of recycling, and consists of utilising the existing pavement materials to construct a new pavement. Heng, et al., (n.d.) recommends this as a variable alternative as the worn pavements are reused and re-laid with the addition of additives, and an adopted construction process. This process minimises the construction vehicles required to install a new pavement and negates the need for the existing pavement material to go to landfill, which benefits the environment.

Recycled asphalt in the form of crushed slab asphalt or asphalt planings has been used as an unbound granular subbase and basecourse material on minor roads and as a low dust surfacing in unsealed road applications, (Austroads, 2009).

Slag, fly ash and ash are also commonly used in pavement materials to supplement the material makeup. These types of additives have been trialled and tested and are regularly utilised in pavement construction. Austroads (2009) recalls that 'approximately 13 500 000 tonne of coal combustion products were produced in Australia and New Zealand in 2006/2007. Of this, about 3 680 000 tonne (27%) was used in projects offering some beneficial use for pavements (e.g. mine site remediation, local haul roads, etc.)'. These additives if readily available should be incorporated into Low Volume Rural Road pavements, to supplement materials and reduce waste.

Alternative technologies have been investigated and materials such as Fuijibeton as a stabilisation mechanism have been used. Vedula, Nath, and Chandrashekar, (2005) note that 'with faster setting and improved CBR of stabilised soil, the pavement due to speedier construction practices, is economical and also effective under constrained traffic conditions'. Terrazyme is another developing alternative technology where a bio-enzyme product improves the strength qualities of soil reducing ruts and potholes which results in a more durable road pavement. Vedula, Nath, and Chandrashekar, (2005) reports the 'advantages of Terrazyme Technology to be considerable improvement in soil CBR, minimum loss of gravel due to erosion or abrasion by the traffic preserving original transverse section of slopes, it also impedes the widespread occurrence of dust from loose fine material on the road surface'.

Recycled material such as glass can also be used a substitute material within road pavements. Austroads (2009) states 'Glass cullet can be used. This glass material is a hard, granular material that can be used as a fine aggregate when crushed. In terms of its physical and mechanical properties, crushed glass cullet behaves in a very similar manner to sand; having a similar particle density'. The use of glass in place of sand can have economic benefits especially when sand material can not be sourced locally.

3.7 Drainage

The consideration of drainage requirements when designing a Low Volume Rural Road pavement is an important design issue. The Technical Guidelines for Agricultural and Rural Roads (1998) highlights this issue indicating adequate drainage is an important requirement. The main factor that impacts on the drainage design is the proposed geometry of the road. Low Volume Rural Road pavements are constructed as close to the surface level of the surrounding topography as possible to assist in draining the pavement surface and cut to fill earthworks balance. Pavements that are constructed on high fill embankments or in cut are prone to deterioration and scour in rainfall events which results in higher costs for maintaining the road pavement. The geometrical location of the Low Volume Rural Road should be such that the existing surface flow regime is not adversely impacted.

3.7.1 Surface Drainage

The surface drainage is dictated by the horizontal and vertical geometry of the road alignment. The surface of the pavement requires adequate cross fall to allow runoff to sheet off the pavement surface not to cause a hazard. The cross fall of a pavement is generally between 2% and 5% and can be two way cross fall or one way cross fall depending on superelevation and the road location. Without adequate cross fall on the pavement surface localised ponds occur in the ruts or deformations of the wearing course and this ponded water has the potential to infiltrate the pavement layers and jeopardise the pavements structural properties, contributing to pavement deformation. Drainage channels are advised to be installed on either side of the road pavement to intercept runoff preventing the ingress of water into the pavement layers. The channels divert runoff longitudinally away from the pavement to appropriate discharge points.

3.7.1.1 Cuts

In areas where the pavement has been constructed in a cut, a drainage blanket could be installed under the subgrade material to allow the excess water from the saturated soils to pass under the road. This blanket is constructed using large stones and is porous. It is

preferred to limit the construction of pavements in cuts as the road surface acts as a drainage channel without the installation of appropriately sized drainage structures.

3.7.1.2 Fills

Low Volume Rural Road's constructed in fill are not advised because the road and pavement act as a levee to flows as the surrounding terrain is flat and lower than the embankment. The material volumes are also increased when constructing a pavement in fill, as it requires larger quantities of imported material. The preferred solution is to construct a pavement where the cut to fill balance is negligible. A pavement on fill is prone to scour and failure in large rainfall events. The runoff infiltrates the fill or gravel materials that constitute the pavement layers as they have porous properties and the material becomes unstable, dislodges and a failure occurs. If the Low Volume Rural Road pavement was constructed above the natural surface level adequately sizes drainage structures such as culverts should be installed to provide the road with an acceptable level of flood immunity.

3.7.2 Subsurface Drainage

Subsurface drainage is not installed as part of a Low Volume Rural Road pavement as the cost of installing subsoils drains outweighs the benefits. Subsurface drainage may be considered in areas where there are poor subgrade conditions or where the water table is high and close to the surface.

3.7.3 Floodways

Crossing natural watercourses and floodways is unavoidable in certain situations. Cost implications drive the design solution proposed to cross the waterway. Types of crossings provided can vary; a concrete bridge structure is the preferred solution however is extremely costly and often impractical for Low Volume Rural Road operation. Timber bridges, drainage culverts and concrete floodway's are more commonly utilised in conjunction with Low Volume Rural Road's. Timber bridges can provide the same immunity and functionality as a concrete bridge however they are less durable and provide a lower serviceability. India's Ministry of Rural Development (2007) states 'timber bridges were popular for low volume roads in the past in states like Jammu & Kashmir, Himachal, Pradesh and the NE region. However, many of these

bridges now need replacement for enabling movement of heavy vehicles. Besides, the availability of timber for future bridging programme is uncertain because of the national priority to conserve forests'. This highlights the constant consideration of external factors when deciding what treatments to adopt in relation to Low Volume Rural Road's. Culverts are commonly installed in watercourses however are costly to construct.

Where the Low Volume Rural Road traffic volumes are low a concrete floodway may be warranted where a concrete pavement is constructed to allow the vehicles to transverse the crossing. This type of crossing should only be provided where the crossing is dry and traversable for long periods of the time. In areas where the crossing is tidal or wet regularly a bridge or culvert would be a preferred solution. The Technical Guidelines for Agricultural and Rural Roads (1998) states 'Rural Roads will have single lane bridges'. This approach is narrow minded as optimum design solutions for structures traversing water ways should be found as single lane bridges do not result in an economical whole of life cost in all situation. Figure 3-3 below shows a culvert failure on the Low Volume Rural Road.

Figure 3-3: Culvert Failure on a Low Volume Rural Road

4 Pavement Designs

India's Ministry of Rural Development (2007) identifies that 'considerable amount of work has been done on the pavement design of Low Volume roads internationally'. This relates to large amounts of research undertaken relating to the design of Low Volume Rural Road pavements. Of these, the following design references provide comprehensive analyses are:

- American Association of State Highway and Transportation Officials (AASHTO) design curves for low volume roads.
- Australian pavement design curves for low volume roads, and
- Chinese pavement design curves for unsurfaced low volume roads.

AASHTO design curves have evolved after extensive observation and testing of performance of roads under various climatic conditions and traffic load repetitions. In the United States of America experience shows that up to 100,000 repetitions of standard axles, gravel roads can be considered, and for traffic less than 10,000 repetitions earth roads are suitable.

The above National Authorities have initiated research projects on pavement performance, for existing in service pavements. Tests covering the diverse climatic conditions prevailing in each country, the soil types available, and the maintenance procedures used have allowed detailed results to be extracted. With these results, modifications to the existing design procedures and practises can be made.

The pavement design approach varies between countries, states and townships. Two adjoining Councils in the same State will not always have a consistent design approach to pavement designs for a Low Volume Rural Road pavement. The commonly used design approaches for Low Volume Rural Road pavements are the use of empirical design charts or onsite design without the use of design guidelines where suitably qualified and experienced personnel provide direction. Siddique and Rajbongshi (2005)

discusses the idea that the aim of pavement design is to provide the most economic support system for the traffic anticipated, considering the characteristics of the subgrade and the available construction materials.

The principles for the pavement designs do not change as the fundamental criteria are always similar. Data required to be analysed for a pavement design consists of:

- Expected Pavement design life (e.g. 25 years),
- Traffic Loads e.g. Average Annual Daily Traffic (AADT), and
- Subgrade strength e.g. Californian Bearing Ratio (CBR).

The pavement design life is specified by the controlling authority of the road and is the desirable life span the pavement (asset) must achieve. The longer the life span required the more detailed the pavement structure must be. The purpose of a pavement design life is to provide the asset owner with an indication of how reliable the pavement will be while in service, and at what point in time considerable amounts of money must be spent to upgrade or repair the roadway asset.

The AADT relates to the volume of traffic that is predicted to use the road pavement. In some instances this number is based on actual existing traffic data achieved by counting the number and type of vehicles that traverse the pavement, and in other instances the value used, is the current traffic data counts with a compounding growth rate applied as a percentage factor catering for the future load demand of traffic that the road must service. The AADT data is specified by the controlling road authority and in some cases it is based on the classification given to the road. Numerous other methods to determine the traffic loading exist. An equivalent standard axle method is one such example. Authorities incorporate a percentage of heavy vehicles within their design data, to account for large vehicles and road freight, which have a higher impact load on the pavement.

The CBR value is the strength of the subgrade material determined by undertaking soil tests. This test is a common test undertaken to assess the strength of the subgrade. The strength of the subgrade is an important factor as the subgrade material provides the support for the pavement and distributes the load from the vehicles. The higher the subgrade strength e.g. CBR value, the lower the resulting thickness of the pavement layers is for a specified traffic loading. Where the subgrade is stronger the structural elements of the pavement can support and distribute the load more effectively.

Most authorities produce a set of design charts or tables and graphs based on local testing and research, or make reference to the applicable accepted road authority's guidelines, which allow for the easy extraction of pavement layer thicknesses and properties, for a pre determined traffic loading or situation. This information is restricted to rural roads and urban roads and doesn't encompass Low Volume Rural Roads.

Petts, Cook and Salter (2008) notes a holistic approach is required where consideration is given to all the factors that affect the pavement design, such as materials, the natural environment, the operational environment and the task that the road is to undertake. This highlights the varying degree of difficulty that is associated with developing a sustainable and suitable pavement design. Figure 4-1 below depicts these factors and shows how many factors are to be considered to produce an optimum pavement design for a Low Volume Rural Road pavement.

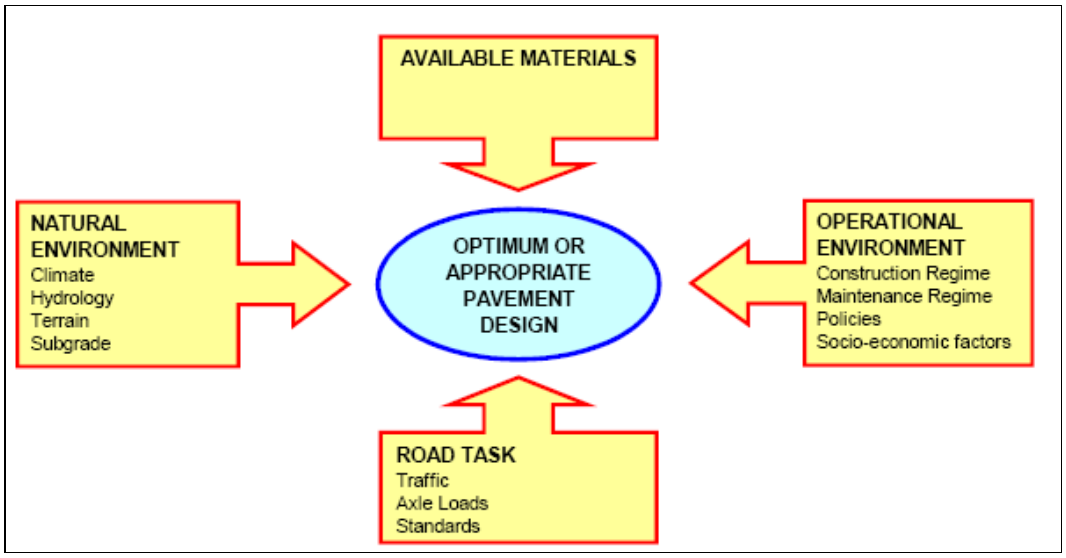

Figure 4-1: Optimising Pavement Design

(Source: Petts, Cook and Salter, 2008)

4.1 Worldwide Design Practises

America, China and Australia have developed comprehensive design guidelines for Low Volume Rural Road pavements which have been referenced for a long period of time. Countries such as India and Afghanistan have recently developed stand alone design guidelines, based on the information and research undertaken from the American, Chinese and Australian guidelines, and retrofitted these to suit their local conditions. There are two types of design guidelines that are common to pavement design, the mechanistic method and the empirical design method.

4.1.1 Indian Design Guidelines

The Indian Congress has published the rural road manual which Vedula, et al., (1995) notes the 'construction of Rural Roads, Indian Roads Congress has brought out Rural the Road Manual IRC SP:20-2002 for design and construction. The design is based on the CBR value of the soil sub-grade and the 10 years projected cumulative traffic with an assumed 6% traffic growth per year'. This manual gives pavement thickness based on:

- 4-day soaked CBR value of soil, and
- Traffic in terms of commercial vehicles per day (CVPD)

Ministry of Rural Development, (2007) is continuing research and development efforts as Low Volume Rural Roads have been recognized as a major thrust area. These efforts are focused at evolving the most suitable and economical designs and developing appropriate technologies for construction, maintenance and rehabilitation of Low Volume Rural Roads, accounting for the type of terrain, climatic and other environmental conditions prevailing in different parts of the country. The Highway Research Board (HRB) of the Indian Rural Road Congress coordinate with the Ministry of Rural Development to identify and prioritise research and development projects in respect of rural roads to evolve suitable and economical performance-based pavement designs for Low Volume Rural Roads, for both sealed and unsealed pavements.

4.1.2 Afghanistan Design Guidelines

The National Rural Access Program has developed matrices which highlight the required pavement structure for a given CBR strength and AADT. The matrices are divided into two separate matrixes. One matrix addresses pavements where the AADT is less than 100, and one where the traffic volumes are between 200 - 500. The pavement designs recommended are based on empirical design charts. The approach indicates that earth roads are acceptable where the AADT doesn't exceed 50 and the subgrade strength is greater than 15. For an in-situ material with a CBR of less than 2 a specialist pavement design should be sort to suit the conditions. All other pavements with ranging CBR and AADT values require a gravel layer within the pavement structure. It is noted that pavements greater than 100 AADT should be give consideration for a surface wearing course. The National Rural Access Program for pavements with a predicted AADT of 200 - 500 a gravel wearing course with a two coast seal is the minimum acceptable treatment. It is expected that pavements should have a design life span of 10 - 15 years based on the pavement structures identified within the matrices.

Low cost solutions are also highlighted by the National Rural Access Program, where cost effective surfacing options are recommended based on the traffic volumes and the roadway geometry. Table 4-1 highlights the low cost surfacing options recommended based on conditions where the application may be suitable.

Table 4-1 Low Cost Surfaces

Roadway Type	Average Annual Daily Traffic (AADT)	Recommended Surface Option	Conditions
Single Lane Roadway	<50	Earth	• Hard Subgrade CBR >12
Single Lane Roadway	<50	Gravel	• Weaker Subgrade CBR <12 • Improved subgrade in case CBR<8%
Single Lane Roadway	50-100	Gravel	• Flat Terrain
Single Lane Roadway (Steep slope)	50-100	Water Bound Macadam (WBM)	• Rolling Mountainous Terrain • Kerb stone are required to protect the carriageway
Single Lane Roadway	100-250	Double bitumen surface treatment	• Specified aggregate is available in close proximity
Single Lane Roadway	100-250	OTTA Seal	• Specified natural material is available in close proximity • Dense Grading should be applied
Two Lane Roadway	250-400	Dressed Stone / Hand packed/ Cobble Stone	• Able workers in area
Two Lane Roadway	400-1000	Bitumen Wearing Course with WBM Base	
Two Lane Roadway	1000-2000	Independent design required	

4.1.3 United States Design Guidelines

In the United States of America various design methods are utilised. A previous survey based on pavement design methods used for Low Volume Rural Road pavements conducted by Hall (2000) found that 37 of the 48 states in the United States use the AASHTO method. The AASHTO design procedure requires information and data input

parameters on the resilient strength of the subgrade material, the desired reliability level of the pavement and the traffic loadings (ESAL's) and what the material properties are for each desired material layer. Design charts for gravel flexible pavements have been developed to allow for extraction of simpler design outcomes, without an onerous design being undertaken.

Hall (2000) makes mention of the United States Army Corps of Engineers procedure for Low Volume Rural Road pavement designs and also the National Crushed Stone Association procedure.

The United States Army Corps procedure is based on the traffic loads (ESAL's), subgrade strength and the Californian Bearing Ratio (CBR). The procedure is simplified to provide a given pavement thickness based on the subgrade strength. With the limited input data, unknown site conditions, environmental impacts and conditions have the potential to be detrimental to the pavement structure resulting in the design being inadequate.

Other design methods used by the State Road Authorities in the United States of America are: Californian procedure, Illinois procedure, Kentucky procedure, Minnesota procedure, Mississippi procedure, New York procedure, Oklahoma procedure, Pennsylvania procedure, Texas procedure, Vermont procedure and the Virginia procedure.

The California procedure uses data input of Traffic Index, the Resistance value (R-value) and the gravel factor to determine the pavement thickness required. The traffic index requires analysing graphs, charts and equations based on truck traffic counts to determine the design life of the pavement. The resistance value is the subgrades ability to resist deformation when a vertical load is applied. The R-value can be determined by a stabilometer test or by undertaking soil samples. The gravel factor is extracted from a chart, based on the material properties. After all input values have been determined the

pavement structure is concluded by the use of reading of the required values from a design chart.

The Illinois procedure is based on a Low Volume Road having less than 400 vehicles per day. The procedure classifies the Low Volume Rural Road and then an appropriate design period is selected. The design requires traffic information, and the appropriate percentage of heavy vehicles. The critical subgrade modulus and the design tables are analysed to determine the required minimum thickness for the wearing course, base course and subbase. There is also a minimum thickness regardless of traffic data that is recommended for the wearing course and the base layer.

The Kentucky procedure relies on the (AADT) and the aggregate thickness which allows the extraction of the required pavement thickness based on a predetermined range of values from the design table. The design table is applicable to Low Volume Rural Road pavements with a maximum AADT of 500. The Kentucky procedure is limited for use as its application is only applicable for pavements with an asphalt stabilised base course.

The State of Minnesota uses a gravel equivalency method, requiring data input of soil strength and traffic loads. Using a table the adopted values for the above properties allows for the extraction of the appropriate soil factor and resulting resistant value. The soil data information is used in conjunction with the traffic volume data, and a resulting pavement thickness is determined. The traffic data is adjusted for the pavement design to allow for seasonal changes and cold climatic conditions which the pavement is subjected to.

The Mississippi pavement design approach is based on the standard principles of design life, traffic loads and CBR. The soil strength (soil support value) is referred to in the Mississippi procedure is an additional variable which is determined from an equation using the CBR value. The equation is based on previous research and testing that has been undertaken on the local Mississippi soil properties. This allows the pavement

design to be extracted from the pre determined design charts. The standard design life for pavements using the Mississippi procedure is 5-8 years.

In the State of New York, the procedure for pavement design is based on the same principles as the AASHTO procedures. However drainage and frost provisions are incorporated into the design and the resulting subgrade modulus charts have been modified to account for these additional provisions.

The Oklahoma procedure or Oklahoma Subgrade Index (OSI) method is similar to most other methods however the design wheel load assumption is different. The method recommended based on previous research and analysis, is where average daily traffic is greater than 400 the minimum design wheel load should be 3175 kilograms. Where traffic is less than 400 vehicles per day a wheel load of 3175 kilograms can be assumed to be an over estimate, if approved by the relevant authority and as a result the pavement thickness may be decreased by 50mm. The minimum allowable base thickness however is 150mm. The Oklahoma subgrade index is one of a few pavement design approaches which considers the implication of overloaded commercial vehicles.

The Pennsylvania pavement design approach adopts standard practices. The variables required are traffic values expressed as (ESALs), CBR ratio, and the Design Freezing Index. Several tables and graphs are referenced to determine the pavement thickness and appropriate layers of pavement required. It should be noted that for a Low Volume Rural Road (less than 400 vehicles per day) the predetermined tables and graphs have already been adjusted to account for the freezing index and no further manipulation is undertaken.

