UNIVERSITY OF SOUTHERN QUEENSLAND
FACULTY OF HEALTH, ENGINEERING AND SCIENCES

MANAGEMENT OF UNSEALED ROADS IN DROUGHT CONDITIONS

A DISSERTATION SUBMITTED BY
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Abstract

In 2018 the entire State of NSW was declared to be in drought; however, Councils must maintain a safe network of unsealed roads regardless of the conditions.

Dry conditions can accelerate defects in the surface of the road such as corrugations, and loose material. Fine particles in the soil are also lost to dust, which is detrimental to human health, and the environment, and the loss of fine particles leaves the road more susceptible to future damage.

If roads are maintained to a high standard, it will be more resilient to adverse weather conditions such as drought or flooding. By improving asset management systems, and maintenance methods, unsealed roads can be improved in quality at a lower cost.

Council's affected by drought in NSW were surveyed to investigate what methods they have employed to maintain the condition of the unsealed road network during drought conditions.

The most important quality of an unsealed road to ensure the road's longevity through adverse weather conditions is the pavement material. This material can be improved by stabilisation and other additives, or by importing better quality material.

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1.0 Introduction

In 2018 the entire state of NSW was declared to be in drought. Many Councils in NSW have since struggled to meet the expectations of their constituents in terms of unsealed road maintenance. Current climate science predicts a continued trend of more frequent and extreme drought events, and so drought conditions are likely to place increased strain on unsealed roads in to the future.

Councils are constantly under financial constraints, which are increased under drought conditions. Roads can deteriorate more quickly in the dry conditions, leave the road more susceptible to wet weather damage, and maintenance costs increase significantly due to the reduced availability of water. It is common for Councils to halt maintenance activities during drought conditions as the increased cost is unable to be absorbed in Council budgets, and water is more precious for environmental and social sustainability concerns.

If the roads are permitted to deteriorate over an extended period, there is an increased risk to road users as the road develops traffic hazards such as corrugations, and loose aggregate on the surface.

Unlike other natural disasters, little financial assistance is provided by higher levels of government to assist with either the immediate or long-term effects of drought on road maintenance, and so Councils must find ways to manage unsealed road maintenance internally.

Additionally, there is no specification within NSW as to what level of service must be provided to unsealed roads, and no guidance as to the best practise to achieve an adequate road quality. This report aims to identify the main issues with maintenance of unsealed roads and investigate potential management recommendations for Local Government Organisations.

2.0 Review of Literature

2.1 Background

In All 6 Australian states, there are 3 tiers of government providing services for the Australian public; The Federal Government, State Governments, and Local Government (often called Councils). Often Councils are required to sustain maintenance of large road networks with limiting funding. Disaster relief funding is available for most natural disasters when infrastructure is damaged; however, that funding is not available for roads effected by drought conditions.

In NSW the Council is the roads authority for Regional and Local roads within their local government area (NSW Government, 1993); however, there is no specification in which these roads must be kept to. As such there is flexibility in the methods used to maintain roads which allows a level of adaptability to unique circumstances.

In August 2018, the entire state of NSW was declared to be in drought, and so all Rural Councils face a similar problem of road maintenance in drought conditions. With limited access to water sources, maintenance of unsealed roads requires greater resources to get water to the work zone in a timely manner. Continuing the work in accordance with a maintenance schedule as normal is therefore not possible if Council's are to remain within their own annual maintenance budget. Council's across NSW have now had to face the challenge of balancing greater social, environmental and economic expectations over an extended length of time.

This paper investigates the problems that arise in unsealed road maintenance during <M drought conditions, and what cost-effective methods and management practises are available to local government organisations to provide an optimum level of service to property owners.

The Commonwealth Scientific and Industrial Research Organisation (CSIRO), has recently indicated that climate shifts are causing more extreme weather patterns, including more intense but less frequent rainfall (CSIRO, 2018). This could mean more prolonged drought periods for much of NSW, and so Council's must be prepared for the related challenges.

2.2 Maintenance in Ordinary Conditions

2.2.1 Road Maintenance Responsibilities of Council

In NSW, each road accessed by the public falls under one of the following categories;

- State Roads
- Regional Roads
- Local Roads
- Crown Roads
- Private Roads

Under the NSW Roads Act (1993) Local Governments are the roads authority charged with the maintenance of local and regional roads within their local government area. Across Australia 56% of the road network is unsealed, in NSW it is closer to 50% (Bureau of Infrastructure, Transport and

Regional Economics, 2018). For regional councils the percentage is often much greater, for instance 61% of Tamworth Regional Council's road network is unsealed (Tamworth Regional Council, 2019).

The roads act does not specify minimum standards for maintenance; however, as the road's authority, Council's must give road maintenance it's due diligence to ensure both the serviceability of the road and the safety of the public. Additionally as Council is a government body, it must use public funds responsibly (1993) (Office of Local Government, 2018)**,** including preventing loss of public funds in legal action due to negligence under the Civil Liabilities Act (NSW Government, 2002).

As resources are limited, it is unreasonable to maintain a completely defect free road network. Instead it is acceptable common practise for each Council to produce and act pursuant to an internal Road Network Maintenance Plan (RNMP) or Pavement Management System (PMS) to reasonably address any safety issues. These plans will often require Council to conduct regular inspections and assessment of infrastructure, prioritising maintenance demands, generating a work schedule, and reporting defects to develop a historic maintenance record.

2.2.2 Road Maintenance Expectations of Council

Property owners within each Local Government Area are required under the Local Government Act (1993) to pay rates to council in exchange for the services council provides. In regional councils, many property owners live in remote areas accessed only by unsealed roads, and do not receive services such as Kerbside waste collection, town water, sewer. Instead one of the main services provided to these property owners is regular routine maintenance of public roads used to access their property.

It is generally acceptable to have some small road defects throughout the local government road networks; however, property owners expect that roads be maintained to a reasonable to service the needs of their daily activities.

Faiz (2012) discusses the importance of this service to the triple bottom line of the community. Liveability aspects such as safe daily travel to and from work, safe travel for children on the school bus, some level of accessibility in wet weather is important for the lifestyle of residents, and a road pavement that can withstand heavy vehicle loading to transport agricultural produce is important for the local economy. Under the roads act it is the right of the public to use roads for these purposes (1993).

Van Wijk et al. (2017) investigated sustainability modelling of unsealed roads, and methods of quantifying sustainability outcomes. Multiple potential financial impacts were investigated as road surface roughness increases. No significant increase was found in fuel consumption, however as safe traveling speeds decrease due to roughness, travel time and time costs increase.

Martin (2001) Investigated community expectations in relation to road maintenance on Victorian Roads. Martin estimated an International Roughness Index (IRI) of 5.1 could be used as a quantitative measure equal to public expectations on unsealed roads. By investigating IRI on five different roads, it was found that four roads were below the community expectation IRI. In addition, Martin also noted that all 5 of the unsealed roads monitored were maintained at below estimated annual management expenditure. A more in-depth study would be required to investigate the causes; however, this research would indicate that shortfalls in maintenance may not always be related to

budget constraints. It is possible that these roads were not maintained due to a shortage of physical resources such as enough plant and staff to keep up with maintenance schedules.

2.2.3 Routine Maintenance Methods

To maintain a safe road, Councils must manage the defects within the road network. Defects that may occur on unsealed road pavements include (Austroads Ltd., 2018):

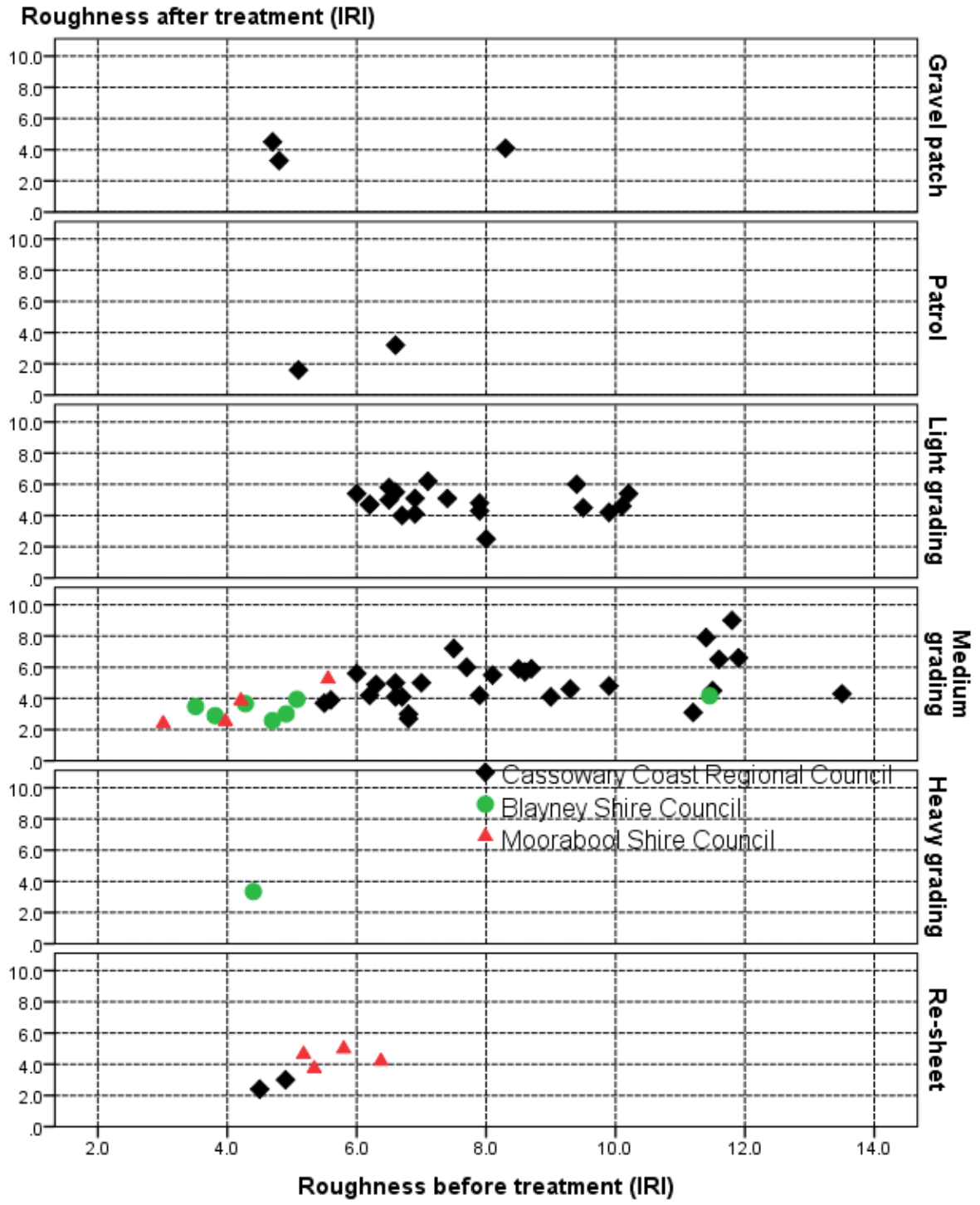
- Potholes;
- Rutting;
- Loss of fines and loose stone surface;
- Corrugations;
- Surface scour;

Austroads (Martin & Choummanivong, 2016) provided 4 main methods of maintenance for unsealed roads and measured their effectiveness in reducing surface roughness. These methods are:

- Light Grading; This method uses a grader only to smooth small sections of road that have deteriorated at a greater rate than other sections.
- Medium Grading; This method uses a grader, smooth drum roller, and water cart to rip and recompact material in the road pavement in the travel lane only
- Heavy Grading; like Medium Grading, this method uses a grader, roller, and water cart to rip and recompact material, however in this case across the full road formation.
- Re-sheeting; Over time an unsealed road surface deteriorates to a degree that overlaying additional base material is necessary to achieve acceptable roughness levels. This involves ripping and recompacting existing road surface and incorporating additional imported loads of gravel to increase the thickness of pavement.

Austroads did not find any significant difference in roughness levels between Medium and Heavy grading, however as the sample size is small, additional studies are required to increase confidence. Figure 1 shows the IRI measurements before and after these maintenance methods were implemented.

Figure 1 (Martin & Choummanivong, 2016) Roughness Data Before and After Maintenance Activities



Sample sizes are limited for all but light and medium grading. Medium grading is shown to improve the roughness on most roads to an acceptable level consistent with the public expectation value estimated by Martin (2001), with some exceptions, particularly when the before roughness value is 11 or higher.

Light grading may show higher average values after grading, still achieves an IRI approximately between 4-6. Where water is scarce, light grading may be a possibility to improve road roughness in drought conditions.

The following Figure 2:, **Error! Reference source not found. Error! Reference source not found.** demonstrate the difference in roughness along sections of roads before and after grading.

Figure 2: (Hore-Lacy, et al., 2015, p. 8) IRI Roughness measurements before and after Grader Maintenance Blading - Kingfisher Drive North Site

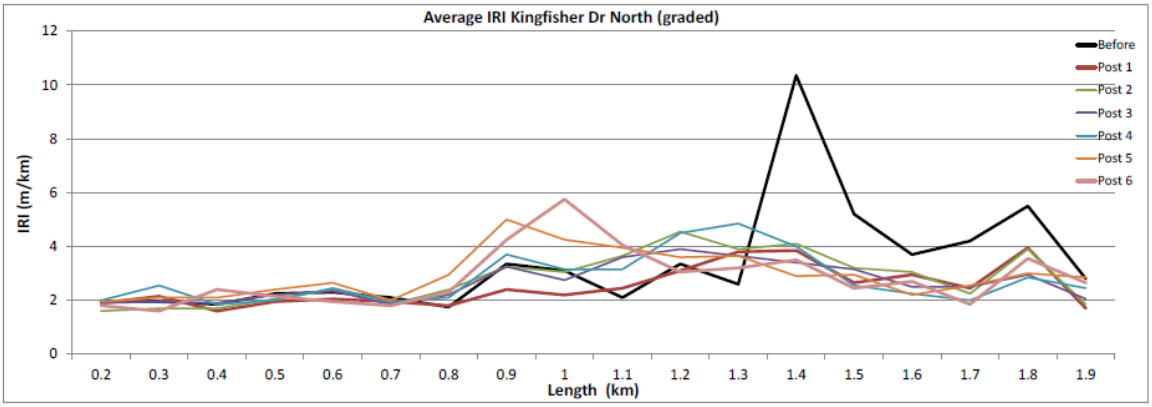


Figure 3: (Hore-Lacy, et al., 2015, p. 9) IRI Roughness measurements before and after Grader Maintenance Blading - Haywood Road East Site

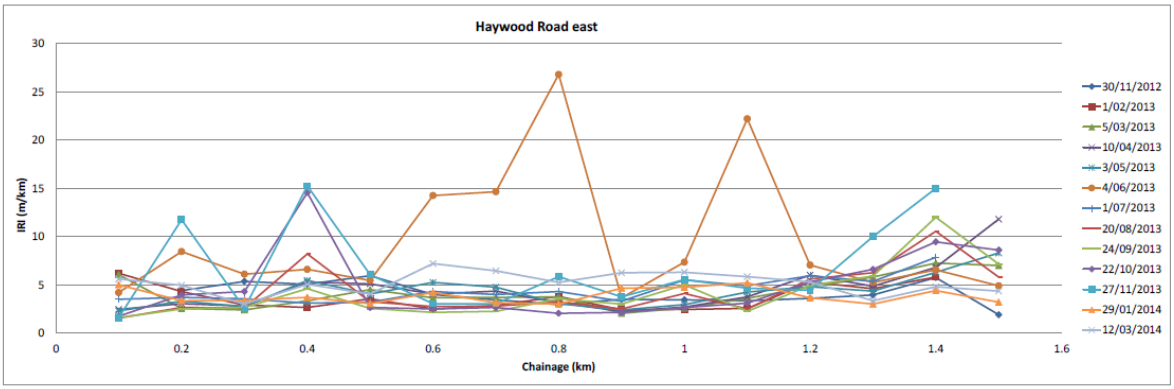
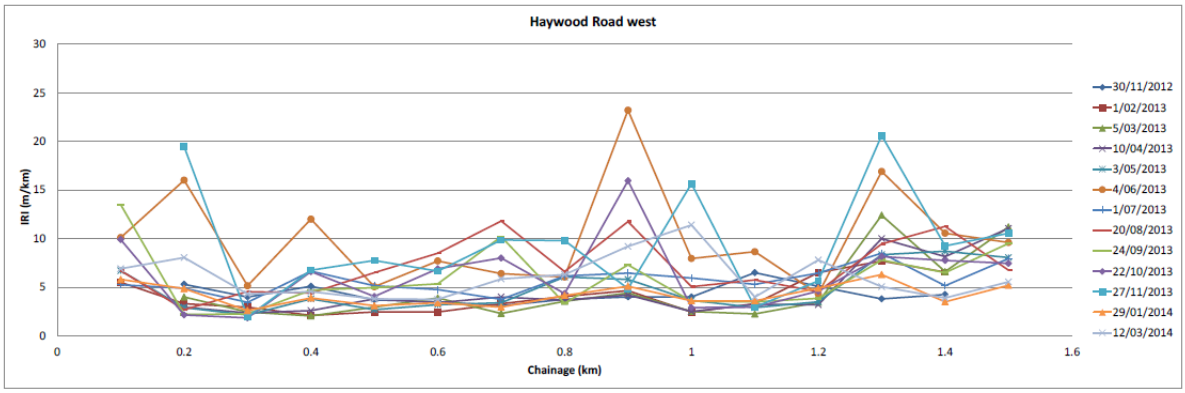


Figure 4: (Hore-Lacy, et al., 2015, p. 9) IRI Roughness measurements before and after Grader Maintenance Blading - Haywood Road West Site



These figures show that certain sections will degrade faster than others after maintenance grading, and the average IRI of a road may skewed due to a few short rough sections such as chainage 1.3km to 1.5km in Figure 2:.Figure 2: IRI Roughness measurements before and after Grader Maintenance Blading - Kingfisher Drive North Site

In normal weather conditions, routine maintenance for most Councils commonly involves a medium to heavy grade once a year (depending on traffic volumes and speed of surface deterioration). This process usually requires the grader to rip or scratch the road surface, mix in additional material from the road shoulders as well as moisture from the water truck, and compact the material with the roller.

Over time, weather and daily traffic will disturb the road surface, causing the fine particles in the soil to be blown away. When enough fines have been lost, there remains only loose stones on the pavement surface which is unstable for traffic. When enough pavement has worn or scoured away, roads required re-sheeting or more material to be hauled and placed for the pavement wearing course.

Austroads (Toole, et al., 2018) discusses the materials used in unsealed pavement construction. As road networks can stretch vast distances, hauling pavement materials that conform with quality specifications are too expensive, and are unnecessary for low volume roads. Instead it is more economical to incorporate materials sourced closer to the work location, despite the lower quality of product.

Historically local construction staff have a good understanding of material quality and therefore can make intuitive judgement calls on how they are incorporated in to road pavements, however it is becoming more common for staff to relocate several times throughout their career, creating a gap in local knowledge.

Austroads notes that material testing is not yet at a completely reliable level, as some materials conforming to material specifications will underperform, and materials that are non-conforming to specifications will perform well. Instead of comparing the material to specifications, Austroads recommends that the material is tested for plasticity, strength, and size grading to better understand the material and to provide better judgement of its suitability for road pavements.

Where the available materials for road pavement are of low quality, it may be necessary to stabilise the pavement with chemical, lime, Cementous, or granular additives**.**

Granular stabilisation aims to correct the material grading by incorporating particle sizes that are lacking in the insitu-gravel. This method of stabilisation can improve the stiffness of a pavement, improve shear strength, and improve resistance to aggregate breakdown.

Lime Stabilisation has been shown to improve strength of pavement in dry and wet weather conditions, reduce dust generation and by doing so reduce frequency of gravel re-sheeting. Cementous binders have a high content of lime in the mix and share similar results in the stabilisation of unsealed pavements, by improving the strength and reducing dust generation.

Chemical binders generally reduce the moisture sensitivity of the pavement material. They include synthetic polymers, natural polymers, ionic compounds and salts.

2.2.4 Road Safety of Unsealed Roads

In 2016 the population in regional and remote communities within Australia accounted for approximately 30% of the entire population (Australian Bureau of Statistics, 2017), however two thirds of all crashes fatalities on roads occurred in regional or remote locations (Bureau of Infrastructure, Transport and Regional Economics, 2018).

Austroads (Lee, et al., 2010) identifies key factors contributing to crash rates on unsealed roads:

- Traffic Volume and composition including seasonal fluctuations;
- Frequency and nature of intersections and accesses
- Roadside developments
- Clear zones
- Geometric Standards
- Signage and delineations
- Surface condition
- Sight distance
- Overtaking opportunities
- Bridges, structures and culverts.

Key factors for rural roads in general also include

- Higher travelling speeds
- More drink driving
- Less seatbelt usage
- Driver fatigue
- Less enforcement

Many local roads will be un-signposted, with no observable speed limit in place. Drivers are expected to drive safely and consider the current road conditions; however, the driver will not be penalised for driving at any speed less than 100km/h. This shapes road users' perceptions about the level of service required on unsealed roads and may give the impression that traffic must be able to safely travel the road at 100km/h and creating a divide in public expectations against realistic level of service provided by Council.

Dissanayake & Liu (2010) have found similar problems and perceptions in the U.S.A. The study investigated counties with different laws regarding gravel road speeds. It was found that there was no safety benefit in erecting speed signs and reducing the legal speed limit, and it only increased the number of traffic offenders. With strict enforcement over prolonged periods, traffic may adhere to the speed limits, but this may not be the most effective use of police resources. Dissanayake also found other factors affecting the 85^{th} percentile speeds including;

- Percentage of Heavy Vehicles
- Width of the road

It was also found that road formations using sandy base material had increased 85^{th} percentile traffic speeds.

2.2.5 Maintenance Specifications

While Austroads provide general technical advice on road maintenance, councils are faced with difficult decisions when it comes to road maintenance in drought conditions. Although drought events are expected to increase in frequency (CSIRO, 2018), there is no best practise to manage the effects of

drought long term on a road network. Each Council may adopt different methods to manage the road network, however many methods of maintenance and management are common among all Councils.

A visual inspection is the most common assessment of road pavement, however there is no common rating system or methodology for carrying out visual inspections in Australia. If the simplest visual inspection parameters are observed, it may be that the need for re-sheeting is only recognised once the subgrade is visible.

Austroads (Part 6) details 2 diligent and quantitative methods for visually inspecting pavements. The methods are utilised in South Africa and the United States.

The South African method simply requires a rating from 1 to 5 be given to each category of potential defects, while the American system uses a rating based on the frequency of defects as a percentage over the full length of the road.

The defects observed in these methods include the following:

- General performance and user satisfaction
- Moisture
- Wearing course
- Crossfall
- Drainage
- Roughness
- Dust
- Potholes
- Rutting
- Erosion
- Skid resistance
- Loose Aggregate
- Cracks

If visual inspections are already being conducted by Councils, it would be a cost-effective improvement to observe and document any additional defect data that is not currently measured. To include any additional data, it is important that the inspector can document this easily and, in a time efficient manner.

2.2.6 Asset Management

Austroads (Smith & Dowling, 2006) reviews a range of literature and information in relation to asset management of unsealed roads, and importantly recognises the importance of taking the risk of extended dry periods in to consideration of road re-sheeting frequency.

Between 2000 to 2002 the Australian Local Government Association (ALGA), on behalf of Austroads, requested basic unsealed road asset management information from every council in Australia. A total of 344 replies were received, of which 243 respondent Councils maintain at least 50km of unsealed road. Only 2% of respondents considered their Pavement Management System (PMS) to be ‘very helpful’ for routine maintenance, and it also became very evident that most Councils did not have measurement systems in place to record and monitor gravel loss rates.

Douglas (2011) Emphasises the importance of a PMS to demonstrate diligent and responsible use of funding to larger forms of government, whilst at the same time efficiently using the limited funding available to Local Governments to manage the road network. The key functions of a useful PMS are to collect data, manage and prioritise pavement deterioration, and select the most appropriate defect treatment type.

Douglas recognises that Local Governments are usually highly restricted with funds available for all maintenance activities, and it is often the case to prioritise work based on a "worst first" process, where the worst defects are the greatest priority. Each year as many of those defects will be rectified, within budget constraints, and as time progresses, the less urgent defects will deteriorate in to urgent defects in a constant cycle of "catch up" maintenance. One low cost key area for improvement could be to improve visual inspection systems to ensure all relevant data is collected without bias, as this data forms the basis of all later decision making.

2.2.7 Services Provided by Council

Local Governments in NSW provide a range of services to the public and must balance budgetary constraints in all areas (Tamworth Regional Council, 2019) (Upper Hunter Shire Council, 2017) (Moree Plains Shire Council, 2018). These services include management and maintenance of:

- Local air fields;
- Local cemeteries;
- Public libraries;
- Information centres;
- Town halls;
- Youth centres
- Day care centres;
- Retirement villages;
- Transport networks, especially roads and footpaths;
- Public toilets;
- Skate parks;
- Sporting fields and other recreational facilities;
- Showgrounds;
- Stockyards;
- War memorials;
- Swimming pools;
- Public water treatment plants;
- Public sewerage networks;
- Local parking areas;
- Waste management centres and kerbside collection services;
- The sustainability and environmental health of the local area;

Additionally, Councils often take on part of the role in:

- Improving the prosperity of the region by investment in local infrastructure and encouragement of local tourism;
- Maintaining and improving the safety and security of the public, including implementing anti-crime measures, and handling feral animals;
- Improving the health and wellbeing of the local public;
- Assist in emergency events;

There are additional costs and assets required to provide these services, such as;

- Employing and training staff;
- Managing and maintaining administrative buildings, works depots, Animal shelters
- Managing and maintaining vehicles, plant and machinery

Whilst some of these services may earn income from public use (such as pool entry fees), the role of local government is to serve the community and so these services commonly run annual financial deficits. Some services such as local road networks may be crucial for the local economy to function,

however they do not directly generate income. Council must therefore rely primarily on the collection of rates, and state government funding to provide the bulk of these services.

Once committed each financial year, there is little ability for Council's to reduce services in other areas, and direct additional funding to road maintenance. It is therefore necessary for Council departments to manage road maintenance within the limited budget regardless of current weather conditions.

Each year, it is common for a small amount of funds be set aside to pay for staff wages when weather delays construction and maintenance work. This may be one of the few sources of funding that can be redirected to road maintenance in drought conditions, however it is often far too small of an amount to make a significant difference to the overall maintenance budget.

2.2.8 Cost of Maintenance Works

Maintenance costs depend on several factors such as material, road environment and distance from the works depot and gravel pit. Tasmania's State Grants Commission compiled average road maintenance cost data in the Table 1.

