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Traffic Management Plan

New England Solar Farm – Stage 1
2x200MW AC

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SMEC Company Details

Approved by:	Julie Tom		
Address:	6/480 St Pauls Terrace, Fortitude Valley Qld 4006		
Signature:	Julie Tom		
Tel:	+61 407 195 085	Fax:	+61 7 3029 6650
Email:	Julie.Tom@smec.com	Website:	www.smec.com

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1 Introduction

1.1 Background of the Project

The New England Solar Farm is a 720MWAC development with storage, located approximately 6 kilometres (km) east of the township of Uralla, which lies approximately 19 km south of Armidale in the Uralla Shire Local Government Area (LGA). The New England Solar Farm will be constructed in three stages:

- Stage One: 400 MWAC solar farm including a 33/330kV substation and operations and maintenance building (O&M Building) located in the Northern Array area.
- Stage Two: 320 MWAC solar farm located in the Northern and Central Array areas with the AC capacity to be the remainder required to achieve a total AC capacity for the New England Solar Farm of 720 MWAC between Stages One and Two.
- Stage Three: Energy storage up to 200 MWAC consisting of battery energy storage, a pumped hydro plant, or other energy storage technology.

The Solar Farm will convert energy from solar radiation into electrical energy to be fed into the electricity grid. A series of PV Modules mounted on a horizontal single-axis tracking (Tracker) structure will convert solar radiation into DC electrical energy which will be fed into power conversion units (PCUs). Using inverters and step-up transformers, the PCUs will convert the DC electrical energy into AC electrical energy and inject it into an internal 33kV reticulation.

The internal 33kV reticulation will interconnect all PCUs composing the Solar Farm with a Solar Farm substation, which will step up the voltage to 330kV and connect to the existing 330kV Transmission line via a 330kV Switchyard that TransGrid will build adjacent to the Solar Farm Substation. Both the Switchyard and the Solar Farm substation will be common to all stages.

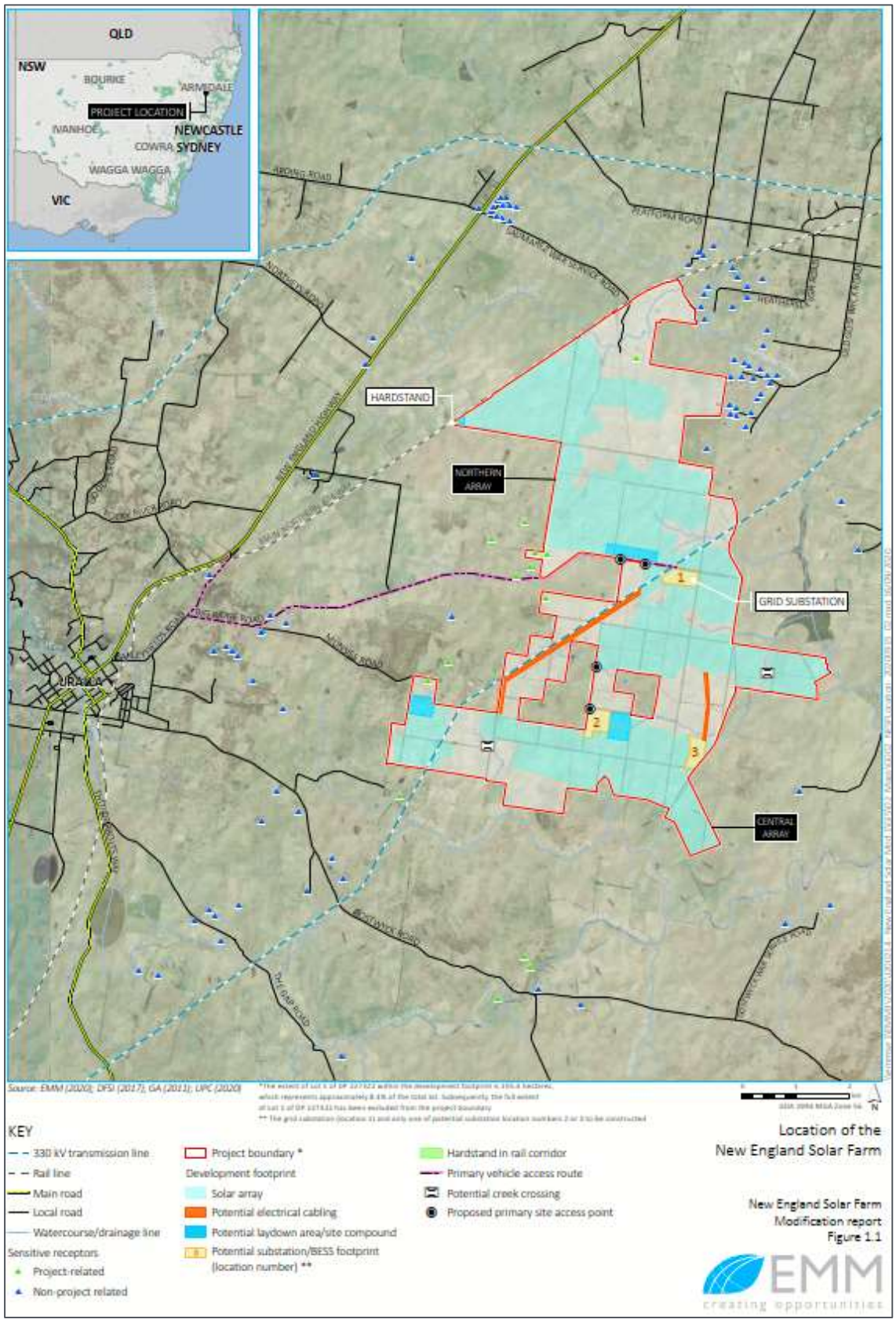
The New England Solar Farm components will include:

- Two solar field areas: Stage 1 and Stage 2;
- 33/330kV Solar Farm Substation;
- Transgrid 330kV Switchyard;
- Associated BESS(s);
  - operations and maintenance (O&M) infrastructure, including:
  - O&M buildings including a control room, meeting facilities, a temperature-controlled spare parts storage facility, supervisory control and data acquisition (SCADA) facilities, a warehouse/workshop and associated infrastructure (e.g. kitchen, toilets and other facilities); and
  - car parking facilities;
  - water supply and wastewater management system.
- Connection infrastructure between the two array areas (including underground or overhead cabling).
- A new internal road network to enable access from surrounding local roads to the array areas during construction and operations.
- Water tanks for firefighting and rainwater harvest.
- Weather Stations
- Security Fencing
- CCTV system to cover the solar fence with public access areas.
- Creek crossings (should they be required).
- Storm Water / Drainage system.
- Spoil soil stockpiles.

During construction, temporary site office compound and laydown areas will be established.

Figure 1-1 shows the location of New England Solar Farm (within the pink perimeter) and surrounding area.

Figure 1-1 New England Solar Farm Locality Plan



1.2 Purpose of the Traffic Management Plan

The purpose of the Traffic Management Plan (TMP) is to meet the requirements stipulated in Condition 6 of Schedule 3 of the Development Consent for the New England Solar Farm for Stage 1, hereafter referred to as 'the Project'. Further details of requirements relating to consent conditions are contained in Section 1.4.

1.3 Objectives of the Traffic Management Plan

The principal objectives of the TMP include the following:

- Preserve public safety
- Minimise public inconvenience
- Minimise adverse changes to the efficiency and accessibility of the road network
- Minimise impact on road users and asset operation
- Maintain the integrity of the public road network
- Engage with the community and other key stakeholders where changes to normal traffic conditions occur
- Minimise traffic interactions and appropriately manage traffic interfaces during the Project
- Management of heavy vehicles used for the delivery of solar farm components, equipment and materials to/ from the Project site, as well as the management of light vehicles associated with personnel working on the Project site.

1.4 Consent Conditions

Table 1-1 details the elements to be included in this TMP as required by Condition 6 of Schedule 3 of the Development Consent and reference to the specific sections of this TMP where each of the requirements are addressed.

Table 1-1 Traffic Management Plan Development Consent Requirements

TMP REQUIREMENTS	REFERENCE TO SCHEDULE 3 DEVELOPMENT CONSENT	WHERE ADRESSED IN TMP
Details of the transport route to be used for all development-related traffic	6 (a)	Section 2.4
A protocol for undertaking independent dilapidation surveys to assess the: • existing condition of Barleyfields Road and Big Ridge Road on the access route, prior to construction, upgrading or decommissioning activities; and • condition of Barley fields Road and Big Ridge Road on the access route, following construction, upgrading or decommissioning activities	6 (b)	Section 3.8
A protocol for the repair of Barleyfields Road and Big Ridge Road on the access route, if dilapidation surveys identify these roads to be damaged during construction, upgrading or decommissioning works	6 (c)	Section 3.9
Details of the road works required by condition 4 of Schedule 3 of the Development Consent	6 (d)	Section 2.5
A protocol for the maintenance of segments 4 and 5 of Big Ridge Road required by condition 5(f) of Schedule 3 of the Development Consent	6 (e)	Section 3.10
Details of the measures that would be implemented to minimise traffic impacts during construction, upgrading or decommissioning works , including:	6 (f)	

TMP REQUIREMENTS	REFERENCE TO SCHEDULE 3 DEVELOPMENT CONSENT	WHERE ADRESSED IN TMP
Temporary traffic controls, including detours and signage		Section 3.11
Notifying the local community about project-related traffic impacts		Section 3.6
Procedure for receiving and addressing complaints from the community about development-related traffic		3.26
Minimising potential for conflict with school buses, other motorists, road users and rail services as far as practicable		Section 3.12
Implement measures to minimise dirt tracked onto the public road network from development-related traffic		Section 3.13
Details of the employee shuttle bus service and measures to encourage employee use of this service		Section 3.14
Scheduling of haulage vehicle movements to minimise convoy length or platoons		Section 3.15
Responding to local climate conditions that may affect road safety such as fog, dust, wet weather and flooding		Section 3.16
Responding to any emergency repair or maintenance requirements		Section 3.9 and 3.10
A traffic management system for managing over-dimensional vehicles		Section 3.17
A driver's code of conduct that addresses: • Travelling speed • Driver fatigue • Procedures to ensure that drivers adhere to the designated transport route • Procedures to ensure that drivers implement safe driving practice, including consideration of other road users	6 (g)	Section 3.7
A program to ensure drivers working on the development receive suitable training on the code of conduct and any other relevant obligation under the Traffic Management Plan	6 (h)	Section 3.5

It is to be noted that relevant roads authorities, including TfNSW and Uralla Shire Council have been consulted and relevant sections of the Traffic Management Plan (TMP) have been updated based on feedbacks/comments received during consultation. Relevant correspondence with TfNSW and Council is provided in Appendix A of this TMP.

1.5 Duty of Care

The TMP together with other project level safety management plans addresses the duty of care on the part of UPC, GLC and sub-contractors who have an influence on the potential hazards associated with the Project to take reasonable care to protect the health and safety of others, including road users who may be at potential risk of harm.

1.6 Site Visit

In preparing this TMP a site visit was undertaken by a qualified person at the time of dilapidation inspection on 25th of August 2020 to assist with identification of site-specific conditions. This will enable full appreciation and consideration of TMP requirements.

1.7 Structure of the Plan

This section of the Plan describes the project and requirements of the TMP, as well as reference to the relevant section of the Plan where each of the requirements are addressed.

Section 2 provides review of development related traffic generation and vehicle routes to be used by the heavy vehicles to transport construction materials to the project site.

Section 3 provides information on TMP administration, induction, consultation/ notification requirements, detailed traffic management measures to be implemented during construction of NESF to manage heavy vehicle movements and to minimise adverse impacts on the road network, TMP review and improvement, as well as auditing and disciplinary procedures.

Section 4 provides a summary of the TMP.

2 Review of Development Traffic and Routes

2.1 Construction Period

Construction of the whole New England Solar Farm (NESF), including the northern array (Stage 1) and central array (Stage 2) is anticipated to take approximately 36 months. The Stage 1 area, including construction of the grid substation, would take approximately 25 months to complete.

2.2 Working Time

As stipulated in Schedule 3, Condition 12 of the Development Consent, working hours for construction activities are as follows:

- 7 am to 6 pm Monday to Friday
- 8 am to 1 pm Saturday
- No work on Sunday and other NSW public holidays.

2.3 Traffic Generation

2.3.1 Construction Stage

Table 2-1 shows the maximum estimated light and heavy traffic generated during the construction of the NESF.

Table 2-1 Construction related Traffic Generation

LIGHT VEHICLES (VPD*)		HEAVY VEHICLES (VPD)		TOTAL (VPD)	
IN	OUT	IN	OUT	IN	OUT
220	220	56	56	**276**	**276**

* VPD – volume per day

Source: Traffic and Transport Assessment, New England Solar Farm (SCT 2019)

As stipulated in Condition 1(a) of Schedule 3 of the Development Consent, the NESF must not generate more than:

- 56 heavy vehicle movements a day during construction
- 6 over-dimensional vehicle movements during construction

Also, as per the Condition 1(b) of Schedule 3 of the Development Consent, the length of any construction related vehicles (excluding OSOM) will not exceed 26 metres.

2.3.2 Operational Stage

As per Condition 1(a) of Schedule 3 of the Development Consent, the NESF must not generate more than 5 heavy vehicle movements per day during the operational stage. These heavy vehicle movements would only be required for infrequent repairs and maintenance, such as replacement of inverters and supply of water (water tankers). The length of heavy vehicles will not exceed 26 metres as stipulated in Condition 1(b) of Schedule 3 of the Development Consent.

2.3.3 Decommissioning Stage

The project generated daily and peak hourly traffic movements have not been calculated and assessed for decommissioning, as these movements are unlikely to exceed the daily and peak hourly project-related light vehicle and truck traffic movements generated during the construction stage, accounting for anticipated mechanical decommissioning processes and associated significantly reduced labour force.

2.4 Access Routes

The key components of the Project, including the solar panels, will be delivered to site via the Port of Brisbane. In this regard, heavy vehicle movements would travel from the north via New England Highway by-passing the Township of Armidale.

Some construction materials may be sourced from other areas, including Port of Sydney and/ or Port of Newcastle and associated heavy vehicles would travel to the site from the south through the Township of Uralla.

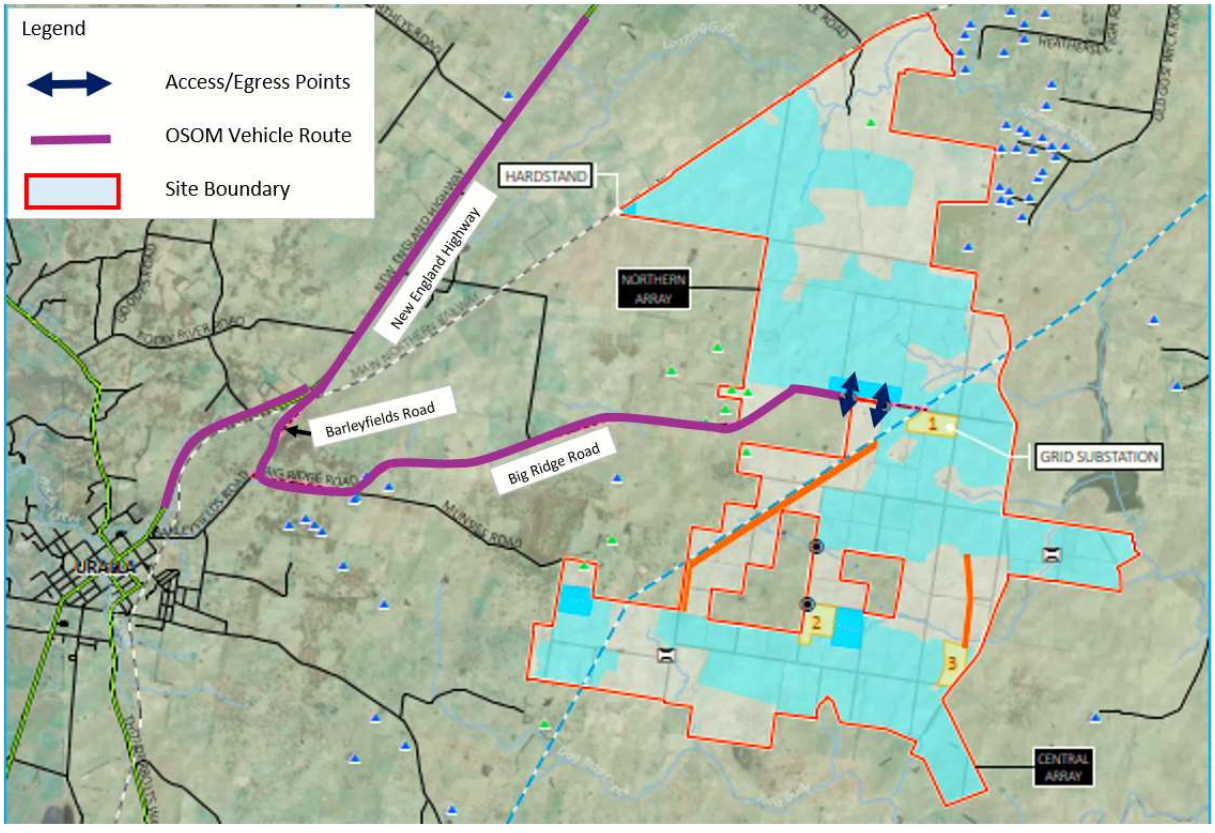
All heavy vehicles associated with the Project must travel to and from the construction site via the New England Highway, Barleyfields Road and Big Ridge Road as stipulated in Condition 3 of Development Consent. All construction related vehicles have to cross the level crossing located on Barleyfields Road approximately 130m south-east of New England Highway/Barleyfields Road intersection. This railway crossing will be upgraded, including road widening, to accommodate construction related vehicle movements. Design of this level crossing upgrade is currently being undertaken in accordance with the Development Consent and relevant standards and endorsement by TfNSW will be required before the project can carry out the upgrades. Prior to commencing any works within the Country Rail Network (CRN) rail corridor on Barleyfields Road (North), GLC will obtain all necessary approvals and licences required to access and perform works within this rail corridor from the relevant rail manager.

2.4.1 Over Size Over Mass Vehicle Route

There will be a total of six high risk over-dimensional vehicle movements that occur during construction, which are required to transfer Substation Power Transformers from Port of Brisbane, or Port of Newcastle to the site. Over-dimensional vehicles travelling from the north will turn left from New England Highway into Barleyfields Road to access the site (Figure 2-1). OSOM vehicles coming from south (Sydney and/or Newcastle) will turn right at the New England Highway/Barleyfields Road intersection to access the site. The New England Highway is a designated OSOM vehicle route and, as such, the geometry of this road is adequate to accommodate OSOM vehicle movements.

All OSOM vehicles will turn left at the Barleyfields Road/ Big Ridge Road intersection to access the project site. Whilst the New England Highway is a designated Over Size and Over Mass (OSOM) vehicle route, Barleyfields Road and Big Ridge Road are not designated OSOM routes. Conditions and loading capacities of these roads have been assessed. In particular, the haulage roads will meet TransGrid's transformer transport road specifications, which ensures the heaviest equipment can safely be accommodated by the road upgrades. Additionally, all OSOM movements will need to be approved by NHVR which will examine road suitability before approving and permitting the use of OSOM vehicles on the haulage route. Refer to section 3.17 for further details on the permitting requirements of OSOM vehicles.

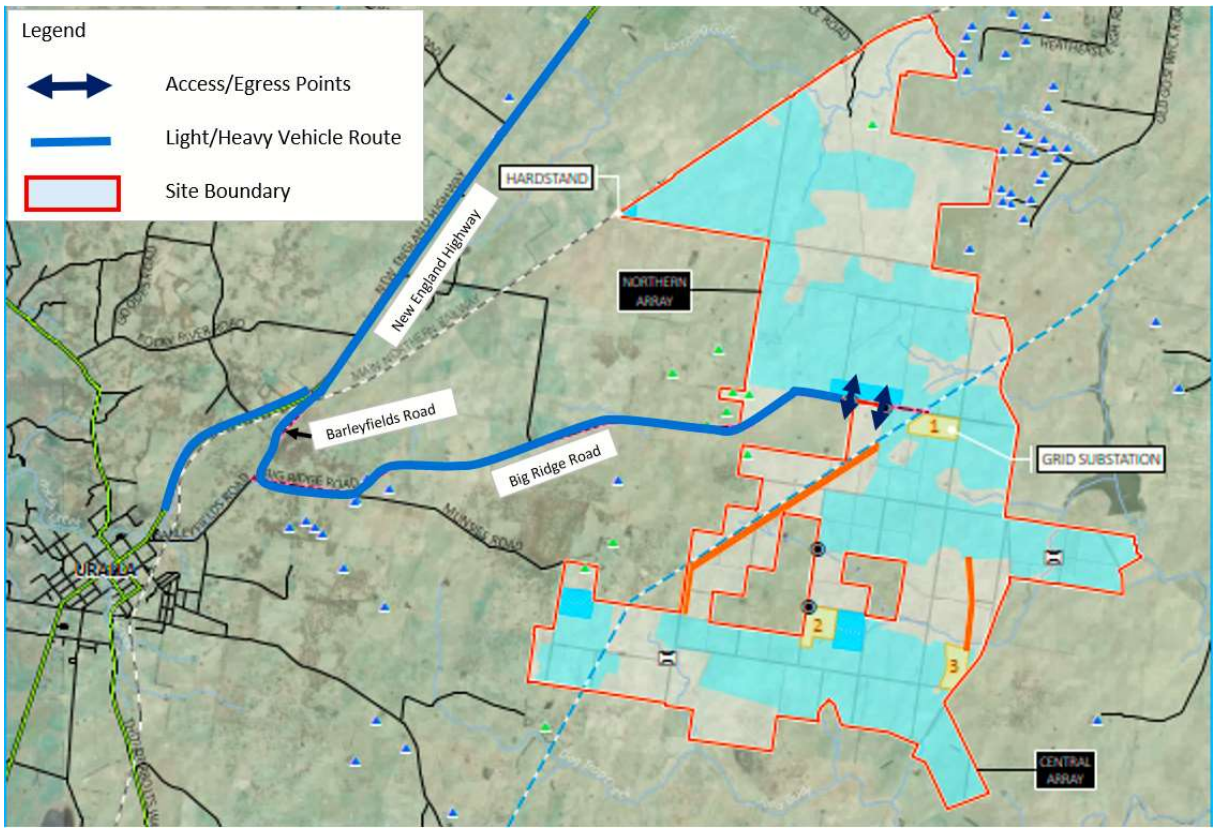
Figure 2-1 Over-Size Over Mass Vehicle Route to NESF Site



2.4.2 Other Traffic Routes (Light and Heavy)

Figure 2-2 shows the heavy and light vehicle routes to access the site. All heavy and light vehicles associated with the development must travel to and from the site via the New England Highway, Barleyfields Road (north) and Big Ridge Road, as shown in the figure.

