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

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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:

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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.

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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.

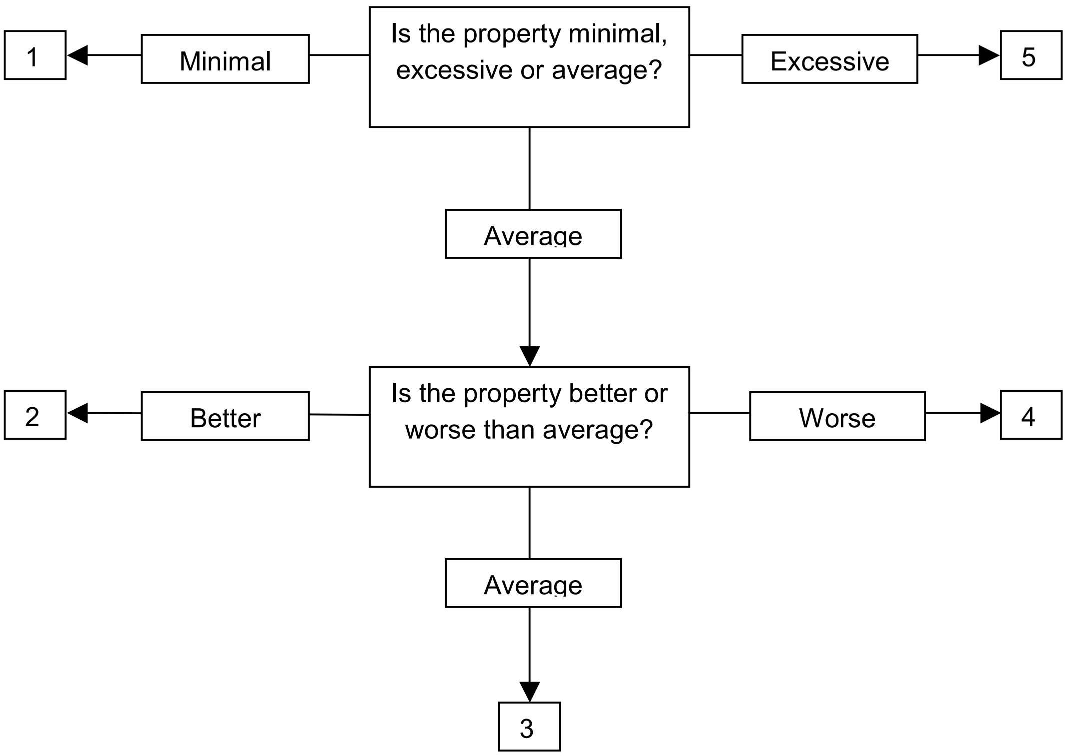


FIGURE A.1: Flow diagram – five point classification system

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

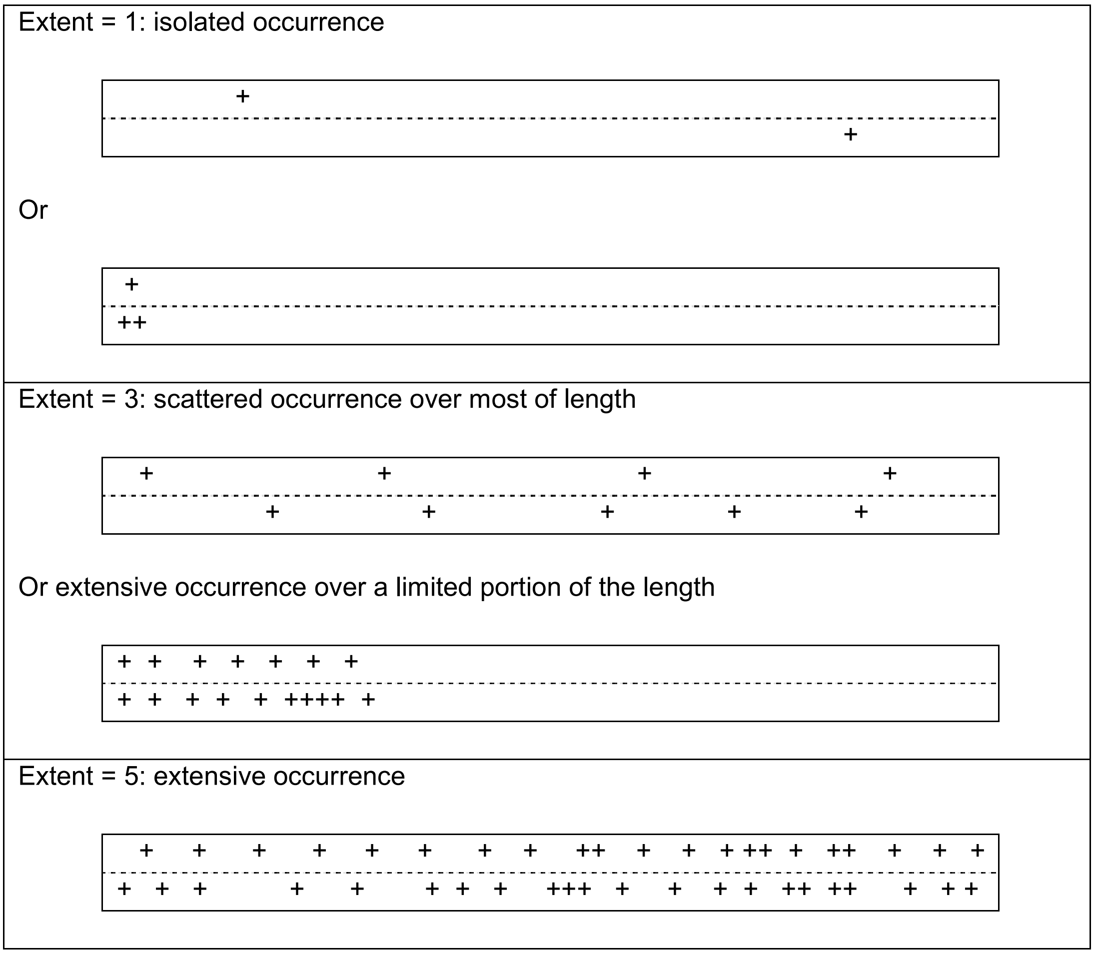


FIGURE A.2: Diagrammatical illustration of extent