Table 1: (Tasmania State Grants Commission, 2011) Per Kilometre Costs of Road Maintenance in Tasmania

		Estimated Life (yrs)	Performance Standard (1)	Cost per Km ($) (2)
URBAN SEALED				
Maintenance	Thin asphalt overlay	22	0.0455	126 630
	Reseals	17	0.0588	49 421
	Other maintenance	15	0.0667	3 720
Rehabilitation		45	0.0222	522 827
Reconstruction		80	0.0125	696 754
RURAL SEALED				
Maintenance	Reseals	18	0.0556	35 172
	Other maintenance	15	0.0667	2 373
Rehabilitation		50	0.0200	125 658
Reconstruction		75	0.0133	288 136
URBAN UNSEALED				
Maintenance	Regrading	1	1.0000	893
	Resheeting	9	0.1111	22 061
	Other maintenance	1	1.0000	1 186
RURAL UNSEALED				
Maintenance	Regrading	1	1.0000	893
	Resheeting	8	0.1250	22 061
	Other maintenance	1	1.0000	1 186

Note: Rehabilitation and reconstruction tasks do not apply to unsealed roads.
(1) Updated for the 2009-10 distribution following consultation with councils and the IPWEA.
(2) Updated for the 2009-10 distribution following consultation with councils and a report provided by Jeff Roorda & Associates.

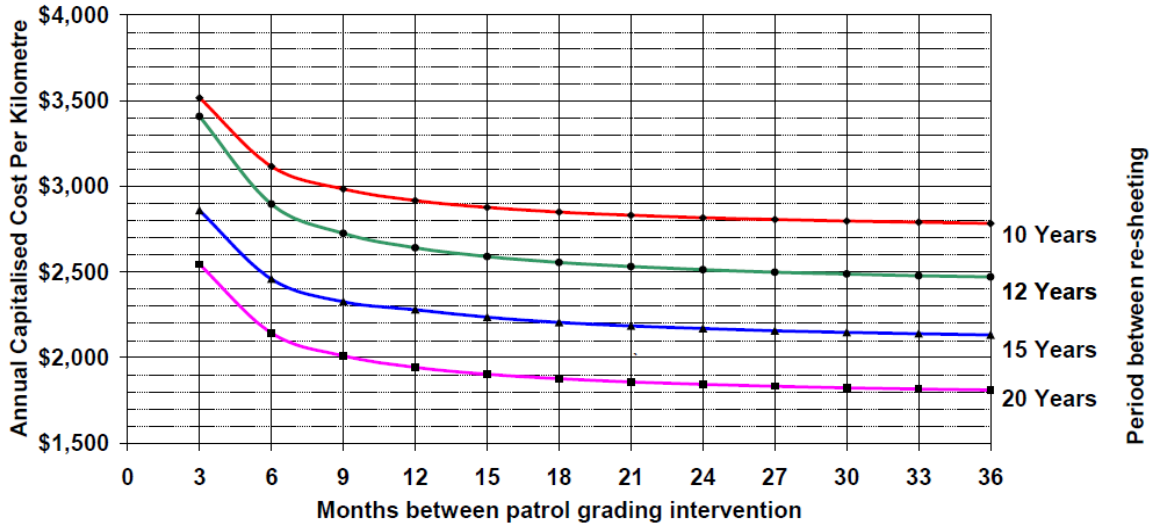
Error! Reference source not found. shows in a long-term comparison, that unsealed roads cost 43% less to maintain than sealed roads in Tasmania.

The information only provides a general overview of costs on existing roads in Tasmania. Cost analysis for specific roads is required to determine the most cost-effective road type. For example, if a road has high daily traffic volumes, it would require more frequent maintenance grading and re-sheeting, and could result in higher maintenance costs compared to sealed roads. For low volume roads, it is highly likely that an unsealed road will cost much less to maintain.

In comparison to ordinary conditions, the cost of maintenance on unsealed roads becomes much greater when water is not readily available. To conduct regular activities such as maintenance grading, or re-sheeting, water must be hauled from greater distances. With greater haul distances, more water carts would be required to keep the other components of the grader crew productive. In addition, the dry conditions can create the need for more frequent grading to prevent corrugations and unravelling of the road surface (as discussed in Section **Error! Reference source not found.**).

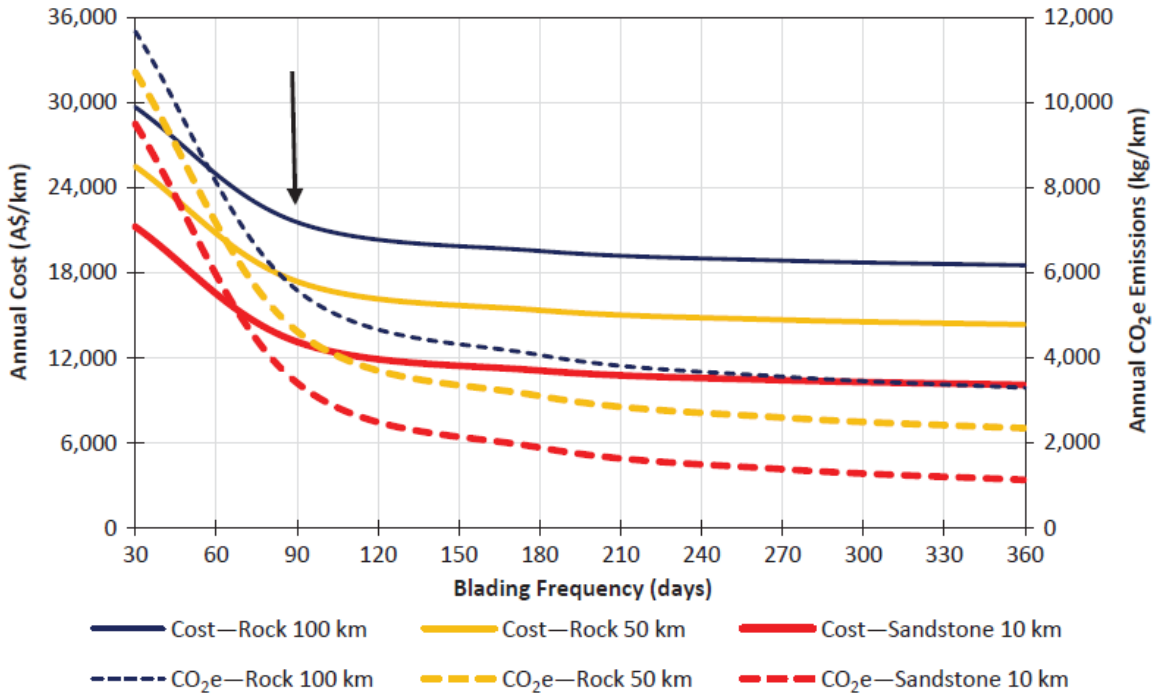
To minimise routine maintenance activity costs, lifecycle costs were also assessed by Austroads (Austroads Ltd., 2018). **Error! Reference source not found.** below shows that grading intervention frequencies were optimised at 12-month intervals for whole of life costs, however if the life expectancy of a re-sheet is increased, the life cycle cost is significantly improved.

Figure 5: (Austroads Ltd., 2018, p. 76) Life Cycle Analysis of Sheeting Life and Grading Intervention



Similarly, the cost of re-sheeting can be drastically reduced by hauling shorter distances, as demonstrated in **Error! Reference source not found.**. It is therefore evident that a balance must be found between the service life of a material used, and the haul distance required to deliver the material.

Figure 6: (Van Wijk, et al., 2017, p. 95) Annual Cost and CO_2e for Two Types of Material and Three Haul Distances



2.2.9 Disaster relief funding

As previously noted; Councils are constantly under financial strain, additional funding is usually required to repair Council assets damaged in natural disasters. Drought conditions are not however declared as a natural disaster under both State and Federal disaster recovery arrangements (Australian

Government, 2018) (NSW Government, 2015).

Higher levels of Government have offered some levels of assistance to Councils; however, these programs are very limited, and are not a solution to the problem. The NSW Government can offer $300,000.00 per Council under the Drought Relief Heavy Vehicle Access Program (Roads and Maritime Services, 2018). This funding is for minor improvements and repairs to roads for heavy vehicle access. If eligible for this funding, Council's will still not be able to maintain all unsealed roads to the expectations of the community.

Additionally, in 2018 the Australian Government announced drought resistance funding of up to $1,000,000.00 per Council for a large range of eligible activities (Australian Government, 2018). As part of the grant conditions, local businesses and suppliers are expected to be used to complete any work, which will increase the cost to Council, and once again will not allow the maintenance of unsealed roads to the expectations of the community.

2.2.10 Related Cost Factors

Hearn (2016) discusses several considerations engineers must make in the future to adapt to climatic changes. The most relevant considerations are:

1. The importance of data collection to assist in predicting future weather patterns
2. Taking future climate effects in to consideration with new infrastructure and making small incremental changes in asset management over time.

The second point is particularly important in managing road maintenance in drought conditions. If rainfall patterns are changing to create more frequent drought events, it is perhaps impractical to take immediate significant action and by doing so overcompensate with over designed assets. It is instead more advisable to create a staged approach to prepare unsealed roads for more frequent drought events.

Section Summary

This section has detailed the maintenance methods and financial responsibilities of Councils in NSW. The key routine maintenance considerations in ordinary conditions are:

- Grading Type;
- Pavement material used;
- Prioritisation of maintenance activities;
- Information recorded on inspections;
- Allocation of resources;

2.3 Maintenance Issues in Drought Conditions

2.3.1 Pavement Loss

Drought conditions are particularly problematic for council's as the dry conditions generate a loss of pavement material on unsealed roads. This is creating a safety, environmental, and financial problem, as it decreases the useful life of the pavement, generates dust, and creates an unstable surface for traffic.

As the road pavement material dries out, the material constitution becomes increasingly unstable. As traffic and wind disturbs the road surface, the lighter finer particles in the material are blown away. Over time this results in only the larger size aggregate to remain on the road surface. This larger aggregate can be spread across the full road width; however it is usually pushed just to the outside of the wheel path creating “dry rutting” as shown in **Error! Reference source not found.** below. If the road is not maintained, over time material will continue to unravel until the subgrade is exposed.

Figure 7 (Austroads Ltd., 2018, p. 54) Dry Rutting on Unsealed Roads

The larger aggregate resting as loose material on the road surface is a safety issue as vehicles can lose control. Walsh (2011) notes that ravelling can be particularly prevalent on corners where lateral shear forces create greater friction with the road surface. This becomes dangerous with loose aggregate dispersed across the width of the road, as there is an even greater risk of losing control.

Road base on unsealed roads generally has a life expectancy of around 8-10 years before more material is required. This is the most expensive requirement of unsealed road maintenance, costing on average $22,061 /km on Tasmanian Roads (Tasmania State Grants Commission, 2011)**.** If the road is subject to prolonged dry periods, loss of material will accelerate the need for re-sheeting.

The rate of material loss can be measured with the following methods (Austroads Ltd., 2018);

- Visual inspection;
- Taking spot levels;
- Ground penetrating radar;
- Formula estimation calibrated to local conditions;
- Differentiating between wearing course and base materials;

Lea and Jones (2007) Categorised skid resistance on unsealed roads within three categories.

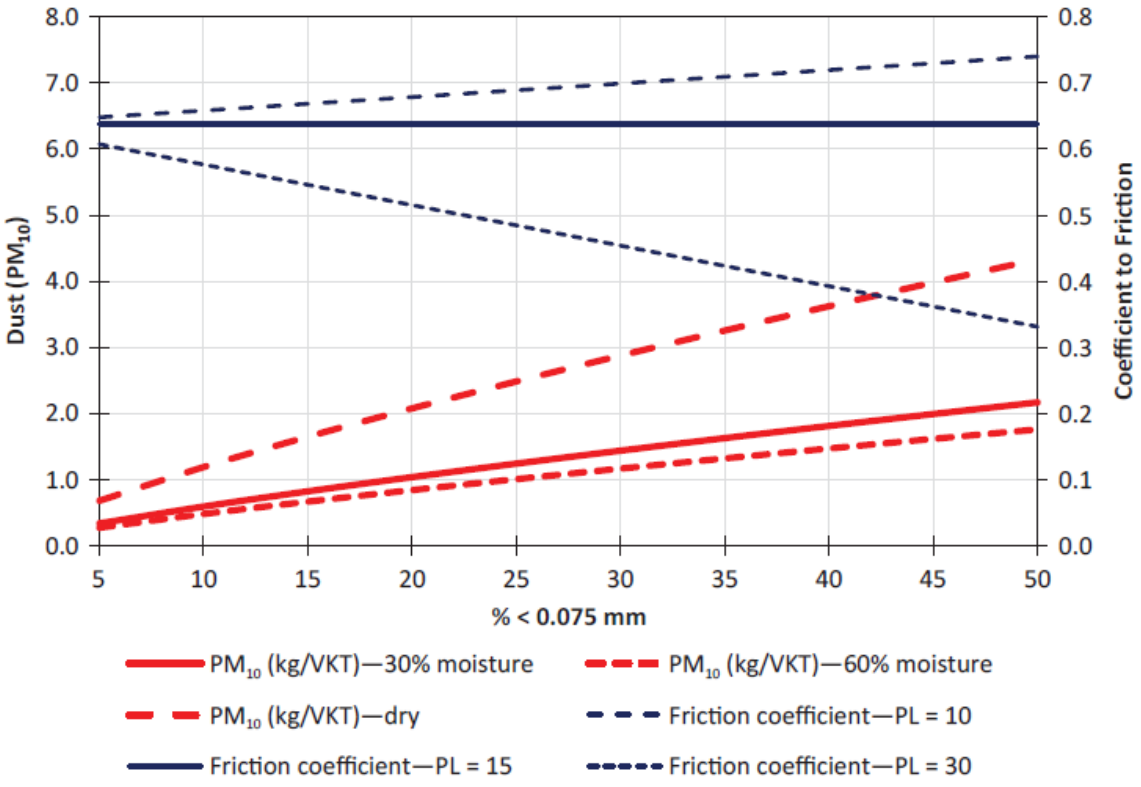
- Intersurface friction
- Sliding;
- Plowing; as the layer of loose material grows on the surface, traffic begins to need to plow through this layer.

It was found that a firm tightly bound unsealed surface will have acceptable skid resistance levels and found little difference between skid resistance measurements for ploughing and sliding scenarios, but overall any presence of loose material on the road surface does create a heightened risk of skidding.

It is also noted that particle sizes of 2mm to 0.85mm (course sand) have a greater effect on skid resistance, as materials with higher proportions of this size particle, did not perform as well in the skid resistance testing.

Van Wijk (2017) found that as the percentage of material passing through a 0.075mm sieve increased, dust generation also increased, particularly in dry conditions. This is shown in **Error! Reference source not found.** below.

Figure 8: (Van Wijk, et al., 2017, p. 94) Effect of Percentage of Fines on Dust and Friction (PL = Plastic Limit)



It is estimated that in the United States 50% of all PM10, and 19% of all PM2.5 particulate matter in the atmosphere is sourced from unsealed roads (Jones, et al., 2008).

As the surface of a pavement dries out, wind and traffic interaction with the pavement can generate dust (Walsh, 2011). Dust is not only a safety concern as it creates a visibility issue for other vehicles, but it can have long term health implications for residents living close to the road.

Particulate matter can cause a range of health problems for anyone exposed to these conditions, including cardiovascular and respiratory diseases (World Health Organisation, 2013). Exposure is particularly troublesome for people with pre-existing lung or heart diseases such as asthma, as well as the elderly and children. Children exposed to particulate matter pollution for prolonged periods of

time can also be detrimental to long term development and functionality of the lungs. It is therefore in the best interest of the community to avoid dust generation on unsealed roads.

2.4.2 Corrugations

Corrugations are wavelike formations in the surface of a road pavement. According to Walsh (2011), corrugations are caused by vehicle suspension systems oscillating due to irregularities in the road surface. As corrugations begin to deform, it can accelerate by inducing similar oscillations in traffic. Austroads (Austroads Ltd., 2018). Sandy soils are particularly susceptible to corrugations, especially in dry conditions.

Corrugations can create a safety hazard to traffic, as traffic lose friction with the road surface, making it difficult to maintain control of the vehicle. This is particularly dangerous at bends in the road.

2.4.3 Other Safety Factors

In dry conditions there is a limited amount of food available for wild animals, and, macropods. As road formations are designed to shed water, moisture will generally be concentrated on either side of a road formation. This allows vegetation to grow even in dryer conditions, which in turn attracts more animals to the side of the road (Coulson, 1989). This is an added traffic hazard to vehicles, not only as the animals can behave unpredictably, but if large animals are struck in the travel lane, there is now an added obstacle in the path of all on-coming traffic. While there is little that can be done to prevent animals on the roadside, it is an important consideration as it effects the safety of all road users and has an environmental effect by reducing local wildlife populations.

Keller (2016) Identifies that sudden intense rainfall events after prolonged dry conditions will likely erode road pavements at causeways or where culverts are overtopped. One suggested solution is to have high strength geosynthetic materials incorporated into the road pavement, that can be draped over the surface could help prevent loss of road pavement in these events.

2.4.5 Monitoring drought conditions

While the effects of drought are devastating on communities, it is not a sudden event like other natural disasters. The changes are often unnoticed for weeks or months until it is too late to implement proactive solutions, and instead Councils must then be reactive as opposed to proactive. The effects are long and drawn out, and a full recovery may not be achieved before the next drought takes effect.

Slifko (2006) claims that droughts are often forgotten about once weather conditions return to normal, and so little work is done to prepare for the next drought. One suggested area for improvement include more localised monitoring of drought conditions, as state-wide approaches to monitoring will not adequately report the extent of drought conditions in different regions of that state.

Slifko also recognises the need for more accurate drought predictions to allow greater preparedness for events. One of the more reliable weather-related tools is the El Nino and La Nina weather patterns that dictate weather occurrences around the Southern Pacific Ocean. Throughout the weather cycle wetter and dryer periods are expected, and so this can be at the very least an indicator to help increase awareness of potential drought events.

It is also suggested that more resources be placed online, and a greater sharing of resources amongst government organisations (Westphal, et al., 2007). By collecting and collating a greater amount of data, resources across government departments are utilised more efficiently, and there is a greater potential to monitor, predict, and plan for future drought events.

Section Summary

Based on the review of literature, the following list of parameters have the largest impact on management decisions surrounding routine maintenance on unsealed roads during drought conditions:

- Financial constraints due to increased costs of conducting routine maintenance;
- Driver behaviour and high public expectations of road quality;
- Little access to additional funding from higher levels of government in recovery;
- Material costs for road re-sheeting, and frequency of re-sheeting;
- Material Quality, dust generation, susceptibility to material loss and corrugations;
- Road Pavement Management systems and inspections;
- Ability to predict drought in advance;

2.4 Uncommon unsealed road methods

2.4.1 Recycled Asphalt Pavement

Koch (Koch, et al., 2013) investigated the use of recycled asphalt pavement (RAP) in unsealed roads, and in particular the use of RAP as an aggregate substitute. Koch found that although it was not as effective as dust suppressants in controlling dust, the use of RAP did significantly reduce dust generation. However loose aggregate on the road surface could be an issue where the mix design percentage was too high or too low, or when mixing was not consistent. Koch also found there was a significantly greater economic benefit to use asphalt materials in recycled hot mix.

Other maintenance practises include stabilisation using cement or lime. This practise is mainly used for sealed roads and use in unsealed pavements is still developing. Most importantly, trial testing of additives used can be more unreliable however ARRB (ARRB, 2001) propose testing samples to find a UCS between 1-5
Austroads (Austroads Ltd., 2018) recommends use of stabilising additives in accordance with Table 2.

Table 2 (Austroads Ltd., 2018) Types of stabilisation and circumstances

Category of stabilisation	Indicative laboratory strength after stabilisation	Common binders adopted	Anticipated performance attributes
Subgrade	CBR[1] > 5% (subgrades and formations)	• Addition of lime. • Addition of chemical binder.	• Improved subgrade strength. • Improved shear strength. • Reduced heave and shrinkage.
Granular	40% < CBR[1] < +100% (subbase and basecourse)	• Blending other granular materials which are classified as binders in the context of this guide.	• Improved pavement stiffness. • Improved shear strength. • Improved resistance to aggregate breakdown.
Modified	0.7 MPa < UCS[2] < 1.5 MPa (basecourse)	• Addition of small quantities of cementitious binder. • Addition of lime. • Addition of chemical binder.	• Improved pavement stiffness. • Improved shear strength. • Reduced moisture sensitivity, i.e. loss of strength due to increasing moisture content. • At low binder contents can be subject to erosion where cracking is present.
Bound	UCS[2] > 1.5 MPa (basecourse)	• Addition of greater quantities of cementitious binder. • Addition of a combination of cementitious and bituminous binders.	• Increased pavement stiffness to provide tensile resistance. • Some binders introduce transverse shrinkage cracking. • At low binder contents can be subject to erosion where cracking is present.

[1] *Four day soaked CBR.*
[2] *Values determined from test specimens stabilised with GP cement and prepared using standard compactive effort, normal curing for a minimum 28 days and 4 hour soak conditioning.*

Polymers create a similar process to lime stabilisation (Austroads Ltd., 2018), where the product coagulates and flocculates the material. These products can by dry-powder polymers, or soluble polymers. The dry powder polymers typically contain fly ash to assist with the distribution of the product through the road base, and hydrated lime to stabilise the soil. The products are mostly effective to suppress dust, and are a cheaper but less effective alternative to stabilisation.

Dust suppressants can be used specifically to reduce dust generation on unsealed roads. The common types of dust suppressants detailed by Jones (Jones, et al., 2008) and ARRB (ARRB, 2000) include:

- Surfactants
- Salts
- Lignin-sulfonates
- Petroleum products
- Electro-chemical stabilisers

Surfactants are used as wetting agents and applied in liquid form. Application is required regularly and often will need to be applied daily. These products are generally used to reduce water consumption where constant wetting is required. Long term use can lead to the pavement material ravelling.

Salts used for dust suppression include calcium chloride, sodium chloride, and magnesium chloride. These salts absorb moisture from the atmosphere and keep the pavement moist. High atmospheric humidity levels are required for these products to be effective, and the salts can corrode the bottom of

vehicles. Reapplication is generally required after rain events, as the product leaches out. It is important that the application rate is not too high, or else the roadside environment will be impacted.

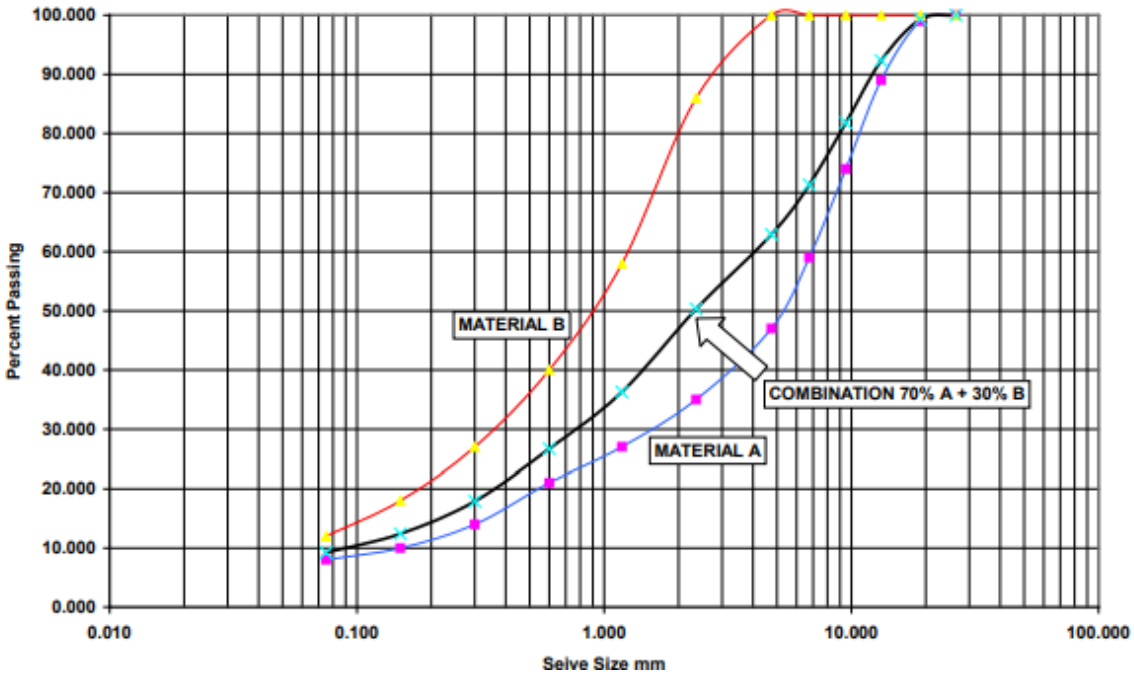
Lignin-sulfonates are natural based polymer product sprayed over the surface of a road to create a hard crust surface. These products require a minimum percentage of fines of around 10%, and will become greasy and slippery if the base material contains more than 30% fines. The product only requires one application to last several months, however the curing time can be up to 8 hours, and the hard crust has a tendency to crack and pothole under heavy traffic conditions

Petroleum products also tend to pothole under heavy traffic due to the hard crust surface, similar to lignin-sulfonate products. Petroleum products must not be used excessively to avoid environmental impacts such as contamination of water streams.

Electro-Chemical stabilisers will only be effective in specific conditions; however, they provide highly positive outcomes when applied correctly. The process is a chemical reaction that bonds particles and expels absorbed moisture which is particularly beneficial for roads with a high percentage of fines.

Mechanical stabilisation or granular stabilisation (Austroads Ltd., 2018) is the process of mixing a material in to the road pavement so that the resultant mixed gravel has an improved particle size distribution (PSD). Figure 9 shows an example mixture where Material B is introduced and mixed with Material A. The resulting material has a much better PSD and is therefore an improved product.

Figure 9: (Austroads Ltd., 2018) Material Stabilisation Particle Size Distribution



As discussed in section 2.2.8, higher quality re-sheeting materials can reduced costs due to the increased useful life of the product. ARRB (ARRB, 2000) proposes the following material specifications of base material for unsealed roads detailed in Table 3:

Table 3: (ARRB, 2000) Particle Size Distribution

Sieve size (mm)	Permitted grading of production (% Passing) nominal size (mm)					
	40 a	**40 b**	**30 a**	**30 b**	**20 a**	**20 b**
53.0	100	100	–	–	–	–
37.5	97 – 100	95 – 100	100	100	–	–
26.5	90 – 95	86 – 95	96 – 100	98 – 100	100	100
19.0					93 – 100	93 – 100
9.50	48 – 67	50 – 74	58 – 75	60 – 82	64 – 85	71 – 87
4.75	31 – 48	35 – 59	37 – 56	42 – 66	44 – 64	47 – 70
2.36	22 – 34	25 – 46	28 – 42	30 – 52	32 – 47	35 – 56
0.425	10 – 18	10 – 26	11 – 20	12 – 30	13 – 22	14 – 32
0.075	4 - 10	4 - 17	4 - 11	4 - 18	3 – 11	6 – 20
Plasticity Index	Not greater than 6 for climatic zones where rainfall > 600 mm Not greater than 10 for climatic zones where rainfall < 600 mm					
Laboratory soaked CBR	In excess of 60 for rural type construction (NOTE: This latter standard is based upon verbal comment received from numerous shire engineers and has yet to be validated by research findings)					

Austroads (Austroads Ltd., 2018) recommends the following material specification for unsealed road use detailed in Table 4.