Figure 2-2 Light and Heavy Vehicle Access Routes to NESF Site



2.5 Proposed Infrastructure Upgrades

Table 2-2 shows the road upgrade/repair works that will be undertaken on the access roads prior to construction of the NESF project, as stipulated in the Appendix 4 of Development Consent

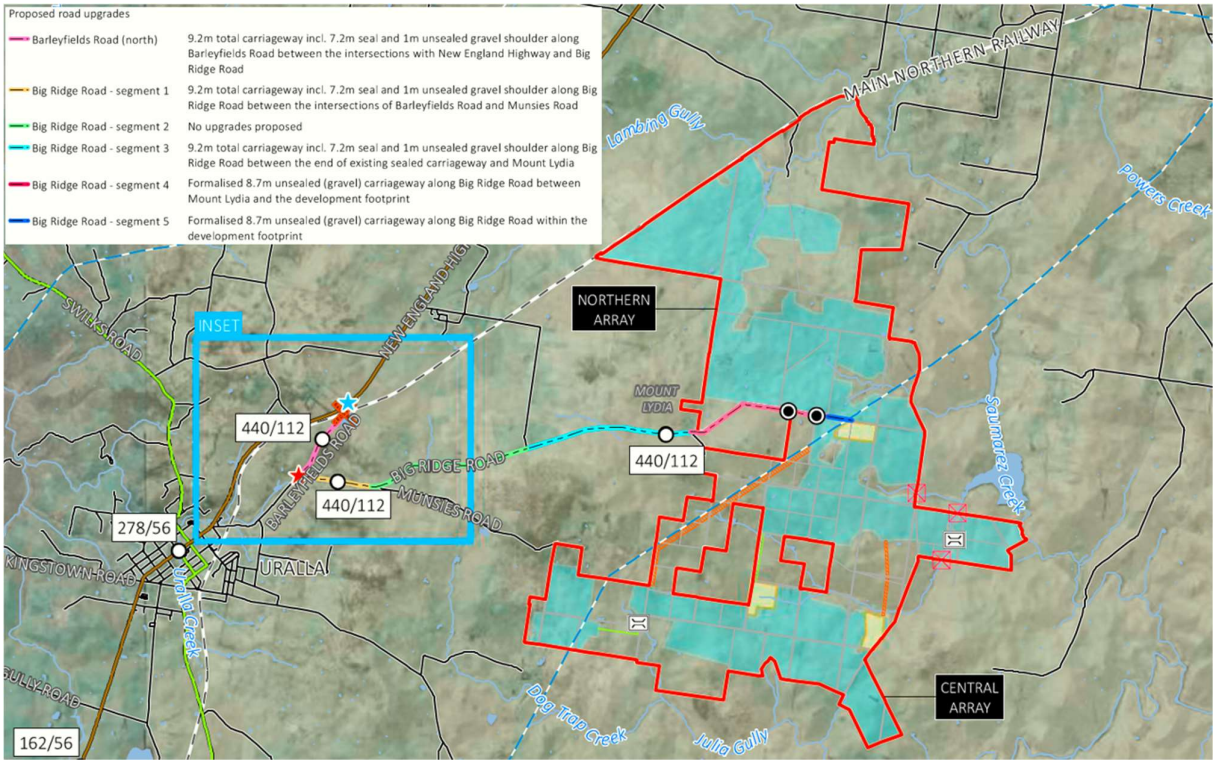
Table 2-2 Required Road Upgrades on New England Highway, Barleyfields Road and Big Ridge Road

ROAD	LOCATION	REQUIRED UPGRADE	TIMING
New England Highway and Barleyfields Road (north)	Intersection	Channelised Right Turn with a short turn slot [CHR(S)] treatment for the largest vehicle accessing the site (excluding over-dimensional vehicles)	Prior to construction
Barleyfields Road	Between New England Highway and Big Ridge Road	Seal to a width of 7.2 m with 1 m unsealed shoulders (total carriageway 9.2 m)	
Barleyfields Road and Big Ridge Road	Intersection	Basic Left Turn (BAL) treatment to cater for the largest vehicle accessing	

ROAD	LOCATION	REQUIRED UPGRADE	TIMING
		the site (excluding over-dimensional vehicles)	
Big Ridge Road	Segment 1	Seal to a width of 7.2 m with 1 m unsealed shoulders (total carriageway of 9.2 m)	
	Segment 3		
	Segment 4	Gravel (unsealed) carriageway to a width of 8.7 m	
	Segment 5		
	Site access points	Rural property access type	

Figure 2-3 shows the location of Barleyfields Road and Big Ridge Road segments where the abovementioned road upgrade works need to be undertaken.

Figure 2-3 Location of Barleyfields Road and Big Ridge Road Segments



Source: Appendix 4, NESF Development Consent

All road upgrades will be undertaken in accordance with the Austroads Guide to Road Design and in consultation with and to the satisfaction of the relevant road authorities, including TfNSW and Uralla Shire Council. Special consideration will also be given to ensure that the capacity of the roadside drainage network relating to the abovementioned roads is not reduce.

It is to be noted that a shortening of the conditioned Austroads treatment from a Channelised Right Turn (CHR) to a shortened Channelised Right Turn (CHR-S) will be implemented at the New England Highway intersection with Barleyfields Road. A CHR-S treatment, in comparison to a CHR treatment reduces the storage capacity for vehicles waiting to turn right from the highway during peak project construction periods. The shortened storage lane

introduces an increased risk of overflow of the right turn bay. In the event of overflow of the right turn bay, waiting vehicles would be placed in the northbound lane of the highway in a 100k/h speed environment.

The following management measures will be implemented to mitigate the risk associated with the Shortened Channelised Right Turn (CHR-S) treatment at the New England Highway intersection:

- *Implementation of a traffic forecasting and scheduling regime*, which aims to meet the key objective of construction traffic not exceeding the capacity of the CHR-S's storage lane.
- *Implementation of a "drive-by" measure for northbound project-related vehicles on New England Highway*. Such vehicles, who intend to turn right into Barleyfields Road but encounter insufficient space in the right-turn storage lane due to other vehicles already being present in the storage lane, must continue straight towards Armidale. The vehicle must then drive 14km north to the New England Highway/Uralla Road roundabout located on the New England Highway, prior to Armidale. At this roundabout, the vehicle will be able to perform the equivalent of a U-turn manoeuvre by navigating around the large roundabout. Upon exiting the roundabout, the vehicle will then travel in a southbound direction on the New England Highway and turn left at the intersection with Barleyfields Road, then continue to site via the approved access route
- *If required, implementation of Traffic Control Plans (TCP's)* to assist in managing vehicle movements through the intersection.

A separate Construction Traffic Management Plan (CTMP) will be prepared by the principle contractor prior to the construction of the abovementioned road upgrade works.

2.6 Internal Roads and On-site Parking Facilities

All internal roads will be designed as all-weather roads and will be constructed in accordance with the Austroads Guide to Road Design.

A loading/unloading facility will be provided to load and unload vehicles on site. All construction related heavy vehicles will enter and leave the site in a forward direction.

Sufficient number of temporary on-site parking facilities will be provided near the temporary lay down area during the construction stage of the Project. Permanent on-site parking facilities will be provided for staff vehicles and other vehicles near the Operation and Maintenance Building.

2.7 Swept Path Analysis

Swept path analysis has been undertaken at the following locations:

- New England Highway/ Barleyfields Road Priority Intersection
- Barleyfields Road/ Big Ridge Road Priority Intersection
- Other critical locations on Barleyfields Road and Big Ridge Road along the heavy vehicle routes.

Note: Sight distances have been considered in the design.

2.7.1 New England Highway/ Barleyfields Road Priority Intersection

Figure 2-4 shows the swept path analysis for the New England Highway/ Barleyfields Road priority intersection using a 26m B-double truck type heavy vehicle. As shown in the figure, heavy vehicles are encroaching the kerb line, while turning right into Barleyfields Road from New England Highway.

The intersection will experience an increase in both traffic volumes and size of vehicle using Barleyfields Road to access the NESF during both construction and operation. As such, this intersection will be upgraded to provide a short channelised right turn lane [CHR-S] in the northbound direction. This coupled with the existing auxiliary left turn lane (AUL) in the southbound direction will enable the increased traffic volumes during construction to turn from these auxiliary turn lanes with minimal impact to general through traffic on the New England Highway.

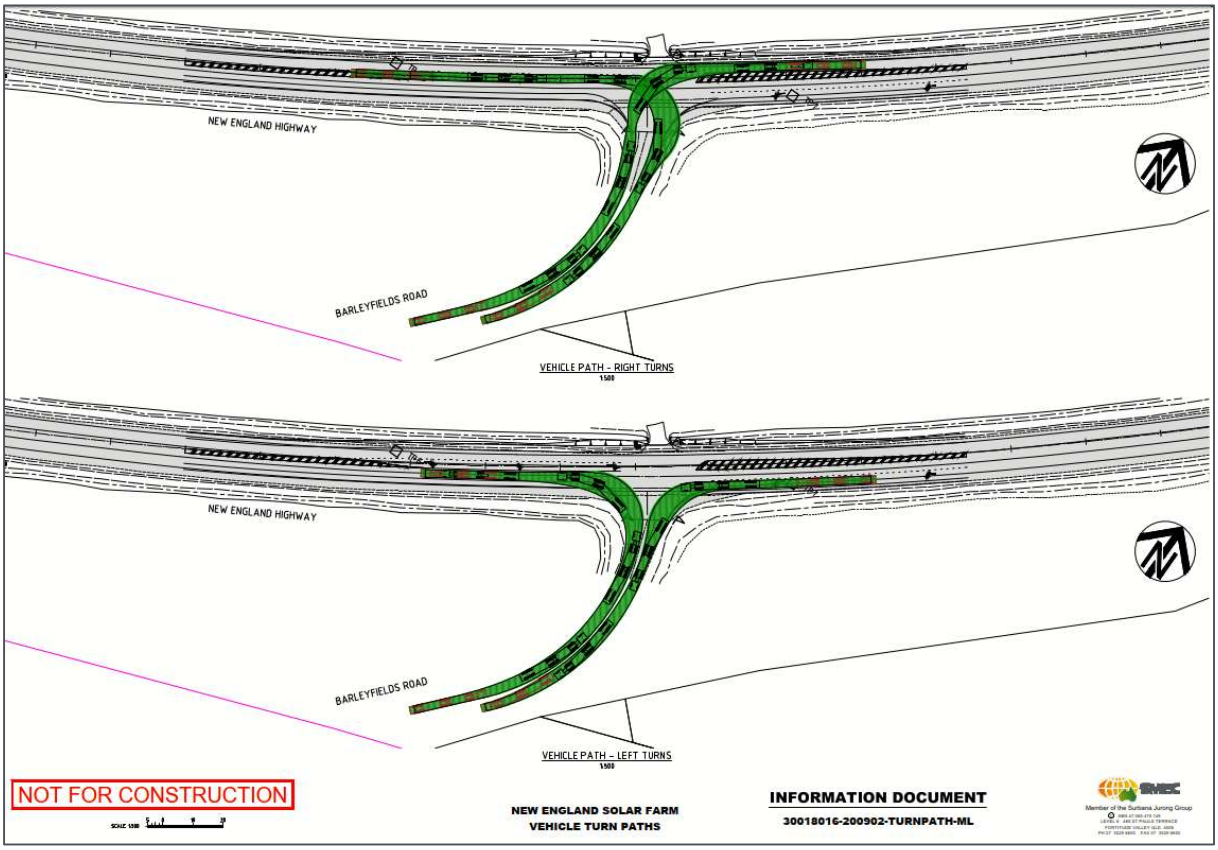
The project is required to regularly cater for up to 26 m B-doubles, however currently Barleyfields Road is not an approved B-double route, according to the TfNSW Restricted Access Vehicle Map, and is, therefore, being upgraded. The current intersection upgrade design demonstrates that the swept path of the 26 m B-double is contained fully within the existing pavement footprint, however the vehicle tracks over the edge lines for both left-in and right-in movements and currently also conflicts with a vehicle waiting on Barleyfields Road to turn out onto the New England Highway resulting in the required widening and re-line marking works that are currently in progress. Additional widening works will be undertaken to upgrade Barleyfields Road to two 3.6 m lanes and 1 m shoulder on either side

and will be required to interface at a point at the intersection which allows for appropriate design vehicle movements to and from the New England Highway.

The National Heavy Vehicle Regulator will be consulted, and a request lodged to use Barleyfields Road and Big Ridge Road if 26m B-Double vehicles or larger are to be used for the project.

In case of vehicles larger than 26 m, the necessary project approvals will be sought with specific control measures.

Figure 2-4 Swept Path Analysis of New England Highway/ Barleyfields Road Priority Intersection



2.7.2 Barleyfields Road/Big Ridge Road Intersection

Figure 2-5 to Figure 2-7 shows swept path analysis for Barleyfields Road/Big Ridge Road intersection as well as critical turning locations on Big Ridge Road using a 26m B-double truck type heavy vehicle. The swept paths undertaken along Barleyfields Road and Big Ridge Road generally indicate suitability for the movement of 26 m B-doubles to and from the intersection with New England Highway.

Figure 2-5 Swept Path Analysis of Barleyfields Road/Big Ridge Road Priority Intersection



Source: New England Surveying and Engineering

Figure 2-6 Swept Path Analysis of Big Ridge Road (approximately 6.85 km east of Barleyfields Road/Big Ridge Road Intersection)



Source: New England Surveying and Engineering

Figure 2-7 Swept Path Analysis of Big Ridge Road (approximately 7.6 km east of Barleyfields Road/Big Ridge Road Intersection)



Source: New England Surveying and Engineering

3 Traffic Management Plan

3.1 Introduction

This section provides information on TMP registers, administration, induction, consultation/ notification requirements, detailed traffic management measures to be implemented during construction of NESF to manage heavy vehicle movements and to minimise adverse impacts on the road network, TMP review and improvement, as well as auditing and disciplinary procedures.

3.2 TMP Registers

Registers to allow for implementation and effective maintenance of the TMP throughout the duration of construction will be prepared by GLC and are detailed in Table 3-1.

Table 3-1 TMP Registers

REGISTER TYPE	DESCRIPTION
Key personnel register	This register will identify all key personnel and provide contact details for UPC, GLC, the Project Manager, Site Supervisor, key subcontractors, as well as contact details for relevant roads authorities.
Incident register	The incident register will record all incidents that occur on site, including date and time of the incident, date-stamped photographs of signs and devices in the vicinity of the incident.
Variations register	The purpose of the variations register will be to record any modifications to approved traffic management measures, including reason for the modification, date and time of modification and residual risk.
Maintenance Log/Register	The purpose of maintenance log/register is to record findings of periodic road inspections and road conditions in order to identify required maintenance/repair works
Complaints register	The complaints register will record any complaints received including party making the complaint, contact details, nature of the complaint, and any follow up actions that have been identified and subsequently taken.
Consultation register	Contact details for key stakeholders who have been consulted during the preparation of the TMP will be recorded in this register. An overview of the main issues raised during consultation will also be provided for each of the consultees.
Vehicle register	A register to keep accurate records of the number of over-dimensional and heavy vehicles entering or leaving the site each day for the duration of the project to ensure compliance with Schedule 3 of the Development Consent.

3.3 Roles and Responsibilities

A summary of key personnel on the project, including roles, responsibilities and contact details is provided in Table 3-2 below.

Table 3-2 TMP Roles and Responsibilities

ROLE	RESPONSIBILITIES	CONTACT DETAILS
Site Supervisor	The Site Supervisor is responsible for overseeing day-to-day activities and has responsibility for practical application of the TMP. The Site Supervisor's responsibilities include:	Liam Carusi (GLC)

ROLE	RESPONSIBILITIES	CONTACT DETAILS
	– Facilitate induction of all project staff, including construction personnel and sub-contractors – Instruct workers on the relevant safety standards, including the correct wearing of high visibility safety vests – Ensure traffic control measures are implemented and maintained in accordance with the TMP – Render assistance to road users and stakeholders when incidences arising as a result of the Project affect network performance or the safety of road users and workers – Take appropriate action to correct unsafe conditions, including any necessary modifications to the TMP.	
Traffic Management Co-ordinator	– Implement the TMP – Amend the TMP, if required, – Manage variations and contingencies and take overall responsibility for traffic management.	Matt Reilly (GLC)
Emergency Response Co-ordinator	– Manage emergency situations	To be provided by GLC
Workers and Subcontractors	– Correctly wear high visibility vests, in addition to other protective equipment required (e.g. footwear, eye protection, helmet sun protection). – Comply with the requirements of the TMP and ensure no activity is undertaken that will endanger the safety of other workers or the general public – Enter and leave the site by approved routes and in accordance with safe work practices. – Schedule travel in advance in agreement with Traffic Management Co-ordinator for heavy vehicles and OSOM	To be provided by GLC
Community Liaison Officer	– Recording and actioning of complaints during construction.	To be provided by GLC

3.4 Work Health and Safety and Occupational Health and Safety Arrangements

The NESF construction site is to be managed under GLC's Workplace Health and Safety (WH&S) Management System.

Road works construction and associated road upgrades are to be managed under GLC's Workplace Health and Safety (OH&S) Management System and related safety management plans prepared by relevant sub-contractors.

Reporting, tracking and corrective action implementation associated with hazards, near-misses and incidents will take place in accordance with GLC's Workplace Health and Safety Management system.

3.5 Induction for Vehicle Operators and Regular Toolbox Meetings

Induction to the Traffic Management Plan will be undertaken by all project staff, including construction personnel and sub-contractors and will be a condition of engagement.

The purpose of the induction is to provide general awareness of the requirements of the Traffic Management Plan in order that the Plan may be implemented prior to commencement of works and to ensure that employees and sub-contractors are aware of the need to comply with the Plan.

The induction will have both an online component and an on-site component. All project staff will be required to complete the online component prior to accessing site. The on-site component will be completed by project staff upon their arrival to site.

Key actions and requirements of staff depending on work to be undertaken will be detailed and an opportunity provided for clarifications to be made, should this be necessary.

The aim of the online induction is to provide project staff the necessary information required to safely access the site as well as ensuring site access occurs in conformance with the conditions of the development consent. The online induction will include:

- Inform the participants of the "drive-by" measure to be executed where the CHR-S storage lane is occupied. Site-wide communications such as pre-start and toolbox talks will include reinforcement of the "drive-by" measure to be undertaken when the CHR-S storage lane occupied
- The permitted access routes to and from the construction site for site staff and delivery vehicles
- The need to adhere to local speed limits
- Standard environmental, WH&S, driver protocols and emergency procedures
- Informing drivers about the narrow bend section of Big Ridge Road after Munsies Road where drivers shall slow down their vehicle speed to pass and radio signalling the traffic co-ordinator prior to approaching the site in order for traffic co-ordinator to hold any departing vehicles from the site to ensure safe and efficient traffic movements.

Ongoing toolbox talks will highlight specific measures for activities being undertaken, which will include site-specific briefings for relevant personnel. The toolbox talks will also include daily weather forecasts and procedures to be followed during any adverse weather conditions as well as reinforcement of the "drive-by" measure to be undertaken at the New England Highway intersection when the CHR-S storage lane occupied.

A point of contact will be provided for any queries that workers may have, and the change management procedure explained so that workers know how changes to the Plan over time will be disseminated.

An audit process will be implemented to ensure driver compliance with the requirements of the Plan and details of enforcement protocols provided should drivers breach restrictions applied.

3.6 Consultation/ Notification Requirements

3.6.1 Consultation

GLC will consult with local community representatives, landowners and statutory consultees, as required, before and throughout the construction period. This will be undertaken by way of direct communication with relevant stakeholders, as well as by way of sign boards, leaflets distributed to community facilities and community liaison led by the community liaison officer.

To date consultation has been undertaken with TfNSW and Council. Comments on a draft version of the TMP have been received from TfNSW, which are addressed in this TMP. Council have also responded and indicated they propose no amendments to the TMP. In this regard, email correspondence from both TfNSW and Council are included in Appendix A.

3.6.2 Notification

The local community and other relevant stakeholders will be provided information about proposed and ongoing activities and impacts, in particular, those which could have potential to cause disruption, such as abnormal load deliveries.

GLC will set up a 'steering group' prior to construction, which will operate throughout the construction phase and will include UPC, GLC, TfNSW, Uralla Shire Council, the Police and community representatives to ensure pro-active notification of all transport issues and impacts, proposed management and mitigation, as well as to ensure stakeholder concerns are appropriately addressed.

In addition, a telephone number will be made available during operational hours and persons with appropriate authority to respond to calls and resolve any problems will be made available.

3.7 A Driver's Code of Conduct

Heavy vehicle drivers hauling for the NESF must:

- Undertake a visitor induction carried out by an approved member of project staff, or suitably qualified person under the direction of NESF management, which is discussed in Section 3.5.
- Hold a valid driver's licence for the relevant class of vehicle
- Operate the vehicle in a safe manner within and external to the project site
- Comply with the direction of authorised site personnel when within the site
- Comply with any specific traffic control measures implemented for the NESF on the internal and external road networks. This includes any traffic control measures which ensures the safe and efficient operation of the CHR(s) treatment for the New England Highway and Barleyfields Road intersection. These measures will be outlined in the Traffic Control Plan.
- Review a map of the local haulage route which shows any constraints or conditions along the roads.

The designated heavy vehicle routes will be discussed with all vehicle operators during the induction process as discussed in Section 3.5. Regular toolbox talks will emphasise the importance of safe driving and adherence to local posted speed limits and penalties for any valid complaints including speeding and inappropriate driving behaviour.

3.7.1 Vehicle Speeds

Increased speed means an increase in the risk of a crash, as well as an increase in severity if an accident occurs. A study undertaken for the Australian Transport Safety Bureau found that travelling 10 km/h faster than the average traffic speed can more than double the risk of involvement in a casualty accident.

