GEOTECHNICAL INCIDENT MANAGEMENT AND MONITORING AS PART OF THE SANRAL SLOPE MANAGEMENT SYSTEM (SMS) for ROUTINE ROAD MAINTENANCE

GUIDANCE MANUAL
DECEMBER 2018

SANRAL
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Version	Changes	Released by	Date
1	Original.	R Damhuis	01/12/2018

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1 INTRODUCTION

The need for a Slope Management System (SMS) for all significant slopes along South Africa's National Roads was identified soon after the inception of the SA National Roads Agency in 1998.

In 2004, a simple, practical SMS, which applied only to cut and fill slopes exceeding 5m in height, was developed using a qualitative risk rating system. This system is now being revised to align with other asset risk models within SANRAL and incorporates a comprehensive slope maintenance management methodology to allow for:

- Improved reporting and record keeping of slope failure incidents;
- Evaluation and analysis of these slope failures;
- Monitoring of certain high-risk slopes or slope protection / stabilisation assets and installations; and
- Slope maintenance and/or remediation interventions, carried out within responsibilities of Routine Road Maintenance contracts; and / or

- As separate site-specific geotechnical intervention contracts.

Arguably the most important step in the slope maintenance management is reporting and monitoring. Reporting must be both prompt and comprehensive, while monitoring must be carried out diligently and routinely, with the resultant observations and measurements documented, stored and interpreted to timeously trigger the need for maintenance and further necessary interventions, including emergency works. The foregoing requires to be followed and carried out meticulously to timeously identify significant changes or trends in behaviour patterns of the slopes, fills, cutting, retaining structures and slope protection interventions.

This Guide deals with routine road maintenance inspections and incident reporting required for the RRM maintenance works necessary to maintain cut and fill slopes, retaining walls, lateral support systems and rockfall installations – collectively referred to as geotechnical assets - in the requisite operational condition. It is compiled as a best endeavour to proactively increase the safety of the traveling public by following a risk-managed approach.

2 SLOPE MANAGEMENT SYSTEM

2.1 Background

The SANRAL risk-based Slope Management System (SMS), applies to the management, monitoring and assessment of the necessary interventions to ensure the safe operation of all cut and fill slopes exceeding 5m in height.

The data which is collected for and drives the system, is stored within a GIS database and contains all pertinent information of the qualifying cuttings, fills or retaining structures, regardless of whether these have a history of instability or not.

This system will eventually migrate across to SANRAL's ITIS or Integrated Transport Information System, and the funding models.

The database contains the following details of the qualifying cuttings and slopes:

- The pertinent data on the dimensions and both the geological and geohydrological characteristics of the site for all deep cuttings and high fills (> 5m);
- Stormwater control measures such as type, dimensions, extent, condition and nature of summit drains.
- All slope stabilization, slope protection/mitigation and slope groundwater drainage/depressurisation measures installed. This may include flexible rockfall and debris flow barriers, rockfall/debris flow retention embankments, rockfall netting/shotcrete slope revetments, with or without dowel bar anchors, and horizontal drains/wells;
- All retaining structures, such as gravity and/or anchored retaining walls, Mechanically Stabilise Earth Walls (MSEW), or precast Concrete Block Retaining Walls (CBRW);
- A record of historical slope/instability related incidents.
- All slope mitigation measures carried out, whether temporary or permanent.

The data base of the nature and condition of slopes and structures is prepared following inspections and assessments undertaken by independent SANRAL appointed Consultants who have been trained and accredited (Engineering Geologists and Geotechnical Engineers / technologists) to undertake the necessary inspections and assessments, either prior to or at the start/during the course of the regional Routine Road Maintenance Contract and updated as when stipulated by the criteria developed for the SMS.

2.2 Operation and integration of the SMS within the RRM contracts

At a high level, the operation and integration of the SMS within the RRM contracts consists of the following:

i. Field inspection and the recording and compilation of a comprehensive data-base of each qualifying section of the route.
ii. Evaluation of the risks and hazard inherent at each qualifying section of the route/slope and the identification of those sections
iii. Items i and ii above are undertaken by independent SANRAL appointed Consultants who have been trained and accredited (Engineering Geologists and Geotechnical Engineers / technologists) to undertake these tasks. These assessments should preferably have been undertaken prior to the commencement of the RRM contract and may trigger the need to implement remedial measures. However, the design and construction of specialist geotechnical and/or structural interventions measures beyond the scope of the RRM contract will be undertaken by independent Consultants and Contractors directly appointed by SANRAL.
iv. Reporting of slope incidents and monitoring of all sections of the route, including high-risk slopes/sections of the route, by the RRM Contractor in accordance with specified procedures and proforma documentation provided in this guideline;
v. Periodic re-assessment and re-evaluation of slope risks based on the data recorded by the RRM contractor; and
vi. Detailed investigation of sections of the route so re-assed as being high risk.
vii. Items v and vi are undertaken by independent SANRAL appointed Consultants who have trained and accredited personnel (Engineering Geologists and Geotechnical Engineers / technologist) to undertake these tasks.

From the foregoing it is clear that the prime responsibilities of the RRM Contractor within the ambit of the operation of the SMS, is ongoing maintenance and minor upgrades and repairs, monitoring and geotechnical incident management.

2.3 Identity and location of each Geotechnical Asset

Each geotechnical asset contained in the SMS data base has been identified using a unique 19-digit identifier. Where cuts (generally) are excessively long or complex, they may be subdivided into a number of sub-cuts.