Texas is another state which has developed its own design procedures. The current average daily traffic counts and the projected 20 years traffic counts are required to undertake the design. The process to design the pavement requires the percentage of heavy vehicles in the traffic counts. As the pavement design is undertaken using a computer generated model and the analysis used is onerous, the pavement design is

complex, however additional predicted data is a benefit of the more detailed modelling. Data such as expected maintenance costs, pavement costs construction costs and user costs can be extracted.

4.2 Australian and New Zealand Design Guidelines

There are many different approaches to pavement design, relating to various degrees of empirical relationships, theoretical analysis and field and laboratory testing. Archondo-Callao (1999) identifies that 'up until the National Association of Australian State Road Authorities (NAASRA) Interim Guide to Pavement Thickness Design was produced in 1979, State Road Authorities had their individual methods for pavement design'. Up until this point pavement research and design in Australia was carried out in a relatively uncoordinated way by the State Road Authorities (SRA's) and the Australian Road Research Board (ARRB). Since this time research by the ARRB and SRA's has been carried out in a coordinated manner to improve the outcomes and encourage an aligned approach to pavement design.

The NAASRA Guide was the first authority to attempt to provide a systematic National approach to pavement design. The assessment of the required pavement design was based on criteria such as design traffic, subgrade evaluation, materials characterisation, construction and maintenance influences and the environment. The guide encompassed guidelines for all the various pavement structures such as flexible pavements, rigid pavements and pavement overlays. The manual was instrumental in adopting a National approach to pavement design. Austroads "A Guide to the Design of New Pavements for Light Traffic" (APRG report 21) has been incorporated into the Austroads "Guide to Pavement Technology – Part 2: Pavement Structural Design" this is the current national standard for Low Volume Rural Road pavements. Bullen (2000) notes the investigatory work carried out by Australian SRAs, have resulted in specifications being developed that effectively allow pavement engineers to use in pavement construction virtually any material they wish. However the onus lies with asset owners and pavement engineers to carry out effective evaluations of locally available materials and to determine the best means of incorporating them into the pavement structure.

4.2.1 Mechanistic Design Approach

For analysing flexible pavements under wheel loads, NAASRA has adopted a mechanistic design procedure based on the linear elastic theory for materials in a horizontally layered system. With the development of technology the mechanistic pavement design procedures were pursued. Mechanistic design considers the pavement to act as a mechanism and analyses it using a computerised model. This is assuming the pavement is a structure and modelling of that structure can occur to predict its behaviours, similar to the structural analysis undertaken on the design of buildings.

This method is not widely used on Low Volume Rural Road pavements by local authorities however there are distinct advantages of the mechanistic procedure, such as:

- The ability to take into account many more variables and test these for sensitivity. This is particularly useful in the analysis of pavement failures.
- The ability to rationally assess the likely performance of materials and loading conditions.
- Accommodate changing load types.
- Characterisations of materials, and
- It uses material properties that relate better to actual pavement performance.

The evolution of pavement design guidelines consisted of the NAASRA Guide to the Structural Design of Road Pavements, which was further revised in the early 1990's to become the AUSTROADS Guide to the Structural Design of Road Pavements. The mechanistic method requires computer modelling and although this type of modelling is beneficial as noted by Luhr, McCullough, and Pelzner (1983) that stated 'computerised pavement-management systems are excellent tools for designing and managing road pavements'. The problem exist that due to the classification of a Low Volume Rural Road pavement as an asset this method is to onerous to be undertaken.

4.2.2 Empirical Design Approach

The empirical design approach is the commonly adopted approach for pavement designs. Many pavement structural design procedures use an empirical approach. The relationships between design inputs, traffic loads, materials, structural makeup, environment, and design life or expected pavement failures are determined using experience, testing, analysis, experimentation or a combination. Although the scientific basis for these relationships is not firmly established, they can be used with confidence, provided the limitations the approach is recognised. Applying an empirically derived relationship to a phenomenon that occurs outside the range of the original predicted data used to develop the relationship is not prudent.

Local authorities reference National standards in their pavement design guidelines. Publications from Austroads, Australian Road Research and State Road Authorities relevant to Low Volume Rural Road pavements are:

1. Guide to Pavement Technology – Part 2: Pavement Structural Design – (Austroads, 2008)

2. Sealed Local Roads Manual – Guidelines to Good Practice for the Construction, Maintenance and Rehabilitation of Pavements (ARRB Transport Research Ltd., 2005);

The above mentioned documents form the basis to undertake a Low Volume Rural Road pavement design or are referenced by the local authority to justify the resulting pavement design charts that they have published. The empirical method is the commonly adopted approach and Luhr, McCullough, and Pelzner (1983) highlight 'in some instances, it is necessary to do pavement design analysis with a limited amount of time, resources, and input information'. The empirical method is an example of a simple time effective analysis that results in adequate pavement designs, this is extremely important as suggested by Youdale, (n.d.) the Australian road network has been built in an environment of restrained funding which has emphasised the need to innovate wherever possible to provide maximum value for the limited funds available.

4.2.2.1 Local Councils

Local Councils commonly adopt one of the following three approaches in regard in to pavement designs. The first approach is where the Council refers directly to an appropriate pavement design guidelines published by a State or National Authority. The second possible approach is where a Council has generated their own relevant standards for their local area and these retrofitted guidelines are referenced. The third option is that no guidelines are referenced and the design is based on a suitably qualified person's assumption of the conditions that are to be in counted, and prediction of the pavements performance. Council's that have produced a set of standalone design guidelines, have modified the desired pavement properties and thicknesses based on a pre-determined pavement design life, applicable traffic load, and available materials, to suit the local municipality requirements. This approach is recommended as is gives the most accurate design for a pavement within the municipality in question. Bullen (2000) states 'Locally available materials for road making may not meet the usual standard road authority requirements for high-quality aggregate and are thus termed "marginal," "non-standard," or even "inferior." Because these materials are a resource that cannot be ignored, locally derived specifications are formulated for specific materials to allow more efficient expansion and maintenance of road networks in remote rural areas'.

4.3 No Design Guidelines

Often Low Volume Rural Road pavements are constructed with limited or no design inputs. Pavements are determined based on local knowledge or expertise by qualified personnel. Considerations are given to the local conditions, surface performance and costs. This results in a pavement that is economically viable for it's intended purpose.

5 Maintenance

The maintenance practices and regimes undertaken on Low Volume Rural Road pavements vary throughout the world based on the funding provided and the serviceability provided by the road. Previously maintenance on Low Volume Rural Roads was not a high priority for the controlling agencies. This is highlighted by the Technical Guidelines for Agricultural and Rural Roads (1998) which state 'the responsibility of building rural roads and their subsequent maintenance were not really taken care by any agency and, thus the people were gradually becoming ignorant on these aspects'. Low Volume Rural Road pavements need to be maintained to preserve the asset in the desired condition, which minimises the safety risks and provides the user with satisfaction. The maintenance of a Low Volume Rural Road is a dynamic situation where for a long period of time no maintenance is required then in a small time period the condition of the road can change as a result of traffic conditions or climatic influences and require immediate maintenance. Henning, Kadar, and Bennett (2006) notes the 'broad objective of maintenance activities on unsealed roads are to:

- preserve the road in a condition close to its intended or as-constructed state and,
- to ensure an acceptable level of service through control of the various deterioration mode'.

The maintenance of a road pavement is based on a number of factors such as the pavements condition, life span, location, composition, costs and safety hazards that exist for a deteriorated pavement. Maintenance of an unsealed road should be undertaken in dry conditions. In wet conditions grading and compaction can be problematic.

Two key types of maintenance are undertaken on a Low Volume Rural Road pavement. The first is routine or scheduled maintenance, and the second is repair or unscheduled maintenance. International Road Federation (2009) notes 'Alliances between the government, private sector and road users can provide a basis for effective maintenance systems'. Alliances between local governments and private agencies would provide a more structured approach to maintenance practises on Low Volume Rural Road pavements. Community awareness and participation in highlighting potential hazards or

maintenance concerns, allows the asset owner to respond quickly to rectify the problem and appease the user, further encouraging future participation. Zimmerman and Peshkin, (2003) note that 'as the challenges associated with managing a low-volume road network increase, agencies have realised the benefits associated with the use of pavement management tools for the road network'. The uses of management tools such as pavement management systems that coordinate maintenance practises are becoming increasingly important.

5.1 Scheduled Maintenance

Scheduled maintenance is the most common form of maintenance undertaken. Roads under a controlling authority are assessed and routinely inspected and maintained to ensure the asset functions as desired. Funding is set aside for maintaining road pavements by the controlling authorities and roads with high traffic numbers or a high classification are given a higher priority and regularly are maintained. A local Low Volume Rural Road pavement servicing only connecting farms would be given a low priority and would only be maintained after an incident or if a hazard has resulted from neglecting maintenance.

Maintenance practices consist of a number of actions. Visual inspections often determine what maintenance to the road pavement is required. Testing methods are used to determine the condition of the pavement; such tests are laser roughness measuring and ground penetrating radars. Visual and physical data from the tests undertaken results in determining the extent of maintenance to be undertaken on the pavement. Re-profiling the pavement wearing course with the use of a grader is the common maintenance practice undertaken. The grading re-profiles the wearing course of the pavement removing ruts, and correcting the pavement deformation.

The Ministry of Rural Development (2007) recommends 'timely and regular maintenance of existing rural roads is absolutely essential and does not admit of any laxity'. This timely and regular maintenance is far more important to ensure that assets already created are maintained and yield services as originally envisaged than to go on

undertaking commitments for creating more assets, and neglecting maintenance. Henning, Kadar, and Bennett (2006) states good performance can be achieved by maintaining the drainage system, selecting quality material, grading and reshaping, re-graveling and controlling vegetation. These are all simple on going maintenance tasks that can be undertaken.

The more regular the maintenance is undertaken the less onerous the maintenance exercise is, however the greater the maintenance cost. The Ministry of Rural Development (2006) notes that a uniform level of service criteria for maintenance of rural roads be developed and adopted across the country (in all States). This system has been implemented using suitable maintenance management systems utilising simple measurements based on the principles of asset management.

Tables 5-1 and 5-2 below indicate typical pavement defects and maintenance actions required.

Table 5-1 Maintenance Defects and Actions Queensland Main Roads

Defect	Level of Intervene	Extent	AADT	Urgent Maintenance Required	Typical Action
Windrows, channels, corrugations, soft slippery areas, course surface texture, loose material, roughness	Safe travelling speed of less than 85% of environmental speed	20% of road	Any	Safe travelling speed of less than 70% of environmental speed	Grade or re-level
Loss of pavement / running surface	Depth left of zero mm	Sub length	Any	Depth of cover remaining of 0mm over > 10% of subsection length	Regravel
Wheel ruts, shoves and potholes	Depth of 80mm	Any	Any	Defect depth of 150mm	Grade/ Repair
Insufficient crossfall	Water ponds or 2% less than design crossfall	Any	Any	Crossfall of 8% or steeper	Grade
Excessive crossfall	Crossfall of 6% or	> 20%	Any	Crossfall of	Grade

	steeper	of sub length		8% or steeper	
Insufficient formation height above natural surface	At natural ground level in rolling country or 100mm in flat terrain,(except flood pain areas – 0mm) measured at the shoulder point	> 20% of sub length	Any	Water ponds, and formation is lower than the natural ground level measured at the shoulder point.	Heavy grade and import fill
Insufficient formation	Width of 8m.	> 20% of sub length	Any	Width of 6.5m or 8m when visibility is restricted.	Grade alignment

(Source: Department of Transport, Queensland (1992))

Table 5-2 Maintenance Defects and Measures

Defect	**Intervention Levels**		**Urgent maintenance (at Isolated location)**	**Typical Action**
	Severity	**Extent (%/km)**		
Rutting	Depth > 90mm	> 35	Depth > 110mm	Medium / heavy grading
Loose material	Depth > 70mm	> 45	Depth > 100mm	Reshape and compact
Corrugations	Depth > 90mm	> 45	Depth > 120mm	Heavy grading and Reshape
Drainage Scours	Depth > 90mm	> 35	Depth > 120mm	Reshape of crossfalls 4-6%
Coarse texture / ride quality	NRM > 220 (environmental speeds < 60%)	> 55	NRM > 270 (environmental speed < 50%)	Heavy grading and Reshape
Potholes	Potholes > 90mm depth	> 35	Potholes > 140mm	Restoration of crown and crossfalls
Gravel Depth	< 30mm	> 30	< 20mm	Regravelling
Table Drain	Ponding > 200mm	> 30	> 300mm	Regrade
Batter Clearing	Vegetation > 600mm	> 30	> 900mm	Slashing
Roadside Vegetation	Vegetation > 500mm	> 20	> 1000mm	Slashing
Culvert cleaning	siltation > 250mm	> 30	> 350mm	Clear out deposits

(Source: Giummarra (2001))

5.2 Unscheduled Maintenance

Unscheduled maintenance relates to the undertaking of fixing or repairing the asset occurs, due to a sudden change in climatic or traffic conditions which has resulted in a pavement failure. The most common form of unscheduled maintenance is remediation works undertaken after a large rainfall event. The intensity and duration of a storm results in the pavement failing and the maintenance crews are required to repair the pavement to provide a traversable road. Other unforseen circumstances, such as a tree falling and blocking the road would enforce unscheduled maintenance.

5.3 Reliability

The reliability of a road pavement is critical to the community and the user of the road. Low Volume Rural Road pavements that are maintained regularly result in the asset being preserved in with accordance with its design intention, and the pavement performs at a higher level of reliability for its design life span. An unsealed surface will ultimately lose gravel material through wear and tear and maintaining the pavement at a defined level of service with minimum capital cost is the desired outcome for the controlling authority of the pavement. With a Low Volume Rural Road pavement there is always a trade off between cost, maintenance, materials and reliability. The optimum solution for achieving the desired outcome varies based on the pavements location and function.

Operating vehicles on poorly maintained Low Volume Rural Road's cost a great deal more for the user compared to operating vehicles on smooth bituminous surfaced roads. These costs include the cost of fuel, tyres, spare parts, vehicle maintenance and time. Heng, et al., (n.d.) state, 'for any country, especially developing countries, there is an important and very direct economic trade-off between investing in better roads and reducing the costs of using those roads'. Figure 5-1 below shows the trade off required between design standards and cost, and that for a given situation that is an optimum solution or balance to be achieved.

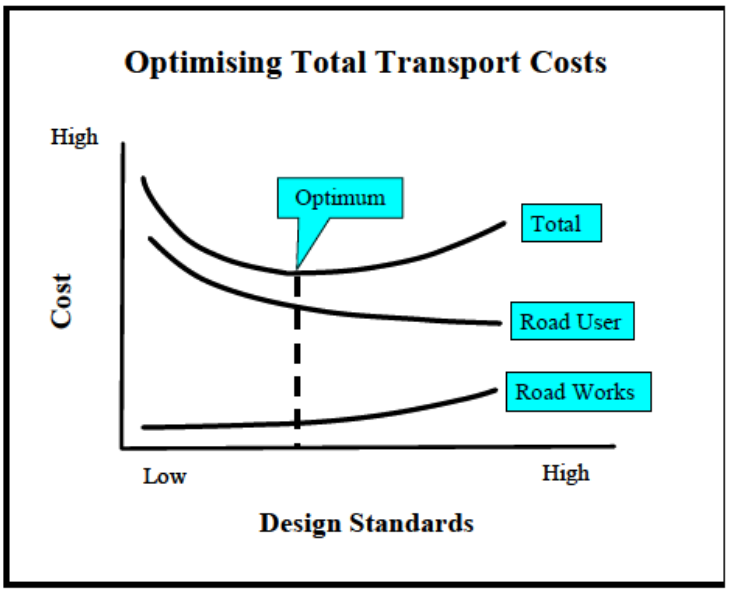

Figure 5-1: Optimising Design Standards

(Source: Heng, et al., (n.d.))

The reliability of a road pavement is an important factor in rating the serviceability of the road pavement. The more reliable the pavement the higher the level of service the road provides. For a Low Volume Rural Road because costs saving construction methods are often endorsed it is important that the surface condition of the pavement remains unchanged and not deteriorated for as long as possible. According to Vedula, et al., (1995) 'one of the main causes of accidents is the changing road surface conditions, low cost facilities, and inadequate maintenance', highlighting the need for careful consideration of materials, construction methods and maintenance.

5.3.1 Pavement Failures

A Low Volume Rural Road pavement is susceptible to numerous pavement failures and deformations over time. Pavement failures are the major cause of maintenance requirements and reliability concerns. The Rural Roads Technical Manual of Afghanistan (2009) states 'cross fall for gravel roads shall be 4% (or up to 8% if super elevated). This is to ensure that potholes do not develop by rapidly removing surface water and to ensure that excessive cross fall does not cause erosion of the surface.

Provision of drainage is extremely important for the performance of gravel roads'. This highlights the concern that the road alignment and geometry is just as important as pavement structure in relation to pavement failures and maintenance concerns. Most road authorities that have published pavement design standards for Low Volume Rural Road's have accompanying Low Volume Rural Road geometric standards and guidelines. Pavement failures can occur because of a multitude of reasons and any substandard process or material used during the design or construction phase without effective integration and intent can accelerate the onset of these pavement failures as each individual element of a pavement is integrated. A summary of typical pavement failures are summarised below. Under visual inspection the majority of these deformations can be identified

5.3.1.1 Potholes

Potholes are the result of water ponding in the pavement as a result of inadequate crossfall. The pavement becomes weakened by this excessive moisture and can fail. Potholes are the result of inadequate compaction during the construction phase or variation in the quality of gravel material used in the pavement. Maintenance practices to remove potholes require grading the deformed material (wearing course), moving it to spoil, and then compacting and re-profiling the wearing surface.

5.3.1.2 Drainage Channels

Where water is concentrated across the wearing surface of a Low Volume Rural Road pavement a drainage channel may form. This movement of concentrated water is as a result of inadequate drainage provision or blockage of the drainage structures. The constant flow path of water across the pavement surface dislodges the material and the surface becomes fragile, weak and erodes. The surface of the pavement where the channel has formed would need to be removed and treated in a similar manner to the treatment of the potholes. Inspection of the surrounding drainage structures would be required to determine if the drainage structures are blocked. If the drainage structures are not blocked provision for regrading the road or installing additional drainage structures should be investigated if there is adequate funding available.

5.3.1.3 Loose Gravel

Loose gravel is a major safety concern where the driveability of the wearing surface is reduced and the surface is littered with loose material. The loose material results from weakly bound pavement gravel material which has been compromised by poor grading or limited plasticity properties. The loose material is easy transported by water or wind away from the pavement or onto the pavement at undesirable locations. To restore the pavement surface to an adequate level of service the material would be removed, the surface would be re-laid and compacted, and graded to ensure the surface is bound.

5.3.1.4 Shoving

Shoving is where movement and instability is present within the pavement structure. This is as a result of plastic deformation of the pavement or the subgrade, because of poor compaction or foreign materials within the pavement. To repair shoving the full depth of the pavement and unsuitable material subjected to the movement would be located and removed. Material would then be replaced, which may involve removal of the subgrade material.

5.3.1.5 Coarse Texture

Course texture affects the drivability of the surface. Where course materials are exposed on the surface the pavements attrition and erosion from separation resulting from movement between large and fine particles occurs. The presence of rock in the subgrade or the use of oversized base course gravel is a reason for course textured gravels to protrude into the wearing surface. The maintenance process to correct the effects of course texture requires the defective pavement to be removed and re-laid, with appropriately graded materials.

5.3.1.6 Corrugations

When a pavement surface becomes wavy and undulating corrugations form. These corrugations occur because a number of reasons, the quality of the base course may not be sufficient, there may be loose surface material which has been the subject of movement or due to traffic loading and vehicle movements, such as turning, braking and accelerating the pavement has deformed. Corrugations are removed by routinely

grading and re-profiling the wearing course surface. Removal of corrugating can also be undertaken by a brush or dragging, this technique requires the use of low cost equipment such as a tire sledge or a metal 'A' frame, which is dragged across the surface to reinstate an acceptable finish which will provide an adequate level of service.