There are two types of speeding:

- Where a vehicle travels faster than the posted speed limit; and
- Where a driver travels within the speed limit but because of road conditions (e.g. fog or rain) this speed is inappropriate.

All posted speed limits are to be strictly adhered to at all times. The existing speed limit on Barleyfields Road and Big Ridge Road is 80 km/h. A temporary speed limit reduction will be implemented on these roads for the duration of construction of the solar farm to enhance and ensure appropriate road safety. The details of the reduced speed limit and other safety measures will be discussed with TfNSW and Uralla Shire Council as part of the Traffic Control Plan.

Vehicle speed on public roads is enforced by the NSW Police Service. There are three types of penalties established under Heavy Vehicle National Law and Regulations (HVNL):

- Infringeable offences – an offence which results in the issue of an infringement notice. It gives the person issued the notice the option of either paying the penalty set out in the notice or electing to have the matter dealt with by a court.
- Court imposed penalties – some offences are not infringeable and must be dealt with by a court. The HVNL sets out the maximum penalty level that the court may apply.
- Demerit points – are managed through each state and territories' road traffic law (NHVR, Penalties and infringements, 2017).

All vehicle drivers operating out of the NESF project site are to observe the posted speed limits, with speed adjusted appropriately to suit the road environment and prevailing weather conditions, to comply with the NSW Road Rules & Heavy Vehicle National Law. Vehicle speeds must be appropriate to ensure the safe movement of vehicles based on vehicle configuration.

3.7.2 Heavy Vehicle Driver Fatigue

Driver fatigue or drowsy driving is a safety hazard for the road transport industry. The main causes of fatigue are not enough sleep, driving at night (during sleeping hours) and working or being awake for a long time (NHVR, 2017). It is one of the biggest causes of accidents for heavy vehicle drivers. National heavy vehicle driver fatigue laws apply to fatigue-regulated heavy vehicles, which are:

- A vehicle with a Gross Vehicle Mass (GVM) of over 12t
- A combination when the total of the GVM is over 12t
- A truck or a combination including a truck, with a GVM of over 12t with a machine or implement attached.

Under the law, working hour options for fatigue management are:

- Standard hours
- Basic fatigue management
- Advanced fatigue management

All heavy vehicle drivers operating out of the NESF project site are to be aware of their adopted Fatigue Management Scheme and operate within its requirements. By law, all drivers have a duty to not drive a fatigue-regulated heavy vehicle on a road while impaired by fatigue.

3.8 Dilapidation Survey Methodology and Protocol

The purpose of undertaking dilapidation surveys is to document the condition of Barleyfields Road and Big Ridge Road prior to and following construction, upgrading or decommissioning of the NESF.

3.8.1 Methodology

The dilapidation survey will be undertaken by a qualified person. The survey will be conducted during daylight hours in clear weather and will include both sealed and unsealed roads. To gather sufficient evidence for the dilapidation survey, GoPro cameras, or similar should be used and attached to the survey vehicle. Cameras should be used to capture the road pavement, as well as the left and right side of the road surrounds, including GPS encoding. The GPS must be overlaid onto images to provide a deliverable that can be viewed on any standard PC.

Videos require to be reviewed by trained technical inspectors and any visible defects logged with a still image from the video, location and description all entered into a register. This serves as a record of the condition at a specific point in time.

3.8.2 Protocol

3.8.2.1 Reporting

A suitably qualified civil engineer with road design and construction experience will review any defects recorded in the register prepared during the dilapidation survey.

A pre-assessment survey of Barleyfields Road and Big Ridge Road conditions has been undertaken by a qualified person and the findings of are summarised in the 'Road Dilapidation Survey' report (dated: 30 September 2020).

A dilapidation report will be prepared, which will specify the need, or not, for any requisite road repair works, including details of the rehabilitation works.

A dilapidation survey will be performed at the following milestones:

- At the completion of the access road upgrades.
- At the completion of construction.
- Prior to any upgrading activities.
- At the completion of any upgrading activities.
- Prior to any decommissioning activities.
- At the completion of decommissioning activities.

The dilapidation report will be submitted to Uralla Shire Council for its concurrence.

3.8.2.2 Consultation

Uralla Shire Council is responsible for the operation and maintenance of Barleyfields Road and Big Ridge Road. A representative from Uralla Shire Council will be invited to participate in the future dilapidation inspections, as appropriate.

3.9 Protocol for Barleyfields Road and Big Ridge Road Repair Works

A dilapidation survey will be undertaken prior and post construction of the solar farm. In addition to dilapidation surveys, road condition inspections will be carried out by GLC every two months during construction stage.

The condition of Barleyfields Road and Big Ridge Road after the solar farm is constructed will be compared to their condition prior to the commencement of construction.

Any degradation in the condition of the road, as identified through differences evident in the pre and post construction dilapidation surveys, will effectively become the road repair works required.

GLC will then lodge a road opening permit application to undertake the works with the Uralla Shire Council, with the 'extent of proposed works' cross referenced back to the Dilapidation Report.

3.10 Protocol for Maintenance of Segment 4 and 5 of Big Ridge Road

Maintenance of Section 4 and 5 of Big Ridge Road during the operational stage of the Project (Stage 1) will follow the general principles provided in Chapter 8 of the Austroads Guide to Pavement Technology (AGPT) Part 6. In particular:

- A visual inspection of the road shall be carried out every 2 years by an inspector with a minimum of 5 years' experience in road maintenance.
- The South African Approach (Section 8.5.1) shall be used to classify the road condition. A copy of the Draft TMH12 is provided in Appendix B.
- The Type, degree and extent of distress shall determine the intervention to be followed - see Table 3-3 below as a guide.
- Interventions shall be undertaken on road segments that are classified as poor and very poor

Table 3-3 Road Distress Type and Potential Interventions

DISTRESS TYPE	PATROL GRADING	RIP AND RESHAPING	REGRAVELLING	DUST SUPPRESSION	RECONSTRUCTION
Loss of gravel			X		X
Potholes		X			
Rutting		X	X		
Erosion		X	X		
Corrugations	X	X			
Loose material	X				
Stoniness		X	X		
Dust	X			X	
Cracking		X	X		X

Segment 4 and 5 of Big Ridge Road will be maintained to the standard identified in Appendix 4 of the Development Consent and Section 2.5 of this TMP for the life of the development.

3.11 Temporary Traffic Controls, including Signage

The principal contractor will develop a Traffic Control Plan (TCP) (prepared by a suitably qualified person) which will show type and location of temporary signage on Barleyfields Road and Big Ridge Road along the construction vehicle route. This temporary signage will include a reduction in the posted speed limit as described in Section 3.7.1 of this Plan. The TCP shall also include installation of signage in the vicinity of the New England Highway/Wood Street intersection and the Big Ridge Road/Barleyfields Road intersection to advise drivers that Barleyfields Road (south) is off limits for construction related vehicles.

Flagging and temporary signage will also be required to ensure drivers are aware of the location of the gatekeepers' residence in the vicinity of the rail crossing on Barleyfields Road, given its close proximity to the road and potential accidental damage.

TfNSW and Uralla Shire Council will be consulted as the TCP is being developed and prior to its implementation. In particular TfNSW will be required to approve proposed traffic signs on the New England Highway. The principal

contractor will seek formal direction from relevant roads authorities for installation of any temporary signage, including restoring the existing speed limit on completion of the Project.

3.12 Safety Initiatives for Transport through Residential Areas and/or School Zones

Before construction starts, local and regional schools will be consulted, where appropriate, for current bus timetables on relevant construction traffic routes. Suitable windows of inactivity (curfew times) will be arranged in agreement with the relevant schools and local Councils, which will apply to both heavy vehicles and over-dimensional deliveries. School bus routes will be reviewed at the beginning of each school term in consultation with the local and regional schools and Uralla Shire Council and, if required, updated windows of inactivity (curfew times) will be arranged.

The local road network is used by school buses during typical school pick up and drop off times. Staff vehicles are unlikely to conflict with school bus services, as they will be accessing and egressing the site prior to and after school hours.

Heavy vehicles will be scheduled to minimise any potential conflict with local school buses by confirming typical times buses run through the area and scheduling heavy vehicle deliveries outside of these times.

John Holland Rail/TfNSW have been consulted for information relating to rail services and frequencies. This information will be used to assist in design of the upgraded rail crossing facilities located on Barleyfields Road (North) and for scheduling of construction materials to the site in order to minimise any impacts on roads and potential queueing on Barleyfields Road (North).

3.13 Management of Dirt Tracked onto the Public Road Network

In order to minimise the impact of dirt tracked onto the public road network, wheel cleaning facilities will be put in place at the site for the duration of construction work. In addition, the Principal Contractor will carry out inspections and deploy where necessary a road sweeper on routes affected by construction traffic and at construction access points prior to commencement of construction and subject to regular review. The Contractor will also ensure a length of capped internal track prior to the public road is provided.

3.14 Management of Employee Shuttle Bus Service

Each company involved in the project will supply and operate their own minibuses. These minibuses will be used for transport to and from site and also for transport within the site. Each company will organise their own pick-ups and drop-offs. Prior to implementing a shuttle bus service, approval will be sought from Uralla Shire Council and TfNSW.

Further, there will be clauses in contracts to ensure private vehicles accessing site are minimised. A permitting process to bring a private vehicle to site may be implemented.

3.15 Scheduling of Haulage Vehicle Movements to Minimise Convoy Lengths or Platoons

The principal contractor will prepare a schedule for delivery of construction equipment and materials to site upon completion and finalisation of the construction program based on the total/daily number of constructions related heavy vehicle movements. In particular, scheduling for delivery of solar farm components from the Port will be undertaken to avoid convoy lengths or platooning on roads, including New England Highway, Barleyfields Road (North) and Big Ridge Road.

3.16 Responding to Local Climate Conditions

The principal contractor will liaise with construction personnel, sub-contractors and suppliers and develop a response to local climate conditions that may affect road safety, such as fog, dust, wet weather and flooding, which will be communicated to relevant parties, as appropriate.

This will include, but is not limited to the following:

- Monitoring of daily weather forecast and provision of a report to staff and heavy vehicle operators
- Inclusion of any adverse weather forecast in toolbox talk topics
- Watering of roads during dry conditions to ensure appropriate mitigation of dust

- Monitoring bush fire forecasts and conditions during the dry season and conveyance of relevant information, as appropriate.

3.17 Over-Size and Over Mass Vehicles (OSOM)

The site will generate up to six high-risk OSOM vehicle movements associated with the delivery of substation components. The delivery may occur from Port of Brisbane (from north) or from Sydney/New Castle (from south). The routes from Brisbane (from north) and Sydney/New Castle (from south) up to the New England Highway/Barleyfields Road intersection is an approved OSOM vehicle route and will be able to adequately cater for the OSOM movements generated as shown in Figure 2-1.

Barleyfields Road and Big Ridge Road are not approved OSOM routes and permission will be sought from relevant roads authorities for use these roads for OSOM vehicles.

Under the Heavy Vehicle National Law, when a heavy vehicle exceeds the general access class weights and/or dimensions a Permit for Heavy Vehicle Access must be obtained.

It will be the responsibility of the heavy vehicle operators involved in the project to obtain and manage their Permit for Heavy Vehicle Access in case it is required. To get the permit, the HV operators will need to lodge a permit application via the NHVR Portal and the NHVR will seek the relevant road managers consent.

The impact of OSOM deliveries will be managed under the use of pilot/escort vehicles as per TfNSW guidelines.

3.18 Framework for Handling/Approval of Exception (for emergency or other unforeseen circumstances) to the exclusion of heavy vehicles utilising the Barleyfields Road (south) during construction of the Project

In case of emergency closure of Barleyfields Road (north) during the construction of NESF, emergency vehicles will access the site using Barleyfields Road (south) via Wood Street, Uralla.

All construction related vehicles are restricted to use Barleyfields Road (south) via Wood Street, Uralla to access the site. Therefore, all construction related heavy vehicle movements to the site will be halted during emergency closure of Barleyfields Road (north) and will recommence following reopening of the road.

3.19 Coordination of Construction Traffic with Seasonal Agricultural Haulage

Due to the nature of agricultural activities in the area primarily consisting of livestock grazing, the agricultural haulage along Big Ridge Road is not heavily seasonally dependant, but rather sporadic in nature and irregular in frequency and volumes.

There currently exists no property access arrangements that need to be maintained during the upgrade of Big Ridge Road so that farming activities are not compromised. A Traffic Control Plan (TCP) will be implemented for the construction of the access roads, in consultation with the property owners who occupy property along Big Ridge Road. The TCP will incorporate the access needs of property owners.

3.20 Incident Procedures

Incidents that occur within an area subject to the Traffic Management Plan and/ or Traffic Control Plan will immediately be reported to GLC and TfNSW.

If a traffic incident occurs within a construction works zone or any other location affected by the works, this will be recorded and reported in accordance with the Roads and Maritime Traffic Control at Work Sites Technical Manual.

Reporting will include recording traffic controls in place at the accident site, including traffic control devices and location, as well as photographic evidence of the signage and incident. The record will be maintained and provided to GLC immediately and TfNSW within 2 days of the incident.

Actions arising from the investigation of the incident will be actioned through the report and immediately corrected for prevention of further incidents.

Serious incidents shall be notified to SafeWork NSW immediately as an urgent investigation may need to be undertaken. Serious incidents include:

- An incident where there has been a fatality

- An incident where there has been a serious injury or illness
- An incident where there is an immediate threat to life, such as major damage to machinery or buildings.

The area where the incident occurred shall not be disturbed and be barricaded for the undertaking of an investigation for up to 36 hours, except to assist any injured persons, to avoid further injuries and issues, or where SafeWork has authorised work to continue.

3.21 Emergency Arrangements

Section 3.18 addresses arrangements in case of emergency closure of Barleyfields Road (north) during the construction of NESF.

Emergency arrangements for the wider Project are addressed in the Fire and Emergency Management Plan, whilst emergency arrangements relating to specific road upgrade works will be addressed in individual CTMP's prepared by relevant sub-contractors.

3.22 Variation from Approved Traffic Management Plan

Revisions to the Traffic Management Plan will be in accordance with relevant requirements and will be made in consultation with TfNSW and other key stakeholders to ensure they remain relevant to the work being undertaken.

The Traffic Management Plan will be updated in response to the identification of hazards, near misses, incidents, accidents, or other processes and procedures that require clarification, or where deficiencies and improvement opportunities have been identified.

Any changes to the TMP will comply with the requirements of Condition 2 of Schedule 4 of the Development Consent.

Amendments will be submitted by GLC to all relevant authorities and all necessary approvals sought, as required.

When amendments are made the entire document will be updated. The revision number will be updated, and amendments recorded on a revisions sheet.

3.23 Traffic Management Plan Review and Improvement

GLC will undertake regular monitoring of traffic related construction activities and associated mitigation both on and off site in order to assess the performance and progress of the Traffic Management Plan.

An assessment of the road network will be undertaken before works start, as well as bi-monthly throughout the period of construction.

The monitoring will focus on determining the adequacy of proposed mitigation measures by assessing the performance of the plan against objectives, such as minimising road user delay, maintaining existing network performance and limiting construction impacts.

The monitoring will assist in determining the need for additional mitigation, if the original traffic management measures prove not to be fully effective. This will ensure that measures in place are effective and achieving desired and intended outcomes.

Further, the monitoring process will check that the safety of road users is being maintained.

Measures use to check compliance will include the following:

3.24 Traffic Management Plan Auditing

Independent audits will be undertaken as per the requirements set out in the development consent to review the performance and progress of the Traffic Management Plan.

Auditing will report on compliance with processes, procedures and directions provided in the Traffic Management Plan. Any non-conformances will be identified, and corrective measures recommended and actioned to prevent the incident occurring again.

Measures used to check compliance will include the following:

- On-site inspections to ensure compliance with site rules relating to movement and management of all vehicles, as well as with transport movement plans

- Off-site inspections to ensure compliance with traffic control plans, transport movement plans, temporary and permanent traffic management measures, nominated truck haulage routes, measures to manage trucks on routes with sensitive receptors and off-site staff parking

Bi-monthly auditing reports are to be maintained so as to provide evidence of conformity to the Traffic Management Plan.

3.25 Disciplinary Procedure

All contractors will be required to adhere to the TMP. GLC will stipulate that all contractors disseminate requirements of the TMP to their sub-contractors by means of a toolbox talk or similar type meeting prior to commencement of construction. Follow-up /refresher talks will be held if found to be necessary.

Failure to follow the procedures outlined in this TMP will lead to disciplinary/ enforcement as follows:

- First offence: Representative receives a yellow card and the supplier receives a warning letter.
- Second offence:
  - If by the same representative, then the representative receives a red card and is banned from site and the supplier receives a warning letter.
  - If by a different representative, then the second representative receives a yellow card and the supplier receives a warning letter.
- Second red card: Supplier will be removed from the applicant's approved supplier list.

3.26 Complaints Procedure

GLC is committed to managing traffic management related complaints from affected community members or stakeholders in a proactive and conciliatory manner. As such, the following measures will be available for community enquiries and complaints for the duration of construction:

- A 24-hour telephone number on which complaints and enquiries may be registered. This number allows stakeholders to have access to the project team during office hours. During construction, but after office hours, the number may be diverted to a paging system and referred to a member of the project team on a roster system
- A postal address to which written complaints and enquiries may be sent
- An email address to which electronic complaints and enquiries may be transmitted

The telephone number, postal address and the email address shall be published in the newspaper(s) circulating in the local area prior to the commencement of construction. This information shall also be provided on the Project website.

Relevant community and stakeholder groups will be progressively informed of the various stages of construction, particularly prior to significant construction generating activities. The community and stakeholders will be informed of the duration of works and the impacts that can be expected and a process will be implemented for registering and responding to complaints.

Any and every complaint will be documented through maintaining an up to date Complaints Register.

The Complaints Register will record:

- A complaint reference number
- The date and time the complaint was received
- Whether the complainant wanted to be contacted
- Nature of the complaint
- Status of the resolution of the complaint.

For the life of the NESF the Complaints Register will be updated on a weekly basis and listed on the NESF website.

As the Complaints Register will be a publicly available document, it is not proposed to include details of who the complainant is on this register.

The Complaints Record will record:

- The date and time of the complaint

- The means by which the complaint was made (telephone, mail or email)
- Any personal details of the complainant that were provided, or if no details were provided a note to that effect
- The nature of the complaint
- Any actions taken in relation to the complaint, including timeframes for implementing the action
- If no action was undertaken in relation to the complaint, the reasons why no action was taken
- If the complainant wanted to be contacted, and if so, whether the action taken was considered acceptable to the complainant.

A copy of every Complaints Record will be filed and held on-site and, on request, be provided to:

- DPIE
- Transport for New South Wales (TfNSW)
- Uralla Shire Council
- The complainant.

As the Complaints Record will contain information on who made the complaint, it is not proposed to make this information publicly available on the NESF website. As soon as is practicable GLC will investigate the cause of the complaint and identify actions required to avoid a recurrence. Regardless of the circumstance, this initial response will be completed with 24 hours of receiving the complaint. If so requested when the complaint was received, Green Light will also contact the complainant to discuss the issue, the cause and advise them of the actions taken to avoid a recurrence and any applicable timeframes to resolving the complaint.

This investigation and contact will be fully documented on a Complaint Record maintained by Green Light and the Complaints Register will be updated on an ongoing basis. Each month, the updated Complaints Register will be provided to UPC\AC Renewables for uploading onto the Project website.

4 Summary

This TMP has been prepared to satisfy Schedule 3 of the Development Consent, which requires a TMP along with other management plans to be provided.

The TMP sets out proposed traffic management and contingency planning measures to enhance road safety and limit the adverse effects of construction traffic on the surrounding road network.

UPC\AC Renewables, GLC and their sub-contractors will adhere to the proposed traffic management measures contained in this TMP. Any material deviation from the proposed measures will be agreed in writing with the relevant road's authorities prior to implementation.

Appendix A – Correspondence with TfNSW and Uralla Shire Council

Subject: Re: New England Solar Farm (SSD 9255) - Traffic Management Plan for review
Date: Friday, 22 January 2021 at 12:29:31 pm Australian Eastern Daylight Time
From: Tim Kirk
To: Development Northern
Priority: High
Attachments: image001.png, image002.jpg, image003.png, image004.png, NESF1-SMEC-CW-00GRL-PLN-001 - Rev4_UPC.docx

Hi Leisa,

Thank you for your comments. I have amended the Traffic Management Plan to address your feedback as attached.

Please give me a call today to discuss if UPC's responses are satisfactory.

Kind Regards,

Tim Kirk | Project Development Manager
UPC\AC Renewables Australia
A UPC Renewables and AC Energy Company

M: +61 403 857 079
E: tim.kirk@upc-ac.com
Hobart: Suite 2, Level 2, 15 Castray Esplanade, Battery Point, TAS 7004
Melbourne: 61 Cromwell Street, Collingwood VIC 3066
Sydney: Level 14, 77 King Street, Sydney, NSW 2000

www.upc-ac.com

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From: Development Northern <development.northern@rms.nsw.gov.au>
Date: Wednesday, 20 January 2021 at 4:42 pm
To: Tim Kirk <Tim.Kirk@upc-ac.com>
Subject: RE: New England Solar Farm (SSD 9255) - Traffic Management Plan for review

Afternoon Tim
Please find attached TfNSW response to your Draft TMP.
In addition to this response, I am currently drafting an email to DPIE regarding the OSOM vehicle quantities they have forwarded to us for comment.
If you have any questions regarding this matter, I am able to contacted on the number below, alternatively Matt Adams will return from leave during the week ending 5 February 2021.
Kind regards

Leisa Sedger
A/Manager, Land Use Assessment
Regional Customer Services | Region North
Regional & Outer Metropolitan Division
Transport for NSW

T 02 6640 1362 | **F** 02 6640 1304
Level 1, 76 Victoria Street, Grafton NSW 2460

From: Tim Kirk [mailto:Tim.Kirk@upc-ac.com]
Sent: Thursday, 7 January 2021 9:46 AM
To: Development Northern <development.northern@rms.nsw.gov.au>
Subject: Re: New England Solar Farm (SSD 9255) - Traffic Management Plan for review

Hi Matt,

Hope you enjoyed the festive season.