This unique identifier is based on the following road metadata:

- Route name, expressed as Route Letter plus 3 digits, eg R065
- Section number, expressed as 'S' plus 3 digits eg S010
- Kilometre distance of the centre point of the slope, expressed as 3 digits for km and to the nearest 10m eg km 1.65 is annotated as km001.65
- Travelling direction as a compass direction, **N**, **S**, **E**, and **W**
- Lane or Carriage way, for dual carriageway roads, expressed as **L** or C**.**
  Dual highways or freeways having separated horizontal and vertical alignments and therefore cuts and fills that are not common for each of the carriageways, are catered for in this manner.
- Side of the road expressed as **L** or **R** with the Left-hand side of the road being the left side looking in the direction of increasing kilometre posts the road with the km distances increasing away from you, that is, the side in which the kilometre distance increases i.e. the +ve side.
- Type of slope (Cut or Fill), expressed as **C** or **F**.

As an example, a cut slope on the N1, Section 3, at km 44.65, northbound, right hand side of road (ie in the median) is indicated as **N001S003km044.65NRC.**

2.4 Geotechnical Incident Management

The management of geotechnical incidents is based on the level of significance of the incident, namely levels 1 to 4, as set out in the flowchart in Figure B. Each successive level so defined poses a significantly greater level of risk to the travelling public.

These levels primarily act as triggers and the obligatory appropriate response required by both the RRM Route Manager and RRM Contractor to an incident. The definition and detailed response/actions required for each of the four levels of Geotechnical Incidents is presented in the following Sections 2.4.1 to 2.4.4.

2.4.1 Level I Geotechnical Incident

A Level I incident can typically be managed locally by the RRM with little or no assistance. The RRM is required to carry out the following:

- Make incident site safe;
- Complete the Routine Maintenance Slope Incident Form; and
- Report the incident as part of their monthly site meeting and report to SANRAL's slope management Service Provider for inclusion into incident statistics.

2.4.2 Level II Geotechnical Incident

The local responders may require some special technical expertise or guidance to manage the Level II incident locally.
The RRM is required to carry out the following:

- Make incident site safe;
- Carry out a Emergency Inspection of the Incident Slope;
- Report the incident **within 12hrs** to the SANRAL RRM project manager, SANRAL Regional Geotechnical Expert, and the SANRAL appointed slope management Service Provider.
  SANRAL RRM PM shall escalate the incident to the SANRAL Regional Manager and SANRAL Risk Manager;
- Display cautionary notice for at least 48hrs after event or as recommended by geotechnical specialist eg. VMS = "WARNING ROCKFALLS" or Falling rocks signs at regular 200m spacings;
- Completion of a Routine Maintenance Slope Incident Form; and
- Report the incident as part of their monthly site meeting and report to SANRAL's geotechnical Service Provider for inclusion into incident statistics.

2.4.3 Level III Geotechnical Incident

A Level III incident is an incident where a level of response is required to protect lives, property and/or the environment.

The local RRM responders will definitely require technical expertise or guidance to manage the incident locally.

The RRM is required to carry out the following:

- Carry out a Routine Maintenance Inspection of the Incident Slope;
- Report the incident **within 8hrs** to the SANRAL RRM project manager, SANRAL Regional Geotechnical Expert, and the SANRAL appointed slope management Service Provider.
  SANRAL RRM PM shall escalate the incident to the SANRAL Regional Manager and SANRAL Risk Manager.
- The SANRAL appointed slope management Service Provider is to visually inspect the site within **48hrs of initial reporting** to him by the RRM. It is the RRM's responsibility to ensure that this inspection is programmed ASAP.

- Display cautionary notice for at least 48hrs after event but for the duration instructed by geotechnical specialist eg. VMS = " WARNING ROCKFALLS", Falling rocks signs at regular 200m spacings, and/or speed reduction signage.
- Completion of a Routine Maintenance Slope Incident Form, and
- Report the incident as part of their monthly site meeting and report to SANRAL's slope management Service Provider for inclusion in incident statistics.