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

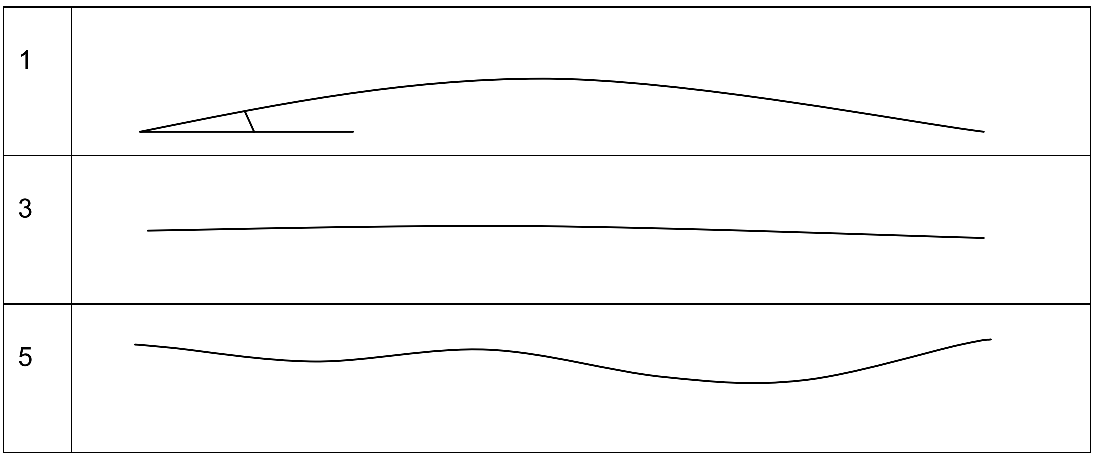


FIGURE B.1 Gravel profile schematics

<table>
<tr><th colspan="6">GRAVEL PROFILE</th></tr>
<tr><td rowspan="3"></td><td colspan="5">Degree 1</td></tr>
<tr><td>X</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td colspan="5">Very good</td></tr>
<tr><td rowspan="3"></td><td colspan="5">Degree 3</td></tr>
<tr><td>1</td><td>2</td><td>X</td><td>4</td><td>5</td></tr>
<tr><td colspan="5">Flat</td></tr>
<tr><td rowspan="3"></td><td colspan="5">Degree 5</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>X</td></tr>
<tr><td colspan="5">Very uneven</td></tr>
</table>