Can you please advise how you are tracking with your review of the Traffic Management Plan, as requested in my earlier email.

Kind Regards,

Tim Kirk | Project Development Manager
UPC\AC Renewables Australia
A UPC Renewables and AC Energy Company

M: +61 403 857 079
E: tim.kirk@upc-ac.com
Hobart: Suite 2, Level 2, 15 Castray Esplanade, Battery Point, TAS 7004
Melbourne: 61 Cromwell Street, Collingwood VIC 3066
Sydney: Level 14, 77 King Street, Sydney, NSW 2000

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From: Tim Kirk <Tim.Kirk@upc-ac.com>
Date: Tuesday, 15 December 2020 at 11:48 am
To: Development Northern <development.northern@rms.nsw.gov.au>
Subject: New England Solar Farm (SSD 9255) - Traffic Management Plan for review

Dear Matthew,

New England Solar Farm – Traffic Management Plan (TMP)

UPC/AC Renewables is seeking your feedback on the New England Solar Farm Traffic Management Plan (TMP). As you are aware, we are required by the NSW Department of Planning, Infrastructure, and Environment (DPIE) to consult with Transport for New South Wales (TfNSW) regarding the TMP before construction of the project can commence. Our construction contractor has prepared this plan, which is attached to this email.

We appreciate your support on this project to date and please let me know how long you will require to complete this review of the plan.

Kind Regards,

Tim Kirk | Project Development Manager
UPC\AC Renewables Australia
A UPC Renewables and AC Energy Company

M: +61 403 857 079
E: tim.kirk@upc-ac.com

Hobart: Suite 2, Level 2, 15 Castray Esplanade, Battery Point, TAS 7004
Melbourne: 61 Cromwell Street, Collingwood VIC 3066
Sydney: Level 14, 77 King Street, Sydney, NSW 2000

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20 January 2021

File No: NTH18/00058/16
Your Ref:

UPCAC Renewables
Level 14
77 King Street
SYDNEY NSW 2000

Attention: Tim Kirk – Project Development Manager

Dear Sir,

RE: State Significant Development SSD 9255
New England Solar Farm - Traffic Management Plan.

I refer to your email of 7 January 2021 requesting comment from Transport for NSW (TfNSW) in relation to the abovementioned Traffic Management Plan (TMP). TfNSW has reviewed the TMP and provides the following comments for your consideration;

- The proposed northbound CHR(s) on the New England Highway at North Baileyfields Road will only have a limited storage capacity for right-turning vehicles. Consideration needs to be given to how the safety and efficiency of the CHR(s) treatment will be managed in relation to storage capacity. This should be included in the Code of Conduct.
- *2.4 - Access Routes* - indicates the existing level crossing on North Barleyfields Road will be upgraded. The inherent details of this upgrade will need to be provided for review.

  If any work is undertaken between the level crossings stop lines, approval will be required from TfNSW prior to commencing work.

  Note: The heavy vehicle access route is incorrectly named Barleyfields Road, this will need to be corrected to read North Barleyfields Road.
- *2.4.2 – Other Traffic Routes (Light & HGV)* – Identified a proposal to use South Barleyfields Road. Clarification of the acronym HGV is required, however TfNSW was of the understanding that South Barleyfields Road was not to be used for access by any vehicles.

  If UPCAC are proposing to utilise South Barleyfields Road a safety assessment will need to be undertaken and submitted for review by TfNSW and Council.
- *2.6.1 - New England Highway/Barleyfields Road Priority Intersection* – This section indicates the largest design vehicle will be a 26m B-Double. Currently North Baileyfields and Big Ridge Road is not approved for use by 26m B-Doubles. A request will need to be lodged with the National Heavy Vehicle Regulator for consideration.
- *3.7 – Code of Conduct* - will need to include a map that shows any constrains or conditions relating to the local haulage route.

- *3.7.1 – Vehicle Speeds* – The TMP proposes a speed limit reduction to 40km/h for the duration of construction.

  North Barleyfields Road has an existing speed limit of 80km/h. Therefore, the proposal for a 40km/h speed limit for a long construction phase would have compliance issues.

  Please clarify if this is for the duration of the road upgrade; or, for the duration of stage 1 construction phase only.

- *3.11 – Temporary Traffic Controls, Including Signage* – The TMP has non standard signs proposed for installation on the New England Highway at the intersection of Wood Street, South Barleyfields and Big Ridge Road.

  Proposed signs on the New England Highway will require prior approval from TfNSW.

  Traffic Control Plans (TCPs) should be prepared by a suitably qualified person and included in the TMP.

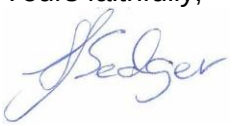
- *3.14 – Management of Employee Shuttle Bus Service* - details of the pick-up points and parking arrangements will be required to be submitted to the Council and/or TfNSW for comments prior to approval.

Any roadwork on classified (State) road/s is to be designed and constructed in accordance with the current Austroads Guidelines, Australian Standards and TfNSW Supplements.

It is emphasised that the following comments are based on the information provided to TfNSW at this time, they are not to be interpreted as binding upon TfNSW and further comment will be provided following formal review of the final Traffic Management Plan (TMP) when referred by the appropriate Consent Authority.

If you have any further enquiries regarding the above comments please do not hesitate to contact the undersigned on (02) 6640 1362 or via email at: development.northern@rms.nsw.gov.au

Yours faithfully,



for Leisa Sedger
A/Manager Land Use Assessment Northern
Regional NSW and Outer Metropolitan
Transport for NSW

Cc; Department of Planning Industry and Environment
GPO Box 39
SYDNEY NSW 2001

Attention: Lander Robinson

Subject: Re: NESF (SSD 9255) - Traffic Management Plan review email to Tim Kirk 21 January 2021
Date: Thursday, 21 January 2021 at 4:40:27 pm Australian Eastern Daylight Time
From: Tim Kirk
To: Matt Clarkson
Attachments: image001.png, image002.png, image003.png, image004.png

Great, thank you Matt.

Regards,

Tim Kirk | Project Development Manager
UPC\AC Renewables Australia
A UPC Renewables and AC Energy Company

M: +61 403 857 079
E: tim.kirk@upc-ac.com
Hobart: Suite 2, Level 2, 15 Castray Esplanade, Battery Point, TAS 7004
Melbourne: 61 Cromwell Street, Collingwood VIC 3066
Sydney: Level 14, 77 King Street, Sydney, NSW 2000

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From: Matt Clarkson <MClarkson@uralla.nsw.gov.au>
Date: Thursday, 21 January 2021 at 12:43 pm
To: Tim Kirk <Tim.Kirk@upc-ac.com>
Cc: Terence Seymour <TSeymour@uralla.nsw.gov.au>, 'Lander Robinson' <Lander.Robinson@planning.nsw.gov.au>, 'Iwan Davies' <iwan.davies@planning.nsw.gov.au>
Subject: RE: NESF (SSD 9255) - Traffic Management Plan review email to Tim Kirk 21 January 2021

Hello Tim

Council has reviewed the TMP and does not propose any amendments.

Regards
Matt Clarkson
Manager of Development and Planning

Uralla Shire Council | Po Box 106 Uralla NSW 2358
p 02 6778 6310 | **f** 02 6778 6349 | **m** 0419 861 719

URALLA SHIRE COUNCIL

From: Tim Kirk [mailto:Tim.Kirk@upc-ac.com]
Sent: Tuesday, 5 January 2021 11:04 AM
To: Matt Clarkson
Cc: Terence Seymour
Subject: Re: NESF (SSD 9255) - Traffic Management Plan review

Hi Matt,

Hope you enjoyed your New Year.

Just wondering if you have any updates on your review of the traffic management plan, as per the below email?

Cheers,

Tim Kirk | Project Development Manager
UPC\AC Renewables Australia
A UPC Renewables and AC Energy Company

UPC\AC Renewables AUSTRALIA

M: +61 403 857 079
E: tim.kirk@upc-ac.com
Hobart: Suite 2, Level 2, 15 Castray Esplanade, Battery Point, TAS 7004
Melbourne: 61 Cromwell Street, Collingwood VIC 3066
Sydney: Level 14, 77 King Street, Sydney, NSW 2000

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From: Tim Kirk <Tim.Kirk@upc-ac.com>
Date: Tuesday, 15 December 2020 at 12:45 pm
To: Matt Clarkson <MClarkson@uralla.nsw.gov.au>
Cc: Terence Seymour <TSeymour@uralla.nsw.gov.au>
Subject: NESF (SSD 9255) - Traffic Management Plan review

Dear Matt,

New England Solar Farm – Traffic Management Plan (TMP)

UPC/AC Renewables is seeking Uralla Shire Council's (USC) feedback on the New England Solar Farm Traffic Management Plan (TMP). As you are aware, we are required by the NSW Department of Planning, Infrastructure, and Environment (DPIE) to consult with USC regarding the TMP before construction of the project can commence. Our construction contractor has prepared this plan, which is attached to the email.

We appreciate your support on this project to date and please let me know how long you will require to complete this review. We hope to receive it by the end of this week if possible.

Kind Regards,

Tim Kirk | Project Development Manager
UPC\AC Renewables Australia
A UPC Renewables and AC Energy Company

M: +61 403 857 079
E: tim.kirk@upc-ac.com

Hobart: Suite 2, Level 2, 15 Castray Esplanade, Battery Point, TAS 7004
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Appendix B – Draft TMH12 Pavement Management Systems: Standard Visual Assessment Manual for Unsealed Roads Version 1

CONTRACT REPORT CR-2000/66
December 2000

Contract Report CR-2000/66

Draft TMH12

Pavement Management Systems:
Standard Visual Assessment
Manual for Unsealed Roads
Version 1

Authors: D Jones and P Paige-Green

PREPARED FOR:

Committee of Land Transport Officials

PRETORIA
South Africa

PREPARED BY:

CSIR Transportek
PO Box 395
PRETORIA
South Africa
0001
Tel: +27 12 841-2905
Fax: +27 12 841-3232

DOCUMENT RETRIEVAL PAGE			REPORT No: CR-2000/66
Title: Draft TMH12: Pavement Management Systems: Standard Visual Assessment Manual for Unsealed Roads (Version 1)			
Authors: D Jones and P Paige-Green			
Client: COLTO	**Client Report No:** CR-2000/66	**Date:** December 2000	**Distribution:** Client Confidential
Project No: 9400/9431/TIJ21	**Programme:** Infrastructure Engineering		**ISBN:**

Preface:

TMH12 provides guidelines for the visual assessment of the condition of unsealed roads at network and/or project level for use in unsealed road management systems. A modular approach to information collection is introduced. Attributes of distress are defined and requirements for training and calibration of visual assessors, quality control, assessment procedures and road segment information data are specified. The different assessment parameters are classified and detailed descriptions of degree and distress, including photographic plates illustrating each condition, for each parameter are given. Examples of assessment forms are provided. Simple guidelines on material identification using an engineering geological classification are included.

The use of the data collected in management systems and maintenance management planning falls outside the scope of the document.

Keywords: Unsealed roads, Road Management System, Road Assessment

Proposals for implementation:

This document has been issued in Draft format under CSIR cover for a limited period. Comments should be forwarded to D Jones who will compile a comments register for discussion by the working group. The document will be updated, if required, and released under a Committee of Transport Officials (COTO) cover in the standard TMH format.

Related documents:

TMH9, TRH22

Signatures:

Language editor:	Technical reviewer:	Prog Manager: B Verhaeghe	Information Centre:	Division Director: P Hendricks

TERMS OF REFERENCE

The objectives of this project were to:

- Identify the inputs that need to be collected to ensure that the GRMS's in use can operate cost-effectively and that the outputs can be used with confidence;
- Prepare a document to guide assessors of unsealed roads, which fulfils the needs of the various road authorities in South Africa.
- Incorporate modularity into the system identifying the absolute minimum requirements and various other alternatives to comply with the requirements of the various management systems in use.
- Provide uniformity in unsealed road assessment in South Africa.

ACKNOWLEDGEMENTS

This manual was compiled by the Division of Roads and Transport Technology of the CSIR on behalf of the South African Committee of Transport Officials (COTA). The contributions of the following individuals in the preparation of the document is gratefully acknowledged:

Mr K Arnold	Free State Department of Public Works, Roads Branch
Mr P Bester	V and V Consulting Engineers
Ms C Davis	North West Department of Transport, Roads and Public Works
Mr E Djelebov	Mpumalanga Department of Public Works, Roads and Transport
Mr B Heynes	VKE Consulting Engineers
Mr D Judd	Jeffares and Green Consulting Engineers
Mr M de Lange	Northern Cape Department of Transport
Mr M Henderson	Provincial Administration Western Cape, Transport Branch
Mr R Lindsay	KwaZulu Natal Department of Transport
Mr C Mathiassen	Eastern Cape Department of Public Works, Roads Branch
Ms E Sadzik	Gauteng Department of Transport and Public Works
Mr M van Heerden	V and V Consulting Engineers
Mr A van der Gryp	Provincial Administration Western Cape, Transport Branch
Ms V van Staden	Gauteng Department of Transport and Public Works
Mr F van Staden	Northern Cape Department of Transport

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A. GENERAL INFORMATION

A.1. Introduction

This document provides national guidelines for the visual assessment of the condition and performance of unsealed roads for use in gravel road management systems, maintenance programming and the monitoring of experiments. Sealed flexible and rigid pavements should be assessed in accordance with TMH 9[1], the Department of Transport Manual for visual assessment of pavement distress: Part 2[2] and TRH 6[3].

Visual assessments on any road can be used to determine:

- Condition indices
- Maintenance and rehabilitation needs
- Priorities at network level

Assessment of the condition of unsealed roads differs significantly from that of sealed roads: unsealed roads are highly dynamic systems with the appearance and condition varying almost from day to day. Although sealed roads are also dynamic systems, the rate of change of typical performance characteristics is much slower and annual observation is generally sufficient to identify changes and provide timeous inputs for maintenance intervention activities. This is considerably more difficult for unsealed roads, and for routine use the visual assessment is most applicable for determining:

- Regravelling requirements
- Whether current blading frequencies are sufficient
- Whether the gravel on the road is suitable for the traffic and environment and what type of distress is typical of the road/gravel combination

Unlike sealed roads, the performance of unsealed roads depends primarily on the functional characteristics. Localised structural failures are usually “repaired” during routine grader maintenance (occasionally spot regravelling is necessary) whereas structural failures of sealed roads require intensive repair to restore functional performance.

This manual is intended for persons undertaking visual assessments of the condition of unsealed roads for:

- Input for gravel road management systems
- Project level assessments for specific roads
- Ad hoc assessments of road condition after significant events (e.g. severe rainfall)
- Training of assessors to rate unsealed roads in a consistent and repeatable manner
- Assessing the condition of specific roads during experiments

A.1.1 Terminology

Various terminologies are used for roads where vehicles travel directly on the natural material (i.e. the road has no formal surfacing). Terms include earth and dirt, usually

applied to roads that are not formally constructed, on in situ material, and gravel, unpaved, unsealed, unsurfaced and metalled, usually applied to roads constructed with an imported compacted gravel layer. Since the concepts discussed in this guide are applicable to all types of roads without a formal surfacing (e.g. bitumen, concrete and block paving), the accepted international term of **unsealed roads** will be used throughout the document.

However, the term **Gravel Road Management System (GRMS)** is widely used and understood and has been retained for use in this document.

A.1.2 Information to be Collected – The Modular Approach

The document has been compiled to allow the content to be adapted for different needs and for different Gravel Road Management Systems (GRMS's). It is therefore not necessary to assess every characteristic illustrated in this manual for every situation. Assessments for strategic network level evaluation require less detailed information than necessary for detailed network level assessments.

Evaluations for **strategic network level analyses** need to provide the information necessary to make strategic decisions such as budgeting, planning and evaluation of the influence of budget constraints on the network performance. Typical characteristics assessed include gravel quantity and quality, road profile and drainage and riding quality, which are necessary for estimating regravelling and maintenance requirements. Evaluations for **detailed network level analyses** include significantly more detail, which can be used for both strategic decision-making at as well as for maintenance planning and budgeting at operational level. In these cases, more information regarding the performance characteristics is collected and both severity and extent are usually assessed. More detail regarding the use and interpretation of the data collected is provided in Section B.11.

By using a modular approach, minimum requirements can be used for most applications whilst more specific requirements are suggested for detailed network level analyses, project level and research activities. The minimum requirements for each province will usually have been identified during development and installation of their specific GRMS.

The information required will dictate the structure and content of the assessment forms used. Each road authority should develop an assessment form for their specific needs. Assessment forms are discussed in more detail in Section B.4.

The following can be achieved by processing the visual assessment data:

(a) Calculation of a **visual condition index** for each assessment length through the combination of the rating for degree and extent for each distress type, together with a weight factor based on the importance of the distress type. The condition index can be used to:

- Give an indication of the condition of each segment of the road assessed.
- Indicate changes in the overall condition of a road network, or individual segments over time.
- Classify a road section into one of five condition categories for statistical or visual presentation, as follows:

VERY GOOD	GOOD	FAIR	POOR	VERY POOR
1	2	3	4	5

(b) Identification of certain required maintenance and/or improvement measures and priorities for use as input for programming and budgeting.
(c) Identification of required maintenance or improvement measures for use at network or project level (implementation) by maintenance teams.

A.1.3 Structure of the Manual

The manual comprises six parts:

- Part A contains general information for the assessor, which should be studied as background to the assessment descriptions in Part B.
- Part B provides detailed guidelines on the functional assessment of unsealed roads and descriptions of the various distress types and descriptions of the various degrees of distress that can be encountered on unsealed roads, the data from which will be used as input for gravel road management systems. The method aims to provide a degree of harmony for capturing relevant information by different road authorities in order that output can be realistically compared. Detailed descriptions and colour photographs of typical examples of each distress type for severity levels 1,3 and 5 are provided.
- Part C contains a glossary of terms used in the document.
- Part D contains examples of assessment forms.
- Part E describes a simple method to assist with identification of material type.
- Part F lists documents referred to in the text.

A.2. Attributes Of Distress

A.2.1 General

The appearance of distress is varied and often extremely complex. The task of describing this is achieved by recording its main characteristics – the so-called attributes of distress. The attributes referred to in this manual are the:

- Type
- Degree
- Extent

These attributes are defined below in general terms. Each of these attributes is described in more detail in Part B. In some cases, information is also provided on the mechanisms and causes of distress.

A.2.2 Types of Distress

The type of distress evaluated will depend on the purpose of carrying out the assessment. The modes of distress needing assessment for strategic network level decisions may differ from those needed for detailed network level decisions. A number of assessment parameters are considered essential for any type of evaluation, while detailed descriptions of distress are often desirable, particularly for detailed network level investigations, project level investigations and research investigations. This manual also

includes other assessment items that have proved useful in research studies and for complementing the more detailed distress attributes and material properties. Typical types of distress encountered on unsealed roads include:

- Loss of gravel
- Potholes
- Rutting
- Erosion
- Corrugations
- Loose material
- Stoniness
- Dust
- Cracking

These can be assessed individually or in terms of their interactive effect on the functional performance of the road together with material properties, road profile, drainage etc. An example of this is the development of corrugations or potholes, which result in deterioration of overall functionality, particularly riding quality. For more detailed investigations, aspects such as cracking or rutting, although not directly related to riding quality for instance, are indicative of material quality or a potentially problematic situation such as periodic slipperiness or water ponding respectively.

A.2.3 Degree

The degree of a particular type of distress is a measure of its severity. Since the degree of distress can vary over the pavement section, the degree to be recorded should, in connection with the extent of occurrence, give the predominant severity of a particular type of distress. The degree is described by a number where:

- Degree 1 indicates the first evidence of a particular type of distress ("slight").
- Degree 3 indicates a warning condition. This would normally indicate that intervention might be required in order to avoid the distress deteriorating to a severe condition.
- Degree 5 indicates the worst degree ("severe"). Urgent attention is required.

The general descriptions of degree of each type of distress are presented in Table A.1. These descriptions relate to the possible consequences of each type of distress and therefore also to the urgency of maintenance or rehabilitation. Degree 0 is recorded if the defect does not occur. Degree 1 generally indicates that no attention is required; degree 3 indicates that maintenance/improvement might be required in the near future, whereas degree 5 indicates that immediate maintenance/improvement is required. Specific classifications for the various types of distress have been compiled, based on these general descriptions (see Part B).

TABLE A1: General description of degree classification

Degree	Severity	Description
0	None	No distress visible
1	Slight	Distress difficult to discern. Only the first signs of distress are visible.
2	Between slight and warning	
3	Warning	Distress is distinct. Start of secondary defects. (Distress notable with respect to possible consequences. Maintenance might be required in near future e.g. potholes can be removed by blading)
4	Between warning and severe	
5	Severe	Distress is extreme. Secondary defects are well-developed (high degree of secondary defects) and/or extreme severity of primary defect. (Urgent attention required e.g. potholes require manual repair).

A flow diagram illustrating the use of the five-point classification system is shown in Figure A.1. The most important categories of degree are 1, 3 and 5. If there is any uncertainty regarding the condition between degrees 1 and 3 or 3 and 5, the defect may be marked as 2 or 4, respectively. This is particularly relevant for research purposes (where frequent visual assessments are carried out), or detailed project level studies.