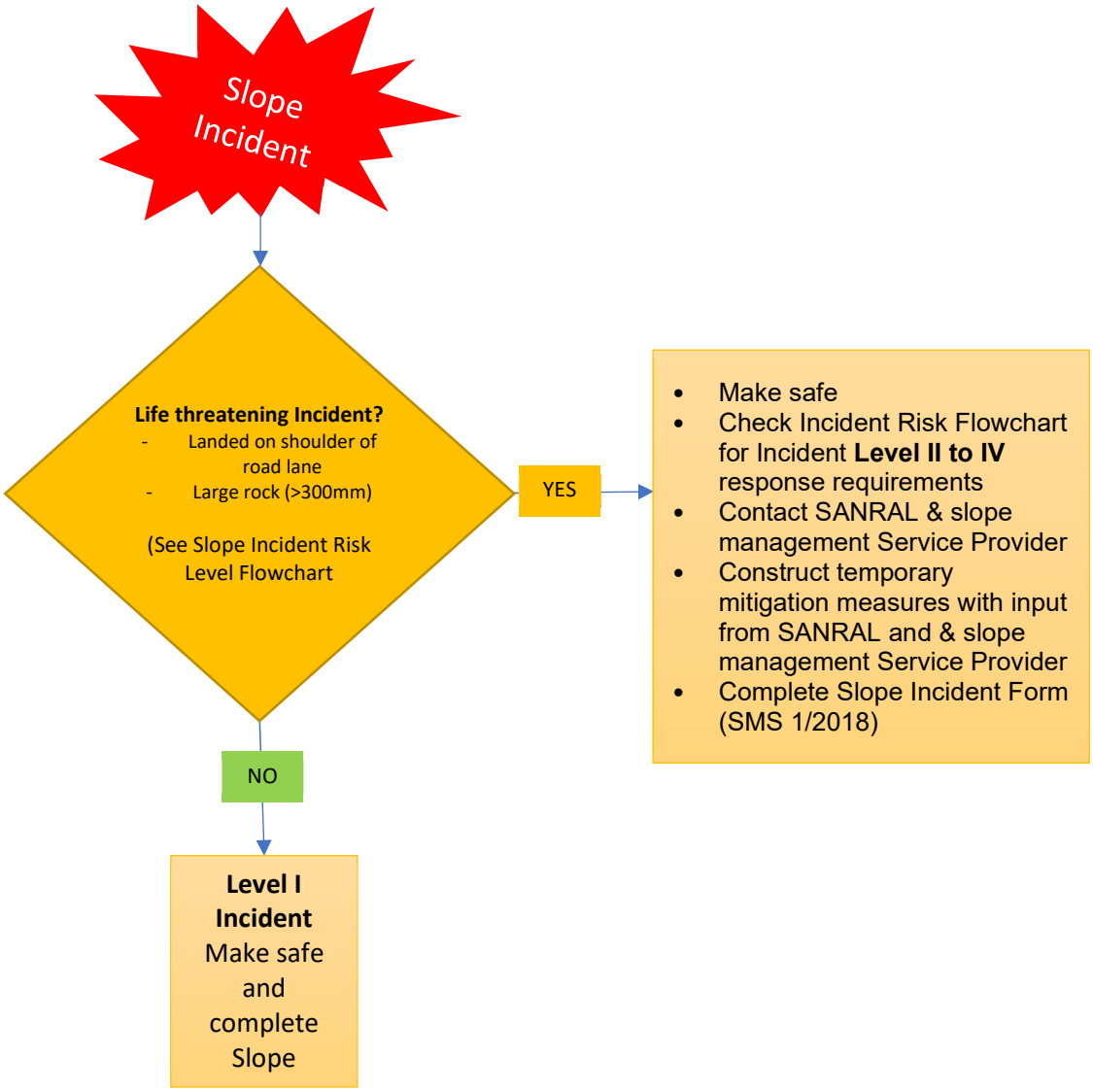
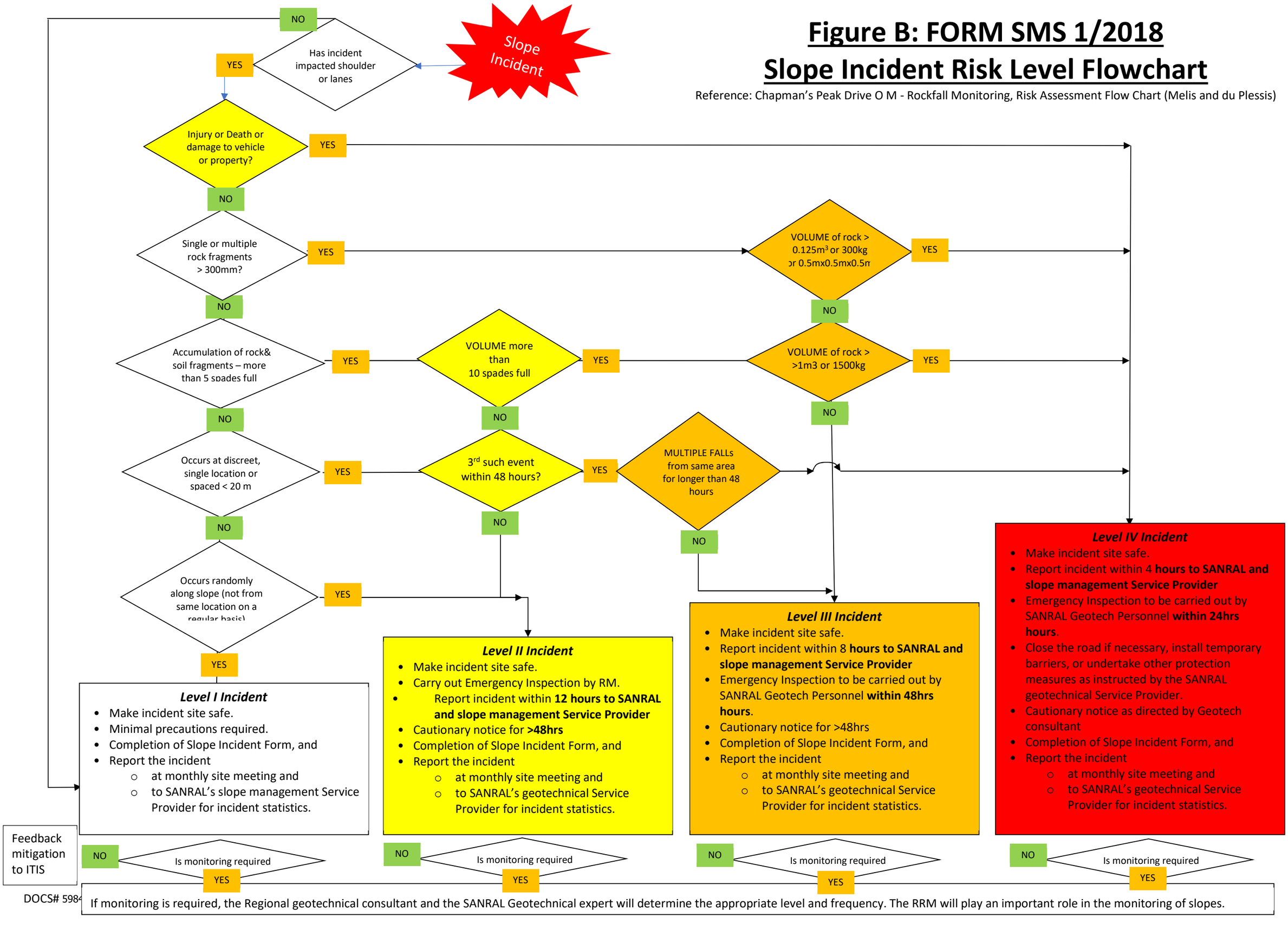