Table 4 (Austroads Ltd., 2018) Particle Size Distribution for unsealed road material

Sieve size (mm)	Per cent passing for all maximum sizes
55	100
37.5	95-100
26.5	90-100
19	80-100
2.36	35-65
0.425	15-50
0.075	10-40
Plasticity	Less than 500 mm annual rainfall – max. 20 More than 500 mm annual rainfall – max. 12 OR Weighted Plasticity Index (PI x % passing 0.425) Max. 500 for low rainfall Max. 250 for high rainfall
4 day Soaked CBR	Minimum 40%

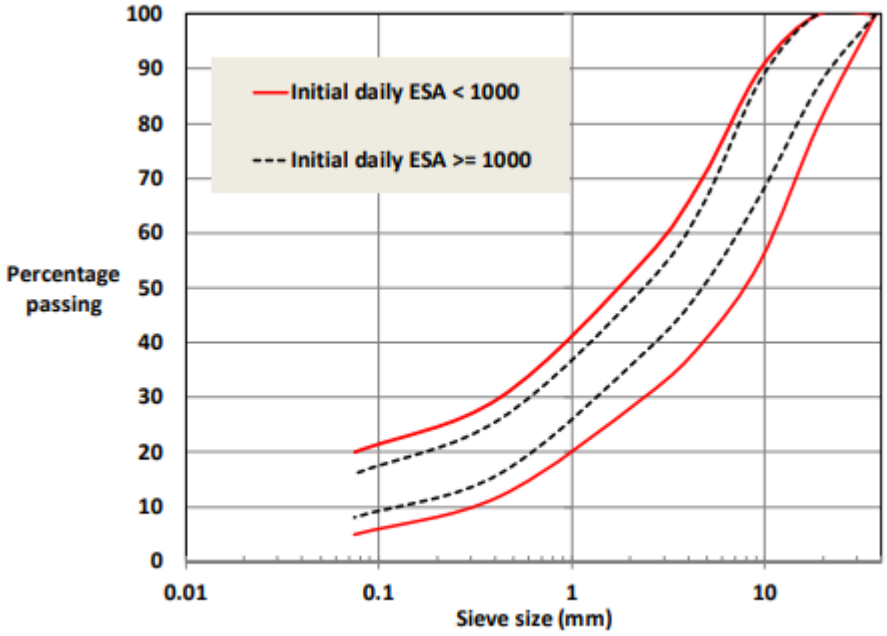
The main differences between these specifications is Austroads recommends a higher percentage of fines, and a higher Plasticity Index (PI), and recommends a lower California Bearing Ratio (CBR). Additionally, Austroads only recommends a maximum aggregate size of 20mm.

Emulsion stabilisation uses a bituminous product to bind the base material together (Austroads Ltd., 2019). These products can be a highly effective stabiliser and dust suppressant for unsealed roads, however very specific material gradings are required for the stabilisation to be effective. Table 5 and Figure 10 below shows the PSD recommended for bitumen emulsion.

Table 5: (Austroads Ltd., 2019) Particle Size Distribution recommendation for bitumen emulsion stabilisation

% Passing sieve (mm)	Initial daily ESA < 1000	Initial daily ESA ≥ 1000
37.5	100	100
19.5	80–100	87–100
9.5	55–90	67–88
4.75	40–70	50–65
2.36	30–55	38–50
0.425	12–30	16–26
0.075	5–20	8–16

Figure 10: (Austroads Ltd., 2019) Graph of Particle Size Distribution recommendation for bitumen emulsion stabilisation



A Gatt seal (Boral Pty Ltd, 2019) is a new bituminous seal type using graded aggregate instead of a single sized aggregate. This process aims to increase the strength of the seal and allows sealing to occur on unsealed roads without any pre-preparation. This added strength makes the seal more susceptible to cracks and potholes under higher traffic volumes.

3.0 Methodology

3.1 Outline

A qualitative survey will be conducted across multiple Councils to understand current maintenance methods. Each survey topic was discussed in detail with a representative from each Council that is directly involved in the budgeting, scheduling, decision making and management of maintenance activities for unsealed roads.

The study will then seek to utilise the theoretic knowledge investigated to devise improvements to local government road maintenance systems and consider the feasibility of these improvements.

The initial survey (See appendix A) requests as much or as little information as Council's are willing to provide to answer questions on their usual maintenance policies, and how they have adapted to drought conditions.

The Councils listed in Table 2 were selected due to the range of different population sizes, different geological make ups. Additionally, the Councils have been selected based on information provided by the NSW Department of Primary Industries (DPI) Combined Drought Indicator (Department of Primary Industries, 2019). Each Council has had a majority of the local government area impacted by "Drought" or "Intense Drought" Conditions in the last 12 months.

Figure 11: DPI Combined Drought Indicator Map

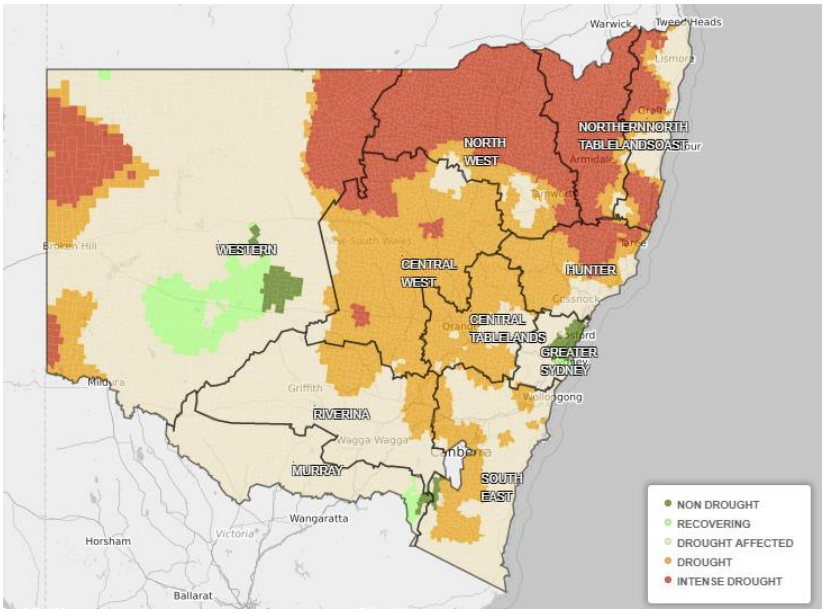


Figure 12: Selected Local Government Areas for Study

Local Government Area	Approximate Population Size	Region
Upper Hunter Shire Council	14 000	Hunter
Moree Plains Shire Council	13 000	New England & North West
Dubbo Regional Council	50 000	Central West & Orana
Tamworth Regional	60 000	New England & North West
Armidale Regional council	30 000	New England & North West
Clarence Valley Council	52 000	North Coast

This qualitative study aims to achieve the project outcomes specified by completing the following objectives:

- Identify the common unsealed road maintenance methods utilised by Councils;
- Identify effects of dry conditions on unsealed road networks;
- Identify the social/political/financial issues faced by Councils;
- Identify uncommon methods of unsealed road maintenance currently trialled;
- Compare methods in relation to triple bottom line sustainability factors;
- Propose a management system based on the methods investigated;

3.2 Current methods of unsealed road maintenance

To ensure a range of issues are realised, multiple councils with a range of land areas, road networks, and populations will be surveyed to capture methods used across rural NSW.

The Councils have been selected based on information provided by the NSW Department of Primary Industries Combined Drought Indicator (Department of Primary Industries, 2019). Each Council has had a majority of the local government area impacted by “Drought” or “Intense Drought” Conditions in the last 12 months.

The usual methods of maintenance will be discussed for each council to better understand the current costs of maintenance, whether this method can be maintained in drought conditions, and how resilient the road pavement may be to dry conditions.

3.3 The effects of dry conditions on unsealed roads

It is important to understand the effect that the drought conditions is having on the unsealed road network, any common, or unique issues that each Council faces in relation to current maintenance practises, and any expected long term effects from the drought.

3.4 Other Issues face by Councils in NSW

Any proposed method of road maintenance must be managed within a local government management system, and so Council’s financial constraints, environmental responsibilities, social or political

issues, and other factors will need to be discussed in order to ensure that any proposed improvements can be integrated in to Local Government management systems. This may also highlight any successful methods used to manage these issues.

3.5 Uncommon maintenance methods

Important information to be gathered from Council will be to discuss any unusual methods of maintenance implemented by Council, how effective these methods were deemed to be, and any factors that may have affected the outcome of the trial. This may uncover key solutions to the issue of drought condition maintenance.

3.6 Comparison of road maintenance methods

Each method identified from the literature review in Section 2, and from the Council Survey results will be compared based on the information provided, with consideration to environmental, social, and financial sustainability.

3.7 Proposal of an unsealed road maintenance management system

Based on the comparison in section 3.6, a proposed set of management policies will be devised to improve unsealed road management in drought conditions across NSW.

4.0 Discussion Results

4.1 Tamworth Regional Council

4.1.1 Background

Tamworth Regional Council (TRC) is in the New England district of New South Wales.
The Local Government area has a total population of over 58,000 people which makes it one of the largest in regional NSW. The road network consists of approximately 1200 km of sealed road, and 1900 km of unsealed road.

The Infrastructure and Works division manage TRC road maintenance. Maintenance teams report to team leaders, known as Specialist operators, who in turn report to area supervisors, who report to the Manager of Infrastructure and Works, Mr Murray Russell. The survey topics were answered by Murray Russell (M. Russell 2019, Personal Communication, 10/6/19) with the results detailed below.

4.1.2 Maintenance in Ordinary Conditions

TRC's unsealed roads fall into two main categories. Approximately 50% of unsealed roads are natural earth roads, and 50% are gravel sheeted roads.

Natural earth roads generally have the lowest traffic volumes and are mostly located in areas where subgrade materials are of a suitable quality to withstand traffic loading, e.g. some areas comprise granite sand subgrades. Local knowledge is used to determine the suitability of material for use on unsealed roads.

Maintenance grading of natural earth roads consist of medium grading as outlined in section 2.2.3 with the gravel lost in the shoulders being ripped and reintroduced back in the travel lane.

TRC does at times utilises material stabilising to at finer sediments to sandy granite soils on natural earth roads. This process has been successful in lowering the frequency of corrugations and improving material grading to create a more durable road base.

Gravel Sheeted roads are often roads with higher traffic volumes, or detour routes. These roads are maintained by medium level maintenance grading; however, only the travel lane is ripped and recompacted to prevent contamination of the sheeted gravel.

The gravel is sourced from a small number of centralised pits in order to best manage the environmental and legislative requirements of quarries, as well as ensure a high quality of material is produced. This has been found to provide a cost-saving by reducing the frequency of re-sheeting. Gravel is hauled an average of 50km for road re-sheeting, and a maximum distance of approximately 80km. The material produced at each quarry for use on unsealed roads is specified as follows:

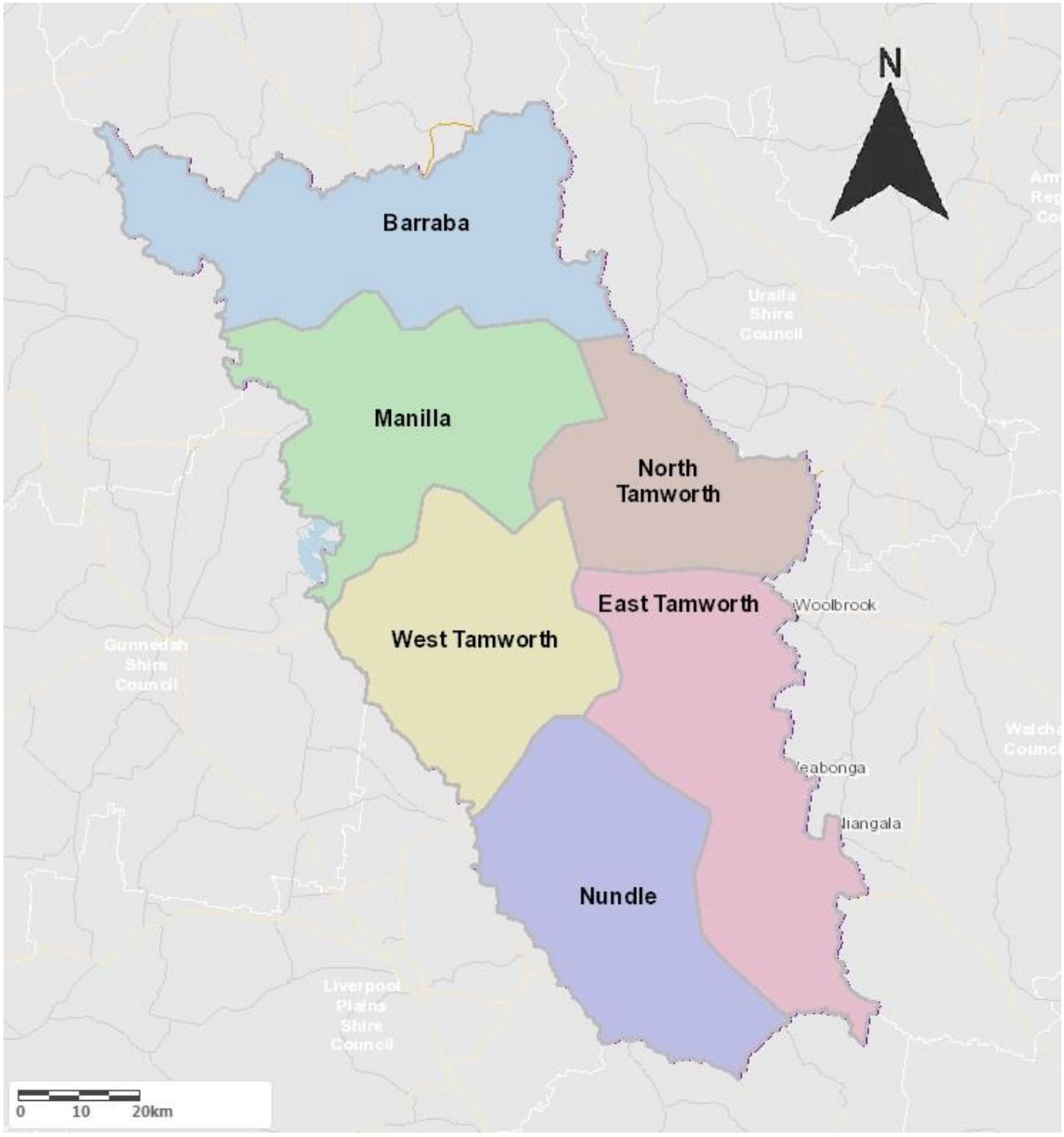
Figure 13: Tamworth Regional Council Particle Size Distribution specification

Sieve Size (mm)	% Passing for all maximum sizes
55.0	100
37.5	100
26.5	100
19.0	90 - 100
2.36	35 - 65
0.425	15 - 50
0.075	10 - 40
PI	4 < PI < 12

Each gravel re-sheet aims to introduce approximately 100mm to 150mm of gravel on top of existing gravel or subgrade material. As re-sheeting will generally occur when the subgrade is visible, each road pavement consists of one layer varying from 0 to 150mm of gravel which slowly wears away over time. The road asset management plan dictates that each road will be re-sheeted once every fifteen years, however currently each road will be re-sheeted once every ten years.

There are six grader crews across the shire that each grade a separate area (Barraba, Manilla, North Tamworth, West Tamworth, East Tamworth, and Nundle). See Figure 14: Tamworth Regional Council Grader Crew Areas below. Maintenance Supervisors will generally inspect and schedule work for two maintenance areas each, in order to break up the road network into more manageable sized areas.

Figure 14: Tamworth Regional Council Grader Crew Areas



The primary mechanism driving grading programs and the frequency that each road is graded, is road inspections or road condition. There is no strict road inspection frequency, however, works supervisors and specialist operators within council will inspect roads regularly, as well as reactively inspect roads that residents raise complaints on. The supervisors will then determine the work schedule ahead of grader crews by considering factors such as the overall condition of the road, the

severity and risk of defects, travel lane widths and site distances, and traffic volumes on each road. If a road is selected for grading, then surrounding roads will also be graded to avoid returning to that location.

The Council does not currently have a pavement management system implemented, however there are plans to develop a system, and analyse all available road data including unsealed road re-sheeting, road defect frequency, in order to optimise the management of all roads.

Road inspections are currently carried out by Specialist Operators, Works Supervisors, and The Manager of Construction and Works. Training is provided to inspectors, and other Engineering staff when opportunities arrive, however staff are primarily trained by exposure to experience.

Inspectors primarily collect defect data, such as corrugations, potholes, unravelling, and where subgrade material is starting to show. The defects are logged in Asset Management Software Asset Edge Reflect. Vehicles also have the capability to test the international roughness index (IRI) of each road, however this is not carried out routinely. Where there is difference in opinion or ambiguity about the road conditions, IRI will be tested to settle the matter. In most circumstances a value of 4-6 is deemed acceptable.

Road re-sheeting is determined from a priority list of unsealed roads, ranked with considerations to current defects, defect history, traffic volumes, and strategic importance of the route.

Funding for re-sheeting sourced from a combination of sources including;

- Annual maintenance funding from rates,
- Special rates for asset maintenance,
- roads to recovery,
- financial assistance grant.

Of these sources of funding, the entire road maintenance budget is determined. Approximately half of the maintenance budget is used for minor routine maintenance, such as repairing potholes, slashing shoulders, and road grading. Out of the remaining funds,
Approximately one third is spent on sealed road reseals, one third on sealing sections of unsealed road, and one third re-sheeting gravel roads.

4.1.3 Maintenance in Drought Conditions

The primary behavioural difference in the approach to maintenance during the current drought conditions, is that the risk assessment of defects is more lenient. TRC is finding that any road grading activities will increase in cost as water is scarce and the road material is very dry. Water carts must take longer to travel further, and make this trip more frequently in order to introduce enough moisture into the pavement. The grader and roller are then standing idle waiting for the water cart to return, and productivity slows. To prevent productivity from dropping, additional water carts would be needed, and so in either scenario, the exercise becomes more expensive.

Ultimately the Council will only grade a road if there has been recent rain, or the road is in a particularly dangerous condition. When inspecting roads, the risk factors considered are the same, however more leniency is given due to the cost and inefficiency of grading.

If possible, grading will be limited to spot grading to conserve water.

There has been no noticeable increase in complaints from the public in relation to road condition, however dust generation has been raised as a significant issue by residents, especially on high traffic roads. Council has raised awareness with the public about the difficulties of managing road conditions in dry weather by posting on the Council's Facebook page. Permanent signage is also in place around the local government area asking drivers to slow down and limit dust generation.

TRC has received a total of $1.3M in drought relief funding. $1M was received from the Australian Federal Government, and $300,000 was received from the NSW State Government. $500,000 of the federal funding was spent on installing water refill stations in towns around the local government area to allow people in remote areas easier access to drinking water. The remaining $800,000 was spent on improving cattle grids on unsealed roads.

Cattle Grids are the responsibility of property owners to maintain, however in the dry conditions, the condition of cattle grids was noticeably deteriorating, creating a traffic hazard for traffic. Council must ensure that the roads and road furniture are maintained to an acceptable safety standard, however it is also a politically sensitive issue to enforce property owners to spend time and money in improving grid conditions.

As a result, drought relief funding was applied for to improve the cattle grid structures and approaches by sealing 20m either side, making minor repairs such as replacing the grid side walls, or by replacing the entire structure.

Additionally, several causeways across the local government area have been sealed on the unsealed road network, in order to limit dust, prevent corrugations, and most of all prevent material loss during large rain events after the extended dry period.

It is the view of Tamworth Regional Council's Manager of Infrastructure and Works, Murray Russell, that drought relief funding is not necessarily the answer to drought relief road management. Instead, it is more important to construct a more resilient road formation to withstand all weather conditions. It is also noted that public awareness is crucial in drought conditions, and that holding the public's expectations of road maintenance in check has been the largest portion of work during the dry conditions.

Loss of pavement material is not measured, and there has instead it has been found that the dry conditions have limited other defects such as road scouring, and potholes, maintenance crews have instead been able to spend time improving drainage and preparing the road formation in preparation for future wet weather.

TRC has trialled some alternative methods for unsealed road maintenance. Recycled asphalt has been trailed on some unsealed sections of road, however it was found the material unravelled quickly, and proved dangerous due to the large chunks of aggregate acting as a loose surface, and chipping vehicle windshields as a projectile.

Polymers have also been trialled on unsealed roads in the local government area, however the results have been mixed.

4.2 Armidale Regional Council

4.2.1 Background

Armidale Regional Council is recently amalgamated from Armidale Dumaresq Council, and Guyra Shire Council in 2015. ARC has a total of approximately 1150 KM of unsealed road. The Local Government area has a population of 30,707.

Unsealed road maintenance is managed by the Service Leader for Roads Maintenance, Parks and Facilities. Mr Mark Burgess completed the survey as he is acting in the position (M. Burgess 2019, Personal Communication, 12/6/19).

4.2.2 Maintenance in Ordinary Conditions

In ordinary conditions, ARC utilises a crew of a grader, roller, and water cart to medium to heavy grade unsealed roads with emphasis on road shape and drainage. There are 4 maintenance areas within the local government area, and a maintenance cycle occurs each year within those areas. Where there is a break in maintenance grading, each cycle will start with the road in worst condition, and the maintenance crew will progress and complete the surrounding roads.

ARC's asset management hierarchy is based on factors such as traffic volumes, and strategic routes such as B class routes, and bus routes. Roads are inspected by technical staff trained in IPWEA recommended road defect inspection courses. Testing roughness has been trialled in the past, however has not been proven to be particularly useful.

ARC uses multiple small pits spaced around the local government area for use on unsealed roads, with an average haul distance of 10km to each unsealed road. A full time Soil laboratory Technician is employed to conduct Quality Assurance testing for road works within the council area, including testing Plasticity Index, California Bearing Ratios, and Particulate Size Distribution tests on each pit.

The experience of grader operators is also highly valued to provide guidance in decision such as re-sheeting frequency, material quality, and re-sheeting is primarily determined by inspections, and rate of deterioration. On average each road is re-sheeted every 5 years and is generally funded by State Government Roads to Recovery Funding.

Each re-sheet consists of a 100mm to 150mm layer of gravel introduced on top of the existing pavement.
Material stabilising has been used by ARC to mix materials on roads in order to achieve a more suitable particulate size distribution. This has been deemed successful in improving the road conditions and reducing the amount of maintenance required.

Liquid dust suppressant has also been trailed. The method of application was different to the manufacturer's recommendations, with the liquid being added to the water cart, and maintenance grading being conducted in an otherwise normal fashion. This allowed the suppressant to mix completely with the material and to a significant depth of pavement, however the results were described as mediocre.

4.2.3 Maintenance in Drought Conditions

Armidale Regional Council has also reduced maintenance activities during the drought due to the limited available water. If maintenance activities were to continue as normal, the cost would be significantly higher due to the cost of hauling water from a greater distance, and a greater quantity of water is required to condition the road pavement. Additionally, ARC has noticed that road conditions are deteriorating more quickly due to the dry conditions, and that the cost increase in maintenance grading cannot be justified as the benefit is short lived.

Roads continue to be inspected regularly, with defect intervention standards being relaxed with consideration to the current conditions. Where conditions have deteriorated significantly, spot grading is conducted.

Maintenance crews are instead focussed on improving drainage and other road conditions in preparation for wet weather. This includes clearing table drains and removing hazardous trees that are at risk of collapse when wet weather returns.

Customer complaints have decreased due to realistic expectations of the public, and the cyclical grading system assures the public that they are in the planned program to received grading when it is next possible. Dust generation has been raised as an issue by the public particularly from roads close to the City of Armidale, with several requests to seal unsealed roads, and sections of road such as in front of dwellings close to the road corridor.

Public awareness has been improved by posting information on the ARC Facebook page, through consultation groups, and from staff interactions with property owners.

$300,000 of state government drought assistance funding has been received by ARC and has been put towards repairing a heavy vehicle access detour route which has been damaged by increased heavy vehicle traffic volumes. The funding has also been utilised to improve drainage and clear hazardous vegetation on unsealed roads.

In the opinion of Mr Burgess, drought relief funding has provided a great opportunity to prepare road conditions ready for wet weather. The drought conditions have made the road pavements more susceptible to erosion, and large trees more susceptible to collapsing.

ARC has also implemented strategies such as sealing bridge approaches due to prolific corrugations forming. This has been found to have shifted where vehicles brake, causing corrugations to form instead on approach to the seal, however this has successfully improved safety conditions by removing the hazard from proximity to bridges.

4.3 Upper Hunter Shire Council

4.3.1 Background

Upper Hunter Shire Council (UHSC) is in the Upper Hunter region of NSW, with the Council main office in Scone. The population of the shire is approximately 14,000. The Council maintains 1165 km of unsealed roads, and 598 Km of sealed roads.

The survey was conducted with the Director of Infrastructure Services, Mr Nicholas Havyatt (N. Havyatt 2019, Personal Communication, 18/6/19).

4.3.2 Maintenance in Ordinary Conditions

Upper Hunter Shire Council uses 4 road classifications to prioritise road maintenance and has 3 zones which are maintained using a cyclical grading program. Unsealed roads are maintained by utilising grader crews consisting of a Grader, Roller, and Water cart to conduct heavy grading of each road. The grader will reintroduce gravel from the shoulders onto the road surface, and correct road shape with each grade.

Historically UHSC has used smaller pits spaced across the shire, but now sources most gravel from centralised pits. Haulage distances are frequently greater than 50km, however the whole of life costs is found to be less due to the reduced maintenance by using a better-quality material. Each re-sheet is approximately 100mm to 150mm of material.

Re-sheeting requirements are determined by inspection, and is desired to be every 10 years, however funding for road re-sheeting is reliant on grants from higher levels of government such as roads to recovery funding.

Inspections are carried out by Outdoor staff and Engineering staff, with most staff trained through experience and mentoring. Inspectors assess the road condition and provide a quantitative rating. Written guidance is provided to all inspectors to reduce bias in the ratings. Inspectors must also document where the hazard or defect is located, e.g. on the shoulders or in the travel path. A total road rating score is then determined based on road class, road condition, and the primary location of the defects.

4.3.3 Maintenance in Drought Conditions

There has been a noticeable increase in public complaints of 30-40%, in relation to road conditions, but no noticeable increase in complaints about dust generation. UHSC has raised awareness with the public by posting information on Community Facebook pages, on the Council Facebook page, and on the Council website. “Drive to Conditions” signs are also installed at the start of many unsealed roads to encourage safe driving by the community.

At the time of the interview, UHSC had not yet received any drought relief funding. Since that time the Australian Federal Government has announced $1M of drought relief funding to be used on non-road related infrastructure. Council’s Director of Infrastructure Nick Havyatt recommends additional funding is needed to manage drought related problems as they occur.

UHSC has also noted long term asset management issues, particularly in relation to material loss. The Council has identified material loss rates 50 to 100% greater than normal, with around 20mm of gravel lost on average across the network. The material lost is mostly the finer particles, which have also made the road pavement more susceptible to future damage and defects.