5.3.1.7 Rutting

Rutting is where tracks or depressions form in the pavement. Inadequate wet strength of the subgrade or base course assist in the onset of rutting. Once a pavement wears, or has been in service for a period of time the surface may form ruts due to traffic loads or erosion of the surface material. If the traffic loads are continually distributed at a localised point or path this may result in the subgrade becoming over compacted and a rut forming. Rutting is removed by grading the material surface and re-profiling the wearing course.

6 Environmental Considerations

The environmental considerations relating to a Low Volume Rural Road pavement have not been of a high concern for the majority of the Low Volume Rural Road's constructed to date. As a result many receiving environments have been detrimentally impacted as a result of Low Volume Rural Roads. The Technical Guidelines for Agricultural and Rural Roads (1998) states 'due to a lack of the required technical expertise and skills, the quality of works done is often found to be poor and sub-standard. This further causes a threat to surrounding environment since the construction of these roads is carried out in an unplanned, ad-hoc manner'. A Low Volume Rural Road has a potentially greater damaging impact on the environment than sealed roads because Low Volume Rural Road's are located in natural environments rather than in urbanised built up areas. Factors impacting the environment for the design, construction, operation and maintenance of a Low Volume Rural Road, are clearing and tree removal, erosion, oxidation, salinity, dust, stormwater and contaminated runoff. The social impacts of environmental disturbance both positive and negative should be duly accounted for in the preparation for the design and construction of Low Volume Rural Road pavements.

6.1 Clearing

The clearing of trees and vegetation to provide a track for access adversely impacts the local Flora and Fauna. Native plants and animals should be considered in locating a Low Volume Rural Road and an adequate refuge and rehabilitation requirements should be considered to minimise the environmental impact. Clearing in arid and semi-arid areas should be minimised as poor soil conditions do not promote the rehabilitation of vegetation. The cross section of the Low Volume Rural Road pavement and required infrastructure should be limited in heavily forested or densely planted natural environments. Stock piling locations for imported gravel if required should be located in sparsely vegetated areas, or already cleared areas to limit the disturbance to the environment. These piles should have adequate erosion and sedimentation control devices installed. Tree roots that are present within the pavement subgrade cause major distress to the pavement structure. Tree roots should not be located in the pavement structure. The removal of vegetation impacts the moisture content of the surrounding

pavement, and this removal increases the moisture content of the subgrade. The addition of planting increases the dryness of the soil, as the vegetation extracts moisture from the pavement layers.

6.2 Erosion

Low Volume Rural Road pavements that are unsealed or sealed pavements and are severely deteriorated are essentially unprotected surfaces which can generate large amounts of sediment. The sediment and suspended solids transported by runoff can cause a vast amount of environmental harm, to receiving water courses or bodies. The more sensitive the receiving waters, the greater the harm to the environment the sediments cause.

6.3 Oxidation

Oxidation relates to asphalt pavement such as a wearing course, and over time the asphalt may be subjected to oxidation which makes the pavement more susceptible to thermal and fatigue cracking and deformation. The oxidation of aged asphalt results from the oils within the asphalt converting to resins, which become toxic and can harm the surrounding environment. Low Volume Rural Road pavements that are unsealed or do not contain asphalt would not be subject to the oxidation process.

6.4 Salinity

Salty soils are a common feature and an environmental problem in arid and semi-arid regions. They have poor or little vegetation production as the soils have limited nutrients. Salinity problems are often associated with high water tables, caused by a lack of natural subsurface drainage to the underground reservoirs. Poor subsurface drainage may be caused by insufficient transport capacity of the aquifer or because water cannot exit the aquifer. For instance, it is situated in a topographical depression. Low Volume Rural Road pavements constructed in saline environments will be subjected to greater deterioration and weathering, and will have an environmental impact as surrounding saline soils will not promote vegetation growth adjacent to the road corridor.

6.5 Dust

An unsealed Low Volume Rural Road pavement in service results in dust being produced when the pavement is under load. A seal on the wearing course reduces this dust however is expensive to construct for long lengths of road. The type of material used as the wearing course also impacts the severity of dust. The fine red soils of Central and Western Australia or more prone to promote dust once a vehicle passes over them compared to the natural gravel materials located around coastal Australia. The impacts of dust on the environment are considerable as fine dust particles are transported by wind into the surrounding vegetation and surrounding communities. Dust has a deterring effect on vegetation growth and is a nuisance to the community, as large amounts of dust can suffocate objects and become a potential health hazard.

6.6 Stormwater

The stormwater regime of an existing area should be maintained to preserve the existing environmental conditions. Changing the existing stormwater flow regime has the potential to cause actionable nuisance to downstream areas. These changes to the path and quantity of stormwater runoff would affect the Flora and Fauna. Constructing the road pavement at the surface level of the existing topography assists in maintaining the existing stormwater regime, this is common practise in regard to Low Volume Rural Road alignments.

6.7 Contaminated Runoff

Water Sensitive design in becoming increasing important in conjunction with the development of infrastructure works. This technology is a new technology relating to the capture and removal of contaminates in surface runoff or containment of hazardous oil and chemical spills by means of a natural treatment system or by proprietary devices. Treatment facilities such as wetlands, bio retention basins, bio retention swales and spill / sediment fore bays are devices to capture spills and hazardous material while removing harmful contaminates such as Nitrogen, Phosphorus and Suspended Solids through

adequate detention time or filtration though a gravel media. Capturing and treating the contaminated runoff reduces the impact on the downstream environment, however these devices are not generally considered in conjunction with a Low Volume Rural Road pavement due to the establishment, operational and maintenance costs associated with the devices.

6.8 Waste

Waste should be reduced in the construction of Low Volume Rural Road pavements. Minimising waste is critical in reducing materials sent to landfills which are problematic to monitor and store. Research by Petts, Cook and Salter (2008) notes that 'materials issues relating to gravel is that resources are largely non-renewable and gravel is a 'wasting' surface'. Therefore the selection of gravel should be undertaken with all factors considered as ultimately the gravel quantity will be waste.

7 Survey

7.1 Survey Methodology

The survey intent was to undertake an assessment of the existing practices that the public sector utilises with respect to the design, construction and maintenance of Low Volume Rural Road pavements. The public sector (Local Governments) was chosen because this sector controls the majority of Low Volume Rural Road's, and is responsible for the design, construction and maintenance of these assets. Super Regional, Regional and Local Shire Councils are the regulating authorities over Low Volume Rural Road pavements in most circumstances and they dictate the roads classification and position in the road hierarchy, the design life of the pavement, construction techniques to be used, and the amount of funding that is provided for future maintenance.

The survey was in a questionnaire format which allowed the intended audience to fill out the survey in a short space of time. The survey consisted of numerous multiple choice questions, and also questions which required short response answers. The survey was not indented to be overly onerous, to encourage participation from external parties. The survey was developed after reviewing the background information relating to current Low Volume Rural Road pavement designs and practises. The content of the survey questions was compiled based on information that would result in sufficient responses to allow an adequate analysis of the current practises relating to Low Volume Rural Road pavement design, construction and maintenance. The survey was divided into five parts. General questions relating to Council Roads formed the first part of the survey, Guidelines and Specifications adopted on the design, construction and maintenance of Low Volume Rural Road pavements formed the second part of the survey. The third part of the survey related to Maintenance, the fourth part of the survey related to the Construction practices, and the final part of the survey looked at the Environmental considerations in relation to Low Volume Rural Road pavements.

Part One of the survey "Council Roads" aimed to investigate the general principles that Council's apply to Low Volume Rural Road's. Questions looked at what percentage of

Council's roads are Rural, and what AADT is used by Council for classifying a Low Volume Rural Road. It also aimed to address what percentage of Council's Low Volume Rural Road's are constructed with an in-situ material (minimalist approach) pavement and what percentage of Low Volume Rural Road pavements have an unsealed gravel wearing course. This section of the survey asked the participant what commonly influences Council's decision to upgrade an existing Low Volume Rural Road pavement, e.g. in-situ to gravel, or unsealed to sealed.

Part Two of the survey "Guidelines and Specifications" investigated what level of documentation if any is required to design and construct a Low Volume Rural Road pavement. Questions also asked what guidelines Council uses or references to determine an appropriate pavement design. The survey also requested details on what reference documentation is used for maintenance and construction practices. Further questions in this section of the survey asked what design documentation is provided when an unsealed Low Volume Rural Road pavement becomes sealed and if there is any testing that is undertaken for the design of in-situ Low Volume Rural Road pavement, and also gravel Low Volume Rural Road pavements. The last question in Part Two of the survey related to current industry standard pavement design analysis programs such as CIRCLY, and if they are used in conjunction with designing a Low Volume Rural Road pavement.

The intent of the third part of the survey "Maintenance" was to investigate the maintenance issues and practises in relation to a Low Volume Rural Road pavement that Council, their maintenance crews or approved subcontractors are aware of. This section comprised of four multiple choice questions which determine whether maintenance is generally programmed or undertaken on an as needed basis, and what constitutes Council's decision to undertaken maintenance on a Low Volume Rural Road. Questions also ask when the maintenance is undertaken if it is fully documented or as directed on site by experienced personnel. The final question looked at what a typical maintenance contract for a Low Volume Rural Road pavement would consist of.

The fourth part of the survey looked at "Construction" and consists of four questions. The questions are aimed to generate a better understanding of the construction process for a Low Volume Rural Road pavement. Questions one and two required written responses regarding what testing is undertaken during the construction of an in-situ and unsealed gravel road pavement. The survey questions also asks if the construction of a Low Volume Rural Road pavement is undertaken in accordance with a fully documented design and specification or if it is as directed on site, with minimal or no documentation.

The fifth and final section of the survey was the "Environmental" section where the participant is asked to identify what are the major considerations with the Council in regard to the environment in association with the design and construction of the Low Volume Rural Road pavement.

Details regarding the person who has completed the survey are required to be filled out at the bottom of the survey. This assisted in the analysis of results, as different levels of staff such as Managers compared to Foremen may have a different knowledge of current practices relating to the Council's current methodology. A copy of the survey is included in Appendix D.

7.2 Survey Scope

The scope of the survey was limited to local Councils in Australian States and Territories. Councils were contacted via phone and email to participate voluntarily in the survey. The information ascertained from the survey is to be used for this project only.

The determination of limiting the scope of the survey to Australian Councils is based on the fact that because of the vast geographical location of the Australian Councils the information received allows for an analytical response to a diverse range of conditions and situations of Low Volume Rural Road pavements, to be concluded, without the

need to seek responses from other countries. The limitation to Australian Councils allows Australian guidelines to be determined.

The survey was sent to Council's representatives after initial contact was made. Each Council nominated the appropriate person / employee to complete the survey after an initial discussion regarding the survey's content. A list of contact personnel and Councils that the survey was sent to is included in Appendix C. The survey was completed by a wide cross section of technical professionals, from Maintenance Foremen to Technical Engineering Directors to ensure all persons involved with Low Volume Rural Road's and their pavements can respond to the survey which in turn provides more accurate findings based on the current industry standards.

7.3 Geographic Coverage

The survey was sent to various Councils, including Metropolitan Super Councils and smaller Rural Councils in every State and Territory of Australia. The survey was limited to Australia only. This was to ensure that an adequate number of responses were received from Councils with varying volumes of Low Volume Rural Roads within their district, and varying emphasis on the functionality of Low Volume Rural Roads.

7.4 Survey Outcomes

The survey responses provided information to allow conclusions to be drawn whether Australian practises regarding Low Volume Rural Road pavements are consistent across the country or if Councils are undertaking their own design and construction solutions, through their own devices. The responses provided the information for the basis of the analytical process to conclude the results detailing current Low Volume Rural Road pavement design, construction and maintenance practises. The information received in the survey responses helped determine an adequate set of guidelines relating to Low Volume Rural Road pavements which can be applied at a National level enabling Councils to adopt a constant approach.

7.5 Survey Results

The survey was sent to the respective Councils at the beginning of April 2010 and participating Councils were contacted at the end of May 2010 to ensure an adequate number of responses were received. For the survey to be functional and appropriate for its purpose, results from a minimum of six Councils had to be received. These Councils must be located in three different Australian States or Territories for an unbiased response.

A total of twenty nine surveys were sent out to local Councils. Of this fourteen Councils responded to the survey. Their responses are included in Appendix E. In Queensland the survey was sent to eight Councils and six responses were received. In New South Wales the survey was sent to two Councils and one response was received. In Victoria five surveys were sent out and two responses were received. For Western Australia and Tasmania two and four surveys were sent out and nil and three responses were received respectively. For South Australia eight surveys were sent out and two responses were received. No surveys were sent to the Northern Territory and the Australian Capital Territory (ACT).

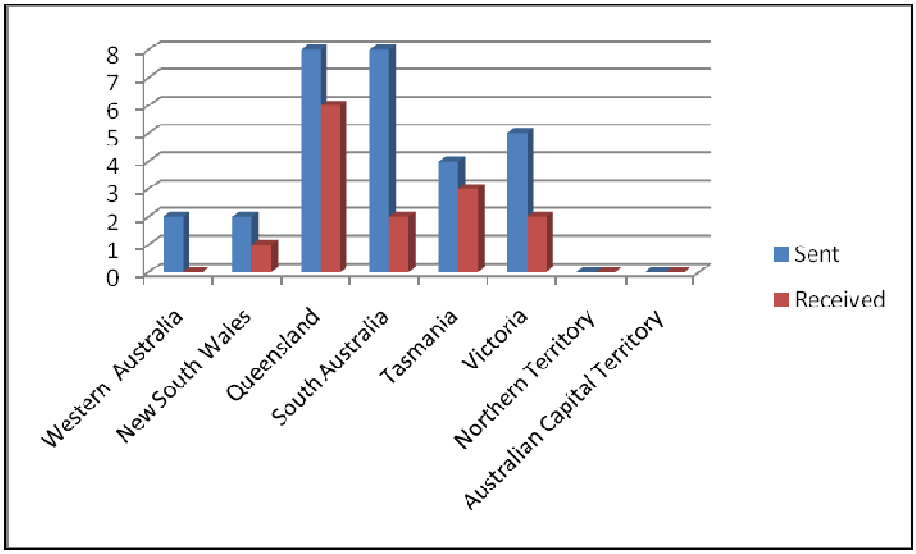

Figure 7-1: Survey Scope and Responses

As seen graphically in Figure 7-1 above the survey was not sent to Council's located in the Northern Territory or the ACT. As a result of no responses being received from Western Australia the survey analysis does not include the three above mentioned states. Therefore the survey results only encompass New South Wales, Queensland, South Australia, Tasmania and Victoria. Queensland had the biggest number of responses and the surveys response rate was 75% in Queensland and Tasmania. Figure 7-2 below shows the participation rate of the Councils in the survey.

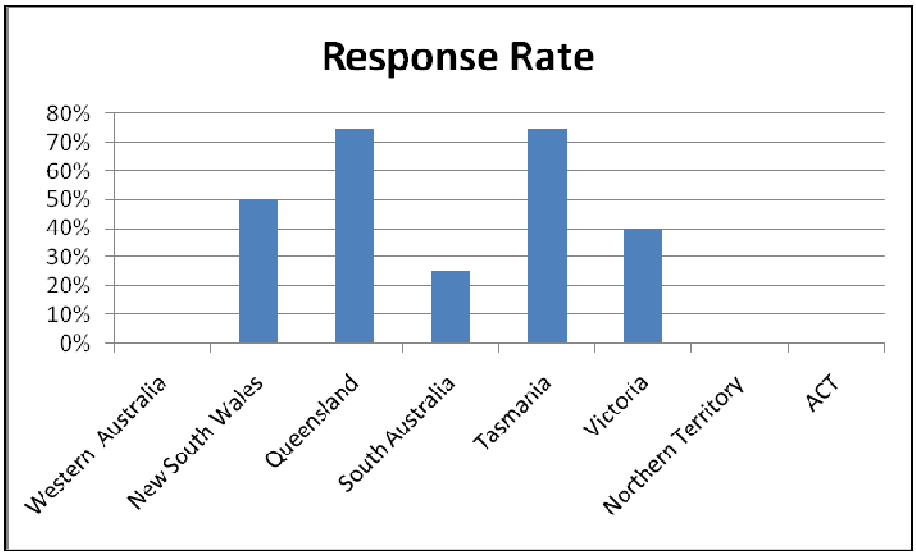

Figure 7-2: Survey Response effectiveness

The location of Councils geograpgically vary and the approach to the practises realting to Low Volume Rural Road pavements also vary. As the survey was applied to forteen Councils the results are weigthed infavour of the State or States which provided the greatest number of responses. The weighting of responses received from each indiviaul State is highlighted below in Figure 7-3. As seen graphically below the responses from Queensland have the greatest weigthing as approximately half of the responses received are from Queensland Councils and the remaining four States make up approximately the other half of the responses.

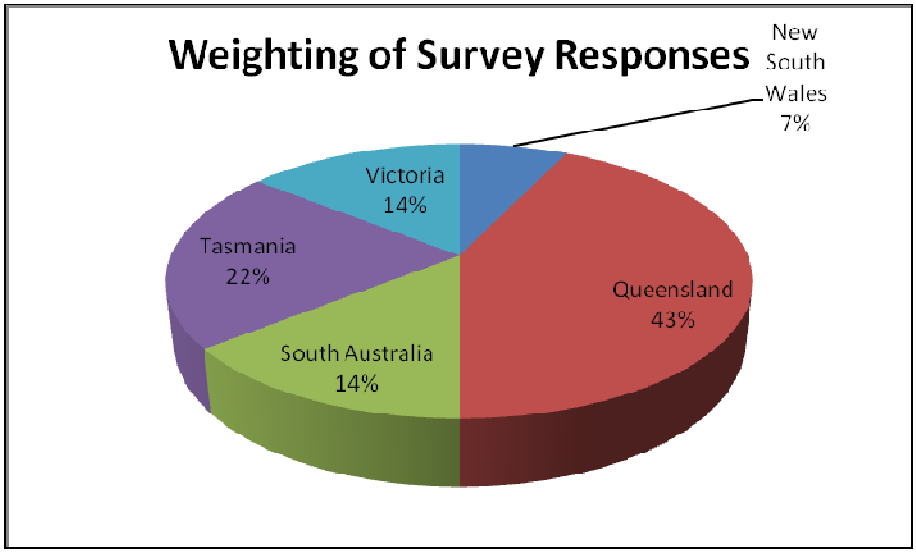

Figure 7-3: Weighting of Survey Responses by State

7.5.1 Council Roads

The survey has identified that the majority of the roads controlled by each Council in their municipality are classified as rural roads. Over 85% of Council's indicated that the percentage of classified rural roads under their control is greater than 61% of total road network. 50% of the Councils have indicated that rural roads constitute over 81% of the total road network. Only one Council, City of Port Lincoln Council has less than 20% of it total road network classified as rural roads. It is unknown from the survey responses exactly what percentage of the rural roads are made up of Low Volume Rural Roads however a significant portion of the rural roads could be categorised as low volume within each municipality. Figure 7-4 below highlights the nature of the responses in regard to the percentages of rural roads for each Council.

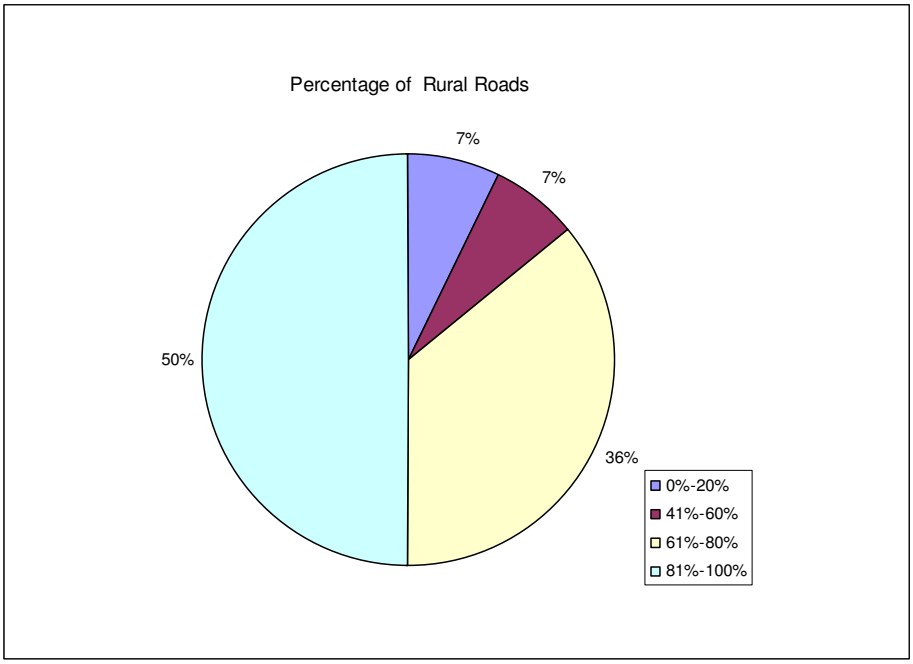

Figure 7-4: Percentage of Rural Roads

Where the pavement is unsealed the rural road would likely be categorised as low volume. A total of 35% of Councils stated that fewer than 20% of the rural roads are unsealed, and 21% of the respondents indicated that over 81% of their rural roads are unsealed. Another 29% indicated that that between 60 and 80% of the rural roads are unsealed. This highlights the varying nature and functionality of Low Volume Rural Roads as no distinct conclusions can be drawn from what percentage of rural roads are unsealed and classified as low volume. The result also indicates that the percentage of rural roads that are constructed with in-situ material varied between municipalities. The respondents from New South Wales, South Australia and Victoria provided aligned responses regarding what portion of road are constructed of in-situ material under their control. Queensland which had the largest number of respondents had varying responses, as 66% or approximately two thirds of surveyed Queensland Councils stated that under 40% of there road network is constructed of an in-situ pavement material. Figure 7-5 below indicates the percentage of unsealed in-situ road pavements graphically.