Figure A: Simplified Flow chart for emergency response

Figure B: FORM SMS 1/2018
Slope Incident Risk Level Flowchart

Reference: Chapman's Peak Drive O M - Rockfall Monitoring, Risk Assessment Flow Chart (Melis and du Plessis)



2.4.4 Level IV Geotechnical Incident

A Level IV incident requires a coordinated response by more than one department outside of their normal responsibilities, and/or which is beyond the capabilities of available resources

The RRM is required to carry out the following:

- Carry out a Routine Maintenance Inspection of the Incident Slope;
- Report the incident **within 4hrs** to the SANRAL RRM project manager, SANRAL Regional Geotechnical Expert, and the SANRAL appointed slope management Service Provider.

The SANRAL appointed slope management consultant is to visually inspect the site within **24hrs of initial reporting** to him by the RRM. It is the RRM's responsibility to ensure that this inspection is programmed ASAP.

- Close the road, if necessary, in conjunction with the SANRAL RRM project manager, SANRAL Regional Geotechnical Expert, and the SANRAL appointed slope management Service Provider. In making the decision, both the risk to road users AND 'economics' of the closure need to be assessed
- Install temporary barriers, or undertake other protection measures as instructed by the SANRAL geotechnical Service Provider.
- Display cautionary notice on a VMS for at least 48hrs after event but for the duration instructed by geotechnical specialist eg. VMS = " WARNING ROCKFALLS". Speed reduction signage mandatory with 'stop/ go' implementation if necessary
- Completion of a Routine Maintenance Slope Incident Form, and
- Report the incident as part of their monthly site meeting and report to SANRAL's geotechnical Service Provider for inclusion into incident statistics.
- SANRAL RRM PM shall escalate the incident to the SANRAL Regional Manager, SANRAL Risk Manager, and SANRAL Engineering Executive for emergency funding.
- SANRAL Regional Geotechnical Expert, and the SANRAL appointed slope management Service Provider to submit report to SANRAL within a further 48hrs, showing the risk and priority (emergency requirements), recommended mitigation measures.

2.5 Reporting and monitoring of failures

Probably the most important step in the SMS, is reporting of incidents and continuous monitoring of designated high-risk slopes using the RRM Slope Incident Form, and reported in the monthly site meeting as a separate agenda item.

This reporting and monitoring aspect is carried out through the Routine Road Maintenance (RRM) contracts, and reported to the client and regional slope management Service Provider for monthly analysis.

In the event of high risk incidents, these shall be reported to the Regional RRM Project Manager, the Regional Geotechnical Manager, and the regional slope management Service Provider within the timeframes as indicated in the preceding section and the Figure B flowchart so as to trigger the level of emergency response required.

No remedial works proceeds until the slope is assessed and advised by a competent geotechnical engineer / technologist or engineering geologist. Incident records of a serious or potential serious nature are reported immediately to SANRAL regional geotechnical representative, providing the properly recorded evidence. These slopes are then monitored on a more regular basis, dependant on severity and risk of the slope, and feedback given to the SANRAL representative on any changes. SANRAL will then arrange for a follow up inspections by specialist personnel.

Incidents of a life-threatening nature shall immediately be made safe though traffic accommodation. No permanent mitigation works proceed, either as RRM works or in a separate contract until the slope is assessed by a competent, experienced geotechnical engineer / technologist or engineering geologist.

3 ROUTINE MAINTENANCE

Regular maintenance is essential for all natural slopes adjacent to the road, man-made slopes and retaining walls to ensure their functionality and to avoid deterioration.

3.1 Responsibilities of the Route Manager

3.1.1 Responsibilities

3.1.1.1 Duty of care

The Route Manager has a Duty of Care to the public to ensure that all hazards that may affect the safety of the travelling public are recognized and mitigated. As such, hazards associated with slopes need to be continuously monitored, especially when a slope with known risks and hazards is encountered. It is incumbent on the RRM consultant to report and ensure that these hazards and risks are mitigated, either through temporary or permanent measures.

3.1.1.2 Recording of incidents

The Route Manager (RM), and the Assistant RM should always keep blank copies of the Slope Incident Form at all times. It is advisable that each of the maintenance crews also keep these on hand to report Level I incidents.

All the relevant details must be completed. Once developed, this will be captured electronically using a mobile phone app.

The Form has been designed for ticking of applicable blocks. There are a few items where the Route Manager needs to use engineering judgment and do basic measurements, e.g. approximate cubic metres of materials that came down the slope.

Photographs must be taken of the slope from each extremity, the general area of the incident, and the failed material.

Sketches or diagrams of approximate/ general arrangement of cracks, slips, fallen debris, etc may also be made to illustrate the incident.

3.1.1.3 Reporting of Incidents

All incidents shall be;

- Reported to SANRAL's geotechnical Service Provider for the required level of intervention for temporary mitigation measures, and /or emergency designs as per Figure B flowchart, and incident statistics.
- Reported and discussed in the monthly RRM site meeting as a separate agenda item. The agenda item shall include a discussion around the risk of the incident to the public, the mitigation measures used, and any lessons learnt in the process.

3.1.1.4 Record keeping

The RM shall keep a record of all slope stability incidents, filed per route, section and km and per cut or fill/embankment available for scrutiny by SANRAL. These records shall be transferred to electronic format on completion of the project and transferred to the SANRAL RRM Project Manager at the contract end.