UHSC has noticed an increase in maintenance costs due poor productivity from maintenance crews. This has been contributed to the limited access to water, and already reduced productivity due to

operator skill. For this reason, there has been a reduction maintenance operation during the drought. Due to the extended time period between maintenance grading, the roads have deteriorated, and it has been difficult to improve the road network back to normal when rain does fall.

A recent project has also been undertaken to seal the last unsealed regional road in the local government area. The limited access to water has affected construction costs, but UHSC has successfully completed the project.

4.4 Dubbo Regional Council

4.4.1 Background

Dubbo Regional Council (DRC) was amalgamated in 2016 from Dubbo City Council, and Wellington Council. DRC maintains over 1300 KM of unsealed roads.

The survey was conducted with the Senior Transport Asset Specialist, Mr Peter James (P. James 2019, Personal Communication, 20/8/19).

4.4.2 Maintenance in Ordinary Conditions

DRC uses a grader crew, consisting of grader, roller, and watercart. On a cyclical program across 2 maintenance zones.

These maintenance zones are the previous Wellington Council area, and the previous Dubbo City Council area.

The typical maintenance routines of the location are detailed below.

Wellington Council Area: The Wellington maintenance zone has a four-month re-sheeting program, utilising two full time maintenance graders and one construction that is used on construction projects for part of the year, and maintenance grading for the remainder of the year. Maintenance rotates over seven zones throughout the year. Available gravel is typically shale, with haulage distances on average between 5-10km, and a maximum of approximately 20km.

Dubbo City Council Area: The Dubbo maintenance zone has one full time maintenance grader and three construction graders. Available gravel is typically sandy conglomerate ridge gravels, with haulage distances of 20-40km, and a maximum of approximately 50km.

Most arterial roads across the local government area are sealed already, and an Asset management plan road hierarchy determines maintenance priority and measures, including further sealing works of arterial roads.

DRC utilises centralised gravel pits as a source of material for unsealed roads, which allows better quality, environmental, and safety management of the pits. Historically the separate

councils have used lots of smaller pits spaced across the local government areas. This has allowed DRC to choose the best strategic pits with the most consistent materials to use as centralised pits. These pits are tested when required for construction jobs, and test reports are kept for comparison of material consistency.

Typical test results provided by DRC are summarised in table ## below :

Table 6: Dubbo Regional Council Typical unsealed road base material test results

Sieve Size (mm)	**DRC - % Passing**
53.0	100
37.5	100
26.5	100
19.0	91
9.5	59
4.75	36
2.36	22
0.425	11
0.075	6
PI	9
CBR	50

The desired CBR of unsealed road material by DRC is 30 or greater, however most pits are often between 50-60. To ensure the material has enough fine particles to hold moisture, a plasticity index of approximately 20 is desired.

Road pavement material thickness is tested regularly. Inspectors dig to subgrade, approximately every 1km, testing a quarter of every road each year. These tests are not conducted for the first 5 years from last re-sheet, due to the greater thickness of pavement.

Re-sheet depth is typically 100mm, and an average of 10mm loss per year is observed. Re-sheeting is desired to occur every 10 years; however this sometimes lags due to budget constraints. Road re-sheeting is funded from roads to recovery, strategic/restricted asset funds, internal revenue, and section 94 contributions.

Asset Edge Reflect software is used to log defects on all transport assets. Regional Roads are inspected each month, Collector roads are inspected every 3 months. Small defects identified from inspections are rectified with small machinery, and larger defects are assessed if they can be managed by alternative methods until the next maintenance grade.

Inspections are carried out by supervisors and set inspection crews. These crews are trained and are experienced in carrying out defect inspections across all road networks from unsealed roads to State highways. Succession planning is utilised to ensure experience is shared to other staff. The inspection crew conducts inspections for only a portion of the year and conducts other small maintenance tasks such as sign and delineation repair for the remainder of the year.

4.4.3 Maintenance in Drought Conditions

DRC has not yet experienced severe drought conditions, and so maintenance activities have continued. A reduction in productivity has been observed due to the longer water haulage distances. Where hauls are particularly bad, 2 water carts are being used which contributes to a higher cost of maintenance work.

Grader operators have good relationship with most farmers which helps with public relations. This relationship is also helping to allow road maintenance activities, as farmers are currently offering water from their dams to continue grading. Council ensures team leaders amongst outdoor staff are well informed of Council matters including grading programs and re-sheeting programs, and this information is then relayed to residents through face to face interactions.

The positive relationship between team leaders and residents is believed to have contributed to public understanding, and so no increase in complaints has been observed during the drought conditions. Dust has not been raised as a huge issue, however where there are problematic patches, a watercart will soak the area initially, and if it is deemed in poor enough condition, the road may be graded.

Dry conditions have not progressed to show a real need for drought funding in relation to road maintenance yet, however as conditions continue to deteriorate, there will be a need. DRC has received $1M from the federal government drought communities funding source, however this has been spent on non-road related infrastructure. The organisation has also received $300K from the State government which has been used to reconstruct a regional road and improve transport routes in the area.

The long-term effects of the drought realised by DRC have been an increase in the frequency of corrugations in sandy soils, due to the finer particles being lost to dust generation. DRC is working to seal unsealed roads near villages over the next 10-12 years to reduce dust for the village residents.

4.5 Moree Plains Shire Council

4.5.1 Background

Moree Plains Shire Council (MPSC) is in the North West region of NSW and maintains 2893km of road, including over 1950km of unsealed road. This unsealed road network is larger than any other surveyed Councils, however the population is the smallest with approximately 9300 people in the shire.

To gain a full understanding of the organisation, an interview was conducted with:

- Outdoor maintenance superintendent John Mather (J. MAther 2019, Personal Communication, 7/6/19),
- Asset Manager Kylie Kerr (K. Kerr 2019, Personal Communication, 4/7/19), and;
- Operations Manager David McMahon (D. McMahon 2019, Personal Communication, 16/7/19) .

4.5.2 Maintenance in Ordinary Conditions

Due to the limited budget and large road network, routine unsealed road maintenance consists of a grader only conducting light grading. Road grading is prioritised after rain events when there is still moisture in the road pavement, and the road is rolled opportunistically by through travelling construction vehicles.

MPSC has recently resolved to adopt a new level of service after consultation with community. The new process will use intervention standards to meet the expectations of the public in terms of road maintenance and conditions.

Under the new levels of service, inspections must be carried out regularly. Inspections are currently conducted by outdoor staff and balanced with additional work such as restoring guideposts and signage. Defects such as corrugations are picked up and recorded in Asset Edge software.

Council has also promoted a self-help program to sheet currently earth roads, with property owners contributing to improve road pavement on lower traffic roads connecting to their driveways.

The previous road grading standards require the following grading frequencies:

- Arterial roads, 4 times per year;
- Sub-arterial, 2.5 times per year;
- Collector roads, 2 times per year;
- A-type roads, 1 grade per year;
- B-type roads, 1 grade per 2 years;

Ideally gravel re-sheeting is required every 5-8 years, however re-sheeting is mostly dependent on grant funding, with roads selected based on inspection and requirement such as traffic volumes.

Material used for re-sheeting is based on local knowledge, e.g. past performance, and issues, with no testing conducted, and each re-sheet introduces a layer approximately 150mm thick. A large portion of roads are earth roads, where subgrade material only is used in the road formation.

MPSC has trialled some methods of stabilisation in order to investigate lower life cycle costs of road maintenance. These stabilisation methods have been trialled on two roads. The details are found in Table 7.

Table 7 Moree Plains Shire Council Unsealed Road Stabilisation Trials

Additive	Road 1 (result)	Road 2 (result)
Polycom (Polymer)	Positive result. The road has required minimal maintenance since stabilising.	Positive result. The road has required minimal maintenance since stabilising
Cement	Positive result. The road has required minimal maintenance since stabilising	Unsatisfactory, with high levels of corrugation.
Lime	Average result	Not trialled

4.5.3 Maintenance in Drought Conditions

Current conditions have not allowed grading to proceed. Although routine maintenance is conducted with only a grader, soil conditions are too dry to achieve compaction, and so maintenance grading is mostly deemed to be ineffective. Inspection continue to be carried out to monitor road conditions and spot maintenance repairs are conducted if defects are severe enough. In the most severe circumstance water may be carted large distances to the sites to ensure the defect is made safe.

In the dry conditions, dust has been a significant issue raised by the public, particularly earth roads where existing subgrade materials have a high clay content. As a result, public complaints have increased.

To inform the public of current maintenance issues, MPSC has made posts on the Council website and on Facebook to warn traffic to slow down and drive to the conditions.

4.6 Clarence Valley Council

4.6.1 Background

Clarence Valley Council (CVC) is on the North Coast of NSW and maintains an entire road network of 2,445km in length, with close to 1000km of unsealed road. The local government population totals approximately 52,000 people. An interview was conducted with the Manager of Civil Services Alex Dalrymple (A. Dalrymple 2019, Personal Communication, 9/10/19).

4.6.2 Maintenance in Ordinary Conditions

CVC is currently in the process of implementing large changes in the management of unsealed roads. Historically CVC has used a cyclical grading program, with each road receiving a set number of medium level grades each year with a grader, smooth drum roller, and water cart. The maintenance grading productivity expected was an average length of 3km graded each day.

The new process requires inspections of each road at the same frequency of the previous cyclical grading program. Heavy grading is then only conducted in small sections to rectify defects and improve road drainage, and the remaining sections of road remain untouched. Productivity in terms of road length has now dropped to 1km per day due to the increase from medium level grading to heavy grading, however by leaving the sections of road in good condition, overall each road is completed much quicker.

This process has been adopted primarily due to the prevailing sandstone base materials used in the area. With each maintenance grade, the pavement loses strength and breaks down into finer particles.

The cost-savings of the new maintenance system are being reallocated to improving material quality. CVC have transitioned to using a network of 14 centralised quarries with a material specification for unsealed roads more stringent than for material used on sealed roads. This material specification has been determined by CVC staff using and improving on specifications provided in ARRB manuals and reports. Each gravel stockpile is sampled at the quarry and tested before it leaves that site.

The material specification required of CVC quarries is detailed in Table 8 below

Table 8: Clarence Valley Council Unsealed Road Base Specification

Sieve Size (mm)	% Passing for all maximum sizes
53.0	100
37.5	95-100
26.5	90-100
19.0	80 - 100
9.5	65 - 90
4.75	50 - 75
2.36	35 - 65
0.425	15 - 50
0.075	10 - 40
PI	4 < PI < 12
CBR	≥15

Gravel re-sheeted roads consist of 100mm of imported material on existing sub-grade, and is scheduled ad hoc, typically when subgrade is visible through the pavement. On average, each road requires re-sheeting every 10 years, however the improved material specification has not been in place for 10 years, and additional useful life of the pavement may yet be realised. Haulage distances can be as long as 60 to 70km. In previous years pavement thickness has been measured by using the corner of the grader to dig a small hole and check the depth. It was found that this method was extremely unreliable and is no longer practised.

All road inspections are carried out by designated road inspectors. The inspection records are qualitative and document the condition of 1km sections along each road. Inspectors assess the road shape, roughness, drainage issues, and any defects such as corrugations, potholes or rutting.

CVC have recently conducted a range of trials to improve unsealed road maintenance. Different materials and additives were trialled for the following products:

- Maintenance grading the existing earth road (Control section);
- Re-sheeting with 100mm of high-quality imported material;
- Polcom polymer stabilisation;
- 1% cement additive stabilisation;
- Fulton Hogan base bind bitumen emulsion;
- Boral Gatt seal;

Each section is 200m

4.6.3 Maintenance in Drought Conditions

CVC has not been severely affected by the drought as yet, and due to the tropical/coastal climate, still has water in most areas of the local government area. If necessary, saltwater could be used to conduct maintenance operations. Some inland areas of the local government area have recently been graded, but if dry conditions continue it is likely there will be no water to continue maintenance operations.

Although water is still available in most areas, dry road pavement conditions have meant that roads can deteriorate quickly. In some circumstance's corrugations are forming as little as two weeks after the road is maintenance graded.

Although unsealed roads make up the majority of complaints received by CVC, as maintenance has been mostly un-impeded, there has been no increase in complaints.

5.0 Summary and Common Methodology

5.1 Maintenance in Ordinary Conditions

5.1.1 Maintenance Methods and Financial Constraints

Each Council has had to make economic decisions to balance limited resources. The main decisions made by Councils to achieve the optimum level of services within the operational budget can be categorised as follows:

1. Grading type
2. Grading scheduling
3. Selected re-sheet material and haul distances

Table 9: Summary of Council routine maintenance method in ordinary conditions

	Grading Type	Grading schedule	Gravel Sources
Tamworth Regional Council	Medium to Heavy	Defect Intervention Based	Central
Armidale Regional Council	Medium to Heavy	Cyclical Based	Dispersed
Upper Hunter Shire Council	Heavy	Cyclical Based	Central
Moree Plains Shire Council	Light	Defect Intervention Based	Spaced
Dubbo Regional Council	Medium to Heavy	Cyclical Based	Central
Clarence Valley Council	Heavy only in specific areas	Defect Intervention Based	Central

Most Councils utilised medium to heavy grading routines to maintain unsealed road surfaces, however light grading is utilised in the Councils with large unsealed road networks and a relatively small maintenance budget e.g. MPSC.

The stated advantages of heavier forms of grading include:

- Reduced dust levels;
- Road conditions deteriorated slower;
- Grading could be carried out without recent rainfall;

Where financial constraints allowed medium to heavy grading, the advantages allow Councils to provide a more consistent road network for the public.

Out of all Council's surveyed, MPSC has a large unsealed road network, and due to the small population size, has a comparatively smaller operational budget, and so the overwhelming financial constraints have dictated the level of grading utilised.

MPSC are also in the process of implementing defect-based service levels of service, as opposed to the current minimum annual grading program. This allows more flexibility should road conditions mostly in good condition, and only minor repairs are required. TRC also implement a similar grading program, however there is no formal intervention standards.

All Councils have implemented either a cyclical grading program, or else a program based on inspections and defect intervention. Despite cyclical grading programs having some economic inefficiencies, Councils often elect to implement this system to satisfy the residents on these roads.

For example, DRC and ARC both stated that the public are generally happy with the services provided by Council, as they can reasonably expect the road will be grading at approximately the same times of year, and they are able to track maintenance crew's progress along these cycles to estimate the next maintenance grade on their roads. The number of grades each year is often seen as the service provided by Council in exchange for the Council Rates paid by the property owners.

All Councils have historically used a network of dispersed quarries and gravel pits spaced across the local government area, in order to source material for unsealed roads and minimised the distance required for gravel haulage. Some Council's are now transitioning to a network of Centralised quarries for the following reasons:

- These quarries provide a higher quality material, and re-sheeting is required less often;
- Management of quarries has become stricter and more onerous over time, and so reducing the number of quarries has made it easier for Councils to comply with safety and environmental requirements;

The two Councils that do not use centralised pits are MPSC and ARC. The large road network in MPSC and smaller operational budget does not allow regular re-sheeting frequencies, however ARC found re-sheeting to be required every 5 years, which is significantly less than the re-sheet frequency of all Council's using centralised pits.

5.1.2 Asset Management, pavement management, and inspections

No Council's currently have a PMS system implemented, however TRC is in the process of developing one. TRC also stated that re-sheeting priority is determined by data collected such as the number of defects recorded, and frequency of grading. All Councils document when grading and re-sheeting occurs on each road as a minimum.

All Councils have suitably trained and experienced staff conduct frequent inspections on unsealed roads and assess the road condition based on road defects. UHSC does not specifically require Works Supervisors or Engineering staff to conduct these inspections. With the exception of DRC, all Council's assess gravel loss based on visual inspections recording sub-grade material visible on the road surface.

Common methods for managing driver behaviour on unsealed have been to install signage such as "Reduce nuisance dust" signs, and drive to the condition's signage.

Multiple trials have been conducted by the Council's surveyed, in order to find more efficient unsealed road maintenance. These methods have been detailed in Table 10 below:

Table 10: Summary of unsealed road trials conducted by Councils

Trial Type	Council	Result and notes
RAP use in unsealed roads	TRC	Undesired results. The produce produced large sized loos aggregate on the road surface
Dry powder (or gel) polymer stabilisation	TRC, CVC, MPSC	TRC: Some improvements were found, but cost increase is not justified CVC: Some initial positive indicators, however within 6 month showed no advantage compared to the control trial. MPSC: Shows positive improvements, with minimal maintenance required at two trials
Liquid polymer stabilisation	ARC	Results were described as mediocre, showing little improvement and the cost is no justified.
Emulsion stabilisation	CVC	Very positive results, no maintenance has been required in 14 months, and no maintenance planed for a further 3 months.
Lime stabilisation	MPSC	Results were poor with maintenance required soon after implementation.
Cement stabilisation	MPSC, CVC	MPSC: Mixed results, with one trial showing good performance and is yet to be re-graded, and one trial forming extensive corrugations. CVC: Mixed results with one trial requiring rework, and one trial in good condition however maintenance intervention will soon be required. Maintenance method is not yet determined.

Material stabilisation	TRC, ARC	Both Councils have stated positive results as a result of material stabilisation. No testing was conducted prior to the imported materials incorporation.
Surfactant dust suppression	TRC	No positive long term effects have been realised, and was deemed impractical to be used on the road network as a whole.

5.1.3 Maintenance in Drought Conditions

In response to current dry conditions, all Councils have responded similarly. Dry conditions within DRC are progressing, however there is still enough water to continue maintenance grading with some allowance for additional water carts or water haulage distance. All other Council's have experience dry conditions for a greater time frame and are only maintenance grading small sections of road if they pose a heightened risk to the public.

Some Councils such as ARC and MPSC have chosen to utilise the grader crew to ensure surface drainage is adequate in preparation for the end of the dry period. ARC has also noted that trees pose a greater risk of collapsing after a long dry period and have also assessed and removed hazardous roadside vegetation.

Public response to each Council has been varied. UHSC, ARC and MPSC have all made posts on the Council webpages, and social media to inform the public of current difficulties in conducting maintenance grading. Despite similar public communication efforts being made, UHSC has had an increase in public complaints, and all other Councils have noticed no increase, or even a reduction in public complaints due to heightened public awareness. All Council's did however note that dust has been continually raised as an issue.

TRC and ARC have also implemented initiatives to seal troublesome sections of road such as bridge approaches, and cattle grid approaches. The benefits of this work include the following:

- Material does not thread and unravel at bridge approach slabs and cattle grids, causing a hard-sharp edge for traffic;
- Corrugations are less prevalent on approach and departure from bridges and cattle grids;
- Cattle grids do not fill up with gravel as quickly, as maintenance graders do not accidently push gravel into the grid when grading up to the cattle grid edge;

Drought relief funding for use on unsealed roads has been received by three Councils. Two of these Councils have used all or part of the funding to upgrade heavy vehicle routes or highway detours, and TRC has spent drought relief funding on improving and sealing approaches to cattle grids.

A summary of the short-term maintenance methods implemented by Councils during drought conditions is provided in Table 11 below:

Table 11: Summary of maintenance methods in drought conditions

	Maintenance	Drought Funding
Tamworth	Roads inspected, spot grading only when necessary Sealing Causeways	Sealing and repairing Cattle Grids
Armidale	Roads inspected, spot grading only when necessary Sealing bridge approaches	Rehabilitation of detour road damaged
Upper Hunter	Roads inspected, spot grading only when necessary Upgrade of high traffic regional road to bitumen seal.	Unrelated to unsealed road maintenance.
Moree	Roads inspected, spot grading only when necessary	N/A
Dubbo	Maintenance continuing as normal, water sourced from farm dams. Reduction of maintenance grading planned if dry conditions continue.	N/A
Clarence	Maintenance continuing as normal in most areas. If dry conditions continue changes will be implemented	N/A

6.0 Analysis

The methods raised in both the literature review, and as part of the Council survey have been compared and assessed based on social, environmental and financial criteria.

The road maintenance methods raised within the review of literature and Council survey include:

- Pavement design using multiple layers
- Light Grading
- Medium Grading
- Heavy Grading
- Defect intervention maintenance scheduling
- Cyclical maintenance scheduling
- Re-sheeting using centralised quarries
- Re-sheeting using Dispersed gravel pits
- Balance between haulage distance and material quality
- Mixing Recycled Asphalt with road base materials;
- Powder Polymer stabilising;
- Liquid Polymer stabilising
- Lime stabilising
- Cement stabilising
- Material stabilising
- Dust suppressants
- Emulsion stabilising

6.1 Social Impact Analysis

To analyse the social impact of different maintenance methods, it is important to recognise the priorities of the service being provided:

- Health and safety of the public
- Reduced road roughness to allow faster travel speeds,

Both priorities are achieved by reducing dust generation, as well as reducing road defects such as corrugations, potholes and loose surface material. Reducing dust generation is particularly important, as the loss of fines in the road pavement will increase the likelihood of other defects forming.

6.1.1 Pavement Design

Road pavement design in theory may consist of multiple layers, including sub-grade, sub-base, base, and wearing course layers. In all Councils surveyed unsealed road pavements consisted of 100-150mm of pavement on untreated subgrade. The wearing course would slowly deteriorate in depth down to sub-grade level over several years.

6.1.2 Grading Type

As demonstrated in Figure 2 Light grading can improve the roughness of an unsealed road by rectifying only sections of road containing defects. Without a roller and watercart, compaction of the material is not as effective, and the material is mainly spread over the surface of the road. Roads can

be maintained with this method, as demonstrated by MPSC, however better compaction of the pavement materials is required in order to prevent loss of fines through dust generation.

Medium grading and heavy grading use the same plant and are similar in methodology, however heavy grading involves reshaping the entire road formation including table drains, while medium grading will only reshape the road. The decision whether to medium of heavy grading is based on whether material from the road shoulders, table drains, and batters can be reincorporated in the road pavement on the travel lanes. This material will often be of low quality, and will include vegetation (grass, tree roots, etc.) and will degrade the quality of any introduced road pavement material.

Vegetation will deteriorate and rot over time if incorporated in the road pavement, reducing the compaction of the material. Removing vegetation from the roadside also destabilises the edge of road formations, making it more susceptible to erosion and dust generation. The lower material quality is also likely to increase dust generation. As an additional benefit of medium grading, greater lengths of road grading can be accomplished each day, due to the decrease scope of work.

6.1.3 Grading Schedules

Grading schedules are an important social impact factor as it can determine how quickly defects can be rectified and is often seen by residents as the level of service paid for by the payment of their Council rates. Due to the material types used in road formations in CVC, more frequent grading has been found to degrade the road pavement more quickly by breaking down the sandstone material. In most other areas, more frequent grading has increased social outcomes, but is likely to be outweighed by financial outcomes as the grading will be often unnecessary.

Cyclical grading is a method to find a balance between grading too often and too infrequently. The Council will specify a specific number of times a road will be maintenance graded each year. This is a high level of service but may mean roads are graded unnecessarily.

Defect intervention-based grading programs require roads to be frequently inspected, maintenance grading is then implemented wherever it is deemed necessary. This allows grading to only be implemented as required. MPSC, CVC, and TRC have all implemented defect intervention-based programs. CVC aim to grade only the sections of road containing defects and leave sections of road in good condition. This has been selected as the sandstone pavement material breaks down with each maintenance grade. TRC choose to grade the entire road, to ensure the remaining sections of road do not deteriorate soon after the grader crew moves on to other areas.

6.1.4 Pavement Material and Stabilisation

Material quality is an important part of the road pavement integrity, and a higher material quality will result in fewer road defects, a reduction in dust generation, and a greater level of service provided for the community. The quality of the material can either be improved by hauling in material from quarries or pits, or by mixing additives and stabilising products to improve the existing materials at that location. Material quality is usually determined by financial considerations; however, it can be financially beneficial to use higher quality materials.

A summary of grading specifications provided by Councils, and as recommended by Austroads and ARRB is given in table ## below. The table also includes material test results of a typical material used in DRC.

Table 12: Summary of material specifications and test results

Sieve Size (mm)	% Passing for all maximum sizes (Specification)				DRC - % Passing (Test Report)
	CVC	TRC	Austroads	ARRB 40 a	
53.0	100	100	100	100	100
37.5	95-100	100	95-100	97-100	100
26.5	90-100	100	90-100	90-95	100
19.0	80 - 100	90 - 100	80 - 100	N/A	91
9.5	65 - 90	N/A	N/A	48 - 67	59
4.75	50 - 75	N/A	N/A	31 - 48	36
2.36	35 - 65	35 - 65	35 - 65	22 – 34	22
0.425	15 - 50	15 - 50	15 - 50	10 - 18	11
0.075	10 - 40	10 - 40	10 - 40	4 - 10	6
PI	4 - 12	4 - 12	Max 12 (annual rainfall > 500m) Max 20 (annual rainfall < 500mm)	Max 6 (annual rainfall > 600m) Max 10 (annual rainfall > 600m)	9
CBR	≥15	N/A	≥40		50

CVC and TRC grading specifications are similar to the Austroad guidelines with almost exactly the same PSD requirements. CVC permit stone sizes up to 40mm, and require material gradings to meet the specification for 9.5mm and 4.75mm material. Both Councils have an average annual rainfall above 600mm with the exception of drought conditions, and as such also conform to Austroads guidelines.

Low CBR values are permitted in CVC and TRC specifications, with TRC not specifying a minimum CBR. The material test from DRC shows a CBR above 50, however the percentage of fines is lower than Austroads specifications and is closer to the ARRB specification. This material may be more versatile for use in sub-base layers of sealed roads, as well a unsealed roads, however it will be more likely to corrugate in dry conditions on unsealed roads.

All Councils included in the table have an average re-sheet life expectancy of 10 years, and are each place close to 100mm of material with each re-sheet (loses of 10mm per annum, confirmed by DRC pavement thickness testing).

Dry powder polymers and liquid polymers can be used to improve existing materials, particularly materials with high percentages of fine sized particles. ARC, TRC, MPSC, and CVC have all trialled

polymer stabilisation, however the results were mostly poor with the exception of the trials conducted by MPSC. With the exception of ARC, application rates and processes were determined by the product manufacturers.

Lime stabilisation is mainly used on road with high volumes of fine particles, and with a high PI. MPSC has conducted one trial using lime stabilisation and fund the results to be “average” with cement and polymer stabilising showing more positive results on the same section of road. These tests may have been improved with USC testing conducted prior to the trials, in order to determine the best percentage of additive to use.

Cement stabilisation is not usually used in the wearing course of unsealed roads as it can not be reworked without reversing the effects of the cement. If it is used on the wearing course, surface defects must be managed with surface treatments only. For example, potholes must be filled and compacted without ripping the existing road formation.
MPSC and CVC have both trialled sections of road with Cement stabilisation. Out of the 3 locations tested across the two Councils, only one test had positive results, however this section has not yet required rework or defect repair.

Emulsion Stabilisation can produce high quality results; however, the product is only successful with specific particle gradings. Emulsion stabilisation trials have been conducted by CVC with positive results. The trial section has not yet required maintenance grading, and there are no plans to conduct routine maintenance within the next three months.