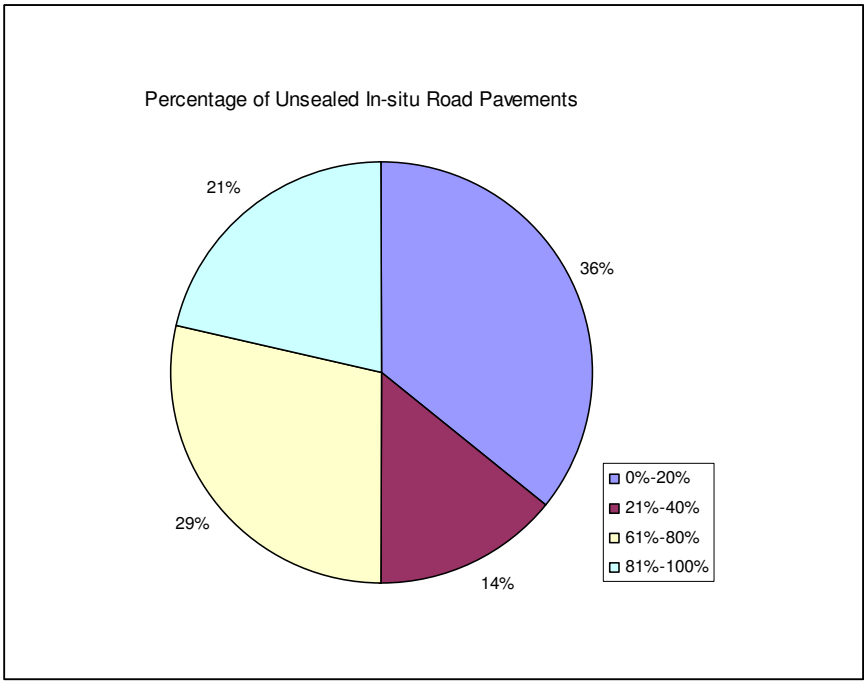

Figure 7-5: Unsealed In-situ Road Pavements

It was found that the majority roads within the road network for each Council are constructed with gravel. Over 71% of Councils indicated that above 60% of their entire road network consists for gravel pavements. Only four respondents (28%) indicated that less than 60% of their road network is made up of gravel pavements. In summary two thirds of Councils surveyed have over 60% of their road networks consisting of gravel pavements. The remaining 40% of Councils roads are constructed with a rigid pavement or an in-situ pavement.

Although the percentage of different road pavement structures, e.g. in-situ material, and gravel material varies, including the lengths of rural roads in each municipality, all the Council's surveyed indicated the AADT which is used to classify a Low Volume Rural Road is below 200. This consensus reaffirms a consistent National approach to classifying acceptable volumes of traffic for varying road classifications. Five Councils (35% of respondents) nominated a cut of 50 vehicles per day for low volume. Four Councils (29% of respondents) nominated a Low Volume Rural road can cater for up to 100 vehicles per day and four Councils (35% of respondents) used 200 vehicles per day

for a cut-off for a road to have a classification of Low Volume. Figure 7-6 below indicates the number of responses for each AADT classification.

Figure 7-6: Number of Responses per AADT

The survey has identified that the main reason for upgrading an existing Low Volume Rural Road, to either a gravel pavement from an in-situ material or sealing an unsealed pavement or reclassifying the roadway is because of increased traffic volumes. All Councils excluding one Council (7% of respondents) highlighted this was part of the consideration process to upgrade a Low Volume Rural Road. Consistency with responses was evident as eight Councils (60% of respondents) indicated that the main reasons to upgrade an existing Low Volume Rural road are:

- Increased traffic volumes,
- Community complaints, and
- Traffic Hazards.

South Australian, Tasmanian, Victorian and New South Wales Councils all provided aligned responses to this question of the survey.

Three Councils (21% of respondents) noted that only an increase in traffic volumes would constitute their decision to upgrade a Low Volume Rural Road. Two Councils (14% of respondents) place significance on increased traffic volumes and community complaints in justifying an upgrade to a Low Volume Rural Road.

7.5.2 Guidelines, Specifications and Testing

With the wide geographical coverage of Councils and the various States each Council is located in, the reference material used in developing Low Volume Rural Road pavement designs and specifications vary. For designing Low Volume Rural Roads State Road Authority manuals, ARRB guidelines, NASSRA and Austroads publications are referred to as appropriate design guidelines.

Four Councils (29% of respondents) indicated that no reference documentation is used to develop pavement designs. The designs are carried out based on local knowledge, expertise and sound engineering judgement. Of these responses all four Councils are from different states. This highlights the vast uncertainty that surrounds Low Volume Rural Road pavement designs and indicates how often processes relating to Low Volume Rural Road pavements are inconsistent and in certain circumstances unregulated.

Of the Councils that provided a response to reference material such as design guidelines, although each Council and State slightly differed in responses, recognised publications were referenced, such as the Unsealed Road Manual from ARRB, State Road Authority Design Guides such as the Department of Transport and Main Roads (DTMR), Queensland Pavement Design Manual and/or NASSRA and Austroads reference material. Figure 7-7 below indicates the percentages of Councils that reference no design guidelines and the percentage that reference State or Nationally recognised publications.

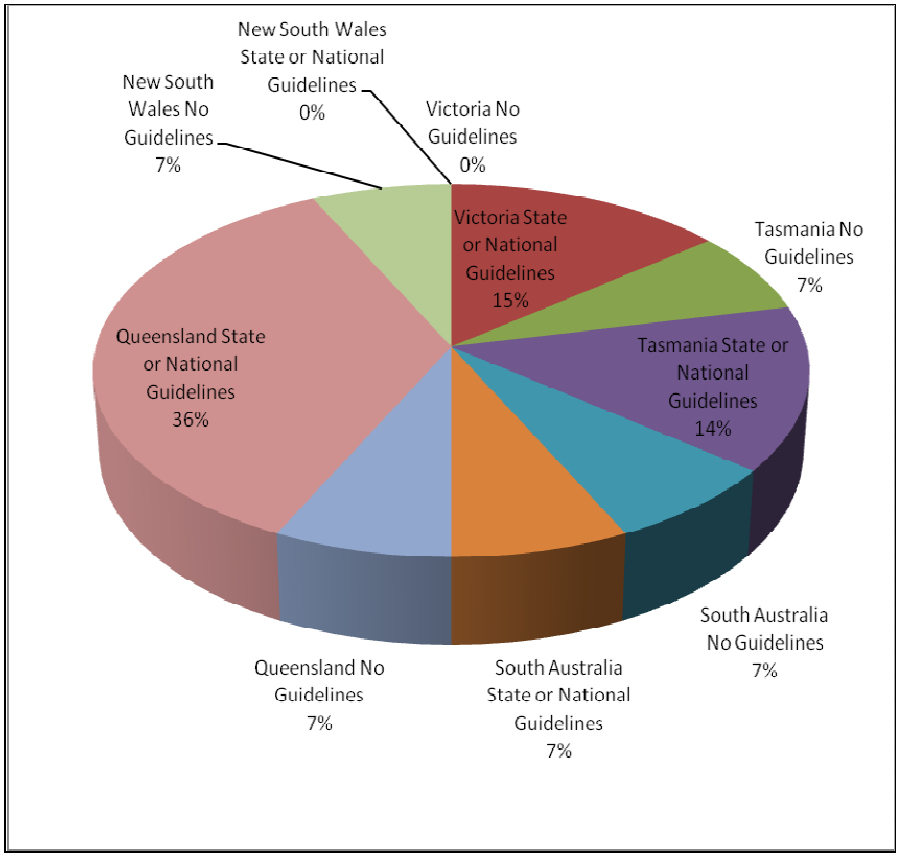

Figure 7-7: Guidelines referenced by Councils in each State

In regard to construction documentation responses to reference documentation used in conjunction with Low Volume Rural Road pavements varied. In some instances no guidelines are referenced and in other instances publications from State and National bodies were referenced. Four Councils (29% of respondents) indicated that no reference documentation or guidelines are used. This is the same number of Councils that responded that no guidelines are referenced for the design procedures. Four Councils from Queensland (29% of respondents) referenced the Queensland Main Roads manuals.

For maintenance practises eight Councils (57% of respondents) have specified that no guidelines are referenced. Therefore maintenance is undertaken as directed onsite and as required, based on community complaints and/or visual inspection. Of the Councils that provided a reference to maintenance guidelines, although each Council and State slightly differed in responses, recognised publications are referenced, such as the

Unsealed Road Manual from ARRB, State Authority Maintenance guides such as DTMR, and/or NASSRA and Austroads reference material. Three Councils (21% of respondents) referenced State guidelines.

Two Councils responded that no documentation is referenced for any of the current practises in relation to Low Volume Rural Road pavements regarding the design, construction and maintenance.

The survey indented to ascertain what practises the Councils currently undertake and how these practises interrelate between Councils and States. In regard to what testing Council's undertake for the design of an in-situ Low Volume Rural road, over twelve Councils (86% of respondents) directed that no testing is undertaken. Only two Councils (14% of respondents) located in Queensland responded that when designing an in-situ pavement tests are undertaken such as laboratory testing or in-situ testing.

In regard to the testing that is undertaken on gravel Low Volume Rural Road pavements during the design process only two Councils (14% of respondents) responded indicating that laboratory testing is undertaken, these two Councils were different Councils to the ones that nominated that testing for an in-situ (earthen) road is undertaken. The remaining twelve Councils (86% of respondents) indicated that no testing is undertaken.

All fourteen of the Councils surveyed indicated that pavement design software, such as Circly which has the capability to undertake mechanistic design procedures is not utilised in conjunction with the design of Low Volume Rural Road pavements. This result indicates pavement designs on Low Volume Rural Roads are undertaken without rigorous programming requirements and computations. This also means that the mechanistic pavement design method is not used in conjunction with Low Volume Rural Road pavements.

7.5.3 Maintenance

Section three of the survey relates to the maintenance practises that are currently undertaken for Low Volume Rural Roads in each municipality. Analysis of the results indicated that a consistent approach to maintenance doesn't occur nationally across all of the surveyed Councils. Programmed maintenance is undertaken by seven Councils (50% of respondents) and six Councils (42% of respondents) undertake maintenance on an as required basis. One Council indicated that it undertakes maintenance as programmed and also as needed which is the desirable practise. Programming maintenance is a proactive approach, where undertaking maintenance as needed is a reactive approach to maintenance. For the asset to be maintained in its desired condition programmed maintenance is ideal where adequate funds are allocated. These funds incorporate maintenance requirements programmed and as needed in case of an unexpected pavement failures or events. Figure 7-8 below indicates the breakdown of each State's current maintenance practises.

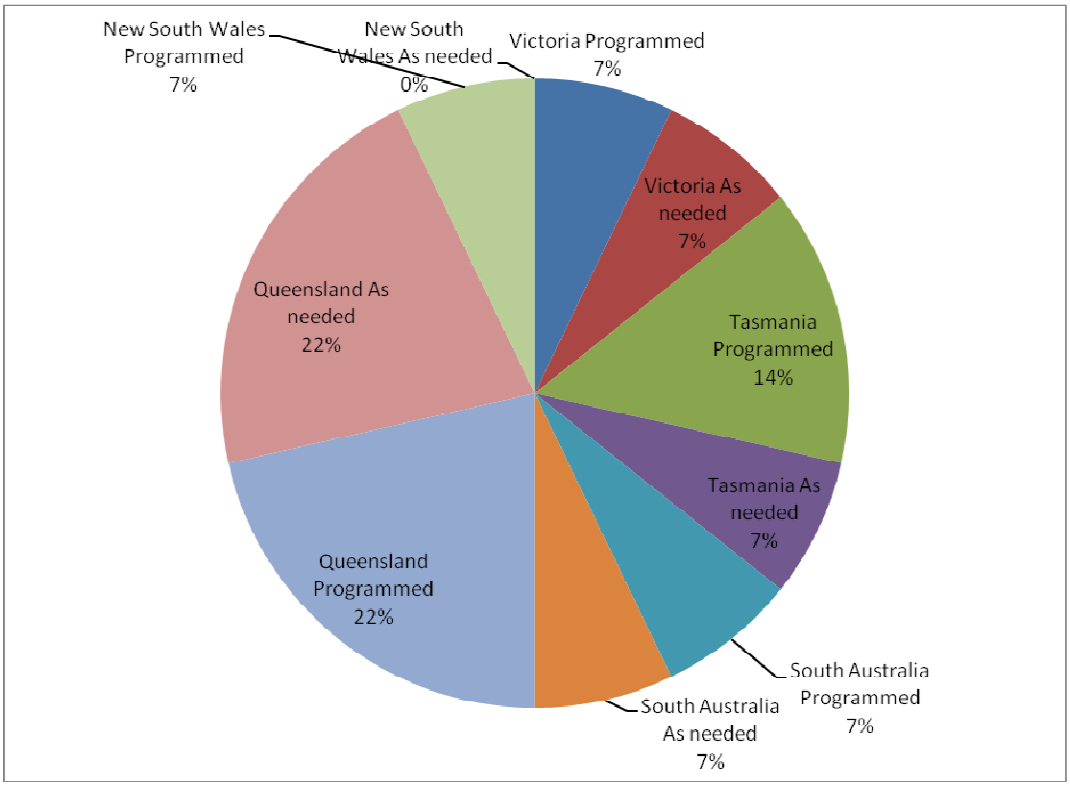

Figure 7-8: Maintenance Practises undertaken by Councils in each State

Undertaking maintenance is essential in satisfying the community requirements and maintaining the asset. Only three Councils (21% of respondents) indicated that the community have no influence on their decision to undertaken maintenance on a Low Volume Rural Road. The remaining eleven Councils have indicated that community complaints do influence Council's planning and decision making to undertake maintenance on local roads. Another reported common influence on maintenance practises is traffic hazards, nine Councils (64% of respondents) indicated that this plays a role in determining and prioritising what maintenance to undertake. Both of the above criteria's (community complaints and traffic hazards) should not be dictating maintenance practises, as the maintenance should be undertaken to appease the community and reduce traffic hazards rather than be undertaken after a problem or incident has been identified.

Ten Councils (71% of respondents) indicated that scheduled maintenance planning and requirements influences their decision to undertake maintenance. This is a desirable outcome as planning for maintenance is an important measure in preserving the asset as desired and minimising the risk of an incident occurring.

Only one Council (7% of respondents) indicated that they undertake maintenance to spend funding. This highlights that funding is a major concern for local governments and their maintenance practises.

Although the responses are similar between the Councils, no two Councils within each State responded with identical results, indicating the maintenance is often interpreted to have varying degrees of importance in various municipalities. This also highlights that there is no set system implemented that incorporates maintenance practises for local governments.

How the maintenance is undertaken signifies an aligned approached. All Councils baring one (93% of respondents) highlighted that maintenance methods (extent and requirements) are undertaken as directed on site. No testing or planning is undertaken as

the site engineers are suitably experienced and qualified to provide the required direction to rectify the problems.

When analysing what constitutes Council's maintenance process, all Councils (100% of respondents) that responded to the question indicated that grading of the pavement is always associated with road maintenance. Eight Councils (57% of respondents) indicated that material is added as part of the maintenance regime on a Low Volume Rural Road. These two operations (grading and adding material) constitute 86% of the total maintenance operations undertaken based on the survey results.

7.5.4 Construction

The surveyed Councils were questioned regarding what testing is undertaken during the construction phase of an unsealed in-situ road. Ten Councils (71% of respondents) indicated that no testing is undertaken during the construction of an unsealed in-situ Low Volume Rural Road pavement. Four Councils (28% of respondents) indicated that some testing is undertaken. These tests consisted of pavement material depth checks, cross fall checks (string line) , in-situ compaction testing, in-situ moisture content testing and visual inspections/ testing such as proof rolling with a water truck, to test for any visual deformations within the pavement and looking at the quality of the in-situ material used.

For gravel roads sealed or unsealed, a larger number of Councils indicated that testing is undertaken compared to in-situ pavements. Seven Councils (50% of respondents) indicated that testing is undertaken, and the remaining seven Councils (50% of respondents) indicated that no testing is undertaken. Tests that were specified consisted of testing and grading the imported materials from the suppliers, compaction testing, subgrade testing (CBR), moisture content testing, pavement depth tests and cross fall checks.

For the construction of a Low Volume Rural Road, Councils indicated that only two types of documentation exist. Seven Councils (50% of respondents) indicated that the processes and methods undertaken are fully dictated on site by suitably qualified personnel resulting in minimal documentation. The remaining Seven Councils (50% of respondents) indicated the some documentation is provided to construct the Low Volume Rural Road pavement however it is largely dictated on site by experience personnel. No Council responded stating the construction of a Low Volume Rural Road pavement requires a fully documented design including drawings, specifications and reports.

The materials that are used for the construction of Low Volume Rural Road pavements vary between Councils and localities. Nine Councils (64% of respondents) indicated that onsite material is utilised in the construction of their Low Volume Rural Road pavements. Where the onsite material is not of adequate quality or standard imported natural gravels or crushed rocks are used. The remaining five Councils (36% of respondents) indicated a mixture of important materials and crushed rocks constitute the pavement materials used.

7.5.5 Environmental

All Councils excluding one Council (7% respondents) identified some environmental concerns and issues that are considered in conjunction with the design, construction or maintenance of Low Volume Rural Road pavements. Environmental considerations were vegetation concerns, erosion and sedimentation control and drainage issues. Eight Councils (57% respondents) noted that damage to roadside vegetation is a concern. Six Councils (43% respondents) indicated that sediment and erosion control is of concern when dealing with Low Volume Rural Road pavement operations. Other environmental concerns that were identified were Pastoral requirements, Fauna and Flora and maintaining watercourses.

7.5.6 Other Comments

Serval Councils commented on general issues that they face, or highlighted interesting facts that surround their current operation and practices in relation to Low Volume Rural Road pavements. A summary is provided below:

The City of Port Lincoln Council indicated roads are predominated sealed. The length of sealed verus unsealed is 160km of sealed roads and 11km of unsealed roads. Of the unsealed roads approximately half are tracks that are rarely used and rarely maintained and classified as low volume.

Latrobe Council indicated that ground conditions within the municipality are similar therefore Council adopts standard design and construction methods. Site specific requirements if anything untoward occurs on site, are addressed during the project management process on site by experienced personnel.

The Coorong District Council classifies all roads under their control. This classification shows what the desired lane carriageway width is and how often maintenance is required for each particular road classification.

Toowoomba Regional Council is in the process of adopting a Quality Assurance (QA) system. This will require testing/additional testing for projects, above what current practises require. As part of this QA improvement process documentation (or additional documentation) for the construction of roads will be required for future projects.

Toowoomba Regional Council is also considering the adoption of a Maintenance Management System for their roads. This will be immediately implemented for Main Roads Maintenance Works (RMPC – Road Maintenance Performance Contract). It is envisaged that within three years this maintenance management system will be adopted and implemented for all Council roads. This will result in going from an ad hoc or as needs basis for maintenance to a planned maintenance program. This approach has been

adopted by other Council's around Australia. Some have already implemented Maintenance Management Systems, but some Councils (including Toowoomba Regional Council) are in the process of adopting and implementing such a system.