Original hard copies shall be kept in accordance with the requirements of other project records.

3.1.1.5 Inspections

Inspections of the slopes and the various sub-assets are required at different intervals and after incidents. Below is an explanation of each.

a) Post rain or seismic event inspection

The RM to inspect the route for incidents and slope drainage channels issues after each significant rain event, and clear any drainage blockages in accordance with Appendix A and make road safe. Significant rain is a subjective term and may differ depending on surface geology and soil characteristics. The effects of an intense thunderstorm, for example will be very different in the Karoo or in the erodible materials of the Eastern Cape.

b) Emergency Inspections

Directly after each slope Incident greater than Level 1, the RM shall carry out an inspection of the failed slope. Under no circumstances may the inspection team climb onto the slope for OHS reasons.

The primary purpose of Emergency Inspection is to establish if there is further obvious imminent failure, as well as the need for basic maintenance for making the road safe which do not demand professional geotechnical knowledge and which can be carried out by any responsible person, including the RM.

In general, these Emergency Inspections should be carried out within 4-6hours of the incident.

The Emergency Inspections covers areas such as, but not exhaustively:

a) Safety of clearing of accumulated debris from drainage channels and slope surface,
b) cracked or damaged drainage channels or pavement,
c) cracked or damaged slope surface cover (shotcrete or drapery),
d) potential for the removal of any vegetation blocking road or destabilising the slope surface and drainage channels,
e) potential for the removal of loose rock debris from rock slopes or around boulders,
f) repair of leaky exposed water services

Abnormal deterioration or features on slopes or retaining walls should be reported immediately.

c) Routine Maintenance Inspections

Routine Maintenance Inspections shall be carried out on all protected slopes, ie slopes with shotcrete or mesh drapery coverings, retaining walls, etc, on a regular basis. The primary purpose of Routine Maintenance Inspection is to establish the need for basic maintenance so do not demand professional geotechnical knowledge and can be carried out by any responsible person, including the RM.

In general, these Routine Maintenance Inspections should be carried out at least once every year but in some instances, may be required more regularly as specified in the contract document.

The Routine Maintenance Inspections are carried out to ascertain the need for maintenance in various areas including, but no exhaustively:

i. clearance of accumulated debris from drainage channels and slope surface,
ii. repair of cracked or damaged drainage channels or pavement,
iii. repair or replacement of cracked or damaged slope surface cover,
iv. unblocking of weep-holes and outlet drainpipes,
v. removal of any vegetation causing severe cracking of slope surface cover and drainage channels,

vi. re-grassing of bare soil slope surface areas,
vii. removal of loose rock debris and undesirable vegetation from rock slopes or around boulders,
viii. repair of leaky exposed water services,
ix. repair or replace rusted steel slope furniture, and
x. maintenance of landscape treatment on the slope.

Abnormal deterioration or features on slopes or retaining walls should be reported immediately.

d) Investigation of high risk slopes

The final step is the investigation of high-risk slopes by a geotechnical engineer or technologist for the design and implementation of slope rehabilitation, improved safety or maintenance measures implemented, which are then reported back to SANRAL for updating the data- base.

4 Routine Road Maintenance Slope Incident Form.

The following notes are for guidance for RRM personnel and other trained personnel or consultants carrying out slope incident inspections as part of the Routine Road Maintenance. These notes are not intended to be an exhaustive study on the reasons for remediation of slope instabilities.

The Form SMS 1/2018has been designed to allow easy designation of the Incident Level by the RM, and must be used in conjunction with the notes below and Appendix A: Typical routine maintenance inspection and works for slope and retaining structures which contains inspection and maintenance guidance notes.

4.1 Assets comprising a slope

Slopes comprise of sub-assets which in turn each individually or collectively contribute to the stability of that slope. The following diagram gives the standard nomenclature for sub-assets making up a slope.