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		

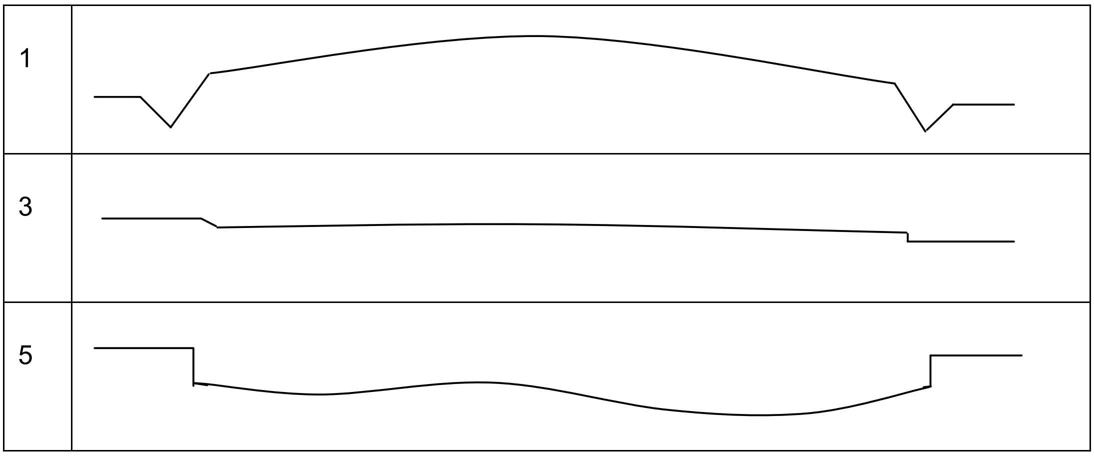


FIGURE B.2: Schematics of road drainage

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

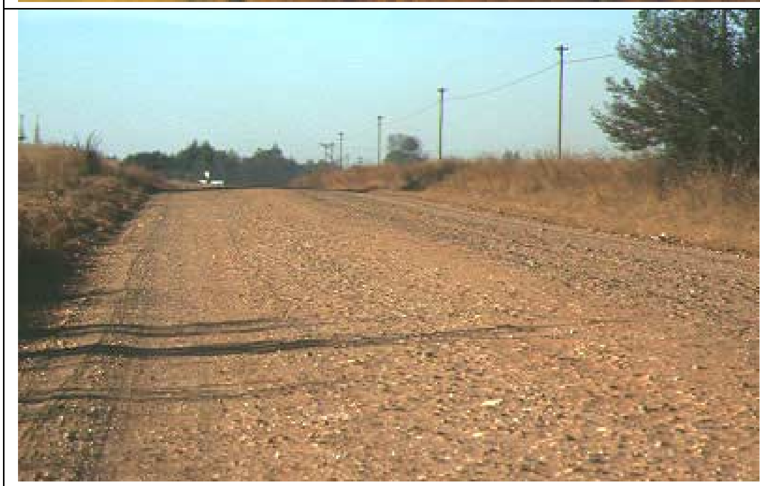
Average

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

<table>
<tr><th colspan="4">DUST (GRMS assessment)</th></tr>
<tr><td rowspan="3"></td><td colspan="3">Degree 1</td></tr>
<tr><td>X</td><td></td><td>5</td></tr>
<tr><td colspan="3">Acceptable</td></tr>
<tr><td rowspan="3"></td><td colspan="3">Degree 5</td></tr>
<tr><td>1</td><td></td><td>X</td></tr>
<tr><td colspan="3">Unacceptable</td></tr>
</table>

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.

<table>
<tr><th colspan="4">TRAFFICABILITY</th></tr>
<tr><td rowspan="3"></td><td colspan="3">Degree 1</td></tr>
<tr><td>X</td><td></td><td>5</td></tr>
<tr><td colspan="3">Acceptable</td></tr>
<tr><td rowspan="3"></td><td colspan="3">Degree 5</td></tr>
<tr><td>1</td><td></td><td>X</td></tr>
<tr><td colspan="3">Unacceptable</td></tr>
</table>

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

<u>Definition and cause</u>
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.

<u>Problem</u>
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.

<u>Assessment</u>
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.

<table>
<tr><th colspan="6">SLIPPERINESS</th></tr>
<tr><td rowspan="3"></td><td colspan="5">Degree 1</td></tr>
<tr><td>X</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td colspan="5">Acceptable</td></tr>
<tr><td rowspan="3"></td><td colspan="5">Degree 5</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>X</td></tr>
<tr><td colspan="5">Unacceptable</td></tr>
</table>

<table>
<tr><th colspan="6">SKID RESISTANCE</th></tr>
<tr><td rowspan="3"></td><td colspan="5">Degree 1</td></tr>
<tr><td>X</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td colspan="5">Acceptable</td></tr>
<tr><td rowspan="3"></td><td colspan="5">Degree 5</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>X</td></tr>
<tr><td colspan="5">Unacceptable</td></tr>
</table>

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.