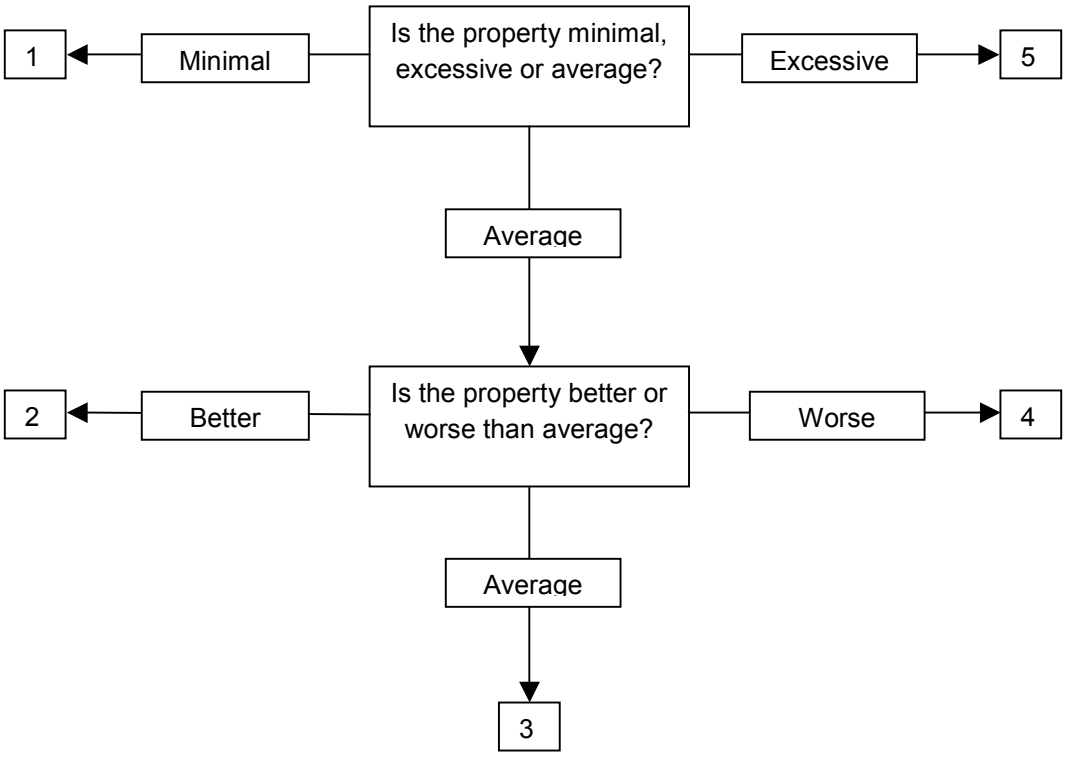


FIGURE A.1: Flow diagram – five point classification system

A.2.4 Extent

The extent of distress is a measure of how widespread the distress is over the length of the road segment. The extent is also indicated on a five-point scale in which the length of road affected by the distress is estimated as a percentage. The general description of the extent classifications is given in Table A.2 and illustrated diagrammatically in Figure A.2.

The extent of the distress should be recorded only for that width of the road affecting the traffic.

TABLE A.2: General description of extent classifications

Extent	Description	Estimate (%)
1	Isolated occurrence, not representative of the segment length being evaluated. They are usually associated with localised changes in the material, subgrade or drainage conditions. Intersections, steep grades or sharp curves may also result in isolated occurrences.	< 5
2		5 – 20
3	Intermittent occurrence, over most of the segment length, or extensive occurrence over a limited portion of the segment length. When occurring over most of the segment length, problems are usually associated with the material quality or maintenance procedures. When occurring over limited portions, the problem is usually a result of local material variations or drainage problems.	20 – 60
4		60 – 80
5	Extensive occurrence. This is usually a result of poor quality or insufficient wearing course material, or inadequate maintenance.	80 - 100

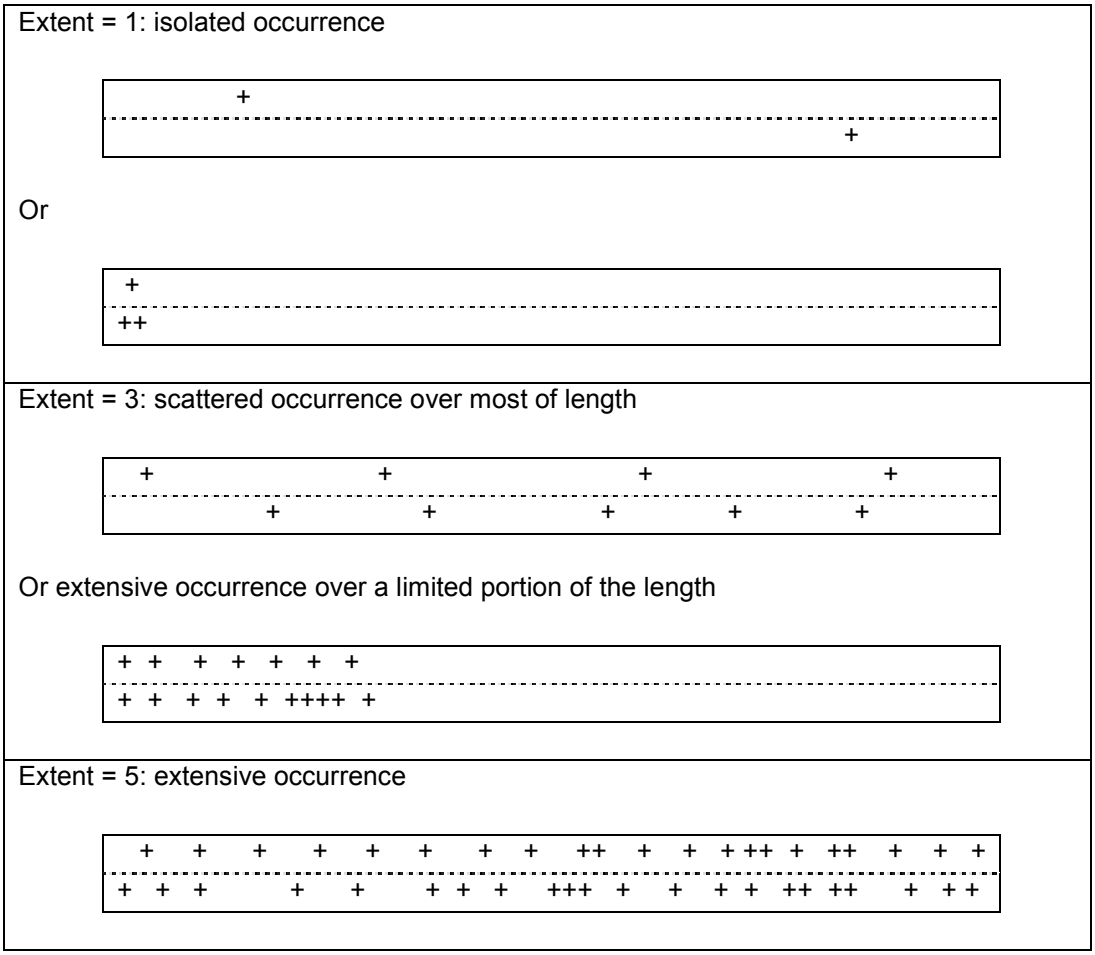


FIGURE A.2: Diagrammatical illustration of extent

Experience has shown that even amongst experienced raters, there is a general tendency to overestimate the extent of defects. This tendency increases with severity of the defect.

Estimation of the extent is not required for strategic network level assessments. However, provision must be made for recording localised problems. The extent is, however, essential for detailed network level assessments, project level assessments and for research purposes.

A.2.5 Examples of the use of Degree and Extent

The following examples illustrate the combined use of degree and extent:

(a) If potholing of degree 5 occurs seldom (i.e. extent 1) and potholing of degree 3 occurs extensively (i.e. extent 5), the degree 3/extent 5 potholing is recorded as the predominant indication of the severity of potholing over the specific road segment in terms of possible maintenance action. In such a case, the degree 5 potholing will be viewed as an area of localised distress requiring routine attention.

(b) If potholing of degree 5 and extent 2, and potholing of degree 1 and extent 4 occurs, degree 5/extent 2 is recorded as the average indication of the problem that is most significant in terms of possible action. (Potholing of degree 1 is not considered significant in terms of possible action.)

(c) For research purposes, the maximum severity possible is of greater interest and not the predominant severity.

A.3. Training and Calibration of Visual Assessors

The accuracy of the visual assessment data depends largely on the knowledge, experience and commitment of the assessors. To minimise the element of subjectivity and to ensure good knowledge of the assessment procedures, it is essential to train and calibrate all assessors before visual assessments are carried out. The intensity and duration of the training session will depend on the experience of the assessors.

It is recommended therefore that an annual training and calibration session be held even if all the assessors were trained during previous years. Changes to guidelines and procedures should also be presented and problems with the previous assessments should be discussed.

The training and calibration programme for assessors should include the following:

- An overview of the objectives of the visual assessment together with a brief description of the data processing procedures and applications of the final results.
- An overview of the causes of the various types of distress. It is essential that the raters understand the causes of the problems to get a realistic rating and to make recommendations on corrective action if required.
- An overview of the method of assessment, including identification of materials, descriptions of various types of distress and ratings for each type. The use of colour slides to show examples is recommended. The visual assessment manual should be studied by all before the training session.
- An overview of the format of the assessment sheet.
- Practical training, assessing at least 10 road segments, preferably in different conditions exhibiting a full range of defects. The method of rating should be discussed on the first segment which should then be rated jointly with further discussion until agreement and understanding is reached. Each assessor should then evaluate each of the remaining segments individually without discussion with other assessors. The assessment forms should then be compared afterwards and any major discrepancies should be discussed. If necessary, more segments should be assessed and discussed individually until acceptable consistency of rating is achieved.

  Problems may be encountered with the estimation of remaining gravel particularly where subgrade is extensively exposed. Assessors may consider the exposures as an imported wearing course, thereby overestimating the gravel quantity/layer thickness. The assessors therefore need to be aware of the need to interpret the road environment and characteristics in distinguishing between imported gravel wearing course and subgrade/road formation.

  It is recommended that, during the practical training, those attributes for which estimates of actual depths and sizes are required should be physically measured to enhance/check the capability of accurate quantitative assessment.

In addition, it is advisable for each project leader to meet with all the assessors within days after the start of the formal assessment to check the initial assessments.

It is essential that raters go through this process of training prior to any visual assessment programme. Post assessment calibrations have shown that where assessors were inadequately trained, the assessment has had to be redone. Where the original assessment was done on contract, they have had to redo it at their own cost.

A.4. Quality Control

An independent assessment of at least 10 to 15 per cent of the gravel road network should be carried out within one week of the roads being assessed to ensure that the study was carried out to an acceptable standard and to ensure that the raters have been consistent.

The following issues should be considered during the quality control exercise:

- Roads totalling between 10 and 15 per cent of the network should be selected, ensuring a good representation of the entire network. The results of the previous years assessment should be used to refine the selection in order that the majority of the roads selected are likely to have a visual condition index in the 3 to 5 bracket. Larger variations between raters are likely on roads in poor condition than on roads in good condition.
- The raters should not be informed of which roads are included in the quality control assessment.
- The person undertaking the quality control assessment should attend the training session together with the other raters.
- Based on the raters' plans, the selected roads should be assessed by the quality control rater within one week of the original assessment. This will ensure that the roads will be in a similar condition when being assessed.
- The results of the original and quality control assessments should be statistically compared. The variation should not exceed 15 per cent. It should be noted that, due to the subjective nature of visual assessments on unsealed roads, the practitioner undertaking the quality control assessment might not necessarily be correct. This will be revealed if different results are obtained by the quality control assessor to that of each of the original raters. If this occurs, the quality control assessment will have to be repeated. Alternatively, if discrepancies of more than one unit occur on two of the essential fields on the assessment form, the original assessment should be queried.
- If the variation in results exceeds the acceptable limit, the assessment forms should be compared to determine where the discrepancy occurs. If it is derived from the entire assessment, the rater and quality controller (and the client if quality control is also contracted out) should visit the sites to understand the discrepancy. If the fault lies with the rater, the assessment will have to be repeated. The rater should either be replaced or retrained.

B. UNSEALED ROAD ASSESSMENT

B.1. Introduction

The objective of a gravel road management system (GRMS) is to obtain a general overview of an unsealed road network for budgeting and strategic planning purposes. The system does not usually identify needs at project level, but is used for high-level decision-making. Project level assessments are more detailed than those done for strategic decision making and are carried out on specific roads identified as requiring attention from the GRMS. They can also be used by district staff for routine management activities, or for specific evaluations such as experimentation, feasibility for upgrading and justification for chemical improvement or dust control. The quantity and quality of data collected will differ between assessments depending on the reason for carrying out the assessment. The level of detail is usually far greater at project level than at strategic level. Direct measurement of certain properties and collection of samples for laboratory testing may also be included.

In order to provide reliable outputs and allow direct comparison between projects, it is essential that the data used in a GRMS is consistent and of high quality. The data capture also needs to be repeatable and done in the most cost-effective manner.

For most project level assessments, the items identified as desirable provide additional value to the essential items. Those items identified as optional need only be collected if required.

With independent road authorities in the provinces, a uniform procedure for the collection of data will allow direct comparisons between the strategic and tactical decisions made in the different provinces.

B.2. Purpose

The data collected for use in the gravel road management system should provide the road authority with objective information to assist with strategic and tactical decision making. This includes aspects such as:

- An indication of the current level of service provided by the network
- The cost of maintaining the current level of service
- The cost of an improvement in service
- An indication of the social and economic impact of these improvements
- The effect of current polices on the future levels of service
- Prioritising roads to be upgraded to sealed standard
- Frequency of blading and regravelling
- Distribution of funds between blading and regravelling
- Benefits from predictions

B.3. Defining Segments

In order to cost-effectively evaluate unsealed roads, it is necessary to segment them into manageable units. Each segment should be relatively uniform in terms of its material type and general performance and should be about 5 km long. They should not be less than 2.5 km to avoid the collection of excessive and repetitive data, unless the segment will be used for experimentation or where a variety of different materials is used. For ease of use and application, the start and end-points of each segment should be related to fixed datum points (e.g. intersections, bridges etc), but this is often not possible on rural roads, in which case, durable marker boards should be erected. The segments remain fixed.

Defining segments in the urban environment is carried out on a different basis. Segment lengths are relatively short and are typically defined by intersections.

The increasing availability, affordability and accuracy of Global Positioning Systems (GPS) technology, will in future allow the specification and easy relocation of arbitrary datum points (e.g. every 5 km, or the change of gravels).

B.4. Assessment Forms

The information required by various road authorities will dictate the parameters used on and layout of the form. A number of examples of assessment forms are provided in Part D. Many authorities already have standard forms, but the examples could be used as a basis for upgrading these or developing new forms for those authorities that do not have any. In keeping with the modular approach advocated in this document, it is recommended that the following minimum information be captured for any assessment. As the intensity of the analysis increases, additional or more information needs to be captured. This is illustrated in the sequence of the four forms in Part D

- Gravel quantity/layer thickness
- Gravel quality and influencing factors or estimates of selected material properties
- Road profile/shape as an assessment of water shedding capacity
- Road drainage in terms of removal of water from roadside
- Riding quality/safety and influencing factors
- Dust
- Trafficability
- Moisture condition

Additional information fields can be added to the forms to suit the individual requirements of any road authority.

It is critical that the data collection form has the same reference to the segment identification as the data inventory. All data must be captured on a standard data sheet to ensure consistency and completeness.

B.5. Assessment Procedure

The successful implementation of a GRMS relies on accurate and repeatable data. These data are captured during the periodic visual assessment of the entire gravel road network. At network level, there is a large volume of data to be collected and assessment needs to be carried out in as short a time as possible.

The results of the assessment are recorded on field assessment forms, which are the links between the rater and the GRMS or any other use. The assessment can be enhanced if the rater has a clear understanding of the desired output of the GRMS. (i.e. will the data be used primarily for strategic planning purposes, or will more tactical applications be derived from them?)

Visual assessments should preferably be carried out in the dry season, as many of the important defects are not easily identified when the road is wet. The dry season is also longer than the wet season over most of South Africa allowing a longer window for this data collection. If detailed assessments are made throughout the year, then cognisance should be taken of the recent weather conditions. Surveys should, however, be completed as quickly as possible to ensure repeatability and to exclude seasonal influences. For GRMS data collection, the daily length of survey should generally not exceed 130 km, based on the ability to assess three segments of 5 km each per hour in an 8-hour day. Shorter daily lengths may be expected if the condition of the road is very variable, in the case of shorter segment lengths, or if detailed assessments are being made.

The assessors should drive at a speed not exceeding 40 km/h when gathering data and should include at least one stop on each segment for a closer assessment of the material quality, layer thickness and general performance. However, for detailed or research assessments, assessors should initially drive over the length of the segment in both directions at a speed not exceeding 20 km/h. While driving, suitable locations for detailed visual assessments and sampling should be identified. The assessment of defects is generally restricted to the trafficked portion of the carriageway and excludes the shoulders and windrows left during blading.

Suitable safety precautions should be taken at all times.

Individual road authorities may require more frequent stops for information gathering and material assessment and sampling. During these stops, actual gravel thickness may be determined. The accuracy of the assessor's rating will generally be influenced by the frequency of stops made, this frequency depending on the condition of the road and its variability. During assessment of the first segment, more stops will probably be required in order to relate the appearance of the road from within the vehicle while moving to that when stationary. Additional stops may be required on segments showing isolated areas of severe distress. The assessor should leave the vehicle during the stops to examine the road more closely. The use of a geological pick during the assessment is recommended.

Unlike assessments for GRMS input, that are carried out at regular intervals (usually annually), detailed assessments may be carried out on a more ad hoc basis. For problem evaluation, a once off assessment may suffice, while for experimentation purposes, frequent assessments over a period will be required. In these types of

assessments, data that is more detailed is often required, which implies that more time needs to be spent on the selected segments.

The first road segment to be evaluated in any assessment requires a thorough orientation to adjust the assessors to the prevailing conditions, because the position of the sun (preferably from the rear), the amount and variability of cloud cover and a wet surface will influence the visibility of the defect (e.g. dust and corrugations). This may entail doubling back in order to acquire sufficient data.

As detailed network level and project level assessments require more detail than network level assessments, it is rarely possible to undertake them only from a moving vehicle. More measurements and material sampling are often required and the locations for these activities should be predetermined or selected once on site. The assessment is usually best carried out by walking the road in both directions.

During the visual assessment of segments, dots can be made on the assessment form in the appropriate positions to indicate the degree of any type of distress that is observed. At the end of the segment, these dots are used to mark a predominant degree of distress for each type of defect. All fields on the form must be completed (none, where no distress is observed) to ensure that no assessment parameters have been overlooked. After completing the form, the assessor should also check road segment information (i.e. correct start and finish information, etc).

B.6. Road Information

The information regarding each road and its segments is required for the data inventory. These are summarised in the list below. They are stored in the GRMS database. Only road number, start and end kilometre of the segment are required on the assessment form.

- Road number
- Start km of segment
- End km of segment
- Node description
- District/region
- Weinert N-value
- Terrain
- Road type (i.e. earth, gravel, treated)
- Design road width
- Traffic data (this will vary from authority to authority)
- Material type (this may change during the life of the road)

It is important, however, that any obvious changes, particularly in the road width, material type or traffic volume, are captured on the form during the assessment and reflected in the section inventory. Fields to check these items can be included on the assessment form if required.

B.6.1 Material Type

Basic classification of the material type is used by some road authorities in conjunction

with the gravel quality (e.g. clay, sand and gravel) to predict performance in their GRMS's. Typical material properties (e.g. grading modulus, plastic limit, various particle size fractions) are linked to standard material types as input parameters for algorithms in the GRMS to predict gravel loss and blading frequencies. In other GRMS's, material type is used purely as a check of the road inventory information.

The general classification of materials minimises laboratory testing and is the most practical method for estimating material property inputs for network level evaluations. However, calibration of the material properties will be necessary for each area. The best results would be obtained by carrying out laboratory testing on representative samples removed from the road, but the resources required usually render this prohibitive. Regravelling of roads over time will make material properties available for more accurate determinations. Accurate identification of the material type is not always necessary and it is suggested that the more general engineering geological classification developed by Weinert[4] be used. Commonly used road construction materials are classified into their engineering geological groups in Table B.1 below.

TABLE B.1: Engineering geological classification and example materials

Group	Material type
Basic crystalline	Dolerite, andesite, basalt, diabase, gabbro, norite
Acid crystalline	Granite, felsite, rhyolite, gneiss
High silica	Chert, quartzite, quartz porphyry
Arenaceous	Sandstone, arkose, conglomerate
Argillaceous	Shale, mudstone
Diamictites	Tillite, breccia
Pedocretes	Ferricrete, calcrete, silcrete, dorbank
Transported	Sand, river gravel

A simple material identification procedure is included in Part E. This is based on the quantity of quartz and the ability of the rater to identify it with a magnifying glass.

B.7. General Information

The general information that needs to be captured includes the name of the evaluator, the date of the evaluation, the road and section numbers and their start and end km's.

B.8. Parameters to be Assessed

The following road characteristics should be assessed as a minimum in a GRMS assessment:

- General performance
- Moisture condition
- Gravel quantity/layer thickness
- Gravel quality and influencing factors or estimates of selected material properties
- Road profile/shape as an assessment of water shedding capacity

- Road drainage in terms of removal of water from roadside
- Riding quality and influencing factors
- Dust
- Trafficability
- Isolated problems
- Maintenance action required

Some road authorities may require additional information for specific needs. For example:

- A road authority that plans to use sand cushioning as a maintenance option for controlling corrugations would need to capture additional information regarding this defect.
- A road authority with ready access to in situ stone processing equipment (e.g. Rockbuster) would need more information on stoniness.

Under certain circumstances, e.g. when assessing in remote areas, it may be cost-effective to assess the road in more detail than would normally be necessary. The extra time involved is minimal compared to the disadvantages of having to return to the site at a later date to gather additional information.

B.8.1 General Performance

An estimate of the general performance should be made. This should be representative of how the travelling public would view the condition and performance of the road. This parameter is recorded for possible use as a crosscheck with any visual condition index calculated from the full assessment (e.g. if general condition is rated as good, but corrugations are rated as severe over most of the road, a misjudgement has been recorded). It can also be used as a first indication of the overall performance of the road network.

General performance is assessed on a scale of **one** to **five** (where one is very good and five is very poor) primarily in terms of driver and passenger comfort and the drivers perception of safety. It should be estimated after driving the segment before the detailed assessment is carried out in order to eliminate any bias that may result after completing the detailed assessment.

B.8.2 Moisture Condition

The moisture condition affects the visual assessment of properties such as dust, corrugations, loose material and skid resistance. It is therefore necessary to estimate the moisture condition for later use if there are queries regarding the influence of any of these properties.

Assessment of the condition is limited to a subjective rating of "**wet**" (damp) or "**dry**" taking the consequences into account (e.g. the road will not be wet if dustiness is significant). Disturbance of windrows or loose material will usually indicate whether the material is wet.

In project level or experimental assessments, more accurate indications of moisture content may be required and can be obtained by sampling the material, placing it in a sealed container and determining the moisture content gravimetrically in an oven. Output from this type of assessment will be the percentage moisture by dry mass of the soil.