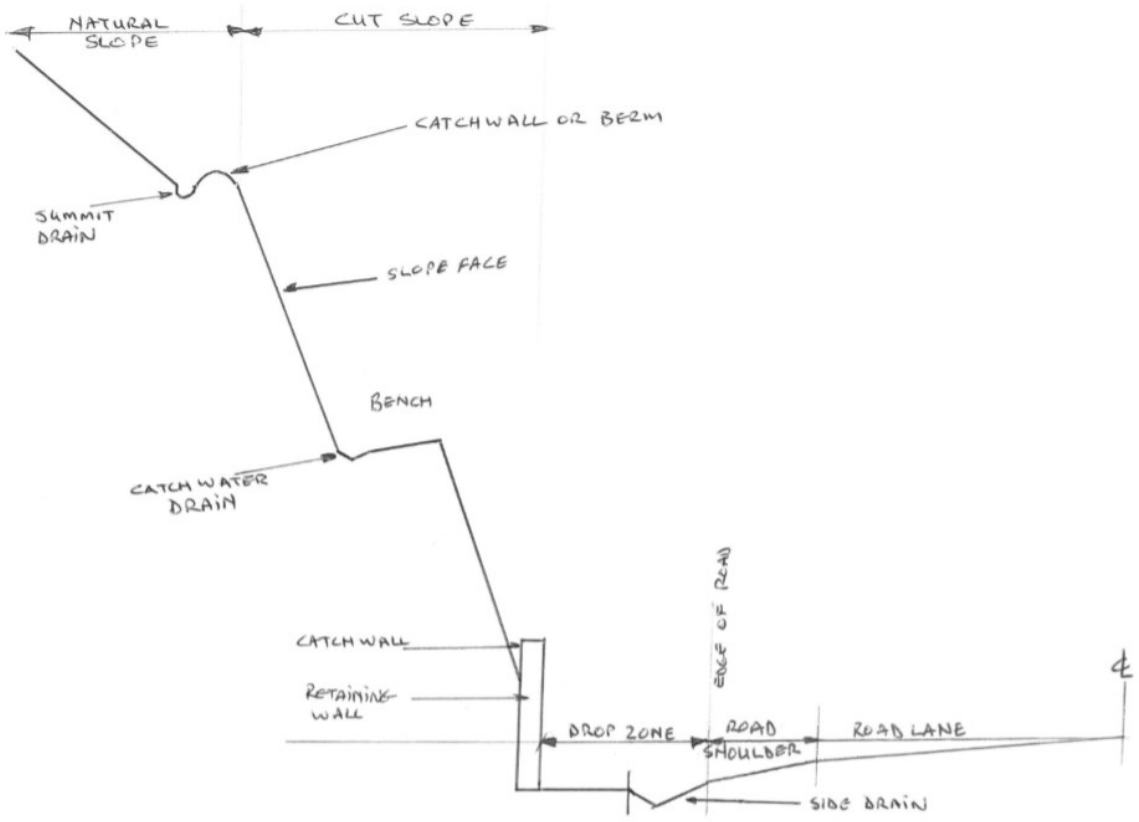


Figure C: Cut slope terminology

4.2 The Slope Incident Form (SMS 1/2018)

This form is relatively self-explanatory with the general information pertaining to the slope where the incident has occurred. Complete each section of the form either completing the data or by ticking the box.

a) Identifying the slopes

Each slope has been identified using a unique 19-digit identifier in the SMS. The RRM however does not need to record this slope number. The RM shall record

- Route name
- Section number
- Kilometre distance of the centre incident
- Travelling direction
- Lane and Carriage way, for dual carriageway roads**.**
- Side of the road expressed as **L** or **R** with the Left-hand side of the road being the left side looking down the road with the km distances increasing away from you, ie the side in which the kilometre distance increases i.e. the +ve side.
- Type of slope (Cut or Fill), expressed as **C** or **F**.

b) GPS referencing of the slope failure

GPS co-ordinates are taken at the failure centre along the slope. Cellular phone or handheld GPS co-ordinates of the centre point of the failure must be taken on the existing centre line of the road. The co-ordinates should be in WGS84 format with degrees and digital minutes.

c) Infrastructure or Property Damage

Each incident has the potential to become a large 3rd party claim. As such, SANRAL needs to understand the nature and extent of any damage to our, or others' property. In addition, it is important in the determination of the correct temporary or permanent mitigation measures.

d) Where did it land?

Record where the rocks / boulders and material came to rest. This is important in trying to understand the risk of damage/injury to property and people. It is important to note where damage has been done to the surface, that is how deep and wide the indentation is as it provided valuable information as the energy potential of the rockfall.

e) Soil or Rock fragment size

Tick the shape which most accurately resembles the fallen rock/boulder and measure the average maximum dimension of the rocks/boulders and record

f) Did it break up?

Many times rock or boulders break up into several pieces on impact with the road. This provides an indication of the weathering of the material and the an indication of the damage it could potentially cause to infrastructure or passing vehicles.

If matrix material was also transported with the boulder, record the approx. quantity and type of matrix material e.g. cobbles, clay, clayey gravel etc.

g) Regularity of incident

Is this the first incident in this area? If yes, then it could be a single event, or the beginning of a series of events. Either way, if the history is known, the correct level of response can be determined.

h) Erosion and vegetation

Erosion is an indication of potential future issues and important in the determination of the correct temporary or permanent mitigation measures.

i) Fire or catastrophic event

Correlate the time of the incident with fire, tree felling, adverse weather, seismic event, baboon damage, etc, if applicable.

j) Origin

Try to figure out where the rock(s)and soil originated from.

k) Photographs

It is extremely critical that extensive photos are taken of each incident so that in the event of a third-party claim, accurate evidence is available. A standard 5 photographs should suffice for most incidents but additional photographs may be required at times to show significant issues that may help the geotechnical engineer determine the cause remotely.