Whitsunday Regional Council manages 800km's of unsealed rural roads. Available material from deco pits is used to maintain the rural roads. Clay materials play a large part in holding the roads together however major damage can occur in the wet season. Finding the right combination of materials is a balancing act and good results have been found from mixing natural stone or aggregate to 40mm diameter with the deco in rural re-sheeting applications. This is based on practical experience and in service testing.

7.6 Survey Conclusions

A summary of conclusions drawn from the survey are detailed below.

7.6.1 Council Roads

All Council's within Australia have Low Volume Rural Road pavements under their control. The survey has reinforced that there are greater lengths of rural roads compared to urban roads in most municipalities throughout Australia. Rural Roads and Low Volume Rural Roads constitute vast lengths of Council's road network of these roads the majority are unsealed, hence classified as Low Volume, however this varies geographically between each Council and State. This indicates that the results obtained from the Councils surveyed can be applied to constitute what methods and practises are currently undertaken with Low Volume Rural roads due to the large lengths of rural roads each Council controls, and their familiarity with these types of pavements.

The traffic volumes which constitute the cut off for a Low Volume Rural Road pavement was consistent across the country as no respondents indicated a volume of greater than 200 vehicles per day was acceptable for this classification of roadway. Therefore 200 vpd is the cut off volume for a Low Volume Rural Road.

The results of the survey clearly indicate where an upgrade to a Low Volume Rural Road pavement was determined to be undertaken the driving factors for upgrading are

increased traffic volumes, community complaints, and traffic hazards. Both community complaints and traffic hazards are as a result of poorly maintained or neglected pavements. Increased traffic volumes are as a result of local zoning changes or population growth and town planning issues. With a Low Volume Rural Road in service the most important part to increasing the longevity of that asset is to conduct appropriate and timely maintenance. This also requires ensuring that the roadway is catering to the in-service traffic as designed and the traffic volumes don't exceed the desired limits. Councils which are governed by funding requirements often are at the mercy of cash flow, hence maintenance practises are sacrificed. Upgrading a Low Volume Rural Road would only occur if the road is in poor condition, if the community voices it concern, or if there has been one or more incidents, traffic hazards or fatalities. The lack of funding and prioritisation of the funding towards Low Volume Rural Road pavements reflects the reasons why the community and traffic hazards are the driving force behind maintenance being undertaken.

7.6.2 Guidelines, Specifications and Testing

Where a pavement design is undertaken, Council's responses show there is not a consistent approach in formalising the design process. Variation in the responses indicates no set criteria or published guidelines are enforced or consistently referred to when developing a Low Volume Rural Road pavement design as a result of no universal standard existing. As a critical element of the pavement performance this approach detrimentally impacts the functionality of the pavement, regardless of regular maintenance provisions and correct construction methods.

Construction guidelines are also not consistently referenced and Councils which did not reference design guidelines also didn't reference construction guidelines. Numerous Councils stated some construction guidelines are referenced however the inconsistency of responses shows a lack of direct integration with guidelines.

The survey results indicated that testing is generally not undertaken on Low Volume Rural Road Pavements during the construction process, regardless of the type of pavement.

In summary the results in Section One of the survey indicate the design, construction and testing relating to Low Volume Rural Roads being undertaken on an ad-hoc basis and not fully controlled and documented in accordance with any guidelines or best practise methods. Each Council undertakes practises based on their own preconceived methods rather in accordance with prescribed standards or practises.

7.6.3 Maintenance

In regard to the maintenance methods used, the survey indicated that maintenance is either programmed or undertaken as needed, identifying all Council's do undertake maintenance and recognise the important of maintenance. However there is no consistent method in dealing with maintenance. Traffic hazards and community complaints regularly instigate unplanned maintenance to be undertaken, similar to the reasons why a Low volume Rural Road gets upgraded.

The extent and type of maintenance to be undertaken shown through the responses in the survey indicates that the maintenance is undertaken as directed on site. All responses to the survey indicated an aligned approach highlighting this is the commonly adopted practise. No documentation is produced for setting out and controlling the maintenance to be undertaken.

The survey results also show that grading, and adding additional materials are the common practises undertaken for maintaining a Low Volume Rural Road pavement. The problem is that is there no evidence that a roller and water truck is used in conjunction with the material replacement and grading which results in a poor standard of rehabilitated pavement, where compaction is not achieved resulting in the wearing course being susceptible to deterioration.

7.6.4 Construction

The results of the construction section of the survey do show consistent approaches are adopted. Testing is generally not undertaken on Low Volume Rural Road pavements; however there is the rare occasion that testing is undertaken and it would consist of one or more of the following tests, a string line test, moisture content tests, in-situ compaction tests or proof rolling.

Complete documentation of Low Volume Rural Road pavements encompassing design and construction is never undertaken in its entirety. If any documentation is produced it is often lacking completeness and the voids in the documentation are filled by assuming that it is acceptable practice for experienced on site personnel to provide direction on site. This assumption often results in substandard and non durable pavements being constructed, and the pavement not being fit for purpose as desired.

Materials used in the construction of the pavement for Low Volume Rural Roads commonly consist of onsite material and readily available material, as indicated by the majority of Councils in the survey responses. Imported materials are not preferred in the construction of Low Volume Rural Road pavements because of the associated transportation costs.

The testing of a pavement is only undertaken on gravel pavements and not on in-situ or earthen pavements during construction, as highlighted by the survey responses.

7.6.5 Environment

The survey responses highlight the environmental concerns are consistent regardless of the pavements location. The common environmental concerns relating to Low Volume Rural Road pavements are erosion and sedimentation control, damage to roadside vegetation and stormwater drainage and / runoff issues.

7.6.6 Summary

Conclusions drawn from the survey results indicate that due to the inconsistency and varying nature of the responses Low Volume Rural Road pavements are not treated as critical assets and often processes and procedures are missed, avoided, or not fully undertaken due to a perception that Low Volume Rural Road pavements are not important compared to other assets. This has resulted in the current approaches relating to Low Volume Rural Road pavements not being consistent with reference material and guidelines. This diversity between the prescribed guidelines and current practises are as a result of numerous factors. The main factor is the misconception regarding the importance of these Low Volume Rural Road pavements and ensuring adequate compliance with guidelines. Budgetary issues and political pressures must not dictate if the prescribed measures are undertaken on these pavements. A blasé approach to the design, construction, maintenance and operation of these pavements has the potential to increase the risk of a negative impact on the social, physical and environmental factors. Undertaking a comprehensive process in relation to Low Volume Rural Road pavements would reduce risk and provide a beneficial solution to all stakeholders.

8 Recommendations

The best practise design guidelines have been summarised below from the survey results and also published literature highlighting criteria to be considered.

8.1 Low Volume Rural Road Classification

Due to the varying functionality and numerous classifications of Low Volume Rural Road's, pavement designs should be based on the functionality of the individual roads and their classification. The classification of roads allows for a more rigorous and regulated design to be undertaken for each applicable situation. This breakdown will also allow for regularity in approaches for designing outside of the prescribed classifications. Each individual Council should adopt the prescribed classifications and conform to the design, construction and maintenance guidelines as far as practical to ensure consistency. A Low Volume Rural Road pavement should be closely designed in coordination with the prescribed alignment requirements.

The cut-off values for traffic volumes (AADT) should be set at 200 inline with the survey responses. All roads above this classification should not be classified as Low Volume Rural Roads. They should be classified and treated as Rural Roads. Low Volume Rural Roads should be broken down into sub classifications for example Track, Access, Minor, and Major.

8.2 Pavement

Austroads "A Guide to the Design of New Pavements for Light Traffic" (APRG report 21) has been incorporated into the Austroads "Guide to Pavement Technology – Part 2: Pavement Structural Design". This should be referenced in the design to Low Volume Rural Roads where Councils wish to validate the design approach. If a different design which is non standard, the design should be aligned with the recommendations of the Austroads Manual. This manual, state guidelines or published Council guidelines must be enforced and referenced when designing a Low Volume Rural Road pavement.

8.2.1 Traffic Volumes and Road Pavement Types

The design life of the pavement should be set at a 20 year maximum. This will allow for the pavement to provide an adequate serviceability for a projected period of time, with adequate maintenance provision. The longer the design life the greater the conservatism to the pavement structure for the varying heavy vehicle volumes which may use the road. Values for the design life of the pavement to be above 20 years are considered excessive because of the functionality of a Low Volume Rural Road pavement.

Regarding Low Volume Rural Roads a classification of the breakdown of the road hierarchy should be adopted to allow for greater certainty in the practices relating to these roads. A suggested breakdown is shown below in Table 8-1:

Table 8-1 Low Volume Rural Road Hierarchy

Classification	**Track**	**Access**	**Minor**	**Major**
AADT	0 to 50	51 to 100	101 to 150	150 to 200
Type	Class A	Class B	Class C	Class D
ESA's	1 x 10^4	3 x 10^4	8 x 10^4	1 x 10^5

The above table should be used to provide a pavement design which would achieve the best practice design solution. The ESA's have been grouped based on a 20 year design life with a 2% heavy vehicle traffic volume. The table above shows the roadway classifications and the expected traffic volumes and the generic pavement type which would be acceptable for each circumstance. A Type Class A pavement is an in-situ material pavement structure. A Type Class B pavement is a single layer of gravel material on a prepared in-situ subgrade. The gravel layers acts as the wearing course of the pavement as well. A Type Class C pavement is a gravel base course with the inclusion of a single sprayed seal surface to act as the wearing course. A Type Class D pavement is a gravel pavement with a bituminous two coat sprayed seal or asphalt wearing course.

For Low Volume Rural Roads there is not a one stop solution that encompasses all issues as numerous factors need to be considered. Generally a Track's pavement material may be in-situ material (earthen) with no gravel wearing course or formation as the traffic volumes are low (Class A pavement). For an Access road an in-situ material may be used, however the carriageway should be formed to provide a roadway cross section. A gravel base course which acts as a wearing course is preferred for the pavement due to the increase traffic volumes (Class B pavement). Minor and Major roads a gravel wearing course and a seal (asphalt in extreme cases), (Class C and D pavements) is required. Each type of treatment may be the most appropriate treatment for any of the classifications of roads depending on the circumstances.

Where the geometry of the roadway is in steep or undulating terrain Class C and Class D pavements should be considered to improve the safety of the roadway and to reduce the risk to the road user, the operation, the maintenance and environmental factors. A spray seal should be considered as the minimum acceptable wearing course treatment in such situations. The inclusion of spray sealed and wearing courses should be considered where there is a possibility of water ingress into the pavement.

Where traffic data changes, such as the percentage of heavy vehicles or seasonal change to recreational or community events impact the traffic volumes the pavement design adopted should be adjusted at the Local Government's discretion, and reference made to Austroads "Guide to Pavement Technology – Part 2: Pavement Structural Design", for applicable alternative design guidelines.

Figure 3-1 should be referenced when designing the pavement thickness for Low Volume Rural Road granular pavement.

8.2.2 Subgrade

For an adequate design to be carried out sufficient preliminary investigation must be undertaken on the subgrade material. CBR tests should be undertaken for Low Volume

Rural Road pavements to be designed. Tests should be at approximately 50m centres where no less than three tests must be undertaken for any length of road.

Where testing is unfeasible practical knowledge of the soil type within the region in conjunction with previous pavements subgrades may be considered for estimating a CBR value for a length of road in certain circumstances, based on adequate data and experienced personal to conclude a sound judgement. The outcomes and assumptions should be documented for future review and assessment.

8.2.3 Stabilised Pavements

Stabilised pavements may be used in areas of concern or where there is an economical justification to using a stabilised material. Where a CBR value and poor soil conditions are encountered, or where low quality material is to be incorporated into the pavement structure, stabilising agents should be investigated as a solution to improve the strength of the pavement structure.

8.2.4 Materials

Materials should be of the highest quality that can be sourced within the local area, where substitute or substandard materials are used justification is required. This may be based on economical reasons or past experience where certain materials are able to function as desired and provide an acceptable solution. Where materials are not easily sourced Figure 3-2 should be reference to help assist in the design assumptions. The assumptions should be documented to allow for future reference and review once the pavement has been in-service.

8.2.5 Recycled Materials

Recycled materials may be substituted in the pavement structure subject to the Local Governments approval. Council's should endeavour to undertaken trial pavements with the inclusion of recycled materials to test their feasibility, before adopting this process.

Councils should investigate and trial pavements as soon as possible as there are substantial benefits in using recycled materials and promoting sustainable practises.

8.2.6 Drainage

Due to the potential ingress of moisture to the subgrade and potential changes in volume in expansive soils and the moistures potential to weaken unbound materials consideration of the pavement solution and adequate surface drainage provision is required. Drainage should be considered in the design procedure of the pavement and minimum design criteria for drainage should be set at a minimum 10 year Average Recurrence Interval (ARI) event. This would require cross drainage structures such as culverts and road side channels to adequately covey a 10 year ARI storm. Water and temperature have a major effect on pavement performance. Temperature directly affects the performance of seals, asphalt and concrete, and water directly affects the performance of unbound granular pavements and subgrade. Water can also affect asphalt. Knowledge of environmental conditions is essential for the design, construction and maintenance of pavements

Subsurface drainage should not be considered in the design of Low Volume Rural Road Pavements.

Where the roadway transverses a floodplain or watercourse, a floodway may be incorporated into the design. The floodway must incorporate adequate design to ensure the time of closure and time of submergence will not adversely impact the surrounding community, industry or road users. Isolation of communities should be avoided where feasible.

8.2.7 Life Cycle Costing

Life cycle costing analysis should be undertaken for each pavement design to help determine the most economical solution for the pavement for the duration of it's life span.

8.3 Construction

The construction of the pavement, inclusive of the construction methods and machinery used should be of the highest standard that can be readily sourced and utilised. Testing should be undertaken during the construction processes. Tests should consist of proof rolls to ensure adequate compaction is achieved. String lines to ensure the geometry of the roadway is acceptable and CBR testing to ensure adequate compaction and water content has been achieved during the construction process. These tests should be undertaken regardless of the pavement materials used.

8.4 Maintenance

A large amount of Low Volume Rural Roads are in service in all States of Australia.

Maintenance should be programmed for each classification of road. The maintenance period and funding required should vary based on the road classification. Unsealed pavements will require routine visual inspections at shorter intervals than sealed pavements. Re profiling and physical maintenance practices should be undertaken as planned to suit the pavements condition and geographical location. Severe road deformation or pavement failures should be addressed as soon as possible. Table 5-1 and 5-2 provide clear directions on maintenance defects and measures to address these defects that should be adhered to.

8.4.1 Scheduled Maintenance

Schedule maintenance should be programmed to suit the pavements requirements and allow for seasonal adjustments and budgetary funds. Road management systems should be developed to allow for successful maintenance planning and resourcing requirements.

8.4.2 Unscheduled Maintenance

Funding should be allocated to allow for unscheduled maintenance as natural disasters and unforseen events can always occur and have a detrimental impact on the road network.

8.4.2.1 Reliability

Load related distress for Low Volume Rural Road pavements generally doesn't occur as there is a greater chance that distress relating to environmental factors commonly necessitates pavement rehabilitation requirements. Defects such as pavement failures, potholes, blockage of drainage channels, loose gravel, shoving, coarse texture, corrugations and rutting can all be identified and therefore planned to be rectified through regular visual inspection.

8.5 Environmental Considerations

The environmental considerations should be accounted for in the design, construction and maintenance of Low Volume Rural Road pavements. Clearing should be limited to the minimum allowable footprint to not adversely impact the existing vegetation. Waste materials from the development of the Low Volume Rural Road pavement should be reduced. Contaminated runoff must be sufficiently conveyed to nominated points of discharge only in environmentally sensitive areas should containment and pollutant removal be considered. Dust should be minimised during and after construction with the construction methods used and the material selection of the wearing course. Stormwater should be conveyed and discharged at nominated points to not adversely impact the surrounding environment. Applicable cultural heritage, flora and fauna, and contaminated land surveys should be undertaken prior to the design. Adequate erosion and sedimentation measures should be installed during the construction of the pavement.

8.6 Key Criteria

Table 8-2 Summary of Key Criteria

Classification	Track	Access	Minor	Major
AADT	0 to 50	51 to 100	101 to 150	150 to 200
Type	Class A	Class B	Class C	Class D
ESA's	1 x 10^4	3 x 10^4	8 x 10^4	1 x 10^5
Pavement Type	In-situ	Gravel / In-situ	Gravel / Sealed / unsealed	Gravel Sealed
Pavement Thickness (min)	Varies	Varies / 100mm	100mm	100mm
Maintenance Programmed (Minimum Requirement)	Visual Inspection / 6 mth	Visual Inspection / 6 mth	Visual Inspection / 3 mth	Visual Inspection / 3 mth
Maintenance (Other)	Immediately after an event	Immediately after an event	Immediately after an event	Immediately after an event
Construction Testing	CBR Testing	CBR Testing Proof Roll	CBR Testing Proof Roll String Line	CBR Testing Proof Roll String Line
Drainage	20 year ARI immunity Adequate cross fall to allow free drainage surface	20 year ARI immunity Adequate cross fall to allow free drainage surface	20 year ARI immunity Adequate cross fall to allow free drainage surface	20 year ARI immunity Adequate cross fall to allow free drainage surface
Environmental	All departmental Surveys Erosion and Sedimentation Control Minimise Disturbance	All departmental Surveys Erosion and Sedimentation Control Minimise Disturbance	All departmental Surveys Erosion and Sedimentation Control Minimise Disturbance	All departmental Surveys Erosion and Sedimentation Control Minimise Disturbance

9 Conclusion

This research has identified the methodology for the pavement designs and associated practises have been undertaken with different approaches in relation to Low Volume Rural Roads. The devised survey was successfully applied to numerous Councils. The results from the survey clearly indicate the intent of Council's is to design in accordance with National and State guidelines however the designs and practises undertaken are not in accordance with the required documentation and intent because of limitations placed on the Councils and external factors such as budgets, material availability or construction processes to name a few. The recommended approach to adhere strictly to National or State guidelines which are founded on previous research, is not occurring. Often these prescribed methods are onerous and to broad for the practical situations that Local Governments encounter. For situations which are outside of the recommended criteria it is diligent to align the approach to the prescribed practises as close as practical to ensure the status quo is achieved. While it is impractical to apply universal guidelines to all Councils and pavements due to the number of variables such as varying climatic and geographical influences in each municipality, the fundamental methodology and approach should change to improve the consistency between approaches.

A single solution to Low Volume Rural Road pavement cannot be concluded as a pavement consists of numerous elements which integrate together resulting in a unique structure. No signal direction or specification can achieve a conclusive design, construction, maintenance or operational outcome relating to a Low Volume Rural Road pavement. A change in any one component impacts the resulting outcome. As such, this research has provided a rational basis for comparing the varying design, construction and maintenance individual elements. In addition each component has been critically evaluated highlighting the key criteria to be considered in conjunction with a Low Volume Rural Road pavement.

The design, construction and maintenance of Low Volume Rural Road pavements were broken down into numerous individual segregated but interrelated elements. For each element, a conclusion on ‘best practice’ was achieved.

10 Further Work

During this study, information on Low Volume Rural Road pavements was found to be vague, conflicting and often ambiguous. This was reflected in the survey responses in which Local Councils provided aligned responses for some items and varying responses for other items. It also became evident that the same Councils provided different responses to the same questions. Therefore, some recommendations for further research become evident.

The survey sent to Councils was sufficient for a preliminary investigation into the current practices relating to Low Volume Rural Road pavements only. The survey that has been used as part of this project provides a sound overview of the practises that relate to Low Volume Rural Road pavements but lacks specific details. The survey should be applied to the Northern Territory and Western Australia as there is many rural communities and Low Volume Rural Road pavements located throughout these States. A failure of this survey and project is that it doesn't include any information in relation to the two above mentioned States.

A more detailed survey should be applied to the relevant Councils requesting further information on the design procedures. This additional survey should be compiled to address more detailed processes with Low Volume Rural Road pavements. This survey should aim to investigate the actual length of each type of Low Volume Rural Road pavements within each municipality. The reasons behind the traffic volume cut offs for classifying Low Volume Rural Roads and the differences with the classifications and how this information is integrated with the pavement material selection type, the alignment criteria and assumed properties for the pavement design, maintenance and construction methods. The additional survey should also request information relating to the current schedule of maintenance that is undertaken. For example, if maintenance is undertaken quarterly, bi annually, or annually, and also if maintenance programming is undertaken and which department is responsible for the programming.