B.8.3 Gravel Quantity/Layer Thickness

Most unsealed roads are constructed with a wearing course of about 150 mm of compacted selected gravel. Under traffic and environmental influences, this gradually wears away and requires periodic replacement. If it is not replaced, the subgrade is exposed to traffic. This material is usually unsuitable as a wearing course and results in trafficability problems and shear failures. In flat areas, drainage of water away from the road will be retarded or even impeded.

The rate of gravel loss is a function of the material properties and the traffic. However, as the traffic increases, or the material quality deteriorates, this annual loss increases significantly. The rate also increases if profile and drainage are poor

During the visual assessment, it is necessary to estimate whether sufficient gravel remains to provide adequate service until the next assessment period. This requires actual measurements of the layer thickness, or judgement by the rater taking into account the material quality, traffic and any evidence of subgrade exposure.

Gravel quantity is either rated on a five-point scale as described in Table B.2, or physically measured on the road by excavating small holes in the wheel tracks. This should be done at a sufficient frequency (e.g. 5 holes on a 5 km segment) to determine a representative average for the segment. Output from the assessment will be millimetres of material remaining. It should be noted that the direct measurement of layer thickness is essentially a measure of the severity of gravel loss, while estimation of the subgrade exposure represents an extent. Although the former is the optimum solution, the latter is a more readily obtained proxy for the severity.

TABLE B.2: Visual assessment of gravel quantity

Rating	Descriptor	Description	mm
1	Plenty	Good shape, and no stone protrusion	>125
2	Sufficient	No exposures of subgrade, but some stone protrusion	100 – 125
3	Isolated exposures	Less than 25 per cent exposure of the subgrade	50 – 100
4	Extensive exposures	Up to 75 per cent exposure of the subgrade	25 – 50
5	None	75 to 100 per cent exposure*	0 – 25
* Total exposure of subgrade should not be confused with plenty of gravel			

When visually assessing gravel thickness, adequate cover of material over pipe drains and culverts can be a good indicator, bearing in mind that all culverts/pipes should have sufficient cover to protect the structures from traffic loads. Exposure of pipe drains, culverts and bedrock indicates neglect of the road and inadequate gravel cover. The same applies to stone exposure. If it is assumed that the surface of the road was level after compaction, the height of stones above the surrounding road surface will give an indication of the amount of gravel that has been lost.

When less than 25 per cent of the imported gravel wearing course material remains, but the exposed subgrade material appears to be performing adequately, the gravel quantity should still be rated as “none” to ensure that the road is prioritised for regravelling by the GRMS.

GRAVEL QUANTITY



Degree 1

X	**2**	**3**	**4**	**5**

Plenty



Degree 3

1	**2**	**X**	**4**	**5**

Isolated exposures



Degree 5

1	**2**	**3**	**4**	**X**

None

B.8.4 Gravel Quality and Influencing Factors

The performance of an unsealed road depends primarily on the quality of the gravel used to construct the wearing course. The properties contributing to good gravel are particle size distribution and cohesion. The gravel should have a range of particle sizes ranging from very fine up to about 40 mm in order to provide a strong framework of stones interlocked by a tight matrix of fines. An excessive number of large stones results in poor riding quality and difficulties with maintenance. The fines need to have some plasticity to provide cohesion when dry. However, plasticity should not be so high that the road becomes slippery and impassable when wet. Optimally, samples of the gravel should be tested for these properties in a laboratory. However, this is usually not feasible during annual assessments and a more subjective evaluation will usually suffice. Training and calibration before the assessment will minimise the subjectivity.

Gravel quality is rated on a five-point scale, as described in Table B.3.

TABLE B.3: Visual assessment of gravel quality

Rating	Descriptor	Description
1	Very good	Evenly distributed range of particle sizes and sufficient plasticity that the material will leave a shiny streak when scratched with a pick. No significant cracking, ravelling and/or excessive oversize
2	Good	Minor ravelling or cracking and/or minimal
3	Average	Cracking, loose material or stones clearly visible,
4	Poor	Poor particle size distribution with excessive oversize. Plasticity high enough to cause slipperiness. Ravelling is sufficient to cause loss of traction.
5	Very poor	Poorly distributed range of particle sizes and/or zero or excessive plasticity. Cracking and/or quantity of loose material/stones are significant and affect safety of road user. Excessive oversize.

The factors influencing the rating must also be recorded. The following factors can be marked:

- Excessive clay and/or silt (i.e. plasticity too high)
- Excessive sand – loose with insufficient fines (i.e. plasticity too low)
- Excessive oversize stones and/or loose gravel

Some GRMS's require estimates of the material properties, particularly the plasticity index. This is usually assessed in three categories, e.g. less than 6, 6 to 15 and greater than 15.

Although the gravel quantity may be rated as "extensive exposures" or "none", it is still necessary to rate the related performance. This should be applied to the predominant surface material on the carriageway, whether it is subgrade or the remaining wearing course. This assessment should be carried out in terms of the road users perception of the road and the ability to carry out effective maintenance

GRAVEL QUALITY



Degree 1

X	**2**	**3**	**4**	**5**

Very good



Degree 3

1	**2**	**X**	**4**	**5**

Average



Degree 5

1	**2**	**3**	**4**	**X**

Very poor

GRAVEL QUALITY – INFLUENCING FACTORS



Excessive clay



Loose sand



Excessive oversize

B.8.5 Road Profile/Shape

The profile (shape) of a road has a major impact on the performance of that road. Roads with good profile tend to shed water rapidly avoiding the development of potholes and potentially impassable conditions. Where the profile is flat, water tends to pond in localised depressions resulting in softening of the wearing course and the development of potholes and other deterioration. Failure to timeously repair a flat road will usually result in the development of ruts under traffic. These may become preferential water paths resulting in erosion, accelerated gravel loss and significant deterioration in riding quality.

It should be noted that rutting in unsealed roads is generally the result of loosening and whip-off of material and is only seldom the result of subgrade deformation/settlement. Routine grader blading usually reduces rutting.

The road profile is rated on a five-point scale where one is very good and the trafficked surface will shed water easily, and five is very uneven resulting in potential localised ponding and/or surface drainage occurring in a longitudinal direction. These are defined in Table B.4 and illustrated in Figure B.1. It should be noted that on grades, the impact of the gravel profile becomes less dominant than the actual grade.

TABLE B.4: Visual assessment of gravel profile

Rating	Descriptor	Description
1	Very good shape	Well formed camber (about 3 - 4 per cent)
2	Good shape	Good camber (about 2 per cent)
3	Flat	Some unevenness with camber mostly less than 2 per cent
4	Uneven	Obvious development of irregularities that will impede drainage and form depressions
5	Very uneven	Development of severe irregularities impeding drainage and likely to cause extensive localised ponding. Water tends to flow to the centre of the road or individual lanes

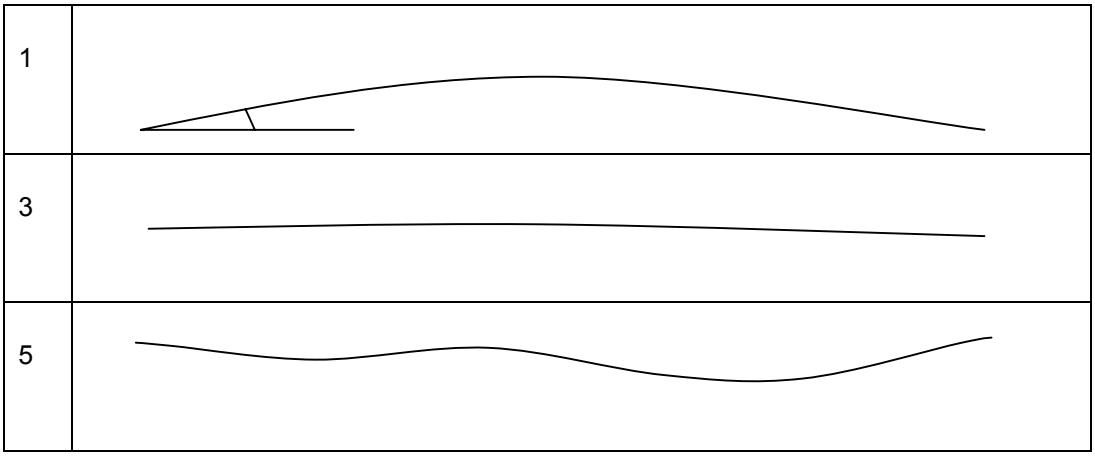


FIGURE B.1 Gravel profile schematics

GRAVEL PROFILE



Degree 1

X	**2**	**3**	**4**	**5**

Very good



Degree 3

1	**2**	**X**	**4**	**5**

Flat



Degree 5

1	**2**	**3**	**4**	**X**

Very uneven

B.8.6 Drainage from the road

There is obviously a strong interrelationship between the road profile discussed previously (drainage off the road) and drainage from the road. However, the profile relates more directly to the capacity of the road to shed water without causing erosion, while drainage from the road relates more closely to the impact of standing water on both the wearing course and underlying road structure. Effective operation of adequate side drains is the predominant aspect to be considered during this rating. This includes removal of water from the zone of influence adjacent to the road as well as erosion effects associated with shoulders and undercutting of the road.

Drainage from the road is rated on a five-point scale where one indicates that the road is well above ground level and has effective side drains leading water away from the road formation. Five is classified as a canal where the road acts as the drainage path in the area. These are defined in Table B.5 and illustrated in Figure B.2. The descriptors are essentially applicable to roads in flat or slightly sloping terrain. Where grades are steeper, roads assessed as degrees 4 and 5 will act as drainage courses during periods of intensive rainfall leading to severe erosion.

TABLE B.5: Visual assessment of drainage/road formation

Rating	Descriptor	Description
1	Well above ground level	Edges of road are at least 300 mm* above natural ground level with effective side drains
2	Slightly above ground level	Road is between 50 and 300 mm above natural ground level. Side drains are present. Stormwater could cross in isolated places.
3	Level with ground	Road is generally at ground level with ineffective side drains. Stormwater could cross in most places.
4	Slightly beneath ground level	Isolated areas of the road are below natural ground level. No side drains are present and localised ponding of water will occur.
5	Canal	Road is the lowest point and serves to drain the entire area.
* If pipes are laid under the road for drainage, then the formation should be at least 500 mm above natural ground level		

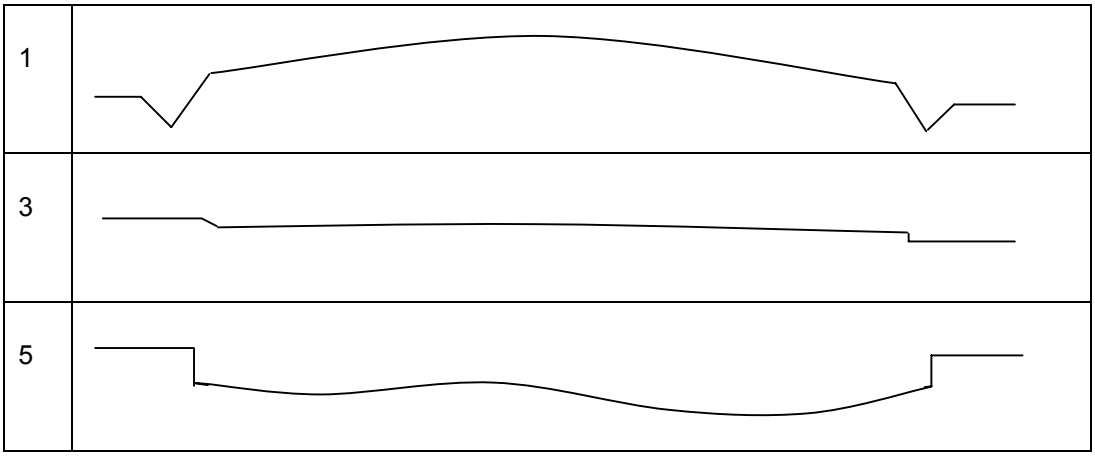


FIGURE B.2: Schematics of road drainage

Additional information may be required on the presence, condition and effectiveness/adequacy of culverts and mitre drains. This will entail written information on the facilities with recommendations on maintenance or upgrading if this is required. In many instances, these are assessed separately during routine maintenance inspections.

DRAINAGE



Degree 1

X	**2**	**3**	**4**	**5**

Well above ground



Degree 3

1	**2**	**X**	**4**	**5**

Level with ground



Degree 5

1	**2**	**3**	**4**	**X**

Canal

B.8.7 Riding Quality and Influencing Factors

The riding quality of the road is probably the major performance parameter affecting driver and passenger comfort and safety. It also has a significant impact on the overall vehicle operating cost associated with the road. Road roughness is best quantified using one of the many items of equipment dedicated to roughness evaluation. However, for the purposes of network assessment, it is usually acceptable to rate the riding quality subjectively.

Road roughness is influenced primarily by maintenance frequency, quality of grader maintenance and material properties. Other factors such as intensive rainfall and heavy seasonal traffic will also have an influence. Certain pavement defects are the direct result of deficiencies in the material properties. These defects influencing riding quality are:

- Corrugation
- Loose material
- Stoniness
- Potholes
- Ruts
- Erosion

More detail is given on these defects in later sections.

Riding quality is most easily rated as a function of the “estimated” comfortable and safe driving speed (unaffected by geometric constraints or road width) that could be driven in a privately owned saloon car. This is estimated while travelling at the speed recommended for visual assessment (40 km/h) and is interpreted as follows (Table B.6):

TABLE B.6: Assessment of riding quality

Rating	Descriptor	Description
1	Very good	Estimated comfortable/safe speed in excess of 100 km/h
2	Good	Estimated comfortable/safe speed between 80 and 100 km/h
3	Average	Estimated comfortable/safe speed between 60 and 80 km/h
4	Poor	Estimated comfortable/safe speed between 40 and 60 km/h
5	Very poor	Estimated comfortable/safe speed less than 40 km/h

Riding quality is usually measured in conjunction with an assessment of the parameters that influence it.

For detailed assessment, appropriate purpose-built equipment (e.g. Linear Displacement Integrator) should be used to provide a quantitative measure. Output from the assessment will be a roughness index over the road segment assessed (e.g. International Roughness Index (IRI) or Quarter Car Index (QI)).

RIDING QUALITY



Degree 1

X	**2**	**3**	**4**	**5**

Very good



Degree 3

1	**2**	**X**	**4**	**5**

Average



Degree 5

1	**2**	**3**	**4**	**X**

Very poor

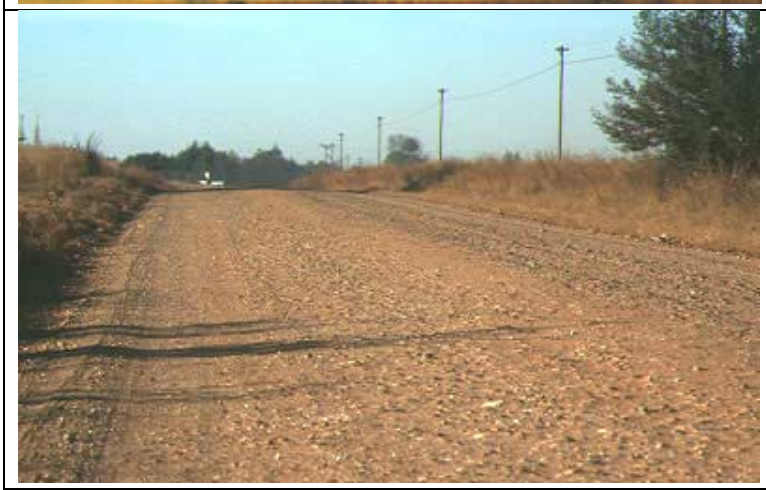
RIDING QUALITY – INFLUENCING FACTORS



Corrugation



Loose material



Stoniness

RIDING QUALITY – INFLUENCING FACTORS



Potholes



Rutting



Erosion

B.8.8 Dust

Definition and cause

Road dust is the dry solid matter consisting of clay and silt-sized particles that is entrained by wind, the wind shear forces created by vehicles and the interaction of vehicle tyres with the road and which disperses and remains in suspension for a period before eventually falling back to the earth's surface. The aerodynamic shape, tyre size and number of wheels on trucks imply that dust generation by heavy vehicles is more severe than light vehicles.

Problem

Dust is undesirable from a number of points of view including safety (loss of visibility), economic (accelerated gravel loss as a result of the loss of fines), comfort of vehicle occupants, health (respiratory diseases), vehicle damage (filters and exposed moving parts), damage to road side vegetation (crops) and environmental impact (air pollution). Dust is generally considered unacceptable by the travelling public when the vehicle generating the dust cannot be seen by a following vehicle.

Measurement

At network level, assessment of dust is necessary as input for prioritising a potential dust problem and determining the costs of applying a dust palliative. In assessing the dustiness of a road, the moisture condition at the time of assessment plays a major role. Dust generation is influenced by many factors and some subjectivity during assessment is inevitable. The following procedure has been developed in an attempt to bring some uniformity to dust assessment.

For the purposes of strategic network level assessments, dust is usually rated as either **acceptable** or **unacceptable** with safety being the major factor taken into account. If the dust generated by a vehicle is perceived to be dangerous, it should be rated as unacceptable. Dustiness should be rated in the rear view mirror while travelling at 60 km/h. This may require that short distances within the segment are monitored at this higher speed. Wind speed and lighting conditions (position of the sun) can influence rating in this way and should be taken into consideration.

For detailed network level, project level and research investigations, dust is best measured with specialised equipment following a prescribed methodology. However, a visual evaluation as well as a subjective assessment of dust on vehicle occupant comfort will suffice in most instances. This is carried out either by the driver of the vehicle travelling at 60 km/h and using the rear-view mirror to assess the dust generated by the raters vehicle, or by an observer at roadside. Occupant discomfort is judged on the necessity to close windows and ventilation systems. Runs should be made in both directions to determine the effect of the sun, with an average degree recorded (rounded upwards where necessary). Trucks generate significantly more dust than cars and LDVs and ratings will usually be unacceptable on most roads. Dust ratings on roads with a daily high percentage of heavy vehicles (e.g. >30 per cent) should be weighted to unacceptable.

The description of degrees of dustiness is given in Table B.7. The extent of dust is not normally estimated.

TABLE B.7: Degrees of dustiness

Degree	Description
1	No loss of visibility
3	Some loss of visibility – no discomfort
5	Dangerous loss of visibility – significant discomfort

DUST (GRMS assessment)



Degree 1

X		5

Acceptable



Degree 5

1		X

Unacceptable

DUST (Detailed assessment)



Degree 1

X	**2**	**3**	**4**	**5**

No loss of visibility



Degree 3

1	**2**	**X**	**4**	**5**

Some loss of visibility – no discomfort



Degree 5

1	**2**	**3**	**4**	**X**

Dangerous loss of visibility – significant discomfort

B.8.9 Trafficability

Definition and cause

Trafficability (or passability) is the capacity of a normal saloon car to negotiate the road without losing traction or without excessive use of low gears. The terms trafficability and impassability are used interchangeably throughout this document (however, impassability should not be confused with the inability to overtake in dusty conditions). The mechanism affecting trafficability is the loss of traction between the tyres and the road resulting from the low shear strength of the material. This results in churning of the material and sinking of the vehicle into the weak layer. Sandy materials are more prone to impassability when dry, while clayey materials are strong when dry, but often become impassable when wet. Impassable conditions may result from continued trafficking of slippery roads.

Problem

The primary objective of importing wearing course gravel during the construction of an unsealed road is to provide an all-weather surface. This objective is not met if the material becomes impassable in wet weather. This is often a particular problem with earth roads where in situ materials are used.

Assessment

Impassability is difficult to assess unless the rater actually experiences the condition at its worst. However, evidence of earlier impassable conditions often remains after the event. This includes:

- Deep depressions and evidence of potholes
- Detouring on the shoulders and verges to avoid wet areas
- Spurious material used to fill depressions and to provide temporary traction (often includes vegetation)

For assessment purposes, trafficability is rated as either **acceptable** or **unacceptable**, the latter only being used when definite evidence is observed over a major portion of the segment.

TRAFFICABILITY



Degree 1

X		**5**

Acceptable



Degree 5

1		**X**

Unacceptable

B.8.10 Potholes

Definition and cause

Potholes are round or elongated depressions in the road surface and arise from the following:

- Poor road shape and drainage
- Poor grader operation practice (e.g. plucking of oversize material and destruction of the crown)
- Compaction of material behind oversize stones under wheel loads
- Poor compaction
- Material and moisture variability
- Enlargement of corrugation troughs
- Deformation of weak subgrades and wearing courses
- Subsidence or excavation of animal and insect burrows
- Disintegration of highly cracked roads (i.e. excessive plasticity)
- Disintegration of soft oversize materials
- Dispersive soils

Problem

Potholes play a significant role in the development of roughness on unsealed roads and may cause substantial damage to vehicles if they are allowed to develop and increase in size. The effect of potholes on vehicles depends on both the depth and diameter of the pothole. The potholes, which affect vehicles the most, are those between 250 and 1 500 mm in diameter with a depth of more than 50 to 75 mm.

Once pothole formation has been initiated (irrespective of the cause), the drainage deteriorates, water ponds in the depressions and the potholes are enlarged by traffic. Enlargement occurs through compaction and remoulding of the weakened material (in the wet state) and removal of the material from the hole by the wheels and splashing. Materials with a low soaked strength are thus likely to develop larger and deeper potholes in shorter periods. The influence of drainage on pothole formation is clearly manifested by the general absence of potholes on grades. Potholes are usually worst at the bottom of vertical sag curves, on level road sections with poor shape, and near bridges. The influence of potholes on riding quality is a function of both the degree and extent of the potholing (i.e. many degree 3 potholes have a greater impact on riding quality than a few degree 5 potholes). The descriptions of degrees of potholing are given in Table B.8.

TABLE B.8: Degrees of potholing

Degree	Description
1	Depressions just visible. Cannot be felt in the vehicle
2	<20 mm deep
3	Larger potholes affecting safety - 20 – 50 mm deep
4	50 – 75 mm deep
5	Large, dangerous potholes requiring evasive action - >75 mm deep

POTHOLES



Degree 1

X	**2**	**3**	**4**	**5**

< 10 mm deep



Degree 3

1	**2**	**X**	**4**	**5**

20 – 50 mm deep



Degree 5

1	**2**	**3**	**4**	**X**

> 75 mm deep

B.8.11 Rutting

Definition and cause

Ruts are parallel depressions of the surface in the wheel tracks. They generally form as a result of loss of gravel from the wearing course by traffic abrasion and less commonly by deformation (compaction) of the subgrade and compaction of the wearing course.