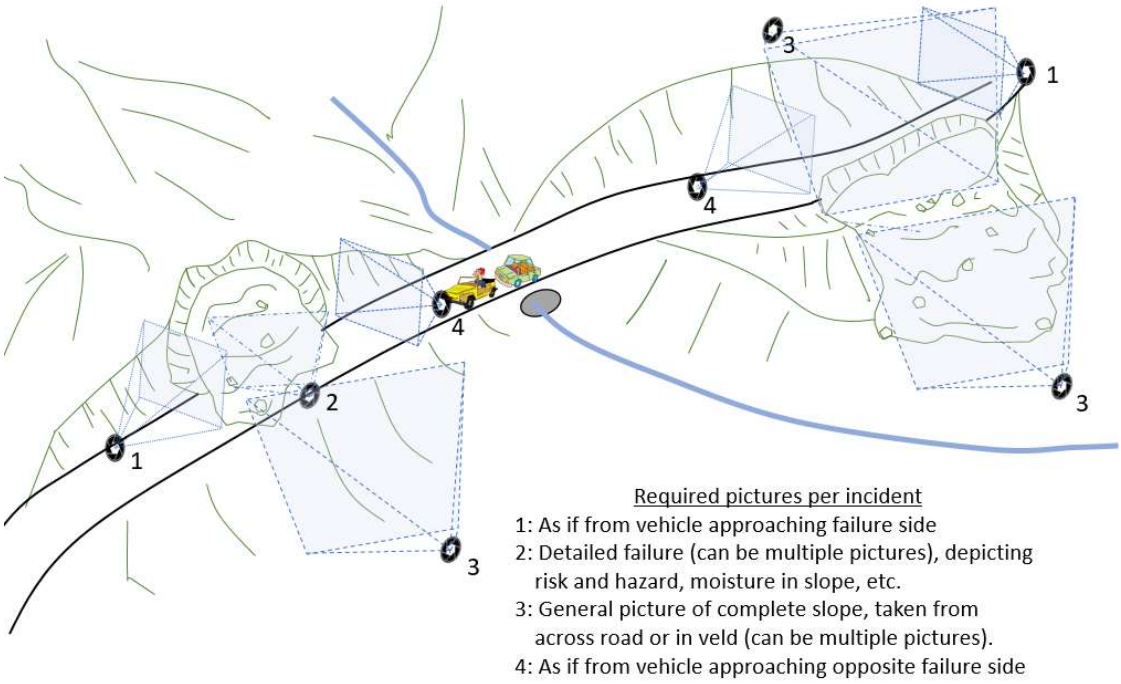


Figure D: Position of required incident pictures

l) Additional Comments / Attachments

Each section has a space for other supporting additional information that the reporter feels necessary to be included, such as:

- Perceived degree of danger to road-user public / road itself etc.
- Also whether the road or some lanes had to be closed entirely, or the traffic diverted?
- Trees and vegetation or services posing a problem
- Cracks above cut slope – water filled? or cracks on road surface –water filled?
- Reporter's view as to probable cause of failure.
- Supplementary sketches of failure/ cracks / events vs. dates if possible, shown in relation to road centre line
- Photographic records /numbers/dates relating to abovementioned sketches.

SANRAL ROUTINE ROAD MAINTENANCE
SLOPE INCIDENT FORM (v1/2018)

ROUTE:	SECTION:	KM:	Carriageway: N / S / E / W Lane: Left (+ve) / Right (-ve)	CUT FILL	LHS RHS
Latitude: °S		Longitude °E			
RRM Incident No:		SMS Incident No:			
DATE:	Time noted:	Time Reported to SANRAL:			
Inspection carried out and signed by	Name:	Signed:	Co:	Tel:	

1 WHERE DID IT LAND?

Drop Zone	Side drain	Road Shoulder	Outer lane (if multiple lanes)	Lane or Inner lane	Opposite lane	Other side of road	Notes

2 DAMAGE TO INFRASTRUCTURE OR PROPERTY

Damage to road - size of pothole or patch to be done	Notes	Damage to retaining structures OR property - describe	Notes

Summit drain	Intact	Damaged	Several breaches	Retaining structure	Intact	Damaged	Destroyed
Slope benches	Intact	Damaged	Several breaches	Slope protection eg netting	Intact	Damaged	Destroyed
Slope Drainage	Intact	Damaged	Blocked	Toe drains	Intact	Damaged	Several breaches

3 SOIL OR ROCK FRAGMENTS:

Gravel with stones	Round rocks	Square rocks	Wedge / Flat rocks	Volume: L x B x H in metres	Maximum Fragment Size: L x B x H in metres	Notes – single or multiple rocks, splatter etc

4 DID IT BREAK UP?

NO	Large pieces (>150mm) with a few small pieces	Large pieces (>150mm) with many small pieces	Many small pieces (Nothing larger than 70mm)	Notes

5 REGULARITY OF INCIDENT IN THIS SPOT?

New Incident	Over 12 months	Less than 12 months	Less than 6 months	Less than 1 month	Adhoc – after rain or other event	Notes

6 EROSION AND VEGETATION: Is the slope…

Severely Eroded	Slightly Erode	Unvegetated	Poorly Vegetated	Well Vegetated: Grass	Well Vegetated: Trees & Grass	Notes

7 FIRE OR CATASTROPHIC EVENT - Prior to the incident?

Fire	Rain – very intensive ……..mm	Rain – Intensive ……..mm	Rain – for extended period >24hrs	Rain – for extended period >48hrs	Rain – for extended period >72hrs	Vegetation or forest clearing

8 ORIGIN: Where did it fall from?

Lower Road cutting	Upper road cutting	Upper natural slope	Unknown	Notes

9 PHOTOGRAPHS

Full slope from slope at lower km end	Full slope from slope at higher km end	Full slope from opposite side of the road, center to incident	Detailed photo of fallen material with size reference guide	Photo of fallen material as if driving in lane from incident	Photo of fallen material as if driving in opposite lane from incident	Other
PHOTO NO	PHOTO NO	PHOTO NO	PHOTO NO	PHOTO NO	PHOTO NO	

ACTIONS TAKEN TO MAKE SAFE (TO BE COMPLETED BY CONTRACTOR AFTER ROAD MADE SAFE)

	Contractor signature Date

5 References

a) *Layman's Guide To Slope Maintenance*, Geotechnical Engineering Office, Civil Engineering and Development Department, The Government of the Hong Kong, Reprinted, April 2013 with updated information.
b) *Chapman's Peak Drive O M - Rockfall Monitoring, Risk Assessment Flow Chart,* Melis and du Plessis
c) *Guidelines On Slope Maintenance For Public*, MPAJ, Public Works Department Malaysia, and the Bukit Antarabangsa Resident Associations, available from http://www.mpaj.gov.my/sites/default/files/guidelines20on20slope20maintenance20for20public.pdf