These additional survey responses would assist in providing direction for the development of standalone national or state guidelines relating to design, construction, maintenance and environmental concerns for Low Volume Rural Road pavements. The additional survey should also only be applied on a state by state basis as due to the wide geographic coverage of the survey undertaken in this project accurate results and findings were often hard to determine. By limiting any further surveys to each State this would assist in providing more accurate and detailed findings where results would be easier to compare, interpret and analyse.

An expression of interest from Councils could be sort to allow the Councils to participate in reviewing and applying the proposed documentation relating to Low Volume Rural Roads to allow for adequate review and troubleshooting of the recommended best practice procedures.

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Appendix A – Project Specification

University of Southern Queensland

FACULTY OF ENGINEERING AND SURVEYING

ENG 4111/4112 Research Project
PROJECT SPECIFICATION

FOR: **Ashley ZANETTI**

TOPIC: INVESTIGATION OF PAVEMENT DESIGN FOR LOW VOLUME RURAL ROADS

SUPERVISORS: Ron Ayers

ENROLMENT: ENG4111 – S1, D, 2010,
ENG4112 – S1, D, 2010,

PROJECT AIM: Investigate the rural pavement design approaches used within Australia and investigate the maintenance and environmental problems that result from rural road pavement defects.

PROGRAMME: (Issue A, 3 March 2010)

1. Research the background information relating to low volume, rural pavements within Australia and overseas, with particular attention to:
    a. Pavement design methods proposed and used;
    b. Pavement materials used;
    c. Pavement construction and maintenance methods used;
    d. Environmental problems associated with construction and operation of these roads, and
    e. Previous surveys of rural pavement design and operation.
2. Devise and trial a survey instrument to gain information from rural councils within Australia
3. Apply the survey to a minimum of 6 relevant councils in at least 3 Australian states.
4. Analyse the survey results and determine the scope of design, construction, maintenance and operational techniques being utilized across the surveyed councils.
5. Compare the survey results with the reviewed published literature and determine a set of guidelines for Australian best practice in regard to pavement design, construction and maintenance of low volume rural roads.
6. Present information and results in normal written and oral formats.

As time permits

7. Investigate as a result of poor pavement design or maintenance the safety hazards of a rural road

AGREED:

16/3/2010. (Student), 16/3/2010. __/__/__ (Supervisors)

Appendix B – Low Cost Surfacing Options

Below is a list of low cost surfacing options and their attributes.

Stone Paving	
Description	Natural stones measuring no more than 20 to 30 cm are laid on a 5 cm sand/gravel bed with the top surface set to the final cross-fall. The large stones are set with the wider face to the bottom. Empty spaces are filled with smaller stones and firmly wedged into place. Compaction is carried out with a vibrating pedestrian roller.
Uses	Surface for low-traffic roads Base for urban roads Base for low-traffic roads
Characteristics	Labour-based construction method Use of locally occurring materials Ease of maintenance
Traffic	For low-volume roads as surface All traffic categories as a base
Cost	Comparable with gravel surfacing if stones can be sourced locally
Life	Stone paving can have a very long life if maintained properly .Stones broken out of the pavement or damaged edges should be replaced immediately in order to avoid costly repairs
Clay or Concrete Brick Paving	
Description	Burnt clay or concrete brick (200 x 100 x 80 mm approximately) laid on a thin layer of sand or base
Uses	Surface for low-traffic roads, especially short sections Surface for urban roads, where speeds are below 50 km/h
Characteristics	Labour-based construction method High load-carrying capacity Reusable surfacing and can have high local resources component Ease of maintenance
Traffic	For low volume as surface for short sections From residential streets to heavy industrial application
Cost	Competitive with asphalt concrete in Europe where labour costs are high. Potential for significant cost savings in developing countries.
Life	Initial life 20 years and more, reusable bricks and blocks
Bituminous Surface Dressing	
Description	A thin film of bitumen applied mechanically or by hand onto the road surface and covered with a layer of stone chipping, then lightly rolled.
Uses	Surface for low-traffic roads and for short sections Surface for urban roads
Characteristics	Permits labour-based construction method Provides durable dust-free running surface Provides waterproof pavement seal and arrests surface deterioration Allows for ease of maintenance
Traffic	Can be used for all traffic categories
Cost	Inexpensive: typically 25% of the cost of an asphalt concrete surfacing.
Life	Typically five to 15 years in a tropical environment

(Source: Lebo, & Schelling(2000))

Appendix C – Surveyed Councils

List of Local Government Councils that had the survey sent to them.

State	Council	Contact	Position	Email	Phone
WA	Cockburn	Simon Lee	Road Hierarchy and Classification	simon@cockburn.wa.gov.au	(08) 9411 3544
WA	Shire of Brookton's	Geoffrey Froward.	Principal Works Supervisor	worksadmin@brookton.wa.gov.au	0428 972 968
VIC	Mansfield Shire	Phil Alexander	Managing Engineer	phil.alexander@mansfield.vic.gov.au	(03) 57758 550
VIC	Loddon Shire Council	David A Turner	Municipal Building Surveyor	dturner@loddon.vic.gov.au	(03) 5494 1200
VIC	Mitchell Shire Council	Matthew Irving	Design & Development Engineer	matthewi@mitchellshire.vic.gov.au	(03) 5734 6341
VIC	Yarriambiack	James Magee	Director of Infrastructure & Planning	jmagee@yarriambiack.vic.gov.au	(03) 5398 0100
VIC	Hepburn Shire Council	Richard Russell	Executive Engineer	rrussell@hepburn.vic.gov.au	(03) 5348 1633
TAS	Brighton	Heath Macpherson	Municipal Engineer	Heath@brighton.tas.gov.au	(03) 6268 7018
TAS	Central Coast Council	Paul Breaden	Engineering Group Leader	paul.breaden@centralcoast.tas.gov.au	(03) 6429 8985
TAS	City of Port Lincoln	Craig Matena	Operations Manager	craig.matena@plcc.sa.gov.au	(08) 8621 2322
TAS	Latrobe	Jonathan Magor	Manager Engineering & Works	JonathanM@Latrobe.tas.gov.au	(03) 6421 4650
SA	Kingston	Bob Bates	Manager Works & Engineering Services	bbates@kingstondc.sa.gov.au	(08) 8767 2033
SA	Flinder Range Council	David Smith	Works Manager	dbs@frc.sa.gov.au	(08) 8646 6638
SA	Pinnaroo	Peter Broughill	Works Manager	wm@southernmallee.sa.gov.au	(08) 8576 3744
SA	Tumby bay	Darren Zechner	Works Manager	dzechner@tumbybay.sa.gov.au	(08) 8688 2101
SA	Wattle Range Council	David Mosel	Manager - Assets & Engineering Services	david.mosel@wattlerange.sa.gov.au	(08) 87330901
SA	DC of Lower Eyre Peninsula	Damian Windsor	Works Manager	damianw@dclep.sa.gov.au	(08) 8676 2106

SA	Coorong District Council	Ron Downs	Rural Roads Supervisor	rdowns@coorong.sa.gov.au	0428 321 193
SA	District Council of Loxton Waikerie	Tom Murch	Works Manager	worksmanager1@loxtonwaikerie.sa.gov.au	(08) 8584 8024
QLD	Mount Isa	Emilio Cianetti	Director of Engineering Services	DirectorEngineering@mountisa.qld.gov.au	
QLD	Toowoomba	Chris Rubie	Manager Construction and Maintenance District	chris.rubie@toowoombaRC.qld.gov.au	(07) 4692 0104
QLD	Gympie Regional Council	Greg Ingham	General Manager Works	greg.ingham@gympie.qld.gov.au	(07) 54810899
QLD	Barcoo	Michael Brown	Works Manager	worksmanager@barcoo.qld.gov.au	(07) 4658 6912
QLD	Lockyer Valley Regional Council	Mitchell Bichel	Works Engineer	mbichel@lvrc.qld.gov.au	(07) 5462 0610
QLD	Toowoomba Regional Council	Nadia Ives	Manager Engineering Services	nadi.ives@toowoombarc.qld.gov.au	(07) 4688 6611
QLD	Townsville City Council	David Hore	Manager Design Office	david.hore@townsville.qld.gov.au	(07) 4727 9000
QLD	Whitsunday Regional Council	James Stewart	Transport & Infrastructure Manager	James.Stewart@whitsundayrc.qld.gov.au	(07) 47613605
NSW	Bland Shire Council (Wyalong)	Allan Curran	Works Supervisor	acurran@blandshire.nsw.gov.au.	(02) 69722266
NSW	Ballina Shire Council	Wes Johnstone	Project Engineer		(02) 6686 1229

Highlighted cells indicate the Councils that responded to the survey.

Appendix D – Survey Template

Low Volume Rural Roads Survey

Council Roads

1) What approximate percentages of council's roads are rural?

☐ 0- 20% ☐ 21- 40% ☐ 41- 60% ☐ 61-80% ☐ 81-100%

2) What approximate percentage of councils unsealed rural roads are constructed of locally available sub grade (in situ) material?

☐ 0- 20% ☐ 21- 40% ☐ 41- 60% ☐ 61-80% ☐ 81-100%

3) What approximate percentage of councils unsealed rural roads are constructed of gravel material?

☐ 0- 20% ☐ 21- 40% ☐ 41- 60% ☐ 61-80% ☐ 81-100%

4) What average annual daily traffic (AADT) figure is used for classifying a low volume rural road?

☐ <50 ☐ 51 - 100 ☐ 101 - 200 ☐ 201 - 1000 ☐ 1001 - 2000 ☐ Other

5) What normally constituents councils decision to upgrade an existing low volume rural road?

☐ increased traffic volumes ☐ community complaints ☐ traffic hazard
☐ need to spend funding

Guidelines and Specifications

6) In regard to rural road pavements what documentation does council reference for:

Design: ……..
Construction : ……..
Maintenance: ……..

7) When upgrading an unsealed road to a sealed road the design documentation is?

☐ not undertaken (maintenance crews know what to do)
☐ done on site as directed by the superintendent
☐ fully documented by the design team with specifications and drawings

8) What testing is predominantly undertaken for the design of unsealed in situ rural roads?

☐ Nil
☐ In situ testing (e.g. beam deflections)
☐ laboratory testing (e.g. CBR)

9) What testing is predominantly undertaken for the design of unsealed gravel road?

☐ Nil
☐ In situ testing (e.g. beam deflections)
☐ laboratory testing (e.g. CBR)

10) Does council model the low volume rural road pavements using programs such as circly / APSDS?

☐ Yes Always
☐ Sometimes
☐ Never

Maintenance

11) Is maintenance of low volume rural roads programmed in a yearly maintenance program or is maintenance performed on an "as needed" basis?

☐ programmed
☐ as needed

12) What normally constitutes councils decision to maintain an existing low volume rural road?

☐ scheduled maintenance
☐ community complaints
☐ traffic hazard
☐ need to spend funding

13) How is maintenance undertaken?

☐ as directed on site
☐ testing and planning before work starts

14) What does the maintenance of a low volume rural road generally consist of?

☐ road is graded
☐ additional material is added to existing formation
☐ existing material removed, subgrade improvement works undertaken and gravel / in situ material is laid and compacted.

Construction

15) What testing is undertaken during the construction of unsealed in situ rural roads?
.....
.....
.....

16) What testing is undertaken during the construction of unsealed gravel rural road?
……
……
……

17) Is construction of a low volume rural road generally?

☐fully documented
☐ documented to some extent but largely dictated by on site personnel
☐ almost fully dictated by on site personnel

18) What materials generally constitute the road pavement?

☐on site material ☐ imported natural gravel ☐ imported crushed rock
☐other……..

Environmental

19) What are the major environmental considerations for construction of a low volume rural road in your area?
……
……
……

20) Are there any other final comments you wish to make about the design, construction and maintenance of low volume rural roads in your area?
……
……
……
……
……
……

Contact
Council: ……
Name: ……
Title: ……
Position: ……
Mobile: ……
Work: ……
Email: ……

Appendix E – Survey Responses

Mitchell Shire Council (Victoria)

Low Volume Rural Roads Survey

Council Roads

1) What approximate percentages of council's roads are rural?

☐ 0- 20% ☐ 21- 40% ☐ 41- 60% ☑ 61-80% ☐ 81-100%

2) What approximate percentage of councils unsealed rural roads are constructed of locally available sub grade (in situ) material?

☐ 0- 20% ☐ 21- 40% ☐ 41- 60% ☑ 61-80% ☐ 81-100%

3) What approximate percentage of councils unsealed rural roads are constructed of gravel material?

☐ 0- 20% ☐ 21- 40% ☐ 41- 60% ☐ 61-80% ☑ 81-100%

4) What average annual daily traffic (AADT) figure is used for classifying a low volume rural road?

☐ <50 ☑ 51 - 100 ☐ 101 - 200 ☐ 201 - 1000 ☐ 1001 - 2000 ☐ Other

5) What normally constituents councils decision to upgrade an existing low volume rural road?

☑ increased traffic volumes ☐ community complaints ☐ traffic hazard
☐ need to spend funding

Guidelines and Specifications

6) In regard to rural road pavements what documentation does council reference for:

Design: ..... 3rd edition
Construction : ..Unsealed.....Roads.....Manual... ARRB.
Maintenance: .....

7) When upgrading an unsealed road to a sealed road the design documentation is?

☐ not undertaken (maintenance crews know what to do)
☐ done on site as directed by the superintendent
☑ fully documented by the design team with specifications and drawings

8) What testing is predominantly undertaken for the design of unsealed in situ rural roads?

☑ Nil
☐ In situ testing (e.g. beam deflections)
☐ laboratory testing (e.g. CBR)

9) What testing is predominantly undertaken for the design of unsealed gravel road?

☐ Nil
☐ In situ testing (e.g. beam deflections)
☑ laboratory testing (e.g. CBR)

10) Does council model the low volume rural road pavements using programs such as circly / APSDS?

☐ Yes Always
☐ Sometimes
☑ Never

Maintenance

11) Is maintenance of low volume rural roads programmed in a yearly maintenance program or is maintenance performed on an "as needed" basis?

☑ programmed
☐ as needed

12) What normally constitutes councils decision to maintain an existing low volume rural road?

☑ scheduled maintenance
☑ community complaints
☐ traffic hazard
☐ need to spend funding

13) How is maintenance undertaken?

☑ as directed on site
☐ testing and planning before work starts

14) What does the maintenance of a low volume rural road generally consist of?

☑ road is graded
☐ additional material is added to existing formation
☐ existing material removed, subgrade improvement works undertaken and gravel / in situ material is laid and compacted.

Construction

15) What testing is undertaken during the construction of unsealed in situ rural roads?

.....
.....N+L.....
.....

16) What testing is undertaken during the construction of unsealed gravel rural road?

Testing at plant of materials by supplier

17) Is construction of a low volume rural road generally?

☐ fully documented
☐ documented to some extent but largely dictated by on site personnel
☑ almost fully dictated by on site personnel

18) What materials generally constitute the road pavement?

☑ on site material ☐ imported natural gravel ☑ imported crushed rock
☐ other……

Environmental

19) What are the major environmental considerations for construction of a low volume rural road in your area?

- Dust
- Sediment control
-

20) Are there any other final comments you wish to make about the design, construction and maintenance of low volume rural roads in your area?

Contact
Council: Mitchell Shire Council
Name: Matthew Iving.
Title: Design and Developement Engineer.
Position: ……
Mobile: ……
Work: 57376341
Email: matthewi@mitchellshire.vic.gov.au.

Yarriambiack Shire Council (Victoria)

Low Volume Rural Roads Survey

Council Roads

1) What approximate percentages of council's roads are rural?

☐ 0- 20% ☐ 21- 40% ☐ 41- 60% ☐ 61-80% ☑ 81-100%

2) What approximate percentage of councils unsealed rural roads are constructed of locally available sub grade (in situ) material?

☐ 0- 20% ☐ 21- 40% ☐ 41- 60% ☑ 61-80% ☐ 81-100%

3) What approximate percentage of councils unsealed rural roads are constructed of gravel material?

☐ 0- 20% ☑ 21- 40% ☐ 41- 60% ☐ 61-80% ☐ 81-100%

4) What average annual daily traffic (AADT) figure is used for classifying a low volume rural road?

☑ <50 ☐ 51 - 100 ☐ 101 - 200 ☐ 201 - 1000 ☐ 1001 - 2000 ☐ Other

5) What normally constituents councils decision to upgrade an existing low volume rural road?

☑ increased traffic volumes ☐ community complaints ☐ traffic hazard
☐ need to spend funding

Guidelines and Specifications

6) In regard to rural road pavements what documentation does council reference for:

Design: ....VicROADS....
Construction : ....VicROADS....
Maintenance: .....

7) When upgrading an unsealed road to a sealed road the design documentation is?

☐ not undertaken (maintenance crews know what to do)
☐ done on site as directed by the superintendent
☑ fully documented by the design team with specifications and drawings

8) What testing is predominantly undertaken for the design of unsealed in situ rural roads?

☑ Nil
☐ In situ testing (e.g. beam deflections)
☐ laboratory testing (e.g. CBR)

9) What testing is predominantly undertaken for the design of unsealed gravel road?

☑ Nil
☐ In situ testing (e.g. beam deflections)
☐ laboratory testing (e.g. CBR)

10) Does council model the low volume rural road pavements using programs such as circly / APSDS?

☐ Yes Always
☐ Sometimes
☑ Never

Maintenance

11) Is maintenance of low volume rural roads programmed in a yearly maintenance program or is maintenance performed on an "as needed" basis?

☐ programmed
☑ as needed

12) What normally constitutes councils decision to maintain an existing low volume rural road?

☑ scheduled maintenance
☐ community complaints
☐ traffic hazard
☐ need to spend funding

13) How is maintenance undertaken?

☑ as directed on site
☐ testing and planning before work starts

14) What does the maintenance of a low volume rural road generally consist of?

☑ road is graded
☐ additional material is added to existing formation
☐ existing material removed, subgrade improvement works undertaken and gravel / in situ material is laid and compacted.

Construction

15) What testing is undertaken during the construction of unsealed in situ rural roads?
……NONE……
……
……

16) What testing is undertaken during the construction of unsealed gravel rural road?

NONE

17) Is construction of a low volume rural road generally?

☐ fully documented
☑ documented to some extent but largely dictated by on site personnel
☐ almost fully dictated by on site personnel

18) What materials generally constitute the road pavement?

☑ on site material ☑ imported natural gravel ☐ imported crushed rock
☐ other……..

Environmental

19) What are the major environmental considerations for construction of a low volume rural road in your area?

Damage to roadside vegetation

20) Are there any other final comments you wish to make about the design, construction and maintenance of low volume rural roads in your area?

Contact
Council: Yarriambiack Shire
Name: James Magee
Title: Director Infrastructure
Position: ……
Mobile: 0427 956 642
Work: ……
Email: jmagee@yarriambiack.vic.gov.au

City of Port Lincoln (Tasmania)

Low Volume Rural Roads Survey

Council Roads

1) What approximate percentages of council's roads are rural?

†**0- 20%** †21- 40% †41- 60% †61-80% †81-100%

2) What approximate percentage of councils unsealed rural roads are constructed of locally available sub grade (in situ) material?

†0- 20% †21- 40% †41- 60% †61-80% †**81-100%**

3) What approximate percentage of councils unsealed rural roads are constructed of gravel material?

†**0- 20%** †21- 40% †41- 60% †61-80% †81-100%

4) What average annual daily traffic (AADT) figure is used for classifying a low volume rural road?

†<50 †51 - 100 †**101 - 200** †201 - 1000 †1001 - 2000 †Other

5) What normally constituents councils decision to upgrade an existing low volume rural road?

†**increased traffic volumes** †**community complaints** †**traffic hazard**
†need to spend funding

Guidelines and Specifications

6) In regard to rural road pavements what documentation does council reference for:

Design: ……..
Construction : ……..
Maintenance: ……..

7) When upgrading an unsealed road to a sealed road the design documentation is?

†not undertaken (maintenance crews know what to do)
†**done on site as directed by the superintendent**
†fully documented by the design team with specifications and drawings

8) What testing is predominantly undertaken for the design of unsealed in situ rural roads?

†**Nil**
†In situ testing (e.g. beam deflections)
†laboratory testing (e.g. CBR)

9) What testing is predominantly undertaken for the design of unsealed gravel road?