Problem

Under local conditions, rutting is usually insignificant in terms of the overall unsealed road surface performance. The probable reason for this is the typically strong, free draining, sandy subgrade prevalent over much of southern Africa, as well as the deep water tables.

Ruts, however, pose potential problems, as they tend to retain rainwater having a negative impact on road safety and also softening the wearing course leading to deformation under traffic. Routine blading of unsealed roads replaces gravel in the ruts and simultaneously compensates for any subgrade deformation that may have occurred. The material graded into the ruts is generally compacted by traffic only when in a moist condition.

Excessively wide roads lead to the formation of definite ruts in both directions, which tend to be deeper than those on roads of normal width (8 m). The probable reason is that lateral movement of vehicles is unnecessary when they pass from both directions and all vehicles travelling in each direction thus consistently travel in the clearly demarcated ruts. This ultimately leads to deep, wide depressions in each direction.

Assessment

Ruts are assessed in terms of their capacity to retain water using a visual estimate of their average depth. If greater accuracy is required, (e.g. for investigation or research purposes) a 2.0 m straightedge and wedge should be used. Because of their high variability, the average of a number of readings should be determined and the rutting in different directions and wheel paths should be provided separately. The descriptions of degrees of rutting are given in Table B.9.

TABLE B.9: Degree of rutting

Degree	Description
1	Rutting is just visible
2	<20 mm deep
3	Rutting between 20 – 40 mm deep
4	40 – 60 mm deep
5	Rutting >60 mm deep affecting directional stability of a vehicle

RUTTING



Degree 1

X	**2**	**3**	**4**	**5**

Just visible



Degree 3

1	**2**	**X**	**4**	**5**

20 – 40 mm deep



Degree 5

1	**2**	**3**	**4**	**X**

> 60 mm deep

B.8.12 Erosion

Definition and cause

Erosion or scour is the loss of surfacing material caused by the flow of water over the road. The ability of a material to resist erosion depends on the shear strength (equal to the cohesion, as the normal stress is zero) under the conditions at which the water flow occurs. If the shear strength of the material is less than the tractive forces induced by the water flowing over the materials, grains will become detached and erosion will occur.

Problem

The result of erosion is runnels (run-off channels) which, when occurring transversely, result in extreme roughness and dangerous driving conditions, and when occurring longitudinally (on grades), form deep "ruts". Associated with this road defect is a significant loss of gravel. Much of this gravel is deposited in the drains and culverts necessitating extensive labour intensive maintenance. Erosion of the wearing course also results in a change in the properties of the material as various fractions of the material are selectively removed.

Assessment

Transverse or diagonal erosion channels can be quantified by their depth and width. However, they are best assessed in terms of their effect on riding quality. Longitudinal erosion channels are assessed in a similar way to ruts by visual estimation or measuring depth with a 2.0 m straight edge and wedge. Assessments should only relate to the trafficked area and not to the side drains. The descriptions of degrees of transverse and longitudinal erosion are given in Tables B.10 and B.11.

TABLE B.10: Degrees of transverse and diagonal erosion

Degree	Description
1	Minor evidence of water damage
2	Seen, but not felt or heard (channels 10 mm deep x 50 mm wide)
3	Can be felt and heard – speed reduction necessary (30 mm x 75 mm)
4	Significant speed reduction necessary (50 mm x 150 mm)
5	Vehicles drive very slowly and attempt to avoid them (>60 mm x 250 mm)

TABLE B.11: Degrees of longitudinal erosion

Degree	Description
1	Evidence of water damage
2	Channels <20 mm deep
3	Channels 20 – 40 mm deep
4	Channels 40 – 60 mm deep
5	Channels >60 mm deep

EROSION – TRANSVERSE



Degree 1

X	**2**	**3**	**4**	**5**

Minor Evidence of water damage



Degree 3

1	**2**	**X**	**4**	**5**

Can be felt and heard – speed reduction necessary – channels 30 mm deep x 75 mm wide



Degree 5

1	**2**	**3**	**4**	**X**

Vehicles drive very slowly and avoid erosion channels – channels > 60 mm deep x 250 mm wide

EROSION - LONGITUDINAL



Degree 1

X	**2**	**3**	**4**	**5**

Evidence of water damage



Degree 3

1	**2**	**X**	**4**	**5**

20 – 40 mm deep



Degree 5

1	**2**	**3**	**4**	**X**

> 60 mm deep

B.8.13 Corrugation

Definition and cause

Corrugations can be either “loose” or “fixed”. Loose corrugations consist of parallel alternating crests of loose, fine-sandy material and troughs of compacted material at right angles to the direction of travel. Fixed corrugations on the other hand consist of compacted crests and troughs of hard, fine sandy-gravel material. Loose corrugations are easily removed by blading, whereas fixed corrugations need cutting or even tining with the grader before the material is re-spread. The wavelength of the corrugations is dependent on the modal speed (i.e. most frequently occurring speed) of the vehicles using the road, with longer wavelengths formed by faster traffic.

Corrugations are caused by the initiation of wheel bounce by some irregularity in the road (or possibly even worn suspension components such as shock absorbers) that results in kick-back of non-cohesive material, followed by compression and redistribution of the wearing course as the wheel regains contact with the road. Only low plasticity materials corrugate significantly, especially those with a high sand and fine-gravel fraction. However, many roads with gravels having plasticity indices of up to nine have produced corrugations. These form when the material is continually spread from the sides of the road back onto the road during grader maintenance. This material is usually deficient in binder (most of it having been blown away with time as dust) and the material forming the corrugations is non-plastic.

Problem

Corrugations are one of the most disturbing defects of unsealed roads causing excessive roughness and poor vehicle directional stability. Corrugations seldom form to any significant extent during the wet season, as the material effectively remains slightly “cohesive” in its wet state through capillary suction and is not adequately mobile to form corrugations. Corrugations are frequently associated with areas of acceleration, deceleration and cornering.

Assessment

Corrugations should be scraped with a geological pick to determine whether they are loose or fixed – this will dictate the type of maintenance that will be required. The severity of corrugations is best assessed from within a moving vehicle at the average speed of the road. The descriptions of degrees of corrugation are given in Table B.12. Dedicated roughness measurement equipment can also be used to determine the road roughness if this level of detail is required.

TABLE B.12: Degrees of corrugation

Degree	Description
1	Not felt or heard in a light vehicle
2	Can be felt and heard – no speed reduction necessary
3	Can be felt and heard – speed reduction necessary
4	Significant speed reduction necessary
5	Drivers select a different path and drive very slowly. Safety is affected

CORRUGATION



Degree 1

X	**2**	**3**	**4**	**5**

Not felt or heard in a light vehicle



Degree 3

1	**2**	**X**	**4**	**5**

Can be felt and heard – speed reduction necessary



Degree 5

1	**2**	**3**	**4**	**X**

Vehicles select a different part of the road and drive very slowly

B.8.14 Loose Material

Definition and cause

Loose material (that material less than 26 mm in size) is formed by the ravelling of the wearing course gravel under traffic. This may be distributed over the full width of the road but more frequently, it is concentrated in windrows between the wheel tracks, or alongside the travelled portion of the road. It is mainly caused by a deficiency of fine material (because of lack of cohesion), a poor particle size distribution (e.g. gap grading) in the wearing course gravel and inadequate compaction. Ravelling is generally worse in the dry season than in the wet season when capillary suction results in apparent cohesion.

Problems

The major problems with roads susceptible to ravelling are:

- The windrows are a safety hazard
- Stones from the loose material may damage vehicles or windscreens
- The rolling resistance of the vehicle is increased by loose material with concomitant increases in fuel consumption and vehicle operating costs
- Windrows of loose material adjacent to the trafficked portion of the road impede surface drainage

Assessment

Loose material is assessed by estimating or measuring its thickness. This is achieved by scraping “paths” through the material to the hard surface with a geological pick and estimating the thickness or measuring it with a straightedge and wedge. The descriptions of degrees of loose material are given in Table B.13.

TABLE B.13: Degrees of loose material

Degree	Description
1	Just visible
2	Loose material < 20 mm thick
3	Loose material 20 – 40 mm thick
4	Loose material 40 – 60 mm thick
5	Loose material > 60 mm thick

Note:

It is important to assess the extent of the loose material as well as the degree in order to differentiate between traffic associated and maintenance associated loose material. Traffic associated loose material is usually limited to windrows, whilst maintenance associated loose material is usually distributed across the road. However, traffic induced windrows should not be confused with windrows left by the grader operator as a source of material for future blading operations. These windrows are usually on the very edge of the road and not along the wheelpaths.

LOOSE MATERIAL



Degree 1

X	**2**	**3**	**4**	**5**

Just visible



Degree 3

1	**2**	**X**	**4**	**5**

Loose material is 20 – 40 mm thick



Degree 5

1	**2**	**3**	**4**	**X**

Loose material is > 60 mm thick

B.8.15 Stoniness

Definition and cause

Stoniness is the relative percentage of material embedded in the road that is larger than a recommended maximum size (usually 37.5 mm). This is one of the few defects that can be controlled, but usually it is not.

The blading process periodically leaves loose stones (larger than 37.5 mm sieve) lying on the surface.

Problem

Excessively stony roads result in the following problems:

- Unnecessarily rough roads
- Difficulty with grader maintenance
- Poor compaction of areas adjacent to stones (leading to potholes and ravelling)
- The development of corrugations
- Thick, loose material is necessary to cover the stones
- Loose stones left after blading are likely to cause vehicle damage and potentially unsafe conditions.

Many geological materials, particularly shale and hornfels, produce flaky or sharp stones under crushing or grid rolling. These can cause extensive damage to tyres and affect the safety of the roads significantly. Some mudrocks may deteriorate rapidly on exposure to the atmosphere from a hard material to a soft, fine-grained “soil”. This causes significant problems, including dust, potholing and rapid gravel loss.

Assessment

Stones can be measured to determine the percentage that the maximum size limit has been exceeded by. This is time-consuming and an estimate of their severity and extent is usually sufficient. It should be noted that the extent of stoniness is usually overestimated by a significant margin. The impact of stoniness on riding quality is best evaluated from a moving vehicle. This can be supplemented by assessing the impact of the stones on the ease of blading. The descriptions of degrees of stoniness are given in Tables B.14 (embedded stones) and B.15 (loose stones). Dedicated roughness measuring equipment can also be used to determine the road roughness if this level of detail is required.

TABLE B.14: Degrees of embedded stoniness

Degree	Description
1	Seen, but not felt or heard in a light vehicle
2	Protruding stones can be felt and heard, but speed reduction not necessary. Blading is not affected.
3	Speed reduction necessary. Road is bladed with difficulty.
4	Protruding stones require evasive action
5	Vehicles avoid protruding stones or drive slowly. Road cannot be effectively bladed.

TABLE B.15: Degrees of loose stoniness

Degree	Description
1	Few loose stones 25 – 40 mm. Driver can change lanes safely
3	Many loose stones 25 - 50 mm or few loose stones > 50 mm. Stones influence drivers actions when changing lanes.
5	Windrows of loose stones 25 – 50 mm or many loose stones >50 mm. Any lateral movement of the vehicle poses a significant safety hazard.

STONINESS - EMBEDDED



Degree 1

X	**2**	**3**	**4**	**5**

Seen but not felt or heard in a light vehicle



Degree 3

1	**2**	**X**	**4**	**5**

Can be felt and heard in the vehicle



Degree 5

1	**2**	**3**	**4**	**X**

Vehicles avoid or drive slowly

STONINESS – LOOSE



Degree 1

X	**2**	**3**	**4**	**5**

Few loose stones 26 – 40 mm. Driver can change lanes safely.



Degree 3

1	**2**	**X**	**4**	**5**

Many loose stones 26 – 50 mm or few loose stones >50 mm. Stones influence drivers actions when changing lanes.



Degree 5

1	**2**	**3**	**4**	**X**

Windrows of loose stones 26 - 50 mm or many loose stones >50 mm. Any lateral movement of the vehicle pose a significant safety hazard.

B.8.16 Slipperiness and Skid Resistance

Definition and cause

Slipperiness is the loss of traction caused by an accumulation of excessively fine or plastic material on the surface of the wearing course in wet conditions. Skid resistance is affected by an excess of loose, fine gravel (between 2 and 7 mm in diameter) that accumulates on the road surface through ravelling under traffic or poor blading practices during dry conditions. This behaves like a layer of ball bearings and the skid resistance is reduced to practically zero. This is especially a problem on corners and at intersections.

Problem

The main problems with slipperiness and skid resistance are the safety implications for road users.

Assessment

Slipperiness is difficult to assess unless the rater actually experiences the condition. However, it can often be evaluated by observing wheel tracks formed during wet weather that are retained in the road after drying and other indicators. Slipperiness is rated as either acceptable or unacceptable. Skid resistance, also rated as either acceptable or unacceptable, should be evaluated in terms of the effect of loose material on vehicle stability and the general impression gained while driving and braking on the dry road. These ratings are summarised in Tables B.16 and B.17

TABLE B.16: Rating of slipperiness

Rating	Description
Acceptable	Exposed and protruding gravel on road surface. No significant cracking (> Degree 3 (Table B.18)). No evidence of tyre impressions remaining on the road surface.
Unacceptable	Smooth clayey surface with few protruding gravel particles. Significant cracking (> Degree 3 (Table B.18)). Evidence of tyre impressions remaining on the road surface. Evidence of compaction and shearing under traffic. Loss of control when driving on a wet surface.
NB The absence of evidence of slipperiness does not necessarily mean that the road will not be slippery. The evidence described above tends to be worn away under traffic within 6-8 weeks, or may be removed by blading.	

TABLE B.17: Rating of skid resistance

Rating	Description
Acceptable	No excessive fine gravel (2-7 mm) in the wheel tracks. Exposed and protruding gravel on road surface. Good directional control when braking.
Unacceptable	Presence of layer of fine gravel (2-7 mm) in the wheel tracks. Loss of directional control when braking.

SLIPPERINESS



Degree 1

X	**2**	**3**	**4**	**5**

Acceptable



Degree 5

1	**2**	**3**	**4**	**X**

Unacceptable

SKID RESISTANCE



Degree 1

X	**2**	**3**	**4**	**5**

Acceptable



Degree 5

1	**2**	**3**	**4**	**X**

Unacceptable

B.8.17 Cracks

Cracks are usually not required as input into GRMS's, but information can be used to support other assessments (e.g. severe cracking is indicative of high plasticity gravels as well as potential for unacceptable slipperiness). These data may also be useful for project level or research assessments.

Definition and cause

Cracking of the wearing course (which usually occurs only during the dry season) is a result of the plasticity being too high or the material being very fine-grained.

Problem

Cracks as such are not a major problem on unsealed roads, but bad cracking may lead to the formation of potholes during the dry season. Materials that crack badly also tend to become slippery when wet. Roads with 100 to 150 mm diameter cracked blocks will often break up under traffic and form potholes.

Assessment

Cracks should be visually assessed on the basis of crack width, which may be measured if necessary as described in Table B.18.

TABLE B.18: Degrees of cracking

Degree	Description
1	Faint – requires close scrutiny
2	Distinct – seen at walking pace
3	Distinct – seen from a moving vehicle
4	Open cracks - ≤ 3 mm wide
5	Open cracks - > 3 mm wide

CRACKS



Degree 1

X	**2**	**3**	**4**	**5**

Faint – Require close scrutiny



Degree 3

1	**2**	**X**	**4**	**5**

Distinct – seen from a moving vehicle



Degree 5

1	**2**	**3**	**4**	**X**

Open cracks - > 3 mm wide

B.8.18 Isolated Problems

During the assessment of unsealed roads, problematic localised areas may be noted. These are such that they should not influence the overall rating of the segment, but a record should be made of the problems for possible later attention. The problem could be indicative of non-uniformity within the segment resulting from different materials, localised drainage problems or excessive material loss. Where isolated problems are identified and indicated as such on the assessment form, it is useful to provide more information in the space allocated on the form for comments.

The isolated problems that should be recorded are:

- Potholes
- Subgrade exposure
- Transverse erosion
- Longitudinal erosion
- Rough areas
- Slippery areas

These problems have been discussed individually in the document.

ISOLATED PROBLEMS



Potholes



Subgrade exposure



Transverse erosion

ISOLATED PROBLEMS



Longitudinal erosion



Rough area



Slippery area

B.8.19 Maintenance Action

During the assessment for GRMS data, the opportunity should be taken to identify possible maintenance action requirements for the segment. Although this would normally be done at project level, the information can be useful to cross-check other parameters rated as well as for overall network level budgeting as a first approximation. Typical maintenance actions include:

- Local repairs – labour intensive spot gravelling often associated with impassability, drainage/erosion problems or removal of excessive oversize material.
- Routine blading – identify the need for continuation of routine blading, or adjustment of the blading programme to be more appropriate to that specific segment.
- Reshaping – where the road profile is incorrect resulting from insufficient or poor maintenance, this option can be marked. Depending on the severity of the problem, reshaping will entail heavy blading with watering and compaction, but could require limited ripping and recompaction in exceptional circumstances.
- Reworking – rip, rebuild to correct width, add additional material and reshape with watering and compaction. Breaking down or removal of oversize material may also be necessary.
- Regravelling – where there is insufficient material to provide the required service until the next assessment, this option should be selected.
- Drainage improvement – where drainage maintenance has been ineffective or insufficient drainage exists, corrective action needs to be taken. This could involve labour intensive clearing and reshaping of side drains and mitre drains, or the installation of new pipes.

Rehabilitation in the traditional sense is not applicable to unsealed roads. Regravelling essentially replaces rehabilitation. The closest possible equivalent is road betterment where geometrics and alignment are improved during the regravelling operation.

B.9. Dust Palliative/Chemical Stabiliser Treatments

Dust palliatives and chemical stabilisers are being increasingly used on unsealed roads to reduce dust and improve material properties, thereby reducing the rate of gravel loss and the number of bladings required per year. Treated segments should be assessed in the same way as untreated unsealed roads. However, comment should be made on whether the product is achieving the purpose for which it was applied (e.g. dust control, improved trafficability) and whether it requires rejuvenation.

B.10. Material Sampling

Material sampling is usually not required for GRMS assessments, but certain road authorities may excavate a hole to measure layer thickness. However, for project level and research investigations, accurate data on the material properties are often required and the materials will have to be sampled from the road. Sampling will usually be required in the following situations:

- Problem identification
- Experimental sections
- If the existing material is to be treated or used as a layer during upgrading of the road

This necessitates the collection of representative samples for laboratory testing. Samples should be removed from holes sufficiently large to provide adequate material for testing according to the method described in TMH5[5]. These holes should be excavated to the full depth of the layer and must have vertical sides. **All material excavated from the hole must be included in the sample.** All sample and observation holes must be repaired by backfilling them with material with similar properties to that excavated. This material should be moistened and compacted into the hole.

B.11. Use of Data

It is not the intention of this document to instruct on the use of the data collected. However, a number of simple preliminary exercises are discussed below.

The primary use of the data collected during the assessment is for input into the gravel road management system. It is thus essential that the visual assessment forms be completed fully and accurately. The success of the decision making process depends on this.

The data collected can be used for determining various indices (e.g. Visual Condition Index (VCI)), similar to that determined for sealed roads as discussed in TRH22[6] (to date there is no TRH document published for GRMS's). It should, however, be noted that comparison of different unsealed road VCI estimates is often not valid in the same way as that for sealed roads. The VCI determined for unsealed roads is a function of the time elapsed since the last regravelling and blading as well as traffic and climatic influences immediately prior to rating. The data collected can also be used:

- As a basis for predicting gravel loss and blading frequency
- For prioritising maintenance actions (e.g. defects with a severity of 4 or 5 should be given immediate attention, while defects with a severity of three should be considered as a warning that will require attention in the near future)
- For monitoring improvement or deterioration in the overall road network as a result of funding fluctuations
- For direct comparisons of the performance of various roads
- For location of specific problems
- As a basis for project level investigations.

For project level and research investigations, the data can be entered into a spreadsheet. The data collected is best assessed by highlighting certain parameters or ratings. This can be rapidly done using simple spreadsheet macros. For instance:

- All segments with corrugation severity ratings in excess of 3 could be highlighted and this could be used to identify possible areas for sand cushioning.
- Highlighting all severity ratings of 4 or 5 could indicate specific segments of road with unacceptably severe problems.

- By combining various ratings and extent, it is possible to prioritise those segments requiring urgent maintenance or upgrading.
- Identify modes of distress for specific roads – i.e. is it material -, maintenance -, or environmentally – related? Remedial measures can then be defined.
- Gravel thicknesses can be plotted over time to indicate the rates of gravel loss for different scenarios.

Further detail regarding the use of data is beyond the scope of this document.

C. GLOSSARY

Assessment segment: An assessment segment is the length of road for which one assessment rating is recorded. In the case of rural road networks, a road link is normally divided into road segments for visual assessment. For urban road networks where road links may be very short, links may be grouped together to form an assessment segment.

Earth road: An unsealed road in which the in situ material is directly travelled by vehicles.

Gravel road: An unsealed road in which an imported material has been placed to provide a riding surface for vehicles.

Gravel Road Management System (GRMS): is part of a Road Management System, which is a set of procedures aimed at maximising the potential serviceability of a road network. These procedures are used by the managers of the road network (usually with the aid of computerised facilities) to evaluate maintenance, improvement and upgrading alternatives, and the establishment of new facilities when needed.

Gravel wearing course: the exposed material imported to protect the foundation from wear by vehicles.

Link: A road link is the length of road from one intersection or interchange to the next.

Overall performance: is a single rating of how the travelling public view the condition and performance of the road. This should include all functional and safety aspects.

Rehabilitation: of unsealed roads generally involves improvement in geometrics as well as pavement structure and materials. Regravelling alone is not regarded as rehabilitation, but as a routine maintenance operation.

Road section: A road section is a length of road with a unique section number (refer to Section A.4.2).

Surfaced road: A road on which a bituminous, concrete or block layer has been placed to provide an all-weather surface for traffic.