Material stabilisation has been trialled to some extent by both TRC and ARC. In both circumstances the existing road pavement had a high percentage of sand, and low percentage of fines. A material with a high volume in fine particles was introduced and mixed with a grader along the road to incorporate the new material into the pavement.
In both case it was stated that the results had a positive effect.

6.2 Environmental Impact Analysis

The main environmental management priorities in relation to unsealed roads is to manage dust, erosion and sediments. Other environmental issues raised include:

- Tree collapse after extended dry periods;
- Use of environmentally harmful stabilisers and dust suppressants;
- Increased animal strikes during dry conditions;

6.2.1 Erosion Control

In wet conditions, there is a risk of material loss due to erosion on unsealed roads, particularly after extended periods of dry weather. This can be detrimental to any vegetation or water sources to which the material is transported.

It is important that the road surface is tightly compacted to avoid moisture penetration, and that adequate crossfall allows water to sheet off to the surface drains without making weak spots such as potholes. Additionally, table drains should be clear of obstructions to avoid water scouring around the obstruction.

Causeways are particularly susceptible to erosion when the causeway overtops, in particular after extended dry periods. The road surface can realistically only be protected by sealing, concreting, or possibly through the use of geotextile (Keller, 2016).

6.2.2 Dust Control

Dust pollution is detrimental to the society, the environment, and the financial bottom line of roads. Dust can create health problems in fauna, can block out sunlight or smother plants and prevent photosynthesis, and can impact on waterway ecosystems. To improve environmental outcomes, dust should be minimised as much as possible.

6.2.3 Other Issues

Dust suppressants such as salts, or petroleum products can leach out in rain, and contaminate groundwater as well as be harmful to roadside vegetation. If these products are to be used, strict controls must be implemented to prevent overuse.

During the dry period ARC has used resources in improving drainage, as well as removing hazardous trees along roadsides. This is important for the safety of road users, however this can also result in instability of the surface formation in the road reserve, reduction in wind protection, and reduction in shade cover over the road which can increase the dust generation of the road. As these roads are often in secluded rural areas, this can also result in a loss of habitat for many species. Safety is a high priority consideration in any Council decision; however it is important to consider the environmental cost of removing trees on the road side.

No solutions have been identified in the management of roadside fauna during dry conditions. With the concentration of water along the edge of road formations, fauna are attracted to the vegetation, increasing the risk of vehicles striking animals along the road. Whilst the risk can not be eliminated, awareness can be raised with the public for both safety and environmental protection purposes.

6.2 Cost Analysis

As Councils maintain roads in perpetuity, the lifecycle cost of each method is the most important consideration when assessing costs, however initial outlay costs may also be a significant factor for many Councils. It is expected where there are large initial costs, the maintenance method is implemented over a long period of time.

6.3.1 Lifecycle costs

As discussed in section 6.1.1, light grading can be a useful method to maintain unsealed roads, however it is not the ideal method. Financially it is a more cost efficient method of maintenance in the short term, however it can allow the road pavement to deteriorate more quickly, and the method is no longer cost efficient if the grader is required to return to the road frequently throughout the year.

Where budget allows, Councils are choosing to employ medium to heavy grading on unsealed roads, as the most cost-efficient long-term method of maintenance grading. There is also a shift amongst Councils towards defect intervention-based grading programs, as opposed to cyclical grading programs, due to the financial savings made by only grading as necessary. These savings can then be spent on improving the road quality in other ways, which further reduces the amount of maintenance required.

Councils are commonly finding financial benefit in closing gravel pits due to the onerous management requirements, and the improved design life of unsealed roads with higher material quality. Councils are often now hauling material approximately 50-80km, however any further and the cost benefit of better material is outweighed by the transport costs.
Multiple Councils have trialled alternative methods to improve the pavement material through stabilisation or other additives. Although some positive results were found using polymer stabilisation, and emulsion stabilisation, the results are too inconsistent to show any consistency or reliability of these methods. It is important to note that no USC trials, or any other form of testing has been conducted for any of these methods to determine the appropriate quantities of additive.

CVC noted positive results with the use of emulsion stabilisation, with significant reductions in annual maintenance since the product has been implemented. The product is highly expensive, particularly where re-sheet material is required to meet the PSD requirements for successful application.

CVC and TRC have provided some indicative costs of unsealed road maintenance methods, these costs are summaries in table ## below (a 6m road formation is assumed):

Table 13: Costs provided by Clarence Valley Council, and Tamworth Regional Council

	Maintenance Grading $/Km	Resheet cost $/Km	Stabilisation cost $/Km	Emulsion Stabilisation cost $/Km
CVC	$4,500	$24,250	-	$23,500
TRC	$2,500	$28,000	$48,000	-

The emulsion stabilisation product used by CVC is the BaseBind product by Fulton Hogan. Fulton Hogan recommend a minimum of an annual application of DustBloc. This reapplication costs approximately $1.30 per square metre, and this would equate to an additional $6,500 per application.

The life-cycle costs of road maintenance methods for CVC has been estimated in table ##. The costs have been estimated for re-sheeting, emulsion stabilisation using the same method as the trial section, and emulsion stabilisation using imported re-sheet material, and applying DustBloc annually.

Note: the useful life of the emulsion stabilised products is not known, and has been estimated

Table 14: Clarence Valley Council Re-sheet Vs Emulsion Stabilisation lifecycle costs

	Re-sheet	**Emulsion stabilisation conducted by CVC**	**Emulsion stabilisation as per recommendations**
Initial cost $/Km	$24,250	$44,750	$47,750
Life expectancy	10 years	Assumed minimum 10 years	Assumed minimum 15 years
Resultant cost per annum	$2,425	$4,475	$3,183
Maintenance costs $/Km	$4,500	$4,500	Grading = $4,500 DustBloc = $6,500
Maintenance frequency	Once every 2 years	Once every 2 years	Grading once every 2 years DustBloc application once per year
Resultant cost per annum	$2,250	$2,250	$8,750
Total Cost per annum	$6,750	$6,725	$11,933

If the lifecycle of the Emulsion Stabilisation product as trialed by CVC can reach 10 years with maintenance grading once every two years, then the costs would be very similar to re-sheeting, but is more likely to withstand dry conditions due to the added dust suppression provided by the emulsion. However, if the product is used as per the manufacturers recommendation, the annual maintenance costs alone are almost as expensive as the entire per annum cost of re-sheeting, thus making the product much more expensive.

7.0 Recommendation

The following road management methods have been developed by considering literature available on unsealed road maintenance, and the current maintenance practises adopted by Councils. These methods have been considered based on financial costs, the service provided to road users on unsealed roads, and environmental factors.

The purpose of these methods is to both improve the resilience of a road pavement to withstand the effects of drought, and to manage road defects during a drought period in order to maintain a safe road network. It is strongly recommended that these methods are transitioned over

7.1 Maintenance in Ordinary Conditions

7.1.1 Maintenance Operations

Routine maintenance methods

- Grading type;
- Grading scheduling;
- Other;

In some circumstances such as MPSC, medium to heavy maintenance grading for an entire road network is not feasible, as it can not be funded. This is a particularly difficult challenge to address. As demonstrated by MPSC, this is currently being addressed by implementing a defect intervention level management system rather than a cyclical grading program.

For Councils with low populations and large road networks, it is recommended that a defect intervention-based system be implemented, and spot grading maintenance is employed to rectify road defects. It may also be possible to utilise other plant such lightweight drags or skid steers to rectify secluded defects at a lower cost. This creates some cost-savings which can then be used to make improvements to the road network, such as sealing, stabilising, or re-sheeting.

In local government areas that are under less significant financial constraints, it is recommended that routine heavy grading (reshaping the entire road formation including surface drains) be conducted on all earth roads or roads without any re-sheet or stabilised material. As there is very little difference between the material in the road shoulders and on the travelled path, it is advantages to reintroduce material that has been lost on the road shoulders, although this is likely to also incorporate some level of roadside vegetation. In this process it is particularly important that road adequate crossfall (approximately 6% grade) is constructed on the travel path, and that surface drains are adequately cleared to provide sufficient road drainage.

On all roads with introduced material or stabilised material, medium grading should be used to avoid contamination of the pavement material, unless pavement material has been lightly graded and swept to the side for the purpose of being reintroduced later. This allows the road pavement to function as designed.

The main advantage of a cyclical grading program is that it is viewed by the public as a greater level of service. Residents are satisfied with knowing when they can expect the road to be graded, and that their Council rates are being spent on providing a certain number of grades per year. This system can at times be inefficient, as maintenance activities are conducted when it is not necessary. It is recommended that a defect intervention management system is implemented by Councils, and with inspections conducted as per section 7.1.3, and public awareness is raised as per section 7.1.4.

It is also recommended that trees be planted in road reserves wide enough to safely accommodate them. The purpose of these trees is to reduce dust generation be providing wind protection and provide shade for the road surface reducing moisture losses.

7.1.2 Pavement Design and Material Selection

A key factor in managing and maintaining a resilient road pavement is the design and materials used in the road pavement. The primary factors effecting the road design include:

- Subgrade California Bearing Ration;
- Subgrade Plasticity Index;
- Subgrade Particle Size Distribution;
- Cost of materials

Subgrades with low CBRs and high PIs will require thicker pavements to avoid deformation. Although there is a cost in determining the subgrade CBR, PI, and current traffic conditions, which are required to develop a pavement design, this step will optimise the construction and material costs and increase the chance of a success. Collection of traffic volumes is also useful for future asset management decisions.

A high-quality re-sheet material is desirable as it satisfies all three criteria of the triple bottom line; Environmental: A higher quality material produces less dust, and less erosion. As a result, there is less particulate matter in the air, and less sedimentation in water streams;

Social: A higher quality mater creates a road pavement more resilient to defects in all weather conditions, and so a greater level of services is provided to road users. Dust pollution is also detrimental to human health, and high dust levels are a road hazard for traffic. A higher quality material improves the health and safety of residents.

Financial: Higher quality materials over a long-term period are more cost efficient as they provide a longer useful life. There is then less haulage costs over the long-term.

It is therefore recommended that material CBR, PI, and PSD tests conform to Austroad guidelines as per Table 4 as a minimum, however it may be worth adjusting the specification to suit the recommendations of Table 5, in order to allow better results, should Emulsion stabilisation be trialled further.

Councils must be able to manage the safety, environmental and quality requirements of all quarries they use. Councils are commonly choosing to reduce the number of pits to reduce operational risks, and to ensure only high-quality materials are being used. Material costs are highly dependent on the location and quality of quarries around the local government area, and so centralised pits must be strategically located to service surrounding roads.

It is recommended that a network of quarries and gravel pits are consolidated and use only the material sources that can achieve conformance with figure ##, figure ## and figure ##. Where Centralised pits are currently being used, it may be importance to investigate additional potential locations. It is particularly important that quarries are located in regions where subgrades contain high quantities of sand.

It is currently common practise to introduce 100-150mm layers of base course material with each re-sheet and allow the material to be worn down over time until the subgrade is visible.
Where subgrades have a high percentage of sand, the CBR is likely to be reasonably high. Given that most unsealed roads will have low traffic volumes, the pavement design is likely to be fairly similar to current practises, with around 100-150mm of gravel introduced.

There has only been one lime stabilisation trial conducted by the Council's surveyed, and this trial did not produce positive results. Lime stabilisation has been repeatedly identified as an additional tool to improve road pavement materials. Where subgrades or locally sourced gravel pits have a higher percentage of fines, it may be more economical to lime stabilise the existing material instead of hauling quality material over large distances. It is recommended that trials be conducted to achieve Unconfined Compressive Strength results of 1 to 3 before any insitu-stabilisation trials commence.

7.1.2 Asset Management, pavement management, and inspections

If grant funding were to increase for management of unsealed road networks, it is likely that asset management standards would need to improve also to ensure a level of confidence that the funding was being used efficiently.

As a minimum it is important to record defects in an easy to interpret management system such as software specifically for asset management purposes. Long term defect trends can then illustrate a pattern of deteriorate, and can identify underlying issues such as drainage, sub-grade, or material quality issues. A priority list of road chainages requiring re-sheeting should incorporate this data, as well as other risk factors such as traffic volumes.

Ideally, inspections of all roads in the local government road network should be carried out by experienced and trained inspectors. Inspector duties may include:

- Conduct routine inspections of sealed and unsealed roads;
- Conduct reactive inspections where complaints are received about road conditions;
- Repair minor defects such as damaged/missing guideposts or signs;

Although a grading schedule may be defect intervention based, inspections should be carried out on a cyclical basis. As a minimum, inspections should

Inspectors should inspect unsealed roads for defects including any early signs of deterioration and document the chainage start and finish of each defect. Defects observable in regular inspections are:

- Drainage issues;
- Potholes;
- Dust and visibility;
- Rutting;
- Erosion;
- Corrugations;
- Loss of shape/crossfall
- Loose Aggregate;
- Signs and guideposts damaged or missing;
- If the sub-grade is visible;
- Visible signs of dust;
- Cracks;

It is unrealistic to conduct testing for skid resistance or dust levels regularly; however, it is important to understand how the material is aging. Where dedicated inspectors are employed, annual testing should be conducted on re-sheeted roads to test the following:

- Pavement depth;
- Loose material;

Roughness tests were not found to be useful by Councils as road conditions could be assessed directly through visual inspection. However, TRC have noted that roughness testing can be useful to demonstrate an impartial assessment of the road. For this reason, it is recommended roughness tests be conducted in conjunction with visual inspections for any inspections in response to public complaints with a maximum IRI of 6 allowable.

7.1.3 Public Awareness

As Council is a service to the community, communication with the public is an important part of this service. Public expectations can place additional pressures on elected Council members, who in turn add pressure to Council staff to improve services. It is also important to communicate what are reasonable expectations of the public.

Information in relation to the grading program should be readily accessible for the public, especially where a defect intervention-based system is implemented. This information should include the roads planned for grading in the short term, as well as the annual inspection cycle, and roads planned for re-sheet each year. This information can be posted on the Council webpage, as well as social media, but should also account for unsealed road residents that do not have reliable internet access, e.g. pamphlets containing annual inspection schedules can be held at the Council administration building for anyone interested.

It is also important for the public to clearly understand how funds are being spent on unsealed roads, and that less grading does not necessarily mean less funding is spent on their roads. An easy to understand video or guide would allow the public to better understand how the Council is managing the unsealed road network.

7.1.6 Grant Funding

Simply increasing grant funding is not a realistic option, however there is opportunity for improvements. Grant funding to improve the road network would improve the resilience of the road to natural disasters and could reduce the amount of disaster relief required to rectify a road network to the pre-existing condition.

Furthermore, disaster relief funding for roads only allows rectification of assets, so for unsealed roads, where material has been lost in a natural disaster, funding will pay for that amount of material lost to be reintroduced. When re-sheeting a road however, a minimum re-sheet layer of 100mm is required to prevent the layer from laminating.

Disaster relief funding and other grant funding sources for unsealed roads should instead be linked to allow for overall management of the road. Funding could be better used to upgrade the road network and improve the resilience of the road against natural disasters. Greater flexibility is required for unsealed road disaster recovery funding, particularly in relation to material loss.

7.2 Maintenance in Drought Conditions

Much of the work needed to ensure roads are resilient to drought conditions are required to be permanently implemented, however once water becomes scarce, the roads must be managed for the safety of road users and residents.

During dry conditions the primary defects likely to occur include:

- Disturbing dust ;
- Corrugations;
- Dry rutting and loose surface material;

7.2.1 Dust Suppression

Dust is the most important factor to be managed in dry conditions, due to the health problems created by dust, and the loss of fine particles makes the road more susceptible to deterioration in future. Even with an ideal base material, it is important to protect the fine particles from being lost to dust generation.

Assuming water is scarce any solution will need to require minimal water. Possible solutions include Sealing, use of dust suppressants, and use of stabilisers.
Cost estimates should be developed particularly for high traffic roads in each local government area, to determine which roads would be economically efficient to seal. Where the cost analysis shows the road should remain unsealed, Councils should then consider if there are any dangerous corners, bridge approaches, cattle grids, or causeways that would benefit from a pavement upgrade and seal.

Additionally, the service provided to residents would be improved by upgrading the pavement and sealing along roads near residential properties, however this is likely to only be achievable with the cooperation of the property owners e.g. an agreement where the property owners pay for part of the initial sealing, and all maintenance costs from that point onward.

On low traffic volume roads, a GATT seal is also an option. In order to reduce the total initial cost of sealing, a Gatt seal could be placed to reduce dust, and protect pavements. This is likely to be a temporary measure, and should only be considered for dangerous corners, bridge approaches and other high risk sections of road, however where these dangerous sections of road are in close proximity to each other, then there may be efficiency in sealing greater lengths.

There are several categories of dust suppressant that can be used to reduced dust generation on unsealed roads, however use of these suppressants is difficult for Council's to manage. As summarised in Section 7.2.1 each dust suppressant category has positive and negative attributes, however management of the negative factors is unrealistic across an entire road network.

Salt type dust suppressants require higher air humidity, can cause damage to vehicles and roadside environments, and require reapplication after rain. Where humidity is high enough for salt products to be effective, rain is more likely to occur even in periods of drought. These products are then mostly used as a temporary solution for specific projects. Due to these factors, it is not suitable for long term use as a dust suppressant across an entire road network.

Surfactants require regular application and use a large amount of water with each application. All Council's have stated water availability as the difficult factor for unsealed road maintenance in drought conditions. Surfactants are therefore not suitable for long term use as a dust suppressant.

Petroleum products and lignin-sulfonates are likely to pothole under heavy traffic due to the hard crust surface. Additionally, lignin-sulfonates require long curing times and work pre-application. Petroleum

products must not be used excessively to avoid environmental impacts such as contamination of water streams.

Lignin-sulfonates also require surface material fines to be between 10-30% and the subgrade material to be clay or silt. Use of these products would therefore be limited to roads with low traffic volumes, to protect imported gravels.
Electro-Chemical stabilisers will only be effective in specific conditions; however they provide highly positive outcomes when applied correctly. Testing must be conducted to determine the chemical make up of the existing material, and the suitability of the dust suppressant product. Due to the highly technical nature and specific conditions required of this product, it is not recommended to be used across an entire road network.

Given the capabilities of dust suppressants, it is unrealistic to adopt use of these products across an entire road network and instead, the proposed recommendation is given in Table 15 below.

Table 15: Dust suppression usage recommendations

	Usage recommendation
Surfactants	Due to the large quantity of water required, surfactants are only suggest in situations where it would reduce water consumption, such as on roads with increased traffic volumes close to towns and villages.
Salt Products	To be used only in humid climates for large construction projects or emergency detour routes where traffic volumes are increased significantly. Strict quality assurance practises must be observed during application to prevent excessive application.
Lignin-sulfonates	Use only on roads with 100-250 vehicles per day, and imported gravel is introduced as per table 4.
Petroleum products	Not recommended due to limitations and environmental risks
Electro-Chemical Stabilisers	Only recommended as an option for roads where dust suppression is a high priority, and other methods are not viable.

It is recommended that further trials of lime stabilisation be trailed with soil testing undertaken prior. UCS tests should achieve approximately 1-3 MPA to determine the percentage of additive to be used. Trials are particularly useful in areas containing high percentages of fine content, and where PI values are high. If lime stabilisation trials successfully provide a road pavement of equal or better quality and economic value, this may negate the need for gravel pits near those locations.

7.2.2 Corrugations

Like dust suppression, the effects of dry conditions can be mitigated through long term maintenance practises to create a more resilient road pavement, however until a cost-effective general-purpose dust suppressant is available, corrugations are a likely to occur during dry conditions.

As the corrugations will generally be formed in the road surface only, the following temporary solutions are available to rectify corrugation defects:

- Light maintenance grading to cut away the corrugations;
- Using a “lightweight drag” behind a vehicle;

These are short term solutions only to improve the roughness of the road until water is more readily available again.

A lightweight drag can be used at low speeds to scour and spread material across the road surface. This is the ideal treatment as corrugations first begin to form because very little material needs to be spread, and less loose material is left on the road surface after the treatment.

As corrugations progress or where economic efficiencies can be achieved due to an abundance of corrugations and loose surface material (see section 7.2.3), light grading may be required to remove the corrugations. This treatment requires the grader to cut away the material just below the base of the corrugations.

It is recommended wherever possible; the material should be left in a small windrow on the road shoulder to be reincorporated in the next medium to heavy grade. During dry conditions it is less likely that vegetation will contaminate the material. When significant amounts of material is being reintroduced to the road pavement, the need for material stabilisation should be investigated to improve the longevity of the pavement in future.

7.2.3 Dry rutting and loose surface material

A road pavement with a well graded particle size distribution should reduce the frequency of unravelling even during drought conditions, however, to manage this defect during drought conditions, light grading should be employed in order to sweep the loose material from the travel lanes.

Similar to road corrugation management in section 7.2.2, the material can be windrowed until conditions allow medium to heavy grading. Material stabilisation may improve the material prior it’s reincorporation into the pavement.

7.2.4 Road Inspections

Ideally, each Council should employ designated road inspectors to assess all roads in the local government area, and may perform other helpful duties in conjunction with their primary objective, such as replacing guideposts and signs, or placing traffic counters on roads inspected.

Inspectors should assess each of the following with a quantitative score, and a qualitative description;

- Drainage issues;
- Potholes;
- Dust and visibility;
- Rutting;
- Erosion;
- Corrugations;
- Loss of shape/crossfall
- Loose Aggregate;
- Signs and guideposts damaged or missing;
- If the sub-grade is visible;
- Visible signs of dust;
- Cracks;

Any defects should be recorded with the road chainage in the description. This will allow road defect histories to identify problematic areas prone to corrugations or potholing and may require re-sheeting or other long-term rectification measures.

7.2.5 Public Awareness

It is important in a local government setting to manage public expectations and reduce the social pressures on the Council. From the Council's surveyed, the methods utilised in addition to usual measures to raise public awareness of the hazards and risks included the following:

- Informative posts on the Council webpage;
- Informative posts on social media pages;

These efforts should be made as a minimum and should inform the public of the increased costs and reduced effectiveness of maintenance grading in dry conditions, as well as the types of defects likely to form due to the conditions.

The posts could be either written or explained in video format. During drought conditions it is likely road maintenance will not be the only issue faced by the public e.g. domestic water usage will be an important message to spread amongst the community, and so road condition information can be incorporated into a larger public awareness campaign.

7.2.6 Drought Relief funding

Where roads are constructed to be more resilient to drought conditions, there should be less need for funding during the drought. During a drought, Maintenance grading will often be limited or cease altogether, and so maintenance funds can be redirected to other maintenance activities as required.

Activities that may require additional funds during drought periods could include and any activities that are aimed at reducing dust. Dust suppressants, or any minor sealing works aimed at reducing dust levels are not likely to have been planned in the maintenance budget. Some small assistance funding may be required to improve dust suppression within the local government area.

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Boral Gatt seal

Personal communications interviews

Koch

Appendix A – Research Specification

ENG4111/4112 Research Project
Project Specification

For: Aaron Dinham

Title: Management of Unsealed Roads in Drought Conditions

Major: Civil Engineering

Supervisors: Amirhossein Heravi

Enrolment: ENG4111 – S1, 2019 ENG4112 – S2, 2019

Project Aim: To investigate maintenance management policies for unsealed roads in drought conditions

Programme: Issue A, 19th March 2019

1. Conduct a literature review on current management practices implemented for the maintenance of unsealed roads in ordinary and drought conditions

2. Identify the parameters likely to impact on the standards applied to maintenance policy

3. Select and investigate approximately 8 NSW Local Government Areas that have experienced prolonged drought conditions in recent history

4. Investigate the management policies implemented by these councils, and assess how each policy has addressed the parameters identified in item 2.

5. Develop a standard management system that incorporates the findings of item 4, and make recommendations on management policy improvements

6. Evaluate how the proposed management system addresses each of the parameters in item 2

If time and resources permit:

8. Investigate a greater range of councils and compare the problems faced between coastal and inland Local Government Areas

9. Assess the costs associated with drought conditions compared to ordinary conditions

Appendix B – Survey Questions

Aaron Dinham Student Research Project Survey Questions

University of Southern Queensland

Maintenance of Unsealed Roads During Drought Conditions

Discussion Questions:

1. **What are the usual maintenance management practises implemented by the Council?**

2. **What are the usual routine maintenance methods implemented by the Council?**

3. **To what extent have drought conditions affected routine maintenance?**

4. **What new maintenance methods have Council trialled due to the drought?**

5. **Are there any solutions to the problem?**

Appendix C – CVC Maintenance Trials Report

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ITEM 6c.19.055 GRAVEL ROAD MAINTENANCE TRIAL – RESULTS AUGUST 2019

Meeting	Corporate, Governance & Works Committee	17 September 2019
Directorate	Works & Civil	
Reviewed by	Director - Works & Civil (Troy Anderson)	
Attachment	Yes	

SUMMARY

In July 2018 Council commenced trials on various treatments for unsealed roads to determine whether the treatments would reduce Council maintenance costs and increase the life of the asset. This report provides an update on the status of the trial.

OFFICER RECOMMENDATION

That the results of the gravel road maintenance trial report be received and noted.

COMMITTEE RECOMMENDATION

Lysaught/Ellem

That the Officer Recommendation be adopted.

Voting recorded as follows
For: Kingsley, Ellem, Toms, Simmons, Lysaught
Against: Nil

COUNCIL RESOLUTION – 6c.19.055

Baker/Ellem

That the results of the gravel road maintenance trial report be received and noted.

Voting recorded as follows:
For: Simmons, Kingsley, Baker, Ellem, Clancy, Novak, Williamson, Lysaught, Toms
Against: Nil

LINKAGE TO OUR COMMUNITY PLAN

Theme 2 Infrastructure

Objective 2.1 We will have communities that are well serviced with appropriate infrastructure

Strategy 2.1.5 Provide safe and effective vehicular and pedestrian networks that balance asset conditions with available resources

BACKGROUND

At the May 2018 Council meeting Council adopted a proposed gravel road maintenance trial to be undertaken (Item 15.081/18). The trial commenced in July 2018. Two sections of Lawrence – Tullymorgan Road were selected to simulate similar conditions experienced around the valley.

AR O 9

The first section (sites 1-5) is located on a straight section of road starting approximately 100m from the intersection Lawrence-Tullymorgan Road and Pringles Way. This a 2 km section split into 5 x 400m test sections.

The second section (sites 6-10) is located in an undulating area over approximately 3 km that has 5 x 400m test sections. The road was divided this way to provide five sections with similar characteristics. Each road segment was brought up to an initial standard with 6% cross-fall on the road and 100 mm of local gravel. Relevant treatments were then applied to the relevant sections as detailed in the table below.