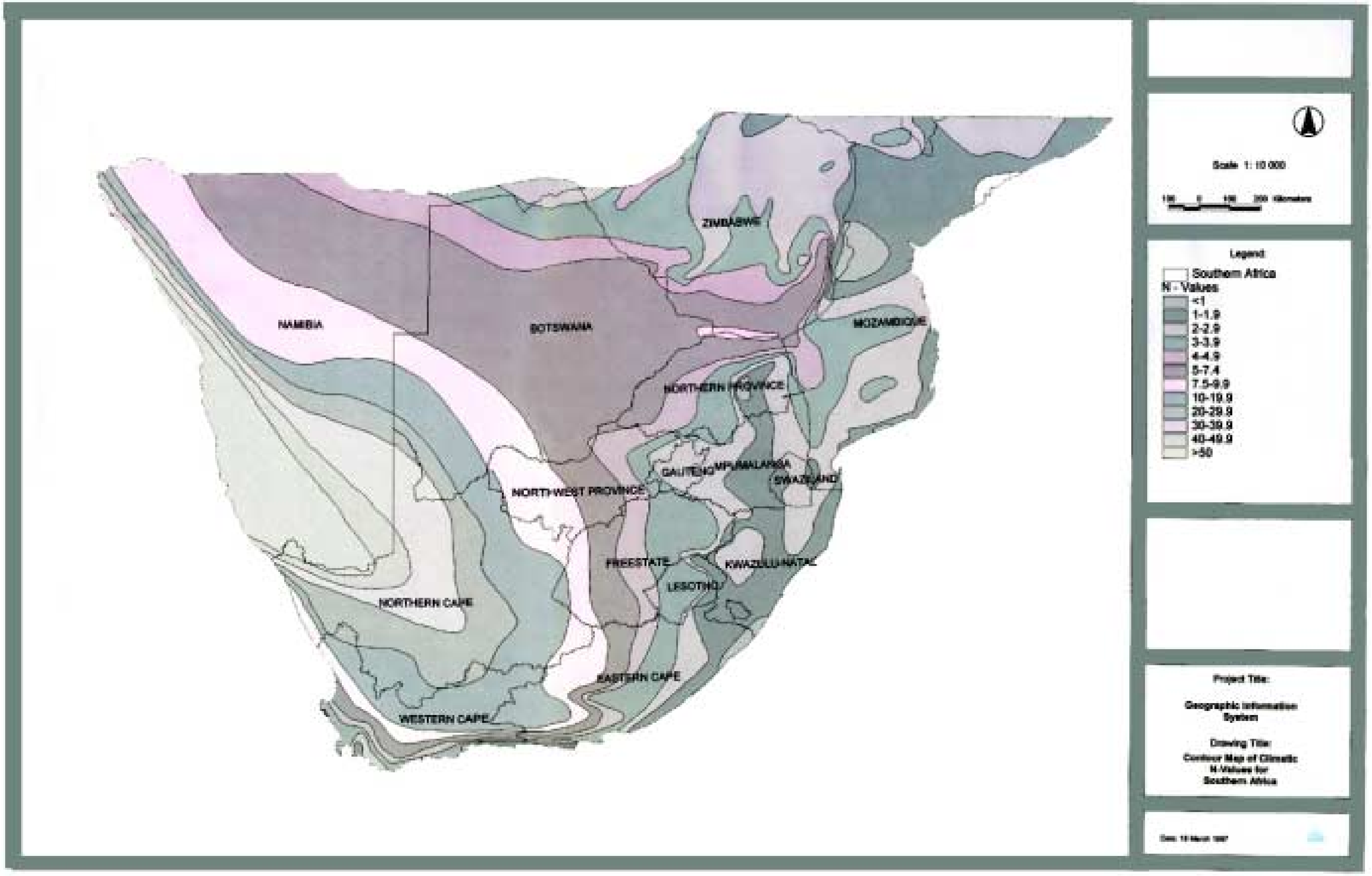
Traffic volume: A single value representative of the quantity of/or type of traffic using a road. Different road authorities use different parameters, e.g. Annual Average Daily Traffic (AADT), Average daily traffic (ADT), Equivalent Vehicle Units (EVU) etc.

“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.


NAMIBIA
BOTSWANA
ZIMBABWE
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 (HCI)		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 (HCI)	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 (HCI)	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 (HCI)	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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