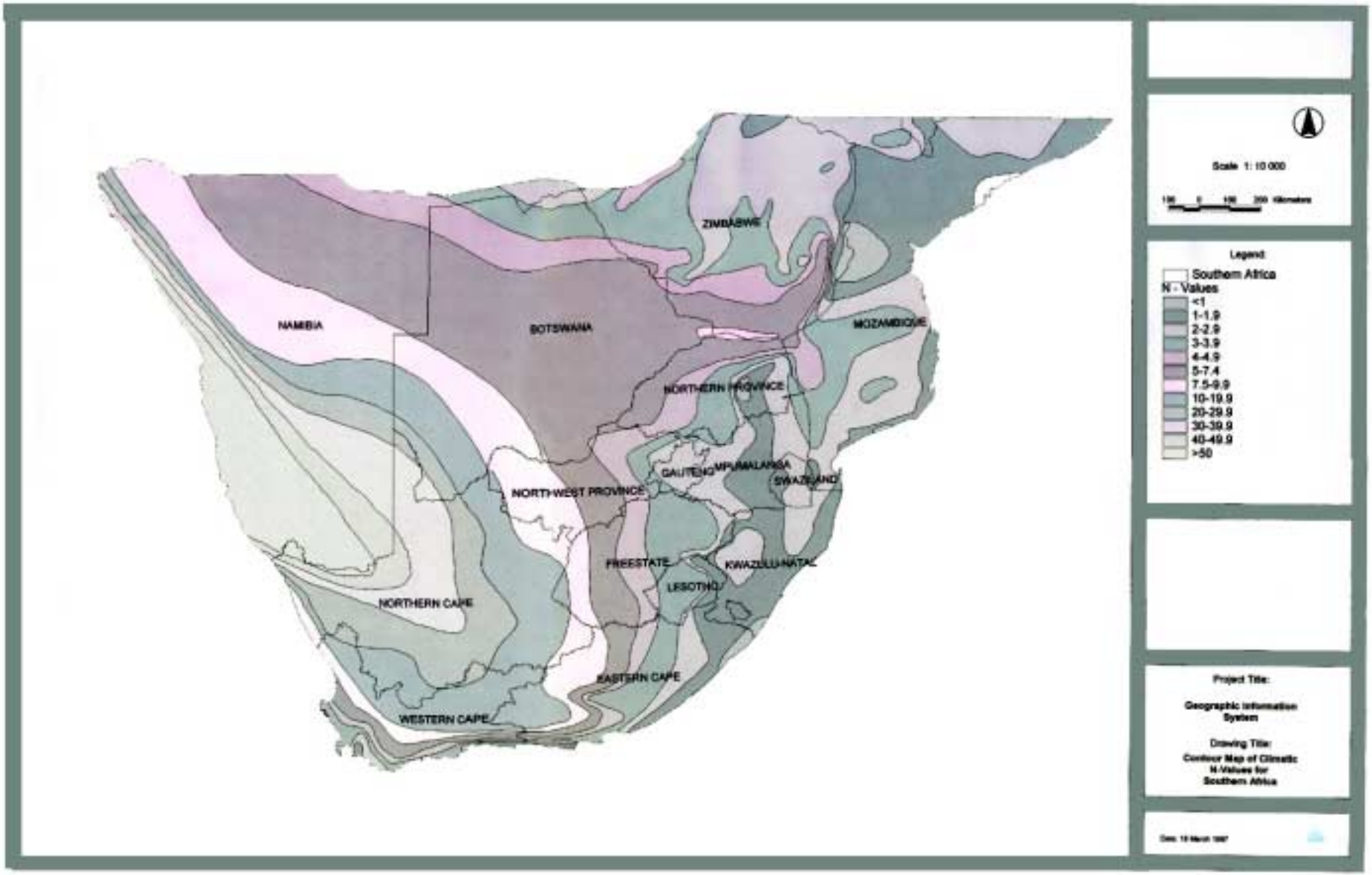
Traffic volume: A single value representative of the quantity of/or type of traffic using a road. Different road authorities use different parameters, e.g. Annual Average Daily Traffic (AADT), Average daily traffic (ADT), Equivalent Vehicle Units (EVU) etc.

"Warning": The condition of various defects is often referred to as "warning". This term indicates a condition that requires some action in the near future and/or a problem that may develop into a more serious one.

Weinert N-value: A climatic index based on evaporation in the warmest month of the year, and annual rainfall. The minerals found during weathering of rocks are a function of the Weinert N-value. A map of Weinert N-values for South Africa is provided in Figure C.1.

Width: Two different road widths need to be considered during visual assessments on unsealed roads.

- Total width, which includes shoulders and is used for calculation of gravel quantities for regravelling
- The trafficked width usually demarcated by windrows at each side, which is used for assessment purposes.


ZIMBABWE
NAMIBIA
BOTSWANA
MOZAMBIQUE
NORTHERN PROVINCE
GAUTENG
MPUMALANGA
SWAZILAND
NORTH-WEST PROVINCE
FREESTATE
KWAZULU-NATAL
LESOTHO
NORTHERN CAPE
EASTERN CAPE
WESTERN CAPE
Scale 1: 10 000
Legend
Southern Africa
N - Values
<1
1-1.9
2-2.9
3-3.9
4-4.9
5-7.4
7.5-9.9
10-19.9
20-29.9
30-39.9
40-49.9
>50
Project Title:
Geographic Information System
Drawing Title:
Contour Map of Climatic N-Values for Southern Africa

D. TYPICAL ASSESSMENT FORMS

Example forms for the following types of assessment are included:

- Form 1 - input for strategic network level assessment
- Form 2 - input for strategic network level assessments with some detailed information for project level maintenance
- Form 3 - input for detailed network level assessment
- Form 4 - evaluation of experimental sections

UNSEALED ROAD ASSESSMENT FORM																							
Evaluator																	Date						
Road No					Section																		
Start km					End km																		
Segment No										Start km							End km						
General performance	1		2		3		4		5		Moisture								Wet				Dry
Gravel quantity	1	Plenty		2	Sufficient		3	Isolated exposures		4	Extensive exposures		5	None									
Gravel quality	1	Very good		2	Good		3	Average		4	Poor		5	Very poor									
Influencing factors		Clay			Sand			Gravel/stones															
Road profile/shape	1	Very good (4%)		2	Good (2%)		3	Flat		4	Uneven		5	Very uneven									
Drainage from the road	1	Well above ground		2	Slightly above		3	Level with ground		4	Slightly below		5	Canal									
Riding quality/safety	1	Very good (>100 km/h)		2	Good (100 km/h)		3	Average (80 km/h)		4	Poor (60 km/h)		5	Very poor (40 km/h)									
Influencing factors	Corrugation			Loose material			Stoniness			Potholes			Ruts			Erosion						
Dust	1	Acceptable		5	Unacceptable																		
Trafficability	1	Acceptable		5	Unacceptable																		
Isolated problems	Potholes			Subgrade exposure			Transverse erosion			Longitudinal erosion			Rough area			Slipperiness						
Maintenance action	Local repairs			Routine blading			Heavy blading			Regravelling			Reshaping			Drains						
Comments (Not captured in the system)																							
Inventory check																							
Material	Basic Crystalline			Acid Crystalline			High silica			Arenaceous			Argillaceous			Diamictite						
	Metaliferous			Carbonate			Pedocrete			Fer		Cal	Gyp		Sil	Transported						
Road width	<8 m		8-10 m		>10m		Road type			Gravel			Earth			Treated						

UNSEALED ROAD ASSESSMENT FORM

Evaluator															Date					
Road No			Section																	
Start km			End km				Position													
Segment No						Start km					End km									
General performance	1	2	3	4	5	Moisture					Wet					Dry				
Gravel quantity	1	Plenty		2	Sufficient		3	Isolated exposures		4	Extensive exposures			5	None					
Gravel quality	1	Very good		2	Good		3	Average		4	Poor			5	Very poor					
Influencing factors		Clay			Sand			Gravel/stones												
Road profile/shape	1	Very good (4%)		2	Good (2%)		3	Flat		4	Uneven			5	Very uneven					
Drainage from the road	1	Well above ground		2	Slightly above		3	Level with ground		4	Slightly below			5	Canal					
Riding quality/safety	1	Very good (>100 km/h)		2	Good (100 km/h)		3	Average (80 km/h)		4	Poor (60 km/h)			5	Very poor (40 km/h)					
Influencing factors	Corrugation			Loose material			Stoniness			Potholes			Ruts			Erosion				
Maintenance action	Local repairs			Blading			Heavy blading			Regravelling			Reshaping			Drains				

	Degree						Extent				
Potholes	0	1	2	3	4	5	1	2	3	4	5
Rutting	0	1	2	3	4	5	1	2	3	4	5
Erosion - transverse	0	1	2	3	4	5	1	2	3	4	5
Erosion – longitudinal	0	1	2	3	4	5	1	2	3	4	5
Corrugation	0	1	2	3	4	5	1	2	3	4	5
Loose material	0	1	2	3	4	5	1	2	3	4	5
Stoniness – embedded	0	1	2	3	4	5	1	2	3	4	5
Stoniness - loose	0	1	2	3	4	5	1	2	3	4	5
Dustiness	0	1	2	3	4	5					
Slipperiness	Acceptable			Unacceptable							
Skid resistance	Acceptable			Unacceptable							
Trafficability	Acceptable			Unacceptable							

Isolated problems	Potholes	Subgrade exposure	Transverse erosion	Longitudinal erosion	Rough area	Slipperiness

Comments

Inventory check

Material	Basic crystalline		Acid Crystalline		High Silica	Arenaceous		Argillaceous		Diamictite	
	Metaliferous		Carbonate		Pedocrete	Fer	Cal	Gyp	Sil	Transported	
Road width	<8m	8-10m	>10m	Road type	Gravel			Earth		Treated	

UNSEALED ROAD ASSESSMENT FORM

Evaluator																		Date			
District														Road No				Section			
Start km			End km											Position							
Segment No										Start km							End km				
General performance	1	2	3	4	5					Moisture							Wet			Dry	
Layer thickness (mm)																					
Layer thickness category	0-25mm					25-50mm				50-100mm				>100mm							
Subgrade exposure	None					Isolated				General											
Gravel quality	Classification					Course				Medium				Fine							
	Max size (mm)					>50				25-50				13-25				<13			
	Estimated PI					<6				6-15				>15							
Road profile/shape	1	Very good (4%)				2	Good (2%)			3	Flat			4	Uneven			5	Very uneven		
Drainage from the road	1	Well above ground				2	Slightly above			3	Level with ground			4	Slightly below			5	Canal		
Riding quality/safety	1	Very good (>100 km/h)				2	Good (100 km/h)			3	Average (80 km/h)			4	Poor (60 km/h)			5	Very poor (40 km/h)		
Influencing factors	Corrugation					Loose material				Stoniness				Potholes				Ruts			Erosion
Maintenance action	Local repairs					Blading				Heavy blading				Regravelling				Reshaping			Drains

	Degree							Extent				
Potholes	0	1	2	3	4	5		1	2	3	4	5
Rutting	0	1	2	3	4	5		1	2	3	4	5
Erosion - transverse	0	1	2	3	4	5		1	2	3	4	5
Erosion – longitudinal	0	1	2	3	4	5		1	2	3	4	5
Corrugation	0	1	2	3	4	5		1	2	3	4	5
Loose material	0	1	2	3	4	5		1	2	3	4	5
Stoniness – embedded	0	1	2	3	4	5		1	2	3	4	5
Stoniness - loose	0	1	2	3	4	5		1	2	3	4	5
Dustiness	0	1	2	3	4	5						
Slipperiness	Acceptable			Unacceptable								
Skid resistance	Acceptable			Unacceptable								
Trafficability	Acceptable			Unacceptable								

Isolated problems	Potholes	Subgrade exposure	Transverse erosion	Longitudinal erosion	Rough area	Slipperiness

Comments

Inventory check

Material	Basic crystalline		Acid Crystalline		High Silica	Arenaceous		Argillaceous		Diamictite		
	Metaliferous		Carbonate		Pedocrete	Fer	Cal	Gyp	Sil	Transported		
Road width	<8m	8-10m	>10m	Road type	Gravel		Earth		Treated			

UNSEALED ROAD ASSESSMENT FORM

Evaluator						Date/time						
Project		Road No			Section			Position				
Material					Slope			Moisture				
Climate					Terrain	F	R	M	Traffic	L	M	H
Map					Photo's							

Overall	1	2	3	4	5	Dust	@	QI/IRI	@
Gravel depth	1	2	3	4	5	mm			
Gravel quality	1	2	3	4	5				
Drainage (road)	1	2	3	4	5				
Drainage (side)	1	2	3	4	5				
Stoniness (loose)		ι							
Stoniness (fixed)		ι ;							
Potholes		ι ;						Max size	
Rutting		88 99 : ;						Max size	
Loose material		88 99 : ;						Biggest	
Corrugations		L F : ;							
Erosion		L T : ;							
Cracking									
Slipperiness	Y	N							
Skid resistance	Y	N							
Passability	Y	N							
Maintenance									
Road reserve									

Notes

Density	Wet	Dry	NMC	Tin No	GMC	Pos		Sample details
150 mm						LO	LI	
100 mm						C		
50 mm						RI	RO	

E. MATERIAL IDENTIFICATION

In order to benefit from the use of gravel road assessments and management systems, it is essential that the materials used are correctly classified. This need not require a high degree of geological expertise.

This appendix contains a guide, modified after Weinert (1980), to the application of the 'rule of quartz' for rock identification. The guide is based on the assumption that the user is sufficiently familiar with the appearance of quartz and opal (amorphous silica) in rocks to recognize them macroscopically, i.e. with the naked eye or a hand lens (magnification 8 to 10 times). The inspection of the sample must always be done on a freshly crushed face and the following equipment should be available:

- Geological hammer
- Hand lens
- Pocket knife
- A bottle of diluted hydrochloric acid (HCl) is useful for the identification of carbonate materials.

To use the guide, begin with the left-hand column and proceed column by column to the right. Every item must be considered and the reader must keep within the same horizontal division proceeding to the right. This will lead to the group in which the inspected material belongs.

In the column to the right of that of the group names, individual rock names are shown. It is not essential that these rock types are individually identified but they are provided as an aid. Many of these names have been used in the past and will need to be assigned to the wider classification groups proposed.

Quartz, Opal	Texture & mineral composition	Colour and luster	Matrix	Fracture face	Intermixed other components	Additional physical characteristics	Group	Possible rock type	Remarks
All quartz or opal (amorphous silica)	Glassy to vitreous, very dense, uniform	Mostly white, but also many other colours, or colourless; shiny or glossy luster	None	Smooth, conchoidal	None	Very hard, cannot be scratched with pocket knife	High-silica rock	Vein quartz Chert Hornfels	
	Dense	Mostly dark shades of grey		Smooth to slightly rough				Hornfels	
	Granular with grains of varying sizes	Many but shades of grey predominant; luster shiny or glossy	Siliceous	Smooth, breaks equally through grains and matrix				Quartize	Occasionally contains sulphide minerals, e.g. pyrite
		Many but shades of grey predominant; luster dull but individual grains may flicker in sunlight		May be smooth or rough depending on strength of cementing matrix	Variable, depending on host material	Cannot be scratched with pocket knife; voids (honeycomb)	Pedogenic material	Silcrete	Distinction from quartzite often very difficult; seek expert advice
				Breaks run through matrix and the unbroken (sand) grains protrude: fracture face feels rough (sandpaper)	Occasionally single minerals, especially feldspar, and rock fragments	Cannot be scratched with pocket knife but single sand grains may be removed in this way	Arenaceous rock	(Quartzitic) sandstone, grit conglomerate	
Mostly quartz or opal (>50%)	Granular, mostly sand grains	Many colours, lustre dull	Calcareous, ferruginous or clayey	Very rough, feels like sandpaper; grains can be removed with needle or pocket knife	Occasionally feldspar; very rarely other minerals	Matrix can be scratched with pocket knife; calcareous matrix 'boils' in hydrochloric acid (HCl)		Sandstone Gritstone Conglomerate Arkose (if containing Feldspar)	May contain mica or sulphide minerals, especially pyrite
	Granular; alternating thin sheets of quartz and mica	Shades of grey, minerals flicker in sunlight	None	Smooth, parallel with bedding, and rough perpendicular to beds	Occasionally minerals other than quartz and mica	Breaks into platy pieces. Scratched easily with pocket knife on bedding planes		Sandstone Gritstone Conglomerate Arkose (if containing Feldspar)	May contain mica or sulphide minerals, especially pyrite
								Mica Schist	
	Granular, grains of various sorts and sizes	Mostly shades of grey; lustre dull	Clayey, rarely siliceous	Rough, feels like sandpaper, grains can be removed with needle or pocket knife	Contains angular to sub-angular fragments of all sorts of minerals and rocks	Strength may vary considerably. Resistance to scratching variable	Diamicite	Greywacke Tillite Volcanic breccia	Recognition of these rocks often difficult, use should be made of expert advice
	Dense to vitreous fine granular	Red to brown, generally dull but grains flicker in sunlight	Ferruginous	Smooth to rough: when rough it feels like fine sandpaper	None	Very heavy	Metaliferous rock	Ironstone	Occasionally shades of colour vary in fine layers (banded ironstone)
Quart or opal prominent (>10%, <50%)	Vitreous, quartz as single crystals or as clusters may float in vitreous matrix; often signs of flow or turbulence	Mostly shades of red from light to dark but other colours as well; lustre dull to slightly shiny	Dense, rather uniform mass	Rather smooth, quartz grains may produce a degree of roughness		If at all, can only be scratched with difficulty with pocket knife; may contain voids	Acid crystalline rock	Felsite Rhyolite Quartz porphyry	These rocks are not easily identified and expert advice may be required
	Granular, crystalline	Generally light coloured; crystals flicker in sunlight	None	Rough; there may be smooth faces of large crystals		Elongated crystals may be in parallel or sub-parallel arrangements		Granite Gneiss (when parallel arrangement of crystals) Pegmatite	
	Sand grains in very finely grained to dense material	Varying, lustre very dull	Clayey	Rough	Not significant	Scratched easily with pocket knife; feels like blotting paper on wet tongue; gritty feel between teeth when bitten	Argillaceous rock	Mudstone Shale Slate	
					Contains angular to sub-angular fragments of all sorts of minerals and rocks	Strength may vary considerably. Resistance to scratching variable	Diamictite	Greywacke Tillite Volcanic breccia	Recognition of these rocks often difficult, use should be made of expert advice
		White, brown, yellowish-brown, reddish-brown to almost black; lustre generally dull, black parts may flicker in sunlight	Carbonate, iron oxide (red) or iron hydroxide (brown)	Mostly rough, white (carbonate) materials may be rather smooth	Any soil or weathered rock	Scratched easily with pocket knife; white material (carbonate) 'boils' in hydrochloric acid (HCl)	Pedogenic material	Calcrete (white) Ferricrete (other colours)	
Quartz or opal scarce or absent (<10%: can only be detected by looking carefully)	Very finely 'bedded' with very thin bands of elongated lenses of quartz between often wavy layers of micaceous and other very fine-gained and dense material	Mostly shades of grey, brown or greenish: perpendicular to layers slightly flickering in sunlight; parallel to layers noticeably silky	None	Rough perpendicular to layers; smooth parallel to layers	None	Feels soapy on layer planes which are also scratched easily with needle or pocket knife	Argillaceous rock	Phyllite Sericite schist Slate	
	Granular, crystalline, appears to be composed of one type of mineral only	Mostly reddish or red but may also be white; often contains a few dark green to black minerals (hornblende)	None	Rough; there may be faces of large crystals	None	Cannot be scratched with pocket knife but can be with a piece of quartz	Acid crystalline rock	Syenite	
		Mostly white but other colours also possible; general flicker in sunlight				Scratched easily with pocket knife; 'boils' in hydrochloric acid (HCl)	Carbonate rock	Marble	
	Granular, crystalline	Generally dark-coloured but a few types are light-coloured or even white. Crystals flicker in sunlight		Rough		Individual minerals react different to scratching	Basic crystalline rock	Amphibolite Diabase Diorite (light-coloured) Dolerite Gabbro Norite	For identification of exact type of rock obtain expert advice
	Granular, crystalline	Shades of green; lustre shiny; flicker in sunlight		Variable, tending to be smooth		Can be scratched with pocket knife; surface may fee 'soapy'		Serpentinite	
	Vitreous and dense. May contain empty or filled voids. There may be individual crystals (e.g. olivine) in dense material	Dark shades of various colours; lustre shiny to dull	Dense, uniform mass	Smooth to finely textured, rough	Voids may be filled with opal or even quartz besides other minerals (e.g. zeolites, calcite) which are mostly white to light-coloured	None		Andesite Basalt	Sill phases of diabase or dolerite may be very similar to basalt: if in doubt obtain expert advice
	Very dense and sub-microscopically fine-grained	Colour variable but mostly shades of grey or red; lustre dull	None	Rough	None	Scratched easily with pocket knife; feels like blotting paper on wet tongue; silty or butter-like fell between teeth when bitten	Argillaceous rock	Mudstone Shale Slate	
	Very dense and sub-microscopically fine-grained	Colour often white but also shades of grey and others; lustre dull				Scratched easily with pocket knife; 'boils' in hydrochloric acid (HCl)	Carbonate rock	Dolomite Limestone	Limestone 'boils' much more vigorously than dolomite
				May be rough or smooth	Any weathered rock	Can be scratched with pocket knife; 'boils' in hydrochloric acid; may contain voids (honeycomb)	Pedogenic material	Calcrete Dolocrete	Calcrete 'boils' much more vigorously than dolocrete
		Colour brown to reddish or yellowish brown, occasionally almost black; lustre generally dull but may flicker in sunlight when black	None	Rough	None	Nodular structure mostly clearly detectable; broken nodules may contain yellowish, soft, clayey material	Pedogenic material	Ferricrete	
	Dense to granular	Black, may flicker in sunlight				Very heavy, magnetic (affects needle of compass)	Metaliferous rock	Magnetite	
	Dense to fibrous	White to light green				Surface may feel slightly 'soapy'		Magnesite	Since confusion with other decomposition products of mafic minerals may occur, expert advice is recommended

Definitions:
Lustre – the character of light reflected by the minerals/rock
Vitreous – glass-like
Conchoidal – type of fracture with curved, ribbed surface

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