The test sections are split as below:

Section No	Terrain	Test Material	Dimensions
1	Straight/flat	Standard resheet material available locally (not necessarily to gravel resheeting specification)	400 m long x 6.0 wide x 100 mm gravel depth
2		Imported resheet material conforming to specification (as per ARRB Unsealed Roads Manual)	400 m long x 6.0 wide x 100 mm gravel depth
3		Standard resheet material available locally with polymer additive (Polycom)	400 m long x 6.0 wide x 100 mm gravel depth
4		Standard resheet material available locally with cement stabilisation (approximately 1%)	400 m long x 6.0 wide x 100 mm gravel depth
5		Standard resheet material available locally with bitumen emulsion additive	400 m long x 6.0 wide x 100 mm gravel depth
6	Undulating	Standard resheet material available locally (not necessarily to gravel resheeting specification)	400 m long x 5.0 wide x 100 mm gravel depth
7		Imported resheet material conforming to specification (as per ARRB Unsealed Roads Manual)	400 m long x 5.0 wide x 100 mm gravel depth
8		Standard resheet material available locally with polymer additive (Polycom)	400 m long x 5.0 wide x 100 mm gravel depth
9		Standard resheet material available locally with cement stabilisation (approximately 1%)	400 m long x 5.0 wide x 100 mm gravel depth
10		Standard resheet material available locally with bitumen emulsion additive	400 m long x 5.0 wide x 100 mm gravel depth

KEY ISSUES

Since the trial commenced each site has been monitored monthly. The first series of results were reported to Council's February meeting (Item 15.024/19). The most recent inspection was undertaken on 29 August 2019 to which the observations from this inspection are noted in the following table. For ease of reference the comments from the February report are also listed.

Section No. & material type	Inspection Results 19/2/2019	Comments 19/2/2019	Inspection Results 29/8/2019	Comments 29/8/2019
1 & 6 Local gravel	Fair	Surface: Loose stones and fines, Shape: Variable crossfall, rutting in some sections, corrugations commencing, flat in some sections. Fines Loss: High resulting in loss of stone and high dust Estimated Intervention: Within 3 months, need to rework with possible adding of material.	Very Poor	Surface: Loose stones and fines, Shape: Variable crossfall, rutting in sections, corrugations, Materials: Loss of fines, gravel material being crushed to fine particles and dust. Original base material visible indicating loss of approximately 100mm of resheet gravel placed as part of the trial. Estimated Intervention: First intervention was after 8 months, Now requires second intervention at next grade. This will revert back to the original grading cycle of twice year and will need import of more material due to poor performance of locally available product.
2 & 7 Gravel conforming to specification	Excellent	Surface: Solid, compact, excellent ride Shape: Crossfall maintained, no rutting or corrugations, water shed quickly Fines Loss: Minimal, no loss of stone, minimal dust Estimated Intervention: None planned, >12 months, probably longer, good material to rework with minimal added material	Excellent	Surface: Solid, compact, very good ride quality. Shape: Crossfall maintained, no rutting or corrugations, water sheds quickly. Fines: Very minimal loss <10mm in first section, (more open to sun and drying winds) but no large stones lost, minor fines and < marble size stones along edge of shoulder, easily recoverable. Minimal dust. Minor isolated potholes appeared along the centre of the first section, these were milled out and repacked with smaller, more efficient equipment as a maintenance technique trial, result appear to be very good. Equal to original pavement. Estimated Intervention: None planned, minimal time 6 months or more, material is available on shoulder of reuse and rework.

3 & 8 Local gravel with polymer additive	Fair	Surface: Loose stone and fines, moderate dust Shape: Variable crossfall, rutting in some sections Fines Loss: High, resulting in loss of stone and high dust. Estimated Intervention: 3- 6 months, need to rework and add PolyCom and possible small amount of material.	Very poor	Surface: Loose stone and fines, rocks crushed to smaller size and more dust. Shape: Variable crossfall, rutting in some sections. Minor corrugations, some potholes. Fines Loss: High, resulting in loss of stone and high dust. Estimated Intervention: First section No 3 was reworked after 8 months and has deteriorated badly again and needs rework with next grade. Back to original twice yearly cycle with no net benefit from use of Polycom additive. Section 8 was not reworked at 8 months but has deteriorated badly and is past intervention level as per Section 3.
4 & 9 Cement stabilised local gravel	Very good	Surface: Some areas highly compacted and stabilised, isolated areas of loose material and loss of fines, reduced dust, Shape: Crossfall variable, generally good, isolated flat sections Fines Loss: Low, isolated areas, minimal dust	Good	Surface: Some areas highly compacted and stabilised, isolated areas of loose material and loss of fines, reduced dust, Shape: Crossfall variable, generally good, isolated flat sections Fines Loss: Low, isolated areas, minimal dust

Section No. & material type	Inspection Results 19/2/2019	Comments 19/2/2019	Inspection Results 29/8/2019	Comments 29/8/2019
		Estimated Intervention: 6 - 9 months, need to rework cement based material, workability requirements of cement stabilisation to be determined.		Estimated Intervention: Section 4 was reworked at 8 months due to poor performance, expected more from Cement Stabilisation first off. Once reworked Section 4 has performed better that original mixing and is performing better than first period. Do not propose to intervene at this time to see how long the reworked material lasts. Section 9 was not reworked as per Section 4. Has performed better than Section 4 however has now approached intervention after 14 months and will need to be reworked next visit to determine workability requirements of cement stabilisation..
5 & 10 Bitumen Stabilised local gravel	Excellent	Surface: Generally highly compacted, isolated small patches of loose material Shape: Very good crossfall Fines Loss: Minimal Estimated Intervention: >12 months, probably longer, need to determine rework requirements due to nature and cost of bitumen additive.	Very Good	Surface: Generally highly compacted, isolated small patches of loose material Shape: Very good crossfall Fines Loss: Minimal Estimated Intervention: >12 months, probably longer, need to determine rework requirements due to nature and cost of bitumen additive. Have undertaken minor isolated pothole repair down centre of Section 10 with good results. Rest of section was holding up extremely well but did not want to the whole section to deteriorate due to minimal issue considered to be caused by installation method variation.

Comments from August 2019 inspection:

As with the initial reporting period the intervening period has been extremely dry. However, there have been some isolated heavy storms in the Lawrence area and the effect on the trial has been varied.

The use of locally available poorer materials has shown the low quality of the material in comparison with other treatments. This has shown up in the poor condition of the material on the ground and the need for grading intervention at much shorter time periods; approximately 6 months compared to 14 months and continuing. This intervention will also require the importing of more material.

To date it appears the cost of haulage of high specification material is more than offset by the extended intervention levels. It is considered that when intervention is required the imported material is easily available for reuse with minimal need to haul more material.

Whilst the use of the high specification material is desired it is not feasible to provide this quality of material to all roads in all incidences. It is recommended that this material would be better utilised in more highly trafficked problem areas on a progressive basis.

Low traffic, limited population area roads with a minimal history of user problems would be better served by use of the locally available materials in the short term with better material being applied as resources permit.

COUNCIL IMPLICATIONS

Budget/Financial
Staff have commenced analysis of the costs for the various treatment. The costs below have been generalised to allow application to any road.

Section No.	Original Indicative Cost	Cost update 29/8/2019
1 & 6 Local gravel	$16.00/tonne for material plus haulage (variable cost). 1 tonne of gravel will cover around 4 – 5 m^2 at a depth of 100 mm. Therefore approximately $8,500 for material for a 400 m section + haulage.	Intervened once at 8 months Plant and labour only. Next intervention will require plant labour and materials. Ideally a full 100mm resheet however due to budget constraints only a cover layer will be applied as required.
2 & 7 Gravel conforming to specification	$18.30/tonne for material plus haulage (variable cost). 1 tonne of gravel will cover around 4 – 5 m^2 at a depth of 100 mm. Therefore approximately $9,700 for material for a 400 m section + haulage. Note that haulage costs may be significant due to longer haul distances.	Minimal intervention to date. Section 2: < 10% of area Trial of pothole milling and replacement. Plant labour and minimal material. Remainder no intervention proposed within 4 months Section 7: No intervention to date, none proposed with 4 months.
3 & 8 Local gravel with polymer additive	PolyCom application – 1 bottle ($600) per 100m. Therefore $2,400 per 400 m, noting that gravel may also need to be added prior to application (as per sites 1 & 6). Application would occur as part of the gravel maintenance process.	Intervened once at 8 months Plant and labour only. Next intervention will require plant labour and materials. Ideally a full 100mm resheet however due to budget constraints only a cover layer will be applied as required.

4 & 9 Cement stabilised local gravel	Cement application – $1,900 per 400 m, noting that gravel may also need to be added prior to application (as per sites 1 & 6). Application would occur as part of the gravel maintenance process.	Section 4: Reworked, Plant and Labour only, good result to date Section 9: to be reworked, result to be assessed over time.
5 & 10 Bitumen Stabilised local gravel	Emulsion application – $9,500 per 400 m, noting that gravel may also need to be added prior to application (as per sites 1 & 6). Application would occur as part of the gravel maintenance process.	Section 5: No action taken Section 10: Only centre isolated potholes reworked, Plant, Labour and minimal material. No further intervention planned within 4 months.

Asset Management
The aim of the trial is to minimise maintenance costs and extend the life of the gravel pavements for the unsealed road network. A combination of the above treatments is likely to ultimately be used to provide cost effective road pavement materials.

Policy or Regulation
N/A

Consultation
N/A

A O **9**

Legal and Risk Management
N/A

Climate Change
Reduced use of materials, less haulage resources, reduced private vehicle running costs and emissions, reduced plant and vehicle running costs and emissions.

Prepared by	Tim Jenkins – Manager Civil Services
Attachment	Gravel Road Maintenance Trial - photographs

Appendix D – CVC Material Specification

clarence
VALLEY COUNCIL

Reference:
Contact:

May 2019

«SUPPLIER»
«ADDRESS»
«ADDRESS2»

Attention: «CONTACT_PERSON»

Dear Supplier

Exercise of Option to Extend
Contract T17/014 - Gravel, Crushed Concrete and Rock Supply to Clarence Valley Council 2017 - 2018

The above mentioned contract is due to expire on 1 July 2019.

Clarence Valley Council wishes to exercise the option to extend the contract for the term of one (1) year as per Term 4:

(a) This deed starts on the Commencement Date and continues until expiry of the Initial Term unless extended under clause 4(b) or terminated in accordance with this deed.

(b) *If applicable, Council may extend this deed on the same conditions for the Further Term by notifying the Supplier in writing at least one month before the end of the Initial Term.*

The new term of the contract will have an expiry date of 1 July 2020. There are no other amendments to the terms and conditions of the contract.

The delivery of goods/services is to be in accordance with the terms and conditions of the original contract.

In addition to the above, as part of Councils commitment to continuous improvement, we have identified a number of opportunities for improvement in the quality assurance and materials specification for resheet material.

Specifically in regards to the quality assurance, please be aware that Council will from time to time request conformance reports for materials being sought under this supply contract. This is already a condition of this contract and it will be more rigorously enforced into the future. As such please ensure that stockpiles provided to Council are tested and copies of the conformance reports can be provided on request.

In regards to the resheet material, the specification in the current contract has a very wide band of material that is considered conforming. Some conforming resheet materials have been found to have very poor performance in the field. Due to this there will be additional conformance requirements added to this specification prior to the next contract period. This new requirement is attached to this letter.

This additional requirement is derived from the ARRB Unsealed Roads Manual, which outlines the relationship between the grading, quantity of fines and the nature of the fines. To conform to this requirement, many existing resheet materials will need additional fines of suitable reactivity.

Prior to this requirement becoming mandatory, Council would like to work collaboratively with suppliers to ensure that this transition is can be made smoothly and without an interruption to supply. If you need assistance with this transition then please contact us at your earliest convenience.

If you have any queries or require further information then please contact Bruce Shorrock on telephone (02) 66403533

Yours faithfully

Bruce Shorrock
Quarries, Quality, Safety & Environment Officer

Attachment – Additional Resheet Conformance Requirements

RTA T106 Coarse Particle Size Distribution

Sieve Size (mm)	% Passing (Existing Specification)	% Passing (New Specification)
53.0	100	100
37.5	95 - 100	95 - 100
26.5	90 - 100	90 - 100
19.0	80 - 100	80 - 100
9.5	Not required	65 - 90
4.75	Not required	50 - 75
2.36	35 - 65	35 - 65

RTA T107 Fine Particle Size Distribution

Sieve Size (mm)	% Passing (Existing Specification)	% Passing (New Specification)
0.425	15 - 50	15 - 50
0.075	10 - 40	10 - 40

RTA T109 Plasticity Index

PI (Existing Specification)	PI (New Specification)
4 - 12	<=12

RTA T117 CBR (4 day soak) at 100% of Standard Maximum Compaction

CBR (Existing Specification)	CBR (New Specification)
>= 15	>=15

Shrinkage Product

The shrinkage product shall be calculated as follows;

$$\boldsymbol{Shrinkage\ Product = Ls \times D_{0.425}}$$

$\boldsymbol{Where}$:

$\boldsymbol{Ls = the\ linear\ shrinkage\ in\ \%\ found\ using\ RMS\ T113}$

$\boldsymbol{D_{0.425} = the\ \%\ passing\ the\ 0.425mm\ sieve\ found\ using\ RMS\ T107}$

SP (Existing Specification)	SP (New Specification)
Not required	125 - 350

Grading Coefficient

The grading coefficient shall be calculated as follows;

$$\boldsymbol{Grading\ Coefficient = \frac{(D_{26.5} - D_{2.36}) \times D_{4.75}}{100}}$$

$\boldsymbol{Where}$:

$\boldsymbol{D_{26.5} = the\ \%\ passing\ the\ 26.5mm\ sieve\ found\ using\ RMS\ T106}$

$\boldsymbol{D_{4.75} = the\ \%\ passing\ the\ 4.75mm\ sieve\ found\ using\ RMS\ T106}$

$D_{2.36} = the\ \%\ passing\ the\ 2.36mm\ sieve\ found\ using\ RMS\ T106$

GC (Existing Specification)	GC (New Specification)
Not required	18 - 32

SUPPLIER	CONTACT PERSON	ADDRESS	
BD & MC Lewis Pty Ltd	Brian D Lewis	283 Lewis Lane	MORoroo NSW 2469
Bretmart Pty Ltd - (T/A Clarence Earthmoving)	Marty Hutchings	544 Armidale Road	ELLAND NSW 2460
CW & VJ Cooper Pty Ltd	Wayne Cooper	75 Chapman Street	GRAFTON NSW 2460
Holmes Pty Ltd	David Holmes	PO Box 848	CASINO NSW 2470
John Lacey Earthmoving Pty Ltd	Paula Fursman	2/13A Lawson Crescent	COFFS HARBOUR NSW 2450
McLennan Earthmoving Pty Ltd	Phil McLennan	10 Duncans Lane	SOUTH GRAFTON NSW 2460
VK & NJ Ellem	Ken Ellem	3164 Kangaroo Creek Rd	KANGAROO CREEK NSW 2460
Thorley Sand Gravel Pty Ltd IFT Thorley Sand Gravel Trust	Tammy Thorley	24 Candole St	TUCABIA NSW 2462
Green Bros Investments Pty Ltd	John Green	1185 Warrego Highway	OAKLEY QLD 4401
Crusher & Screen Hire Pty Ltd	Matt Howe	Level 21, 133 Castlereagh Street	SYDNEY NSW 2000
Mt Zion Quarry Pty Ltd/TA Greensill Bros	Jarrod Greensill	PO Box 141	SOUTH GRAFTON NSW 2460

Appendix E – TRC Material Specification

4.01 General requirements

1 SCOPE AND GENERAL

1.1 Scope

This worksection sets out the quality system or quality control, set out of works, work as executed drawings, environmental protection, site facilities, meetings, supply by Principal, utilities and authorities requirements and project specific requirements.

1.2 cross references

The following documents referred to in this worksection are:

Associated Work sections

- 4.02 - G10 Traffic Management
- 4.03 - G22 Work Health and Safety (Construction Works)
- 4.04 - G36 Environmental Protection (Management System)

1.3 Referenced documents

The following documents are incorporated into this work section by reference:

Standards

AS 1319-1994	Safety signs for the occupational environment
BS 6472	Guide to evaluation of human exposure to vibration in buildings
BS 6472.1-2008	Vibration sources other than blasting

2 PROJECT SPECIFIC INFORMATION

2.1 Location and description of project

Description

This tender is for Contract No. T043/2019, Winning and Crushing of Material in Council Managed Pits. The works comprise of winning material and crushing won material to specification.

It is a Quality Assurance contract with method of payment being Schedule of Rates.

The Works in this Contract comprise of the following:

- WHS of site;
- Environmental protection of work site;
- Winning of material – Rip and Push / Drill and Blast;
- Crushing of material to specification; and
- Quantity Verification.

Location

Site

Suttons Pit ID114

Spains Lane Pit ID179

Mills Pit ID205

Danbury Roadside Pit ID104

553 Pit ID553

DAG Pit ID505

Hobdens Pit ID311

Gate 41 Pit ID308

Longcorner Roadside Pit ID301

Old Bundarra Road / Savalle Pit ID214

Pera Linton Road / Woodsreef Scrape Pit ID211

Linton Road Pit No2 (Right Side) ID218

PP Board pit ID333

Site Access

Conditions of Contract refer

Possession

Conditions of Contract refer

2.2 Extent of work

Works under this Contract comprise the supply of labour, materials and plant to complete the Works.

It includes but is not limited to the following items of construction which shall be carried out in their entirety in strict accordance with and to the true intent and purpose of, the Conditions of Contract, these Technical Specifications and under the supervision of the Principal's Representative:

Preamble:

. Contractor should be able to demonstrate that they are capable of undertaking the works.

General:

. Notification of all appropriate property owners adjoining the Works if any (Council to undertake);

. WHS management of works;

. Erosion and sedimentation control of the works; and

. Traffic control of the works during construction if applicable (Council to provide).

Scope of Works:

. Establishment of all plant, equipment and labour necessary for the winning, crushing, screening and stockpiling of overburden and gravel material to <20mm; to produce a product suitable for rural road repair conforming to the requirements of Table 1 – Material Specifications, section 3 of this specification;

. Winning and stockpiling of topsoil and overburden (provisional item);

. Winning of material to be crushed;

. Loading of material into crushing system, including blending of material where required;

. Crushing of material;

. Screening of material conforming to Table 1 - Material Specifications;

. Reprocessing of oversize material as required to meet Table 1 – Material Specifications;

. Stockpiling of materials in uniform windrows to suit stockpile area.

Cleanup:

. Contractor is to leave sites in a clean tidy manner with all materials stockpiled neatly.

2.3 Work by others

Liaison

Attention is drawn to the Conditions of Contract regarding the obligation of the Contractor to co-ordinate the Works with any simultaneous and/or adjacent work by others. The Contractor shall liaise with these Contractors and Authorities to avoid disruption, delays and possible conflict.

2.4 Other project specific items

The Contractor shall provide, equip and maintain an adequate First Aid Treatment Centre on the site and shall have an experienced First Aid person available at all times when work is in progress.

The First Aid facilities shall be clearly marked and readily accessible to all personnel at all times. The minimum provisions under this Clause shall satisfy the current statutory requirements.

3 GENERAL

3.1 Material Specification:

All material produced under the terms of the Contract shall comply with the following minimum specifications;

Sieve Size (mm)	% Passing for all maximum sizes
55.0	100
37.5	100
26.5	100
19.0	90 - 100
2.36	35 - 65
0.425	15 - 50
0.075	10 - 40
Plasticity Index (PI)	4 < PI < 12

Table 1 - Material Specifications

3.2 Winning of Material

The Contractor shall win a quantity of material such that all material is crushed, screened and stockpiled. Council shall direct the Contractor as to the location of the material to be won.

The Contractor shall win material by either continuous stripping of batters or by excavation and benching of steep batters. Benches shall be no greater than 6m high and minimum 4m wide. Winning operations shall be conducted such that following the completion of works the site is left in a neat and tidy condition with batters no greater than 1:4 (H:V). All loose material shall be gathered and stockpiled.

3.3 Crushing, Screening and Stockpiling

The Contractor shall crush, screen and stockpile all won material subject to the requirements of Table 1 – Material Specifications. All oversize material shall be stockpiled and

reprocessed in the crushing system such that no waste material remains and all material meets the maximum particle size requirements of Table 1.

Processed material shall be stockpiled in uniform windrows no greater than 5m high, or as site conditions allow.

3.4 Suitability of Source Rock

If the quality of the raw source rock being crushed requires blending to ensure that the requirements of Table 1 are met, it shall be the responsibility of the contractor to contact Councils representative to discuss an appropriate mix ratio and source of supplementary material to be blended with the source rock. Typically, the supplementary material will be overburden stripped and stockpiled at the site.

It will be the contractor's responsibility to transport the supplementary material to the crushing site. Crushing and screening of the source rock and supplementary material shall be carried out in one operation to achieve a uniform finished product.

Council makes every effort to ensure that the source rock at each pit is of an acceptable standard, however the Contractor may encounter material that they consider to be unsuitable for crushing. In such instances, the Contractor shall contact Council's Representative for direction.

Unsuitable material shall be moved to a location nominated by Council's representative.

3.5 Measurement of material

The method of measurement will be negotiated with the successful tenderer and will depend on the plant, equipment and measuring devices available. All measurements will be verified by detailed survey by Council personnel and this can be utilised to calibrate an agreed conversion factor.

3.6 Rehabilitation of Site

The rehabilitation of the site is the responsibility of Council, however the Contractor is to ensure that the site is left in a neat and tidy condition with no loose material remaining on the floor of the pit or in batters or benches.

3.7 Site Security

Designated sites

Where the Drawings indicate construction working areas and areas for temporary site facilities such as the storing of materials, use of plant and erection of sheds, work shall not be performed nor the site occupied outside these areas.

Where pits included in the crushing program are fenced and locked, the Contractor shall be provided with a key to the gate to allow access to the pit, which shall be returned to Council following vacation of the site. The key is not to be reproduced, given away or lent to others. The gates to pits are to be locked at all times to prevent entry by others. The Contractor is not to attach their own locks to the gates of any pits.

Where pits included in the crushing program are not fenced or locked, the Contractor shall make their own arrangements for security of their plant and equipment. Access to stockpiled materials shall be maintained at all times.

Security

The Principal will not be responsible for the safe-keeping of any of the Contractor's plant, equipment, tools, materials or other property. The Contractor may provide, and pay for, any

security fencing considered necessary around any office, workshop or storage area, subject to the Principal's Representative's approval.

Council accepts no responsibility for the security of plant and equipment used in Council managed pits.

Temporary fencing

If existing fencing on the Principal's property is cut or altered by the Contractor, or if there is no existing site fencing, the Contractor shall provide and maintain temporary fencing to the satisfaction of the Principal's Representative during the Contract to prevent unauthorised entry into the Principal's property, and shall reinstate the fencing and remove temporary fencing on completion of the work.

Safety signs

The Contractor shall erect appropriate regulatory, hazard, emergency information and fire signs, in accordance with AS 1319 Safety signs for the occupational environment, at prominent locations around the working areas and temporary site facilities. Signs shall include, but are not limited to: mandatory signs for personal protective equipment such as eye, head and foot protection, and DANGER signs such as 'DANGER, Construction Site. No Unauthorised Access'.
All words on word-message signs shall be approved by the Principal's Representative prior to sign manufacture or purchase.

3.8 Standards and test methods

Australian Standards

Unless otherwise specified in the Contract, and where applicable, materials, workmanship and test methods shall be in accordance with the relevant standard of the Standards Australia or appropriate Local or State Road Authority.

Applicable edition

A standard applicable to the Works shall be the edition last published 14 days prior to the closing date for tenders unless otherwise specified.

Overseas standards

Overseas standards and other standard documents named in the Specification shall be applicable in the same manner as Australian Standards to relevant materials and workmanship.

Copies to be kept on site

Copies of any standards quoted or referred to in the Specification shall be kept on the site if so specified.

Test methods other than Australian Standards

Test Methods, other than Australian Standards, specified in the Technical Specifications shall refer to the issue dates current at 14 days prior to the closing date for tenders unless otherwise specified.

4 ENVIRONMENT

4.1 Protection of the environment

Conformance to Acts

All work shall be carried out in such a manner as to avoid nuisance and/or damage to the environment.

The Contractor shall comply with the requirements of any Environmental Impact Statement and Assessment Report or Review of Environmental Factors for the project, the conditions of approval imposed by the Environment Protection Authority, the Protection of the Environment Operations Act, the Rural Fires Act and any other Local Council requirements and environmental Act relevant to the project. No variation in costs or extensions of time will be considered due to these requirements.

Erosion control

The Contractor shall plan and carry out the Works to avoid erosion, contamination and sedimentation of the site and its surroundings in accordance with the design plans and specification 04.04 G34M - Environmental Protection Management Plan.

No toxic chemicals

Herbicides and other toxic chemicals shall not be used on the site without the prior written approval of the Principal's Representative.

Noise and smoke

No noise or smoke or other nuisance, which in the opinion of the Principal's Representative is unnecessary or excessive shall be permitted by the Contractor in the performance of the Works under this Contract.

Should work outside customary working hours be approved, the Contractor shall not use, during such period, any plant, machinery or equipment which in the opinion of the Principal's Representative is causing or is likely to cause a nuisance to the public.

No noisy works and/or works likely to disturb nearby residents shall be undertaken during the hours precluding such activity as specified in Limits on Noise.

Dust control

The Contractor shall ensure that fugitive dust from disturbed areas is minimised by a method approved by the Principal's Representative.

Details of dust control are to be submitted in writing to the Principal's Representative two (2) weeks prior to commencing excavation/earthworks operations.

4.2 Limits on noise

Plant with silencers

The Contractor shall only use plant that have effective residential class silencers fitted to all engine exhausts, have engine covers fitted, and are maintained in good order.

Working hours

Operational hours of plant, including the entry and/or departure of heavy vehicles, shall be restricted to 7 am to 5 pm Monday to Friday, 7 am to 12 pm on Saturdays. Work may be allowed outside these hours with the prior approval of the Principals Representative.

Maximum noise levels

Noise emanating from the construction site when measured at any noise sensitive location (such as a residential premise), as determined by the Environment Protection Authority's publication *Environmental Noise Control Manual*, shall not exceed an assigned L10 sound pressure level threshold (noise level exceeded for 10% of the sample time). The intent of this requirement is to avoid excessive noise and long periods of elevated noise that is reasonably anticipated to annoy or adversely effect the adjacent community. Evaluation of noise frequency is necessary to ensure local acceptability.

Responsibility for damage

The Contractor will be responsible for any damage and compensation payments as a result of non observance of the above requirements. No claim by the Contractor arising out of these requirements will be considered by the Principal.

4.3 Limits on ground vibration

Levels

It is the intent of this worksection that ground vibration levels, transmitted from operating items of plant in the vicinity of residential premises, shall not exceed levels that are close to the lower level of human perception inside the premise nor will cause structural damage to the building.

Practices and vibration thresholds acceptable shall be determined in accordance with the current Statutory Regulation. Where such regulation is not available, or jurisdiction is disputed, the criteria given in this clause shall apply.

Limits

Vibration (RMS Z-Axis) generated by construction works shall not exceed:

- Curve 4—for the period of 1 month or less.
- Curve 2—for the period of more than 1 month.

as defined in British Standard BS 6472.1 '*Evaluation of Human Exposure to Vibration in Buildings (1 HZ to 80 HZ)*' when measured inside nearby residential premises.

Peak particle velocity

Ground vibrations generated by construction works shall not exceed a peak particle velocity (VR max) limit of 5 mm/sec when measured within one metre of any residential premise.