- **Nil**
- In situ testing (e.g. beam deflections)
- laboratory testing (e.g. CBR)

10) Does council model the low volume rural road pavements using programs such as circly / APSDS?

- Yes Always
- Sometimes
- **Never**

Maintenance

11) Is maintenance of low volume rural roads programmed in a yearly maintenance program or is maintenance performed on an "as needed" basis?

- programmed
- **as needed**

12) What normally constitutes councils decision to maintain an existing low volume rural road?

- scheduled maintenance
- **community complaints**
- **traffic hazard**
- need to spend funding

13) How is maintenance undertaken?

- **as directed on site**
- testing and planning before work starts

14) What does the maintenance of a low volume rural road generally consist of?

- **road is graded**
- additional material is added to existing formation
- existing material removed, subgrade improvement works undertaken and gravel / in situ material is laid and compacted.

Construction

15) What testing is undertaken during the construction of unsealed in situ rural roads?
…NIL……
……
……

16) What testing is undertaken during the construction of unsealed gravel rural road?
……NIL……
……
……

17) Is construction of a low volume rural road generally?

- fully documented

☐ documented to some extent but largely dictated by on site personnel
☐ **almost fully dictated by on site personnel**

18) What materials generally constitute the road pavement?

☐ **on site material** ☐ imported natural gravel ☐ imported crushed rock
☐ other……..

Environmental

19) What are the major environmental considerations for construction of a low volume rural road in your area?
.....Native Vegetation.....
.....
.....

20) Are there any other final comments you wish to make about the design, construction and maintenance of low volume rural roads in your area?
……Councils roads are predominately sealed .160km sealed and 11km unsealed. Of the unsealed half are tracks that are rarely used.……
……
……
…….....
.....

Contact **Craig Matena**
Council: City of Port Lincoln…….
Name: …….
Title: **Operations manager**…….
Position: …….
Mobile: **0427215903**…….
Work: **08 86212322**…….
Email: **08 86212399**…….

Latrobe Council(Tasmania)

Low Volume Rural Roads Survey

Council Roads

1) What approximate percentages of council's roads are rural? both sealed and unsealed

☐ 0- 20% ☐ 21- 40% ☐ 41- 60% ☑ 61-80% ☐ 81-100%

2) What approximate percentage of councils unsealed rural roads are constructed of locally available sub grade (in situ) material?

☑ 0- 20% ☐ 21- 40% ☐ 41- 60% ☐ 61-80% ☐ 81-100%

3) What approximate percentage of councils unsealed rural roads are constructed of gravel material?

☐ 0- 20% ☐ 21- 40% ☐ 41- 60% ☐ 61-80% ☑ 81-100%

4) What average annual daily traffic (AADT) figure is used for classifying a low volume rural road?

Minor Residential
Unsealed Residential

Rural Residential - <500 vpd
Unsealed Collector Roads - <250 vpd

☑ <50 ☐ 51 - 100 ☐ 101 - 200 ☑ 201 - 1000 ☐ 1001 - 2000 ☐ Other

5) What normally constituents councils decision to upgrade an existing low volume rural road?

☑ increased traffic volumes ☑ community complaints ☐ traffic hazard
☐ need to spend funding

Guidelines and Specifications

6) In regard to rural road pavements what documentation does council reference for:

Design: Tasmanian Municipal Standards
Construction : Municipal construction specifications.
Maintenance: Transport Services - Service Level Agreements

7) When upgrading an unsealed road to a sealed road the design documentation is?

☐ not undertaken (maintenance crews know what to do)
☑ done on site as directed by the superintendent
☐ fully documented by the design team with specifications and drawings

8) What testing is predominantly undertaken for the design of unsealed in situ rural roads?

☑ Nil
☐ In situ testing (e.g. beam deflections)
☐ laboratory testing (e.g. CBR)

9) What testing is predominantly undertaken for the design of unsealed gravel road?

☑ Nil
☐ In situ testing (e.g. beam deflections)
☐ laboratory testing (e.g. CBR)

10) Does council model the low volume rural road pavements using programs such as circly / APSDS?

☐ Yes Always
☑ Sometimes Condition assessments.
☑ Never

Maintenance

11) Is maintenance of low volume rural roads programmed in a yearly maintenance program or is maintenance performed on an "as needed" basis?

☑ programmed
☐ as needed

12) What normally constitutes councils decision to maintain an existing low volume rural road?

☑ scheduled maintenance
☐ community complaints
☐ traffic hazard
☐ need to spend funding

13) How is maintenance undertaken?

☑ as directed on site
☐ testing and planning before work starts

14) What does the maintenance of a low volume rural road generally consist of?

☑ road is graded - Seasonal
☑ additional material is added to existing formation - Periodic, depending on traffic volume.
☐ existing material removed, subgrade improvement works undertaken and gravel / in situ material is laid and compacted.

Construction

15) What testing is undertaken during the construction of unsealed in situ rural roads?

pavement material depth
cross fall
in situ compaction testing (where necessary).

16) What testing is undertaken during the construction of unsealed gravel rural road?

pavement material depth
cross fall
insitu compaction testing (where necessary)

17) Is construction of a low volume rural road generally?

☐ fully documented
☑ documented to some extent but largely dictated by on site personnel
☐ almost fully dictated by on site personnel

18) What materials generally constitute the road pavement?

☐ on site material ☐ imported natural gravel ☑ imported crushed rock
☐ other……..

Environmental

19) What are the major environmental considerations for construction of a low volume rural road in your area?

Material type for wearing course, drainage, surrounding vegetation ... considerations are generally site specific.

20) Are there any other final comments you wish to make about the design, construction and maintenance of low volume rural roads in your area?

Ground conditions within the Latrobe municipality are generally similar, therefore Council adopts standard design & construction methods requiring minimal testing on site. Variations and site specific requirements are documented within the project management process.

Contact
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Central Coast Council (Tasmania)

Low Volume Rural Roads Survey

Council Roads

7) What approximate percentages of council's roads are rural?

61-80%

8) What approximate percentage of councils unsealed rural roads are constructed of locally available sub grade (in situ) material?

0- 20%

9) What approximate percentage of councils unsealed rural roads are constructed of gravel material?

81-100%

10) What average annual daily traffic (AADT) figure is used for classifying a low volume rural road?

101 - 200

11) What normally constituents councils decision to upgrade an existing low volume rural road?

increased traffic volumes community complaints traffic hazard
~~need to spend funding~~

Guidelines and Specifications

12) In regard to rural road pavements what documentation does council reference for:

Design: Austroads Guides, ARRB unsealed road manual
Construction : Austroads Guides, ARRB unsealed road manual
Maintenance: Austroads Guides, ARRB unsealed road manual

7) When upgrading an unsealed road to a sealed road the design documentation is?

~~not undertaken (maintenance crews know what to do)~~
~~done on site as directed by the superintendent~~
fully documented by the design team with specifications and drawings

8) What testing is predominantly undertaken for the design of unsealed in situ rural roads?

Nil
~~In situ testing (e.g. beam deflections)~~
~~laboratory testing (e.g. CBR)~~

9) What testing is predominantly undertaken for the design of unsealed gravel road?

☐ Nil
☐ ~~In situ testing (e.g. beam deflections)~~
☐ ~~laboratory testing (e.g. CBR)~~

10) Does council model the low volume rural road pavements using programs such as circly / APSDS?

☐ ~~Yes Always~~
☐ ~~Sometimes~~
☐ Never

Maintenance

11) Is maintenance of low volume rural roads programmed in a yearly maintenance program or is maintenance performed on an "as needed" basis?

☐ programmed
☐ ~~as needed~~

12) What normally constitutes councils decision to maintain an existing low volume rural road?

☐ scheduled maintenance
☐ ~~community complaints~~
☐ ~~traffic hazard~~
☐ ~~need to spend funding~~

13) How is maintenance undertaken?

☐ as directed on site
☐ ~~testing and planning before work starts~~

14) What does the maintenance of a low volume rural road generally consist of?

☐ road is graded
☐ additional material is added to existing formation
☐ ~~existing material removed, subgrade improvement works undertaken and gravel / in situ material is laid and compacted.~~

Construction

15) What testing is undertaken during the construction of unsealed in situ rural roads?
Nil……
……
……

16) What testing is undertaken during the construction of unsealed gravel rural road?
Gravel products have been tested at quarry
……
……

17) Is construction of a low volume rural road generally?
(Assume reconstruction)
☐ ~~fully documented~~

~~documented to some extent but largely dictated by on site personnel~~
almost fully dictated by on site personnel

18) What materials generally constitute the road pavement?

~~on site material~~ imported natural gravel imported crushed rock
~~other……..~~

Environmental

19) What are the major environmental considerations for construction of a low volume rural road in your area?
Drainage
.....
.....
.....

20) Are there any other final comments you wish to make about the design, construction and maintenance of low volume rural roads in your area?
……
……
……
……
…….....

Contact
Council: Central Coast Council, Tasmania
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Position: Engineering Group Leader
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Tumby Bay Council (South Australia)

Low Volume Rural Roads Survey

Council Roads

13) What approximate percentages of council's roads are rural?

†0- 20% †21- 40% †41- 60% †61-80% x 81-100%

14) What approximate percentage of councils unsealed rural roads are constructed of locally available sub grade (in situ) material?

†0- 20% †21- 40% †41- 60% †61-80% x 81-100%

15) What approximate percentage of councils unsealed rural roads are constructed of gravel material?

†0- 20% †21- 40% †41- 60% †61-80% x 81-100%

16) What average annual daily traffic (AADT) figure is used for classifying a low volume rural road?

x <50 †51 - 100 †101 - 200 †201 - 1000 †1001 - 2000 †Other

17) What normally constituents councils decision to upgrade an existing low volume rural road?

x increased traffic volumes x community complaints x traffic hazard
†need to spend funding

Guidelines and Specifications

18) In regard to rural road pavements what documentation does council reference for:

Design: Ausroads Guide to Rural Road Design……..
Construction : As above ……...
Maintenance: None……..

7) When upgrading an unsealed road to a sealed road the design documentation is?

†not undertaken (maintenance crews know what to do)
X done on site as directed by the superintendent
X (Some) fully documented by the design team with specifications and drawings

8) What testing is predominantly undertaken for the design of unsealed in situ rural roads?

x Nil
†In situ testing (e.g. beam deflections)
†laboratory testing (e.g. CBR)

9) What testing is predominantly undertaken for the design of unsealed gravel road?

xNil

† In situ testing (e.g. beam deflections)
† laboratory testing (e.g. CBR)

10) Does council model the low volume rural road pavements using programs such as circly / APSDS?

† Yes Always
† Sometimes
x Never

Maintenance

11) Is maintenance of low volume rural roads programmed in a yearly maintenance program or is maintenance performed on an "as needed" basis?

† programmed
x as needed

12) What normally constitutes councils decision to maintain an existing low volume rural road?

† scheduled maintenance
x community complaints
x traffic hazard
† need to spend funding

13) How is maintenance undertaken?

x as directed on site
† testing and planning before work starts

14) What does the maintenance of a low volume rural road generally consist of?

x road is graded
x additional material is added to existing formation
† existing material removed, subgrade improvement works undertaken and gravel / in situ material is laid and compacted.

Construction

15) What testing is undertaken during the construction of unsealed in situ rural roads?
…Nil……
……
……

16) What testing is undertaken during the construction of unsealed gravel rural road?
……Nil……
……
……

17) Is construction of a low volume rural road generally?

† fully documented
† documented to some extent but largely dictated by on site personnel

x almost fully dictated by on site personnel

18) What materials generally constitute the road pavement?

X on site material ☐ imported natural gravel ☐ imported crushed rock
☐ other……..

Environmental

19) What are the major environmental considerations for construction of a low volume rural road in your area?
.....
.....
.....

20) Are there any other final comments you wish to make about the design, construction and maintenance of low volume rural roads in your area?
……
……
……
……
…….....

Contact
Council: DC Tumby Bay…….
Name: Darren Zechner …….
Title: …….
Position: **Works Manager**……..
Mobile: **0427882074**…….
Work: …….
Email: …….

Coorong District Council (South Australia)

Low Volume Rural Roads Survey

Council Roads

19) What approximate percentages of council's roads are rural?

†0- 20% †21- 40% †41- 60% †61-80% x 81-100%

20) What approximate percentage of councils unsealed rural roads are constructed of locally available sub grade (in situ) material?

†0- 20% †21- 40% †41- 60% †61-80% x 81-100%

21) What approximate percentage of councils unsealed rural roads are constructed of gravel material?

†0- 20% †21- 40% †41- 60% 61-80% x 81-100%

22) What average annual daily traffic (AADT) figure is used for classifying a low volume rural road?

X <50 †51 - 100 †101 - 200 †201 - 1000 †1001 - 2000 †Other

23) What normally constituents councils decision to upgrade an existing low volume rural road?

X increased traffic volumes x community complaints x traffic hazard
†need to spend funding

Guidelines and Specifications

24) In regard to rural road pavements what documentation does council reference for:

Design: ……..
Construction : …When resheeting we work on putting 180mm of material on.
……..
Maintenance: ……..

7) When upgrading an unsealed road to a sealed road the design documentation is?

†not undertaken (maintenance crews know what to do)
X done on site as directed by the superintendent
†fully documented by the design team with specifications and drawings

8) What testing is predominantly undertaken for the design of unsealed in situ rural roads?

X Nil
†In situ testing (e.g. beam deflections)
†laboratory testing (e.g. CBR)

9) What testing is predominantly undertaken for the design of unsealed gravel road?

x Nil
¦In situ testing (e.g. beam deflections)
¦laboratory testing (e.g. CBR)

10) Does council model the low volume rural road pavements using programs such as circly / APSDS?

¦Yes Always
¦Sometimes
X Never

Maintenance

11) Is maintenance of low volume rural roads programmed in a yearly maintenance program or is maintenance performed on an "as needed" basis?

X programmed
¦as needed

12) What normally constitutes councils decision to maintain an existing low volume rural road?

X scheduled maintenance
X community complaints
X traffic hazard
¦need to spend funding

13) How is maintenance undertaken?

X as directed on site
¦testing and planning before work starts

14) What does the maintenance of a low volume rural road generally consist of?

¦road is graded
¦additional material is added to existing formation
¦existing material removed, subgrade improvement works undertaken and gravel / in situ material is laid and compacted.

Construction

15) What testing is undertaken during the construction of unsealed in situ rural roads?
We look at the quality of rubble we are using.
……
……

16) What testing is undertaken during the construction of unsealed gravel rural road?
……None……
……
……

17) Is construction of a low volume rural road generally?

¦fully documented

¦ documented to some extent but largely dictated by on site personnel
X almost fully dictated by on site personnel

18) What materials generally constitute the road pavement?
Local Rubble

X on site material ¦ imported natural gravel ¦ imported crushed rock
¦ other……..

Environmental

19) What are the major environmental considerations for construction of a low volume rural road in your area?
.....Trees and the possible sand drift in the sandy areas
.....
.....
.....

20) Are there any other final comments you wish to make about the design, construction and maintenance of low volume rural roads in your area?
…All our roads have classification which shows what width the road to be constructed and how often it shall be graded
……
……
……
……
…….....

Contact
Council: …Coorong District Council…….
Name: **Ron Downs**…….
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Work: ……85723611…….
Email: …rdowns@coorong.sa.gov.au…….

Mt Isa Shire Council (Queensland)

Low Volume Rural Roads Survey

Council Roads

25) What approximate percentages of council's roads are rural?

†0- 20% †21- 40% †41- 60% **X** 61-80% †81-100%

26) What approximate percentage of councils unsealed rural roads are constructed of locally available sub grade (in situ) material?

†0- 20% †21- 40% †41- 60% †61-80% **X** 81-100%

27) What approximate percentage of councils unsealed rural roads are constructed of gravel material?

†0- 20% †21- 40% **X** 41- 60% †61-80% †81-100%

28) What average annual daily traffic (AADT) figure is used for classifying a low volume rural road?

†<50 **X** 51 - 100 †101 - 200 †201 - 1000 †1001 - 2000 †Other

29) What normally constituents councils decision to upgrade an existing low volume rural road?

X increased traffic volumes **X** community complaints **X** traffic hazard
†need to spend funding

Guidelines and Specifications

30) In regard to rural road pavements what documentation does council reference for:

Design: Nil (Normally done on site as design resources including available funding is low)
Construction : Based on typical Main Roads Specifications and Industry Standards.
Maintenance: Governed by Budgets available

7) When upgrading an unsealed road to a sealed road the design documentation is?

X not undertaken (maintenance crews know what to do)
X done on site as directed by the superintendent
†fully documented by the design team with specifications and drawings

8) What testing is predominantly undertaken for the design of unsealed in situ rural roads?

X Nil
†In situ testing (e.g. beam deflections)
†laboratory testing (e.g. CBR)

9) What testing is predominantly undertaken for the design of unsealed gravel road?

† Nil
† In situ testing (e.g. beam deflections)
X laboratory testing (e.g. CBR)

10) Does council model the low volume rural road pavements using programs such as circly / APSDS?

† Yes Always
† Sometimes
X Never

Maintenance

11) Is maintenance of low volume rural roads programmed in a yearly maintenance program or is maintenance performed on an "as needed" basis?

X programmed (Budget pending)
† as needed

12) What normally constitutes councils decision to maintain an existing low volume rural road?

X scheduled maintenance
X community complaints
X traffic hazard
† need to spend funding

13) How is maintenance undertaken?

X as directed on site with (depending on roads strategic value) some testing and planning before work starts

14) What does the maintenance of a low volume rural road generally consist of?

X road is graded
X additional material is added to existing formation (where needed & funds permit)
† existing material removed, subgrade improvement works undertaken and gravel / in situ material is laid and compacted.

Construction

15) What testing is undertaken during the construction of unsealed in situ rural roads?
In situ moisture content for mixing
……

16) What testing is undertaken during the construction of unsealed gravel rural road?
In situ moisture content for mixing
Compaction testing
……
……

17) Is construction of a low volume rural road generally?

† fully documented

X documented to some extent but largely dictated by on site personnel
☐ almost fully dictated by on site personnel

18) What materials generally constitute the road pavement?

X on site material ☐ imported natural gravel ☐ imported crushed rock
☐ other……..

Environmental

19) What are the major environmental considerations for construction of a low volume rural road in your area?

Erosion
Water supply permits & access & availability of water for construction (ensuring that works are not competing with pastoral requirements - especially in a time of drought)
Cultural Heritage
.....
.....
.....

20) Are there any other final comments you wish to make about the design, construction and maintenance of low volume rural roads in your area?

……
……
……
……
……

Contact

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Toowoomba Regional Council (Queensland)

Low Volume Rural Roads Survey

Council Roads

31) What approximate percentages of council's roads are rural?

☐ 0- 20% ☐ 21- 40% ☐ 41- 60% **x** ☐ 61-80% ☐ 81-100%

32) What approximate percentage of councils unsealed rural roads are constructed of locally available sub grade (in situ) material?

x ☐ 0- 20% ☐ 21- 40% ☐ 41- 60% ☐ 61-80% ☐ 81-100%

33) What approximate percentage of councils unsealed rural roads are constructed of gravel material?

☐ 0- 20% ☐ 21- 40% ☐ 41- 60% ☐ 61-80% **x** ☐ 81-100%

34) What average annual daily traffic (AADT) figure is used for classifying a low volume rural road?

x ☐ <50 ☐ 51 - 100 ☐ 101 - 200 ☐ 201 - 1000 ☐ 1001 - 2000 ☐ Other

35) What normally constituents councils decision to upgrade an existing low volume rural road?

x ☐ increased traffic volumes **x** ☐ community complaints ☐ traffic hazard
☐ need to spend funding

Guidelines and Specifications

36) In regard to rural road pavements what documentation does council reference for:

Design: ARRB/AUSROADS Local roads manual
……..
Construction : ……..
Maintenance: ……..

7) When upgrading an unsealed road to a sealed road the design documentation is?

☐ not undertaken (maintenance crews know what to do)
☐ done on site as directed by the superintendent
x ☐ fully documented by the design team with specifications and drawings

8) What testing is predominantly undertaken for the design of unsealed in situ rural roads?

x ☐ Nil
☐ In situ testing (e.g. beam deflections)
☐ laboratory testing (e.g. CBR)

9) What testing is predominantly undertaken for the design of unsealed gravel road?

x Nil
In situ testing (e.g. beam deflections)
laboratory testing (e.g. CBR)

10) Does council model the low volume rural road pavements using programs such as circly / APSDS?