APPENDIX A: TYPICAL ROUTINE MAINTENANCE INSPECTION AND WORKS FOR SLOPE AND RETAINING STRUCTURES

Sub-asset	Typical inspection / maintenance works	Guidance	Maintenance intervals
Surface Drainage, Summit drains, Sumps and Silt Traps	a) Clear debris, undesirable vegetation and other obstructions. b) Repair minor cracks with cement mortar or flexible sealing compound. c) Rebuild severely cracked channels.	• Works may be required outside site boundaries to prevent debris from blocking the drainage system. • Where large tree roots have damaged drainage channels, appropriate portions of the roots should be removed, taking care not to jeopardize the stability of the tree. Alternatively, the channels may be realigned. • The summit drains, bench drains or drains at the top of retaining structures should be checked for the presence of gaps in the ground alongside the channels to stop erosion next to the drains.	Annual and after major rainfalls
Weepholes and Horizontal drains	a) Clear obstructions (e.g. weeds and debris) in weepholes and pipe ends. b) Probe with rods for deeper obstructions.	• Pipes/ Horizontal Drains are prone to being blocked. Where pipes have been used on slopes and are leaky or severely blocked, they should be replaced.	Annual and after major rainfalls
Rock or masonry walls	a) Repair of missing or deteriorated pointing in masonry walls.	• Clear behind if the wall was designed as a road protection barrier.	Annual and after major rainfalls
Impermeable Surface Cover (e.g. guniting and shotcrete; Stone pitching)	a) Remove undesirable vegetation growth. b) Repair cracks or spalling. c) Regrade and repair eroded areas. d) Replace surface cover that has separated from underlying soil. e) Replace missing or deteriorated joint fillers and sealant. f) Remove dead, decaying or unstable trees.	• Cracked impermeable surface cover should be repaired by cutting a chase along the line of the crack, which is to be filled with similar slope cover material or flexible sealant. • Where large tree roots have damaged the surface cover, the cover should be replaced and tree rings should be provided.	Annual

Sub-asset	Typical inspection / maintenance works	Guidance	Maintenance intervals
		• Specialist advice may be sought in treating trees. Tree felling application should be obtained from relevant authority where necessary.	
Vegetated Surface Cover	a) Regrade eroded areas with compacted soil followed by replanting. b) Replant vegetation in areas where the vegetated surfacing has died. c) Trim vegetation if overgrown. d) Removed dead, decaying or unstable trees. e) Remove trees that with roots that are impregnating and destabilising rocks.	• Surface erosion may indicate an inadequate drainage system. • Where erosion is shallow and does not affect the performance of existing surface drainage channels, the eroded area may be repaired by trimming and installing rock weirs to make good to normal condition. • Possible sources of concentrated flow should be identified and rectified.	Annual
Rock Slopes	a) Remove loose rock debris. b) Remove dead, decaying or unstable trees.	• Many failures in rock slopes involve minor rockfalls. Rock slopes should be examined for the presence of loose blocks and these should be removed or stabilized if found.	Annual for all slopes and after major rainfalls for known problem slopes
Soil slopes	a) Regrade and repair eroded areas. b) Check for fences, poles and trees that tilt or move c) Check for new cracks appearing on the slope. d) Remove sloughed material from base of cutting and behind retaining wall (0.5m vertical)		Annual for all slopes and after major rainfalls for known problem slopes
Retaining walls	a) Report on seepage traces on and adjacent to slopes or retaining structure should be recorded in photograph or detailed hand-sketched drawing. Flow from seepage sources, weepholes, cut off drain, joint between masonry blocks, horizontal drains, etc. should be recorded and examined for signs of migration of sold material to check whether internal erosion of the ground is taking place. Account should be taken of those seepage traces that indicate the highest seepage level. b) Obvious cracking, deformation or displacement of the wall, opening or spalling of joints must be reported immediately.		Annual
Cable and mesh netting / drapery	a) Each mesh panel is joined to its adjacent panels, resulting in one continuous drapery panel across the rock face. The completed mesh drapery will allow any loose rock that falls from the rock face to ravel		Annual for all slopes and after

Sub-asset	Typical inspection / maintenance works	Guidance	Maintenance intervals
	down behind the mesh to the catchment area (without bouncing out into the roadway) for removal by maintenance forces. b) Inspectors must check for loose boulders stuck below the netting and clusters of fragmented material that is accumulating in places that may pull the rock dowel out or tear the mat c) Check for mesh that is damaged or broken d) Release trapped rock fragments if necessary (drape bulging)		major rainfalls for known problem slopes
Rockfall Barrier Systems	a) Inspectors to check for obvious damage and boulders and other obstacle that are at rest against the barrier and report for removal.		
Soil Nail Walls	a) Check for nails and rock dowels that are obviously loose.		Annual
Groundwater Seepage	a) Seepage traces on and adjacent to slopes or retaining structure should be recorded in photograph or detailed hand-sketched drawing. b) Flow from seepage sources, weepholes, cut off drain, joint between masonry blocks, horizontal drains, etc. should be recorded and examined for signs of migration of sold material to check whether internal erosion of the ground is taking place. c) Account should be taken of those seepage traces that indicate the highest seepage level. d) Where there are signs of abnormal seepage from, or moisture on, the surface of the slope or masonry wall, or signs that the seepage has increased substantially and suddenly, the causes should be investigated and reported immediately to SANRAL. e) Arrangements should be made for clearing weepholes where blockages are suspected. f) Where there are traces of seepage from a slope or retaining structure in an area where weepholes, horizontal drains or proprietary drainage mats have not been provided, the source of seepage should be determined and consideration should be given to recommending adequate drainage to be installed.		After major rainfalls for known problem slopes
Leaking water pipes	a) Water pipes are often buried below ground, especially in urban areas, and any leaks may be very difficult to spot. However, it is a vital part of slope maintenance and your local water authority must be informed immediately if there is suspicion of a leaking water pipe.		Annual