Responsibility for damage

The Contractor shall be responsible for any damage and compensation payments as a result of non-observance of the above requirements. No claim by the Contractor will be considered by the Principal.

5 UTILITIES AND AUTHORITIES

5.1 General

This section includes the location and protection of utilities and services, programming of the work by other Authorities and the Contractor, and an outline of utility adjustments required during the construction of the Works.

5.2 Relations with utility authorities and other agencies

Principal to arrange adjustments to utilities

The Principal's Representative will arrange for all necessary adjustments to utilities required to conform to the Drawings unless specified otherwise or noted on the Drawings. The Principal's Representative will make every endeavour to arrange for such adjustments to be performed expeditiously and with a minimum of inconvenience to the Contractor. Work shall comply with the Streets Opening Conference's Information Bulletin on Codes and Practices.

Check on presence

Before proceeding with excavation or other work in any area, the Contractor shall liaise with the utility authorities to ascertain the presence of any utility services and check that all necessary utility relocations have been completed.

The 'Dial Before You Dig' Service, telephone 1100, may be contacted to obtain presence of water, sewer, stormwater, gas, electricity and telephone services and some cables and pipes of companies and other organisations.

Additional adjustments

Where the Contractor's method of working results in additional adjustments to their plant being deemed necessary by any other Authority the Contractor will arrange for and bear all costs relevant to those additional adjustments. This applies regardless of any approval to the method of working by the Principal's Representative.

Minimum interference with services and other contractors

The Contractor shall conduct the operations so as to interfere as little as possible with the operations of other Authorities or their contractors on or near the site of the works. The Principal reserves the right to permit other Authorities and others to work on or near the Works being constructed under the Contract.

Responsibility for maintenance and protection of services

The Contractor will not be responsible for the maintenance of any facilities installed or constructed by the various Authorities or structures and other facilities constructed by others (except where such structures and facilities form part of the Contract), but will be responsible for the protection of such facilities and structures during the Contract period.

Delays due to works by authorities

In certain instances the Contractor may be required to provide the various Authorities the opportunity to remove, relocate, or work on their facilities before the Contractor proceeds with succeeding construction operations.

Should the Contractor suffer any delay in excess of the times set out in this worksection owing to the moving of any such services, or the operations of any Authority controlling such services, the Contractor may apply to the Principal's Representative for an extension of time in accordance with the Conditions of Contract.

The Contractor shall have no right to monetary compensation or to any claim for damages because of any loss owing to such delays, nor shall the Contractor stop the Works without the express permission in writing of the Principal's Representative because of any operation by other Authorities.

5.3 Location and protection of services and utilities

Contractor to verify locations

Prior to the commencement of any excavation the Contractor shall verify the location and depth of all Public Utility Mains and Consumer Services and shall be responsible for any damage caused, the repair of the damage, and payment of all charges associated therewith.

Contact: DIAL 1100 BEFORE YOU DIG is a free service, from anywhere in Australia, of locating underground pipe and cables (possible within two working days). See www.1100.com.au.

Precautions

During the excavation of Works, the Contractor shall take every precaution that is necessary, in the opinion of the Principal's Representative, to secure existing gas, water or drainage pipes, sewers, electric conduits or other existing works, wherever met with both underground and overhead, or that are adjacent to these Works, from injury and shall maintain the same until in the opinion of the Principal's Representative, the backfilling of excavation and the general progress of the Works render further precautions unnecessary.

The Contractor shall comply with the Statutory Requirements for maintaining safe working clearance to overhead electrical services.

Repairs to damage caused by contractor

Damage to existing water, gas or drainage pipes, sewers, electric conduit or other existing works or services, shall be repaired by the Contractor to the satisfaction of the Principal's Representative and the relevant Authority at the Contractor's cost.

Notice to divert services

Where it is found necessary to remove, divert or cut into any existing sewer, drainage pipe, gas or water main, service pipes, electric conduits or other existing works, the Contractor shall give at least 3 days notice of the Contractor's requirements to the Principal's Representative, who will advise what arrangements should be made for the alteration of such existing works.

Liaison

Where the installation of service mains, pits and consumer service connections is to be carried out by the various Utility Authorities the Contractor shall liaise and co-ordinate with the relevant Authorities for the installation to coincide with the construction work of this Contract.

The Contractor shall be responsible to programme the installation such that all work is completed by the relevant Authorities so as not to hinder or delay the progress of the construction work of this Contract.

Limitations to work methods

Attention is directed to the possible existence of vibration and other working limitations in the vicinity of underground and overhead facilities. The extent of these limitations are liable to the absolute discretion of the Authority concerned.

The Contractor shall be deemed to have included consideration of these potential limitations in the method of construction as proposed for approval by the Principal's Representative in accordance with the provisions of this worksection.

The cost of such limitations on working methods shall be determined in accordance with the Conditions of Contract.

Disclaimer to information shown on drawings

Information shown on the Drawings concerning utility services has been compiled from information obtained from various Utility Authorities and is not guaranteed correct or complete. Services may exist which are not shown on the Drawings, or which are at locations or elevations different than those shown on the Drawings.

6 PAYMENT

Payment shall be made as per the Schedule of Rates in the Tender Submission Documents.

Payment will be made on a monthly basis subject to the receipt of an invoice and reports summarising the Contractors activities, including the following as a minimum;

- A brief summary of weekly activities including hours crushing per day;
- Quantity of material won each day;
- Quantity of material crushed, screened and stockpiled each day;
- Cumulative totals of material crushed, screened and stockpiled for each pit and for the Contract;
- Details of any stoppages including plant down time;
- Number of employees on site;
- Hours worked by each employee on site;
- Total hours worked;
- Total hours of crushing, screening and stockpiling;
- Average Rate of Production for crushing, screening and stockpiling;
- Details of any reportable accidents or incidents.

Appendix F – TRC Polycom test results

Ravel Tests	Duri Wallamore Road						
	Chainage from New Winton Road						
		9/01/2017	7/03/2017	7/06/2017	7/09/2017	16/11/2017	
Polymer Section 0.05km to 2.900km		kg per m²	kg per m²	kg per m²	kg per m²	kg per m²	
Chainage	0.200	0.77	2.90	6.00	8.00	13.00	
	0.800	1.21	2.40	13.20	13.20	18.00	
	1.400	1.08	3.03	12.10	13.00	20.00	
	2.000	1.52	2.88	18.50	20.00	21.00	
	2.600	0.94	2.06	8.30	13.80	18.00	
Average		1.10	2.65	11.62	13.60	18.00	9.40
Maintenance Grade Section 2.900km to 6.600km							
Chainage	3.100	1.6	2.78	10.50	11.00	19.95	
	3.700	0.63	4.38	12.00	12.10	15.80	
	4.300	0.71	3.80	7.70	10.00	13.00	
	4.900	1.88	3.03	17.10	20.20	31.00	
	5.500	2.36	3.65	16.50	19.40	21.00	
Average		1.44	3.53	12.76	14.54	20.15	10.48
Gravel Resheeting Section 6.600km to 8.900km							
Chainage	6.800	1.95	2.14	17.40	20.50	26.00	
	7.200	2.25	4.20	17.30	20.00	30.10	
	7.600	1.98	4.04	25.95	28.00	34.50	
	8.000	1.7	3.25	10.10	12.00	17.00	
	8.400	1.81	3.80	16.00	16.70	19.80	
Average		1.94	3.49	17.35	19.44	25.48	13.54

Appendix G – DRC Material Test Reports

CALIFORNIA BEARING RATIO REPORT

Client:	Western Plains Regional Council - Wellington	**Source:**	Bodangora Rock & Gravel Stockpile
Address:	Po Box 62 Wellington NSW 2820	**Sample Description:**	silty GRAVEL
Project:	Material Assessments	**Report No.:**	D3053-CBR
Job No.:	D16085	**Lab No.:**	D3053

Test Procedure: RMS T117 California bearing ratio of remoulded specimens of road construction material

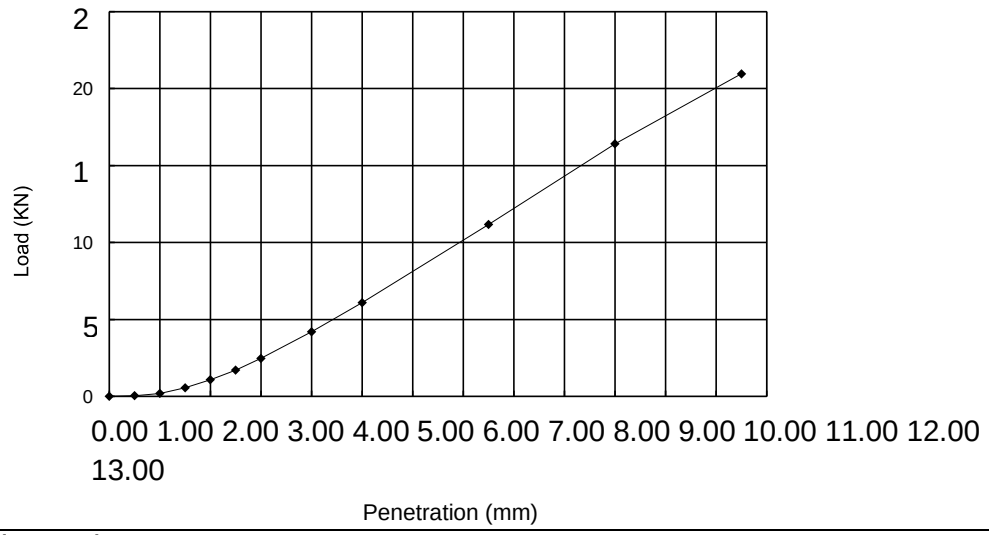
☑ RMS T111 Dry density/moisture relationship of road construction materials

☐ RMS T112 Dry density/moisture relationship of road construction materials (modified compaction)

☑ RMS T120 Moisture content of road construction materials (standard method)

Sampling: Sampled by Macquarie Geotechnical Staff in accordance with RMS T100	**Date Sampled:**	29/07/2016

Preparation: Prepared in accordance with RMS T105



Target Density & Moisture Ratio

Target Laboratory Density Ratio %	100	Target Laboratory Moisture Ratio %	100

Compaction and Placement Data

Compaction Used	Standard	Dry Density
Maximum Dry Density t/m3	2.23	At Compaction 2.25 t/m3 101.0 % Comp.
Optimum Moisture Content %	9.5	After Soaking 2.25 t/m3 101.0 % Comp.

Clarence Valley Council

No. of Layers	3	Moisture Content		Moisture
Blows per Layer	53	At Compaction %		Ratio (%)
Drop of Rammer	300	After Soaking %		99
mm Mass of	2.7	After Penetration (Top 30mm)	9.4	105
Rammer kg	4.5	%	10.0	111
Surcharge Used kg		After Penetration (Entire Depth)	10.5	105
		%	10.0	
% Ret. 19mm Sieve	9	Swell After4 Days Soaking %	0.3	

Note: material coarser than +19mm Sieve was discarded (as per test method)

California Bearing Ratio

CBR (4-day Soaked) = **50.0 %** **5.0 mm** **Penetration**

Notes:

Authorised Signatory:

NATA

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except in full. 10/08/2016

Alan Pile

Date:

NATA Accredited Laboratory Number: 14874

MACQUARIE GEOTECH

Macquarie Geotechnical
6/57 Douglas Mawson Drive
Dubbo NSW 2830

ANALYSIS OF ROAD MATERIALS REPORT

Client:	Western Plains Regional Council - Wellington	**Source:**	Bodangora Rock & Gravel Stockpile
Address:	Po Box 62 Wellington NSW 2820	**Sample Description:**	silty GRAVEL
Project:	Material Assessments	**Report No.:**	D3053-MA
Job No.:	D16085	**Lab No.:**	D3053

Test Procedure:

- ☑ RMS T106 — Coarse particle distribution of road construction materials (by dry sieving)
- ☑ RMS T107 — Fine particle distribution of road construction materials
- ☑ RMS T108 — Liquid limit of road materials
- ☑ RMS T109 — Plastic limit and plasticity index of road construction materials

Sampling: Sampled by Client — **Date Sampled:** 29/07/2016

Preparation: Prepared in accordance with RMS T105

RMS TEST METHOD		RMS 3051 SPECIFICATION				TEST RESULTS
		DGB20(HD)	DGB20	DGS20	DGS40	
		Base		Subbase		
T106	% Passing 75.0mm	-	-	-	-	100
	A.S.Sieve % Passing 53.0mm	-	-	-	100	100
	A.S.Sieve	-	-	-	95 - 100	100
	% Passing 37.5mm A.S.Sieve	100	100	100	75 - 95	100
	% Passing 26.5mm A.S.Sieve	95 - 100	95 - 100	95 - 100	64 - 90	91
	% Passing 19.0mm A.S.Sieve	78 - 92	78 - 92	70 - 90	-	72
	% Passing 13.2mm A.S.Sieve	63 - 83	63 - 83	58 - 80	42 - 78	59
	% Passing 9.5mm A.S.Sieve	-	-	-	-	46
	% Passing 6.7mm A.S.Sieve	44 - 64	44 - 64	43 - 65	27 - 64	36
	% Passing 4.75mm A.S.Sieve	33 - 49	33 - 49	30 - 50	20 - 50	22
	% Passing 2.36mm A.S.Sieve	14 - 23	14 - 23	10 - 30	10 - 23	11
T107	% Passing 0.425mm A.S.Sieve	7 -	7 -	4 - 17	4 - 12	6
	% Passing 0.075mm A.S.Sieve	14 3	14 3	2 - 10	2 - 7	3
	% Less than 0.0135mm	- 7	- 7			
	% Retained Between AS Sieves			-	-	
	19.0mm - 13.2mm	7 - 17	6 - 18	-	-	
	13.2mm - 9.5mm	8 - 16	7 - 17	-	-	19
	9.5mm - 4.75mm	14 -	13 -	-	-	13
	4.75mm - 2.36mm	24 8 -	25 7 - 19	-	-	23
	2.36mm - 425micron	18	14 -	-	-	14
	425micron - 75micron	14 - 28	30	-	-	11
	75micron - 13.5micron	6 - 13	6 - 13			5
		3 - 7	3 - 8	Max 23	Max 23	2
T108	Liquid Limit (%) (if non-plastic)	*Max 20	Max 23	Max 20	Max 20	26
T109	Plastic Limit (%) (if plastic)	Max 20	Max 20	Varies	Varies	17
T109	Plasticity Index (%)	Min 2 - Max 6	Min 2 - Max 6			9

Notes: *The maximum value of the Liquid Limit may be increased to 23 for non-plastic crushed rock, provided that the value determined is not influenced by the presence of adverse constituents (e.g. mica). NP = Non Plastic

Clarence Valley Council

Authorised Signatory:

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Appendix H – UHSC Inspection and Risk Management Policy

UPPER HUNTER SHIRE COUNCIL

RISK MANAGEMENT – PROCEDURES – Inspection, Evaluation and Maintenance of Roads

Revised March 2013
Version 3

Purpose

The procedure controls the process of determining the types of hazards that require consideration for repair, setting priorities and the timeframe that repairs should be undertaken on Council roads within the road maintenance budget.

Objectives

- To apply the risk management principles of identification, evaluation and treatment of risks to road pavement maintenance.
- To implement a formal system of road pavement inspections which record identified risks including defined hazards.
- To develop and maintain a risk register for road pavements through inspections and incorporate reports of road pavement hazards received from the public and/or employees.
- To implement a method of prioritising the risks identified by the various sources.
- To establish reasonably practicable response times, in which to effect repairs or provide temporary warnings, for the risks identified based on resources available.
- To establish a system of documenting all important steps of the procedure to allow ongoing review and to provide evidence to defend road pavement-related claims against Council.

Inspections

Risk management is the systematic application of management policies, procedures and practices to the tasks of identifying, analysing, assessing, treating and monitoring risks. The first step undertaken in any risk management program is the process of determining what can happen, why and how.

This is the systematic identification of hazards within the road network. This road network is that which is described in Council's 'Road Register' (as per the requirement under the Road Act 1993 and compliance with AAS-27).

Inspections are a formalised and sometimes independent assessment of sections of the road network, looking for hazards that may require repair and maintenance. It is carried out with regard to the standards and safety principles, by knowledgeable and skilled personnel.

An inspection program has been developed, and the information gathered by this program shall be used as the main method of identifying all the known hazards and risks associated with the road network.

3 Major Types of Inspection

- Formal – (planned periodically)

- Complaint from road user
- Hazard report from Council Employee / Councillor

Formal Inspections

The purpose of these formal inspections is to identify:

A. Those assets that have defects; B. The

severity of these defects; and

C. The location of the defect.

The above sources of information allow Council to gauge the condition of the road network. Without this information, it is impossible to have a true and accurate picture of the condition of the network and therefore, impossible to ascertain the level of risk that Council is exposed to.

The inspections are to be recorded using the 'Inspection Form' and guidelines in these Procedures.

Complaints from road users

Complaints from road users are a valuable source of knowledge about the condition of the road network between inspections. Each complaint is registered using Council's Complaints handling procedure and then referred to the appropriate Technical Services staff member who will investigate the complaint.

Hazard reporting by Employees and Councillors

Council staff regularly travel the road network on the way to and from their work locations throughout the Shire. During this travel, Council staff members are encouraged to inspect, record and report defects to their Supervisor or through Council's Customer Request Management system. Once the report is logged, it is handled as any other complaint.

Opening of Council Owned Roads/Footpaths by Contractors and Others

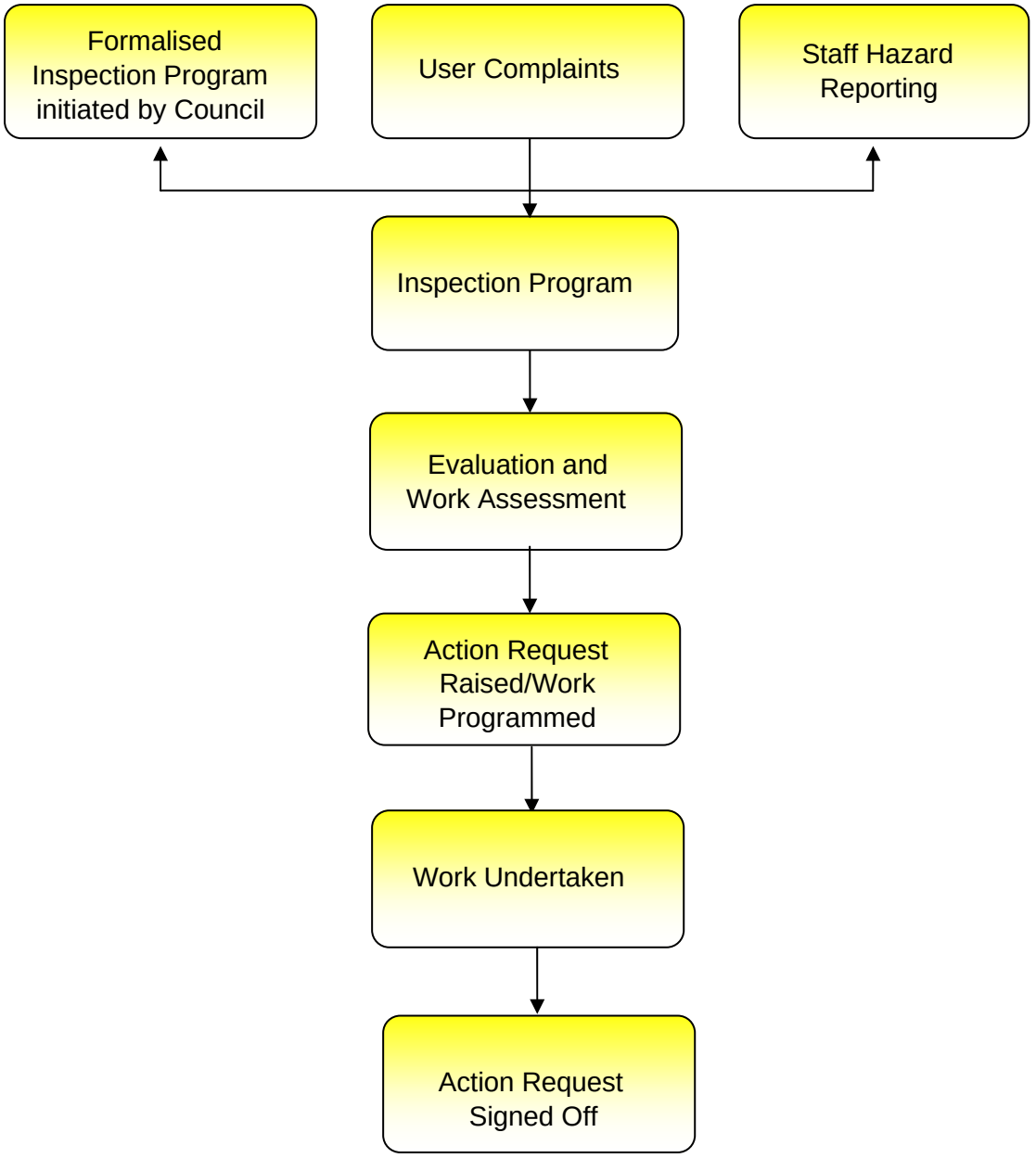
The extent and standards of work shall be in accordance with the provisions of:

NSW Street Opening Conference, Guide to Codes and Practices for Street Openings

AUS- SPEC # 2, Specification 306 – Road Openings and Restorations.

In accordance with the Roads Act 1993, all persons other than Utility/Service Providers, are required to obtain permission from Council before digging up and disturbing the surface of a Council owned public road (including footpaths), and comply with any conditions imposed by Council.

Figure 1. Typical Maintenance and Repair Flowchart



Inspection Intervals

The frequency of routine inspections will vary depending on the road classification.

Roads maintained by Council shall be inspected generally in accordance with the intervals listed in the table below.

Table 1

	Road Class				
	Link Road (Regional Road)	Collector Road (Rural 1)	Access Road (Rural 2)	Access Road (Rural 3)	Access Road (Rural 4)

Inspection Frequency	3 Monthly	Yearly	Yearly	Yearly	Yearly

Evaluation

During the inspection process roads are inspected in accordance with criteria set out in Tables 2, 5 and 6, based on the **location** of the defect within the road reserve, and the **hazard type and severity**.

The **road hierarchy weighting** as shown in Table 3 is the third parameter used in the evaluation process.

The above values are used to determine a Road Risk Rating (RRR) as shown in Equation 1.

This Road Risk Rating then allows Council to prioritise the corrective action it intends to take, or allows the control measures to be scheduled as per Tables 7 and 8.

Equation 1 Road Risk Rating Calculation

Road Hierarchy Weighting (Table 3)	**+**	**Condition Score X 3** (Table 5 or 6)	**+**	**Location Score** (Table 2)	**=**	**Road Risk Rating**

Control of Risk

Control of risk exposure requires control measures to be implemented. Some of the control measures that Council will be able to use to lessen its exposure to risk are as follows:

- Use of warning signs and lights to alert road users of the potential hazard that exists ahead;
- Erection of temporary barriers or barricades and lights around the area until it can be repaired;
- Effecting repair of the damaged area; or
- Planning and allocating resources for the long term replacement of the road network or structures.

Monitoring/Quality Control

The effectiveness of the inspection, assessment/evaluation, and control mechanisms outlined in this procedure will be assessed by the Director of Technical Services or the Manager of Civil Assets on an annual basis.

The quality of risk amelioration works, repairs and other road works will be monitored by the Manager of Operations or Manager of Civil Assets and supporting supervisory staff on a daily basis with reports being submitted to the Director of Technical Services on an ongoing basis through staff meetings, briefings or written reports where appropriate.

Allocated Resources

The reduction and minimisation of urgent and high priority risks is Council's highest priority. An annual budget, which will reflect the level of effort required to remediate all urgent and high priority sites in the first instance will be sought from Council.

Following approval of the actual budget a priority based works program will be developed. The extent of the works will be determined by the capital resources available.

The Maintenance and Repair Program, based on available resources, will be approved by the Director of Technical Services.

Table 2 Damage Location within the Road

Location Score	Description
1	Road reserve
2	Road shoulder
4	Traffic lane
5	Total carriageway

Table 3 Road Hierarchy Weightings

Hierarchy Category	Weighting
Link Roads (Regional)	5
Collector (Rural 1)	4
Access (Rural 2)	3
Access (Rural 3)	2
Access (Rural 4)	1

Table 4 Road Hierarchy Urban and Rural Roads

Type/Category	Primary Function	Typical Daily Traffic Volumes
Link (Regional)	Strategic freight linkage routes	> 200 vpd
Collector (Rural 1)	High usage local collector routes.	> 100 vpd
Access (Rural 2)	Medium usage property access routes.	> 30 – 100 vpd
Access (Rural 3)	Low usage property access routes.	10 – 30 vpd
Access (Rural 4)	Very low usage property access routes.	< 10 vpd
Urban	TBC	TBC

See Table 8 for individual road hierarchies**.**

Table 5 Sealed Roads

Condition Score	Hazard Type - Severity

1	▪ edge drop 20-50mm ▪ pothole with diameter 200-300mm and/or depth 50-75mm ▪ deformations 50-100mm deep ▪ guideposts in poor condition ▪ crash barriers in poor condition ▪ road markings missing or illegible in a non-critical location
2	▪ small sized object on road <100mm ▪ edge drop 50-75mm ▪ deformations >100mm ▪ guideposts missing ▪ regulatory/warning signs in poor condition ▪ crash barriers missing or in a dangerous condition/location
3	▪ pothole with diameter >300mm and/or depth >75mm ▪ edge drop 75-150mm ▪ moderate spill of granular material ▪ medium sized object on road 100mm – 200mm ▪ deformations >100mm and ponding hazard
4	▪ edge drop >150mm ▪ large sized object on road >200mm
5	▪ large spill of oil, wet clay or other slippery substance ▪ regulatory signs missing or illegible ▪ guideposts in a dangerous condition or location ▪ road markings missing or illegible in a critical location ▪ very large obstruction on road eg. tree, tree branch

Table 6 Unsealed Roads

Condition Score *	**Hazard Type - Severity**

1	▪ trafficable in all weather conditions ▪ very good ride quality ▪ minor potholes/scouring/corrugations ▪ guideposts in poor condition ▪ crash barriers in poor condition ▪ moderate spill of granular material
2	▪ trafficable in all weather conditions ▪ good ride quality ▪ isolated potholes/scouring/corrugations ▪ regulatory/warning signs in poor condition ▪ large spill of granular material ▪ small size object on road - 100mm
3	▪ may be slippery in wet weather ▪ fair ride quality ▪ numerous minor potholes/scouring/corrugations ▪ guideposts missing ▪ crash barriers missing ▪ medium size object on road -100-200mm
4	▪ may be boggy during wet weather ▪ poor ride quality ▪ some major potholes ▪ noticeable corrugations ▪ large sized object on road – max dimension > 200mm
5	▪ may be impassable in wet weather ▪ very poor ride quality ▪ excessive potholes ▪ severe corrugations ▪ regulatory/warning signs missing or illegible ▪ guideposts in a dangerous condition or location ▪ very large obstruction on road eg. tree, tree branch

*Condition score guideline

Unless the hazard is isolated, roads will generally be assessed based on lengths which exhibit similar characteristics or condition. The condition score assigned to each length or segment, using the above set of descriptors, should be that which best describes the average condition of the assessed length.