Yes Always
Sometimes
x Never

Maintenance

11) Is maintenance of low volume rural roads programmed in a yearly maintenance program or is maintenance performed on an "as needed" basis?

x programmed
x as needed

12) What normally constitutes councils decision to maintain an existing low volume rural road?

x scheduled maintenance
x community complaints
traffic hazard
need to spend funding

13) How is maintenance undertaken?

x as directed on site
testing and planning before work starts

14) What does the maintenance of a low volume rural road generally consist of?

x road is graded
additional material is added to existing formation
existing material removed, subgrade improvement works undertaken and gravel / in situ material is laid and compacted.

Construction

15) What testing is undertaken during the construction of unsealed in situ rural roads?
……nil……
……
……

16) What testing is undertaken during the construction of unsealed gravel rural road?
……nil……
……
……

17) Is construction of a low volume rural road generally?

☐ fully documented
☐ documented to some extent but largely dictated by on site personnel
x almost fully dictated by on site personnel

18) What materials generally constitute the road pavement?

☐ on site material **x** imported natural gravel **x** imported crushed rock
☐ other……..

Environmental

19) What are the major environmental considerations for construction of a low volume rural road in your area?
.Fauna/
stormwater.....
.....

20) Are there any other final comments you wish to make about the design, construction and maintenance of low volume rural roads in your area?
……nil
……
……
……
…….....

Contact
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Gympie Regional Council (Queensland)

Low Volume Rural Roads Survey

Council Roads

1) What approximate percentages of council's roads are rural?

☐ 0- 20% ☐ 21 - 40% ☐ 41 - 60% ☐ 61-80% ☑ 81-100%

2) What approximate percentage of councils unsealed rural roads are constructed of locally available sub grade (in situ) material?

☑ 0- 20% ☐ 21 - 40% ☐ 41 - 60% ☐ 61-80% ☐ 81-100%

3) What approximate percentage of councils unsealed rural roads are constructed of gravel material?

☐ 0- 20% ☐ 21 - 40% ☐ 41 - 60% ☐ 61-80% ☑ 81-100%

4) What average annual daily traffic (AADT) figure is used for classifying a low volume rural road?

☐ <50 ☑ 51 - 100 ☐ 101 - 200 ☐ 201 - 1000 ☐ 1001 - 2000 ☐ Other

5) What normally constituents councils decision to upgrade an existing low volume rural road?

☑ increased traffic volumes ☑ community complaints ☑ traffic hazard
☑ need to spend funding

Guidelines and Specifications

6) In regard to rural road pavements what documentation does council reference for:

Design: Austroads Codes, Qld Structs, GRC PSPB
Construction : DTMR Std Specs, IPWEA Std Specs
Maintenance: Std practices

7) When upgrading an unsealed road to a sealed road the design documentation is?

☐ not undertaken (maintenance crews know what to do)
☐ done on site as directed by the superintendent
☑ fully documented by the design team with specifications and drawings

8) What testing is predominantly undertaken for the design of unsealed in situ rural roads?

☐ Nil
☑ In situ testing (e.g. beam deflections)
☐ laboratory testing (e.g. CBR)

9) What testing is predominantly undertaken for the design of unsealed gravel road?

☑ Nil
☐ In situ testing (e.g. beam deflections)
☐ laboratory testing (e.g. CBR)

10) Does council model the low volume rural road pavements using programs such as circly / APSDS?

☐ Yes Always
☐ Sometimes
☑ Never

Maintenance

11) Is maintenance of low volume rural roads programmed in a yearly maintenance program or is maintenance performed on an "as needed" basis?

☑ programmed
☐ as needed

12) What normally constitutes councils decision to maintain an existing low volume rural road?

☑ scheduled maintenance
☑ community complaints
☑ traffic hazard
☐ need to spend funding

13) How is maintenance undertaken?

☐ as directed on site
☑ testing and planning before work starts

14) What does the maintenance of a low volume rural road generally consist of?

☑ road is graded
☑ additional material is added to existing formation
☑ existing material removed, subgrade improvement works undertaken and gravel / in situ material is laid and compacted.

Construction

15) What testing is undertaken during the construction of unsealed in situ rural roads?

..... [illegible] ..... N.T. .....

16) What testing is undertaken during the construction of unsealed gravel rural road?

N/A

17) Is construction of a low volume rural road generally?

☐ fully documented
☑ documented to some extent but largely dictated by on site personnel
☐ almost fully dictated by on site personnel

18) What materials generally constitute the road pavement?

☑ on site material ☑ imported natural gravel ☑ imported crushed rock
☐ other.....

Environmental

19) What are the major environmental considerations for construction of a low volume rural road in your area?

Erosion control, dust prevention

20) Are there any other final comments you wish to make about the design, construction and maintenance of low volume rural roads in your area?

No

Contact
Council: Cootamundra Regional Council
Name: Greg Hughes
Title: Manager Works West
Position:
Mobile:
Work:
Email:

Locker Valley Regional Council (Queensland)

Low Volume Rural Roads Survey

Council Roads

1) What approximate percentages of council's roads are rural?

☐ 0- 20% ☐ 21- 40% ☐ 41- 60% ☐ 61-80% ✓ 81-100%

2) What approximate percentage of councils unsealed rural roads are constructed of locally available sub grade (in situ) material?

☐ 0- 20% ✓ 21- 40% ☐ 41- 60% ☐ 61-80% ☐ 81-100%

3) What approximate percentage of councils unsealed rural roads are constructed of gravel material?

☐ 0- 20% ☐ 21- 40% ☐ 41- 60% ✓ 61-80% ☐ 81-100%

4) What average annual daily traffic (AADT) figure is used for classifying a low volume rural road?

☐ <50 ✓ 51 - 100 ☐ 101 - 200 ☐ 201 - 1000 ☐ 1001 - 2000 ☐ Other

5) What normally constituents councils decision to upgrade an existing low volume rural road?

✓ increased traffic volumes ✓ community complaints ✓ traffic hazard
☐ need to spend funding

Guidelines and Specifications

6) In regard to rural road pavements what documentation does council reference for:

Design: Main Roads as Austroads Rural Road Design Manual
Construction : Main Roads Specs
Maintenance: Nil

7) When upgrading an unsealed road to a sealed road the design documentation is?

☐ not undertaken (maintenance crews know what to do)
☐ done on site as directed by the superintendent
✓ fully documented by the design team with specifications and drawings

8) What testing is predominantly undertaken for the design of unsealed in situ rural roads?

✓ Nil
☐ In situ testing (e.g. beam deflections)
☐ laboratory testing (e.g. CBR)

9) What testing is predominantly undertaken for the design of unsealed gravel road?

☑ Nil
☐ In situ testing (e.g. beam deflections)
☐ laboratory testing (e.g. CBR)

10) Does council model the low volume rural road pavements using programs such as circly / APSDS?

☐ Yes Always
☐ Sometimes
☑ Never

Maintenance

11) Is maintenance of low volume rural roads programmed in a yearly maintenance program or is maintenance performed on an "as needed" basis?

☐ programmed
☑ as needed

12) What normally constitutes councils decision to maintain an existing low volume rural road?

☐ scheduled maintenance
☑ community complaints
☑ traffic hazard
☐ need to spend funding

13) How is maintenance undertaken?

☑ as directed on site
☐ testing and planning before work starts

14) What does the maintenance of a low volume rural road generally consist of?

☑ road is graded
☐ additional material is added to existing formation
☐ existing material removed, subgrade improvement works undertaken and gravel / in situ material is laid and compacted.

Construction

15) What testing is undertaken during the construction of unsealed in situ rural roads?

N.I. testing

16) What testing is undertaken during the construction of unsealed gravel rural road?

Nil testing

17) Is construction of a low volume rural road generally?

☐ fully documented
☑ documented to some extent but largely dictated by on site personnel
☐ almost fully dictated by on site personnel

18) What materials generally constitute the road pavement?

☐ on site material ☐ imported natural gravel ☑ imported crushed rock
☐ other……

Environmental

19) What are the major environmental considerations for construction of a low volume rural road in your area?

Remnant vegetation

20) Are there any other final comments you wish to make about the design, construction and maintenance of low volume rural roads in your area?

Contact
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Toowoomba Regional Council (Queensland)

Low Volume Rural Roads Survey

Council Roads

37) What approximate percentages of council's roads are rural?

†0- 20% †21- 40% ☺**41- 60%** †61-80% †81-100%

38) What approximate percentage of councils unsealed rural roads are constructed of locally available sub grade (in situ) material?

†0- 20% ☺ **21- 40%** †41- 60% †61-80% †81-100%

39) What approximate percentage of councils unsealed rural roads are constructed of gravel material?

†0- 20% †21- 40% †41- 60% ☺ **61-80**% †81-100%

40) What average annual daily traffic (AADT) figure is used for classifying a low volume rural road?

†<50 †51 - 100 ☺ **101 - 200** †201 - 1000 †1001 - 2000 †Other

41) What normally constituents councils decision to upgrade an existing low volume rural road?

☺ **increased traffic volumes** †community complaints †traffic hazard
†need to spend funding

Guidelines and Specifications

42) In regard to rural road pavements what documentation does council reference for:

Design: Main Roads Pavement Design Manuals & Austroads Pavement Design Manuals (including for Light/low Traffic)
Construction : Main Roads Specifications, Council QA system
Maintenance: Main Roads RMPC manual

7) When upgrading an unsealed road to a sealed road the design documentation is?

†not undertaken (maintenance crews know what to do)
☺ **done on site as directed by the superintendent**
☺ **fully documented by the design team with specifications and drawings**
(depending on the job, could be either of these or a mix of them)

8) What testing is predominantly undertaken for the design of unsealed in situ rural roads?

☺ **Nil**
†In situ testing (e.g. beam deflections)
†laboratory testing (e.g. CBR)

9) What testing is predominantly undertaken for the design of unsealed gravel road?

☺ **Nil** (but if large jobs, we will undertake some basic testing)
☐ In situ testing (e.g. beam deflections)
☐ laboratory testing (e.g. CBR)

10) Does council model the low volume rural road pavements using programs such as circly / APSDS?

☐ Yes Always
☐ Sometimes
☺ **Never**

Maintenance

11) Is maintenance of low volume rural roads programmed in a yearly maintenance program or is maintenance performed on an "as needed" basis?

☐ programmed
☺ **as needed**

12) What normally constitutes councils decision to maintain an existing low volume rural road?

☐ scheduled maintenance
☺ **community complaints**
☺ **traffic hazard**
☐ need to spend funding

13) How is maintenance undertaken?

☺ **as directed on site**
☐ testing and planning before work starts

14) What does the maintenance of a low volume rural road generally consist of?

☺ **road is graded**
☺ **additional material is added to existing formation**
☐ existing material removed, subgrade improvement works undertaken and gravel / in situ material is laid and compacted.

Construction

15) What testing is undertaken during the construction of unsealed in situ rural roads?
Nil……
……
……

16) What testing is undertaken during the construction of unsealed gravel rural road?
Depends on size of job. Could include CBR, compaction, grading curve, and occasionally moisture content

17) Is construction of a low volume rural road generally?

fully documented
documented to some extent but largely dictated by on site personnel
☺ **almost fully dictated by on site personnel (but bigger jobs have some documentation)**

18) What materials generally constitute the road pavement?

on site material ☺ **imported natural gravel** imported crushed rock
other……..

Environmental

19) What are the major environmental considerations for construction of a low volume rural road in your area?
Soil & erosion control, table drains/drainage, minimal impact on surrounding vegetation. No detailed environmental impacts undertaken unless known to be a highly environmentally sensitive area.

20) Are there any other final comments you wish to make about the design, construction and maintenance of low volume rural roads in your area?
We are in the process of adopting a QA (quality assurance) system right at the moment (currently being rolled out). This will require testing/additional testing for jobs than what we are currently doing. Also, will require some documentation (or additional documentation) for construction of roads.

We are also currently considering the adoption of a Maintenance Management System for our roads at Council. I assume that this will be almost immediately implemented for Main Roads maintenance works (RMPC – Road Maintenance Performance Contract). And I assume that in the next 3 years we will be adopting and implementing a Maintenance Management System for all council roads – this will mean we will be going from "ad hoc" or needs basis (and also rotational maintenance still done in some areas) for maintenance to a planned maintenance program.

Councils around Australia seem to be going in this same direction. Some have already implemented Maintenance Management Systems, but some Councils (including Toowoomba Regional Council) are in the process currently of adopting and implementing such a system.

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Whitsunday Regional Council (Queensland)

Low Volume Rural Roads Survey

Council Roads

1) What approximate percentages of council's roads are rural?

☐ 0- 20% ☐ 21- 40% ☐ 41- 60% ☐ 61-80% ☑ 81-100%

2) What approximate percentage of councils unsealed rural roads are constructed of locally available sub grade (in situ) material?

☐ 0- 20% ☐ 21- 40% ☐ 41- 60% ☑ 61-80% ☐ 81-100%
DECOMPOSED GRANITE.

3) What approximate percentage of councils unsealed rural roads are constructed of gravel material? DECO IS NOT CONSIDERED TYPICAL GRAVEL

☐ 0- 20% ☑ 21- 40% ☐ 41- 60% ☐ 61-80% ☐ 81-100%

4) What average annual daily traffic (AADT) figure is used for classifying a low volume rural road?

☐ <50 ☐ 51 - 100 ☑ 101 - 200 ☐ 201 - 1000 ☐ 1001 - 2000 ☐ Other

5) What normally constituents councils decision to upgrade an existing low volume rural road?

☐ increased traffic volumes ☑ community complaints ☑ traffic hazard
☐ need to spend funding

Guidelines and Specifications

6) In regard to rural road pavements what documentation does council reference for:

Design: AUSROADS / MAIN ROADS
Construction : MAINROADS / INTERNAL STANDARDS
Maintenance: MAINROADS

7) When upgrading an unsealed road to a sealed road the design documentation is?

☐ not undertaken (maintenance crews know what to do)
☑ done on site as directed by the superintendent
☑ fully documented by the design team with specifications and drawings

8) What testing is predominantly undertaken for the design of unsealed in situ rural roads?

☐ Nil
☐ In situ testing (e.g. beam deflections)
☑ laboratory testing (e.g. CBR)

9) What testing is predominantly undertaken for the design of unsealed gravel road?

☑ Nil
☐ In situ testing (e.g. beam deflections)
☐ laboratory testing (e.g. CBR)

10) Does council model the low volume rural road pavements using programs such as circly / APSDS?

☐ Yes Always
☐ Sometimes
☑ Never

Maintenance

11) Is maintenance of low volume rural roads programmed in a yearly maintenance program or is maintenance performed on an "as needed" basis?

☐ programmed
☑ as needed / MAKE MAINTENANCE ACTIVITIES PROGRAMMED

12) What normally constitutes councils decision to maintain an existing low volume rural road?

	% of occurance
☑ scheduled maintenance	40 %
☑ community complaints	20%
☑ traffic hazard	25%
☑ need to spend funding	5 %

13) How is maintenance undertaken?

☑ as directed on site
☐ testing and planning before work starts

14) What does the maintenance of a low volume rural road generally consist of?

	% of occurar
☑ road is graded	60%
☑ additional material is added to existing formation	40%
☑ existing material removed, subgrade improvement works undertaken and gravel / in situ material is laid and compacted. (ONLY FOR PROBLEM SECTIONS).	<10%

Construction

15) What testing is undertaken during the construction of unsealed in situ rural roads?

COMPACTION TESTING – FOR A UNSEALED RURAL ROAD
THIS IS DONE VIA A VISUAL INSPECTION OF A
(FULL) WATER TRUCK.

16) What testing is undertaken during the construction of unsealed gravel rural road?
SAME PROCESS.

17) Is construction of a low volume rural road generally? (UNSEALED?)

☐ fully documented
☑ documented to some extent but largely dictated by on site personnel
☐ almost fully dictated by on site personnel

18) What materials generally constitute the road pavement?

☑ on site material ☑ imported natural gravel (DECO PIT NEAR BY) ☐ imported crushed rock
☐ other.....

Environmental

19) What are the major environmental considerations for construction of a low volume rural road in your area? (ASSUME REHAB OF EXISTING UNSEALED RURAL RD).
* AVOID DAMAGE TO VEGETATION BY MACHINERY/ETC
* ENSURE DRY CREEK BEDS / WATER COURSES ETC ARE MAINTAINED).

20) Are there any other final comments you wish to make about the design, construction and maintenance of low volume rural roads in your area?
* WBC MANAGES OVER 800 kms of unsealed road.
* 9/10 this is done via trial and true methods (TE EXPERIENCE)
THE SHIRE IS LUCKY TO HAVE A EXTENSIVE No OF VIABLE DECO PITS, HOWEVER TESTING + EXPERIENCE HAS REVEALED DECO FROM CERTAIN PITS IS MORE SUITABLE THEN OTHERS. CLAY PLAYS A LARGE PART IN HOLDING THE ROAD TOGETHER DURING THE DRY SEASON HOWEVER IT ALSO CAN RESULT IN MAJOR DAMAGE DUE TO HEAVY VEH IN THE WET SEASON. THIS IS A BALANCING ACT, GOOD RESULTS HAVE BEEN FOUND FROM MIXING NATURAL STONE/ALL OF APPROX 80mm DIA WITH THE DECO: USED IN RURAL RESHEETING

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Bland Shire Council (New South Wales)

Low Volume Rural Roads Survey

Council Roads

1) What approximate percentages of council's roads are rural?

☐ 0- 20% ☐ 21- 40% ☐ 41- 60% ☐ 61-80% ☑ 81-100%

2) What approximate percentage of councils unsealed rural roads are constructed of locally available sub grade (in situ) material?

☑ 0- 20% ☐ 21- 40% ☐ 41- 60% ☐ 61-80% ☐ 81-100%

3) What approximate percentage of councils unsealed rural roads are constructed of gravel material?

☐ 0- 20% ☐ 21- 40% ☐ 41- 60% ☑ 61-80% ☐ 81-100%

4) What average annual daily traffic (AADT) figure is used for classifying a low volume rural road?

☑ <50 ☐ 51 - 100 ☐ 101 - 200 ☐ 201 - 1000 ☐ 1001 - 2000 ☐ Other

5) What normally constituents councils decision to upgrade an existing low volume rural road?

☑ increased traffic volumes ☑ community complaints ☑ traffic hazard
☐ need to spend funding

Guidelines and Specifications

6) In regard to rural road pavements what documentation does council reference for:

Design: .....
Construction : .....
Maintenance: .....

7) When upgrading an unsealed road to a sealed road the design documentation is?

☐ not undertaken (maintenance crews know what to do)
☐ done on site as directed by the superintendent
☑ fully documented by the design team with specifications and drawings

8) What testing is predominantly undertaken for the design of unsealed in situ rural roads?

☑ Nil
☐ In situ testing (e.g. beam deflections)
☐ laboratory testing (e.g. CBR)

9) What testing is predominantly undertaken for the design of unsealed gravel road?

☑ Nil
☐ In situ testing (e.g. beam deflections)
☐ laboratory testing (e.g. CBR)

10) Does council model the low volume rural road pavements using programs such as circly / APSDS?

☐ Yes Always
☐ Sometimes
☑ Never

Maintenance

11) Is maintenance of low volume rural roads programmed in a yearly maintenance program or is maintenance performed on an "as needed" basis?

☑ programmed
☐ as needed

12) What normally constitutes councils decision to maintain an existing low volume rural road?

☑ scheduled maintenance
☑ community complaints
☑ traffic hazard
☐ need to spend funding

13) How is maintenance undertaken?

☑ as directed on site
☐ testing and planning before work starts

14) What does the maintenance of a low volume rural road generally consist of?

☑ road is graded
☑ additional material is added to existing formation
☐ existing material removed, subgrade improvement works undertaken and gravel / in situ material is laid and compacted.

Construction

15) What testing is undertaken during the construction of unsealed in situ rural roads?

N/A

16) What testing is undertaken during the construction of unsealed gravel rural road?

[illegible]

17) Is construction of a low volume rural road generally?

☐ fully documented
☒ documented to some extent but largely dictated by on site personnel
☐ almost fully dictated by on site personnel

18) What materials generally constitute the road pavement?

☒ on site material ☒ imported natural gravel ☐ imported crushed rock
☐ other.....

Environmental

19) What are the major environmental considerations for construction of a low volume rural road in your area?

Water management, soil erosion, litter impact on [illegible]

20) Are there any other final comments you wish to make about the design, construction and maintenance of low volume rural roads in your area?

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