Table 7 Road Risk Action Response for Sealed Roads

Risk Rating	Priority	Control Mechanism		Response Time
5	**Low**	Monitor		Not applicable
6 to 9	**Low**	Programme into maintenance works	►	As resources permit
		Effect repair	►	*Within 6 months*
10 to 14	**Medium**	Programme into maintenance works	►	As resources permit
		Effect repair if necessary	►	*Within 3 months*
15 to 18	**High**	Programme into maintenance works, make safe if necessary eg., signpost	►	As soon as practical
		Inspect by competent person and make safe	►	Within 24 hours
		Effect repair if necessary	►	*Within 2 weeks*
>18	**Urgent**	Programme into maintenance works, make safe eg., signpost	►	Immediately
		Inspect by competent person and make safe	►	*Within 4 hours*
		Effect repair if necessary	►	*Within 2 working days*

Note: Control mechanisms and response times for **isolated hazards** are in italics.

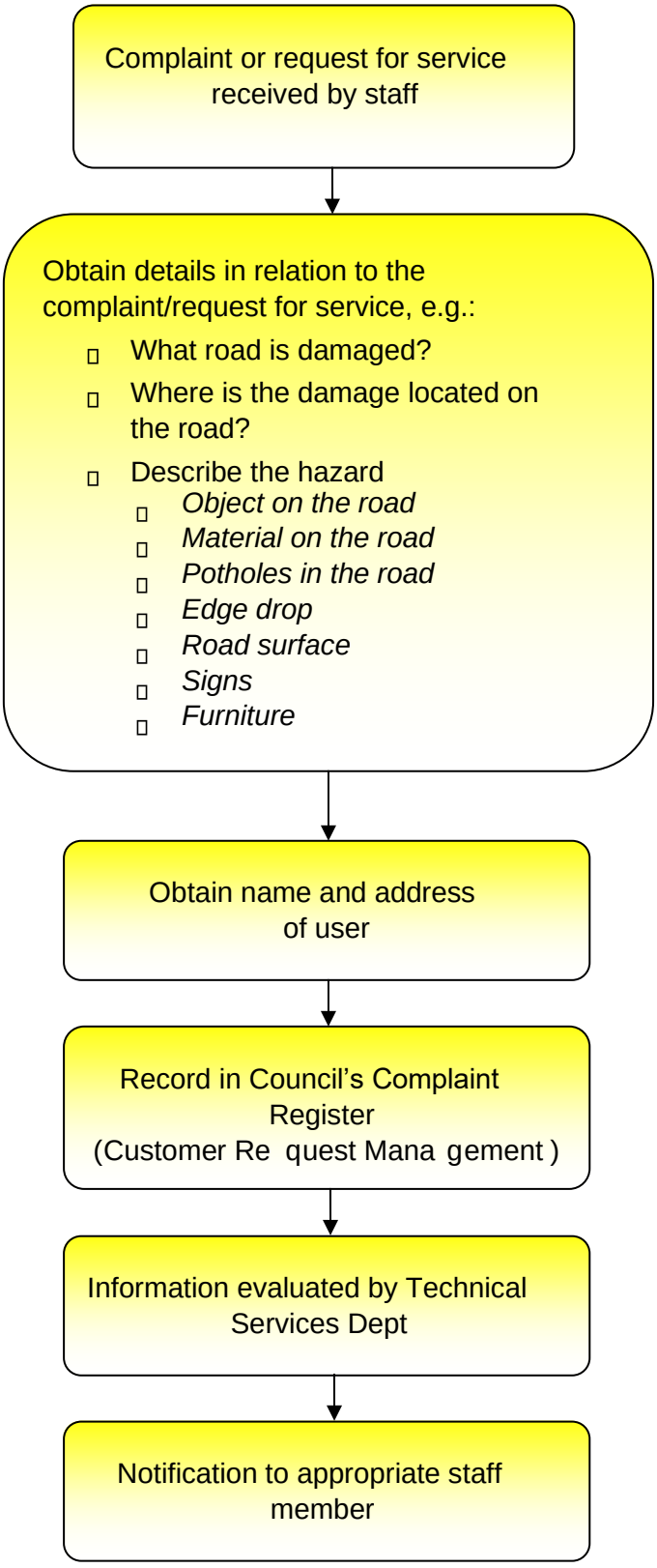
Table 8 Road Risk Action Response for Unsealed Roads

Risk Rating	Priority	Control Mechanism		Response Time
11 or less	**Low**	Monitor		Not applicable
12 to 15	**Low**	Programme into maintenance works	►	As resources permit
		Effect repair	►	*Within 6 months*
16 to 19	**Medium**	Programme into maintenance works	►	As resources permit
		Effect repair if necessary	►	*Within 3 months*
20 to 22	**High**	Programme into maintenance works, make safe if necessary eg., signpost	►	As soon as practical
		Inspect by competent person and make safe	►	Within 24 hours
		Effect repair if necessary	►	*Within 2 weeks*
>22	**Urgent**	Programme into maintenance works, make safe eg., signpost	►	Immediately
		Inspect by competent person and make safe	►	*Within 4 hours*
		Effect repair if necessary	►	*Within 2 working days*

Note: Control mechanisms and response times for **isolated hazards** are in italics.

APPENDIX 1

COUNCIL'S ACTION REQUEST FLOWCHART



APPENDIX 2

AN EXAMPLE OF USING THE EVALUATION METHOD

The following calculations are based on fictitious situations.

Routine Road Inspection

The damage is located over the whole carriageway. This gives a **location** score of 5 as defined in Table 2.

The road is an unsealed Link Road with >200 vehicles per day (vpd). Link Roads have a **road hierarchy weighting** of 5 as defined in Table 3.

The surveyed section has major potholes and corrugations over the segment length. Using Table 6 the condition of the road most closely resembles the **hazard type and severity** descriptions under condition score 4.

Using Equation 1 the Road Risk Rating is 5 + 12 + 5 = 22

Reading from Table 8 shows that the priority is high, that the area should be made as safe as possible eg. by signposting, speed restriction etc. and maintenance work programmed for as soon as practical.

Inspection of a reported hazard

A tree branch has fallen across a sealed Council Collector (Rural 2) Road and is blocking one lane of the road.

The **location** score is 4, the **road hierarchy weighting** is 4 and the **hazard/severity** type is 5. Therefore the Road Risk Rating is 23.

Using Table 7 the hazard should be inspected within 4 hours of notification and made safe by signposting if it cannot be removed. The tree branch should be cleared within two working days.

Table 8

RURAL ROAD NETWORK - HIERARCHY									
Road	Location	No	Sealed	Gravel	Formed	Unformed	Total	Hierarchy Type	Hierarchy Category
Above Moonan	E14	2		0.520	0.480		1.000	Access Road	Rural 4
Albano	H13	5		2.330			2.330	Access Road	Rural 4
Allan Bridge	G12	10	4.380				4.380	Collector Road	Rural 1
Allan Cunningham	F11	12	1.530				1.530	Access Road	Rural 3
Alma	F12	15		1.770			1.770	Access Road	Rural 4
Alyndale	D6	20		0.710			0.710	Access Road	Rural 4
Armstrong	G13	25	0.120				0.120	Access Road	Rural 4
Ashbrooke	D11	30	0.100	2.590			2.690	Access Road	Rural 3
Ashwood	F9	32		0.470			0.470	Access Road	Rural 4
Avocado	G6	35	1.000	6.610			7.610	Access Road	Rural 3
Back Creek	G13	40		2.330			2.330	Access Road	Rural 3
Banool	E11	45		0.310			0.310	Access Road	Rural 3
Barrington	D16	50		1.610	3.220		4.830	Access Road	Rural 3
Barrington Forest	E16	55		11.450			11.450	Collector Road	Rural 1
Beales Creek	E8	60		2.670		1.930	4.600	Access Road	Rural 3
Belltrees	F13	65	2.250	4.350			6.600	Access Road	Rural 3
Binks	H5	70	0.190	3.070			3.260	Access Road	Rural 3

Blairmore Lane	H11	75	5.470				5.470	Access Road	Rural 3
Blairmore Point	H11	80	0.500				0.500	Access Road	Rural 4
Blue Mountain Creek	E15	85		0.180			0.180	Access Road	Rural 4
Bobs Camp	F12	90		3.110			3.110	Access Road	Rural 3
Borambil Racecourse	F3	95		3.870			3.870	Access Road	Rural 3
Bowmans Gully N	F13	100		4.460			4.460	Access Road	Rural 3
Bowmans Gully S	G13	110		3.460		7.060	10.520	Access Road	Rural 3
Branch Creek M	C13	115		6.360			6.360	Access Road	Rural 3
Branch Creek	C16	120		9.170			9.170	Access Road	Rural 3
Brawboy	E9	125		11.920			11.920	Access Road	Rural 3
Bridges	E13	130		3.360			3.360	Access Road	Rural 3
Brumlo	D14	135		2.450			2.450	Access Road	Rural 4
Bulgin	F3	136		1.130			1.130	Access Road	Rural 4
Bunnan (MR 62)	F9	140	64.010				64.010	Link Road	Regional
Callemondah	C16	145		13.680		3.380	17.060	Access Road	Rural 3
Carters	F15	150		2.980	4.670		7.650	Access Road	Rural 4
Caslicks	E14	155		1.400	0.890		2.290	Access Road	Rural 4

RURAL ROAD NETWORK - HIERARCHY									
Road	Location	No	Sealed	Gravel	Formed	Unformed	Total	Hierarchy Type	Hierarchy Category
Cattle Creek	E3	160		13.570			13.570	Access Road	Rural 3

Cliftlands	F11	165	0.800	2.820			3.620	Access Road	Rural 3
Clydesdale	D11	166		0.310		1.580	1.890	Access Road	Rural 4
Cockatoo Gap	D7	168		1.210			1.210	Access Road	Rural 4
Comiala	G4	170	5.220	6.830			12.050	Access Road	Rural 2
Common	F11	172	0.450	1.720			2.170	Access Road	Rural 3
Cooba Bulga	E3	175	0.280	15.410			15.690	Access Road	Rural 3
Coogah	C12	180	0.300	3.640			3.940	Access Road	Rural 3
Cooinda	F1	182		0.480			0.480	Access Road	Rural 4
Coolah	F2	185	3.030	8.610			11.640	Access Road	Rural 3
Coonawarra	E14	190		0.800			0.800	Access Road	Rural 4
Cream of Tartar	E6	195		2.760			2.760	Access Road	Rural 4
Cressfield	E11	200	4.760	2.400			7.160	Collector Road	Rural 1
Cullingral	H6	205	13.360				13.360	Collector Road	Rural 1 to 13km
Cullingral	H6	205		4.860			4.860	Access Road	Rural 3 13km to end
Dales Creek	F8	210	0.320	15.840			16.160	Access Road	Rural 3
Dalvey	G12	215		1.130		3.940	5.070	Access Road	Rural 4
Dangarfield	G12	220		2.570			2.570	Access Road	Rural 4
Darkwood	F4	225		4.730			4.730	Access Road	Rural 3
Dartbrook	G11	230	8.000				8.000	Collector Road	Rural 1
Davis Creek	G14	235	0.100	15.870		4.910	20.880	Access Road	Rural 3
Depot	G6	237	1.030	1.090			2.120	Access Road	Rural 3

Donalds Creek	E14	240		6.480			6.480	Access Road	Rural 3
Dry Creek	E11	245		6.370			6.370	Access Road	Rural 3
Duggan	I6	250		0.370			0.370	Access Road	Rural 4
Dunblane	H7	255		1.220			1.220	Access Road	Rural 4
Easeys	E8	257		0.320			0.320	Access Road	Rural 4
Edmonds	D13	260		2.090			2.090	Access Road	Rural 3
Ellerston	D15	265		0.800			0.800	Access Road	Rural 3
Eulalia	E13	270		2.330			2.330	Access Road	Rural 4
Fernleigh	C14	275		2.900			2.900	Access Road	Rural 4
Flags	H7	280	7.770	15.450			23.220	Access Road	Rural 2
Flight Springs	H5	285	4.560	8.820			13.380	Collector Road	Rural 1
Forest Reserve	H6	290		6.920			6.920	Access Road	Rural 3
Gateleys	D11	295		0.800	2.010		2.810	Access Road	Rural 4
Gibbergunyah	F9	300		3.650			3.650	Access Road	Rural 3
Glen Creek	F12	305		2.010			2.010	Access Road	Rural 3

RURAL ROAD NETWORK - HIERARCHY

Road	Location	No	Sealed	Gravel	Formed	Unformed	Total	Hierarchy Type	Hierarchy Category
Glen Oak	D15	307		2.170			2.170	Access Road	Rural 4
Glen Ruby	H7	310		1.910			1.910	Access Road	Rural 4
Glenalvon	C10	315		2.460			2.460	Access Road	Rural 3

Glenbawn	G12	320	13.900				13.900	Collector Road	Rural 1
Glencoe	G13	325		3.480	3.300		6.780	Access Road	Rural 3
Glenroy M	G5	330		6.700			6.700	Access Road	Rural 3
Glenroy S	B16	335		2.410			2.410	Access Road	Rural 3
Glenvale	C15	340		1.240			1.240	Access Road	Rural 4
Gloucester	D17	342			16.980		16.980	Access Road	Rural 4
Golden Highway	G5	345	85.700				85.700	State Highway	Highway
Green Creek	C13	350		9.430			9.430	Access Road	Rural 3
Gum Ridge	F5	352		2.260			2.260	Access Road	Rural 4
Gummum	F6	355		8.820			8.820	Access Road	Rural 2
Gundy (MR 105)	F12	360	18.960				18.960	Link Road	Regional
Halcombe	G11	365		2.030			2.030	Access Road	Rural 3
Halls	G11	370	0.900	6.630			7.530	Access Road	Rural 3
Hampshire	E5	380		9.910			9.910	Access Road	Rural 3
Haydons Lane	C11	385	1.600				1.600	Access Road	Rural 3
Haydons Woolshed	C11	390			3.220		3.220	Access Road	Rural 4
High Park	D5	392		0.370			0.370	Access Road	Rural 4
Hognos	A17	395		8.530			8.530	Access Road	Rural 4
Hulks	H4	400		5.040			5.040	Access Road	Rural 3
Hunter (MR 105)	F13	405	32.640				32.640	Link Road	Regional

Hunter	C15	406	2.000	14.000			16.000	Collector Road	Rural 1 to Ellerston
Hunter	C15	406	3.600	22.400			26.000	Access Road	Rural 2 Ellerston to Glenrock
Hunter	C15	406		19.700			19.700	Access Road	Rural 3 Glenrock to end
Idaville	F5	410	19.230	3.330			22.560	Collector Road	Rural 1
Inglewood	D6	412		0.430			0.430	Access Road	Rural 4
Isis Ford	D13	415		1.000			1.000	Access Road	Rural 3
Jewisky	E8	420		2.000			2.000	Access Road	Rural 4
Judy Kelly	E6	425		2.370			2.370	Access Road	Rural 4
Kars Springs	E8	430	8.900	13.860			22.760	Collector Road	Rural 1
Kenelea	G13	435		2.860		3.890	6.750	Access Road	Rural 4
Kia Ora	G12	440	0.700				0.700	Access Road	Rural 3
Kiernans Creek	E9	445		6.520		1.930	8.450	Access Road	Rural 3
Killoe	H5	450		9.550			9.550	Access Road	Rural 4

RURAL ROAD NETWORK - HIERARCHY

Road	Location	No	Sealed	Gravel	Formed	Unformed	Total	Hierarchy Type	Hierarchy Category
Krui	E5	455		2.990			2.990	Access Road	Rural 3
Kruilaya	G3	457		0.790			0.790	Access Road	Rural 4
Kuloo	E4	460		6.800			6.800	Access Road	Rural 3
Lawlers lane	G6	462	0.280				0.280	Access Road	Rural 3
Leighton Park	F12	465		1.400	2.160		3.560	Access Road	Rural 3

Leitch	I6	470		1.580			1.580	Access Road	Rural 4
Lettybrook	G5	475		2.090			2.090	Access Road	Rural 4
Lincoln	B13	478		1.000			1.000	Access Road	Rural 4
Little Creek	E8	480		2.610			2.610	Access Road	Rural 4
Llangollen	F3	485	6.500				6.500	Collector Road	Rural 1
Malumla	G14	490		1.210			1.210	Access Road	Rural 4
Mareeba	E11	495	1.450	1.950	0.810		4.210	Access Road	Rural 3
Martin's Lane	E2	500		1.460			1.460	Access Road	Rural 3
Mckenzies	B13	505		3.380			3.380	Access Road	Rural 3
McMullins	G13	507		0.080			0.080	Access Road	Rural 4
Meerimuka	F12	510		1.960			1.960	Access Road	Rural 4
Middle Creek	E6	515		11.230			11.230	Access Road	Rural 3
Middlebrook Drive	F11	520		1.460	0.230		1.690	Access Road	Rural 4
Middlebrook Rd	E11	525	15.280	5.320			20.600	Access Road	Rural 2 to Washpools
Middlebrook Rd	E11	525		4.180		0.920	5.100	Access Road	Rural 3 Washpools to end
Millers Creek	E9	530		1.830			1.830	Access Road	Rural 4
Miranee	E12	535		3.270			3.270	Access Road	Rural 3
Moobi	F11	540	4.090				4.090	Collector Road	Rural 1 to Yarrandi Rd
Moobi	F11	540		8.050			8.050	Access Road	Rural 3 Yarrandi Rd to end
Moonan Brook	E15	545		8.800	2.980		11.780	Access Road	Rural 3

Mossvale	E14	550		7.710			7.710	Access Road	Rural 3
Mount Erin	E6	555		16.900			16.900	Access Road	Rural 3
Mountain Station	F6	560	10.470	3.110			13.580	Collector Road	Rural 1
Mountain View	B13	565		4.430			4.430	Access Road	Rural 3
Mt Terrell	E8	570		2.990			2.990	Access Road	Rural 4
Nandowra	G11	575	11.200				11.200	Collector Road	Rural 1
Nectarbank	F12	580		0.800			0.800	Access Road	Rural 4
Neeleys Lane	G2	585		4.100			4.100	Access Road	Rural 4
Netherton	G11	590		0.710			0.710	Access Road	Rural 4
Neverfail	H4	595		3.630			3.630	Access Road	Rural 4
New England H'way	F11	600	38.300				38.300	State Highway	Highway
Night Soil Depot	F11	601		0.400			0.400	Access Road	Rural 4

RURAL ROAD NETWORK - HIERARCHY

Road	Location	No	Sealed	Gravel	Formed	Unformed	Total	Hierarchy Type	Hierarchy Category
Noblet	F11	603	1.300	0.230		1.690	3.220	Access Road	Rural 2
Old H'way-Blandford	C11	605	0.320				0.320	Access Road	Rural 3
Old Scone	G6	602-10		1.660			1.660	Access Road	Rural 3
Omadale Brook	D15	605		4.020			4.020	Access Road	Rural 3
Orham Creek	B16	610		0.800	5.950		6.750	Access Road	Rural 4
Pages Creek	C15	615	5.060	19.880			24.940	Access Road	Rural 2
Pages River	C11	620		6.450	1.270		7.720	Access Road	Rural 3

Paradice Park	C11	625	1.530				1.530	Access Road	Rural 2
Parkins	C12	630		1.450			1.450	Access Road	Rural 4
Pembroke	G4	635		12.000			12.000	Access Road	Rural 2 to Pembroke Stn
Pembroke	G4	635		12.570			12.570	Access Road	Rural 3 to end
Petwyn Vale	D11	637		1.300			1.300	Access Road	Rural 3
Pheasants Creek	D17	640		1.250			1.250	Access Road	Rural 3
Poly Fogal	C18	645		5.470			5.470	Access Road	Rural 2
Possum Springs	H5	647		2.170			2.170	Access Road	Rural 4
Prices lane	G6	648	0.890				0.890	Access Road	Rural 3
Puan Buan Pit	F10	650		1.440			1.440	Access Road	Rural 4
Puddledock	D15	655		0.640			0.640	Access Road	Rural 4
Ranch	F11	660		1.260			1.260	Access Road	Rural 4
Redwell	G4	655		9.930			9.930	Access Road	Rural 4
Ridgelands	F8	670	0.650	16.260			16.910	Access Road	Rural 3
Rileys	B13	675		7.000			7.000	Access Road	Rural 3
Ringwood Merriwa	H5	680	13.480				13.480	Collector Road	Rural 1
Ringwood Scone	C17	685-10		3.440			3.440	Access Road	Rural 3
Roma	E5	695		11.400			11.400	Access Road	Rural 3
Rosebud	F4	700		2.080			2.080	Access Road	Rural 4
Rossgole	G11	705	2.200	12.900		0.190	15.290	Access Road	Rural 3
Rothbury	G5	702		2.730			2.730	Access Road	Rural 4

Rotherwood	F3	710	4.350	13.000			17.350	Collector Road	Rural 2
Rouchel Carters	G13	713		0.900			0.900	Access Road	Rural 4
Rouchel Gap Rd	G12	715		2.490			2.490	Access Road	Rural 3
Rouchel Rd	G12	720	25.200				25.200	Collector Road	Rural 1
Sandy Creek	D12	725	0.200	4.310			4.510	Access Road	Rural 3
Sargeants Gap	B14	730		11.390			11.390	Access Road	Rural 2
Scotts Creek	C12	735	2.650	17.470			20.120	Access Road	Rural 3
Segenhoe	G12	740	11.780				11.780	Collector Road	Rural 1
Settlement Lane	H4	745		0.230			0.230	Access Road	Rural 4

RURAL ROAD NETWORK - HIERARCHY

Road	Location	No	Sealed	Gravel	Formed	Unformed	Total	Hierarchy Type	Hierarchy Category
Smiths	F11	747		0.350			0.350	Access Road	Rural 4
Sondon	C16	750		1.210			1.210	Access Road	Rural 4
Sophia Creek	F10	755		2.300			2.300	Access Road	Rural 3
Sparkes Creek	E10	760	0.150	8.010		2.660	10.820	Access Road	Rural 3
Springfield	G5	765		1.970			1.970	Access Road	Rural 4
Stewarts Brook	E14	770	9.900	14.620	1.480		26.000	Access Road	Rural 2
Stock Route S	F11	772			0.890		0.890	Access Road	Rural 4
Stoney Creek	G13	775		7.160			7.160	Access Road	Rural 3
Stotts Lane	F2	777		1.600	3.810		5.410	Access Road	Rural 4
Studleigh	G14	780		1.540			1.540	Access Road	Rural 4

Summerhill	G2	785	2.980	10.900			13.880	Collector Road	Rural 1
Sunnybrae	C16	790		7.240	1.930		9.170	Access Road	Rural 4
Sunnyside	F5	795		4.370			4.370	Access Road	Rural 3
Tangaratta	E2	797		0.400			0.400	Access Road	Rural 4
Thompsons Creek	E10	800	0.800	3.580			4.380	Access Road	Rural 3
Thompsons Lane	G11	805		0.400			0.400	Access Road	Rural 4
Thompsons Rd		807		0.530			0.530	Access Road	Rural 4
Timor-Crawney	B13	809	9.600	15.500			25.100	Collector Road	Rural 1
Timor Creek	B13	810		7.720			7.720	Access Road	Rural 3
Timor-Gundy	D13	812	4.210	9.230			13.440	Collector Road	Rural 1
Timor PO	C13	815		1.130			1.130	Access Road	Rural 4
Timor Rd	C12	820	21.500				21.500	Collector Road	Rural 1
Tinseys	C13	825		2.820			2.820	Access Road	Rural 3
Tomalla	D15	830	2.000	28.910	13.390		44.300	Access Road	Rural 2
Tullong	F11	835	1.880				1.880	Access Road	Rural 2
Tunbridge	H6	840	1.350	7.830			9.180	Access Road	Rural 3
Turanville	G11	845		4.040			4.040	Access Road	Rural 3
Tyrone	F8	850		2.010			2.010	Access Road	Rural 4
Ulan 214	G2	855	8.260				8.260	Link Road	Regional
Upper Dartbrook	E10	860	13.420	11.540			24.960	Collector Road	Rural 1

Upper Rouchel	G14	865		21.980	1.920		23.900	Access Road	Rural 3
Vinegaroy 618	F2	870	11.820				11.820	Link Road	Regional
Wallington	F11	875		4.570			4.570	Access Road	Rural 3
Warlands Creek	C11	880	0.600	10.670			11.270	Access Road	Rural 3
Waverley	E13	885	3.450	12.400			15.850	Collector Road	Rural 1
Webimble	F8	890		1.960			1.960	Access Road	Rural 4
Wells Gully	H12	895	1.500				1.500	Access Road	Rural 3

RURAL ROAD NETWORK - HIERARCHY

Road	Location	No	Sealed	Gravel	Formed	Unformed	Total	Hierarchy Type	Hierarchy Category
Westwood	H8	900	3.360	2.590			5.950	Access Road	Rural 3
Willow Tree (358)	F7	905	26.860	12.110			38.970	Link Road	Regional
Willungra	E4	910		4.520			4.520	Access Road	Rural 4
Willy Wally	G4	915		1.670			1.670	Access Road	Rural 4
Witneys	G6	917		0.310			0.310	Access Road	Rural 4
Wollar	H4	920	2.860	18.710			21.570	Access Road	Rural 2
Womelguy	F14	925		0.890			0.890	Access Road	Rural 4
Worondi	I8	930	0.630	3.230			3.860	Access Road	Rural 3
Wrights	D11	935			1.450		1.450	Access Road	Rural 4
Wyoming	G3	940		3.940			3.940	Access Road	Rural 4
Yallambie	F2	942		0.930			0.930	Access Road	Rural 4
Yarrandi	F10	945	0.500	5.630			6.130	Access Road	Rural 3

Yarrawonga	D3	950		9.010			9.010	Access Road	Rural 3
Zanzibar	C15	955		0.900			0.900	Access Road	Rural 4
Totals			586.550	1033.550	73.040	34.080			
Note. River Road deleted, it is in the village of Blandford									

UPPER HUNTER SHIRE COUNCIL
LOCAL ROADS INSPECTION REPORT

Road Name: _____ Inspection Type:
Routine / Complaint

Road Hierarchy: _____ Inspected By:
_____ Date: _____

Inspection Start Point (ch): _____ Inspection End Point (ch): _____

Segment		**Pavement**		**Hazard/Severity (tables 5, 6)**		**Ro**
Start Chainage	End Chainage	Seal	Unseal	Condition Score (tables 5, 6)	Description	Road Hierarch Weightin

LOCATION SCORE:	Road reserve (1)	Road shoulder (2)	Traffic Lane (4)	Total C
ROAD HIERARCHY WEIGHTINGS:	Regional (5)	Rural 1 (4)	Rural 2 (3)	Rural 3

I certify that I have inspected this road/section in accordance with the Procedures for 'Inspection, Evaluation & Maintenance of Roads' and found no unacceptable distress levels other than those recorded above.

Signed:

_____ Date: _____