VOLUME 4 GEOTECHNICS AND DRAINAGE
SECTION 1 EARTHWORKS

PART 3

HD 41/03

MAINTENANCE OF HIGHWAY GEOTECHNICAL ASSETS

SUMMARY

This document provides best practice guidance for the inspection and maintenance management of the highway Geotechnical Asset and sets out the Standard to be applied for trunk roads (including motorways) in England.

INSTRUCTIONS FOR USE

1. This document supersedes HA 48/93, which is now withdrawn, and supplements Section 1.9 Volume 2 of the Trunk Road Maintenance Manual.

2. Remove existing contents page for Volume 4 and insert new contents page for Volume 4 dated February 2003.

3. Remove HA 48/93, which is superseded by HD41/03, and archive as appropriate.

4. Insert HD41/03 in Volume 4, Section 1, Part 3.

5. Archive this sheet as appropriate

Note: A quarterly index with a full set of Volume Contents Pages is available separately from The Stationery Office Ltd.

THE HIGHWAYS AGENCY

SCOTTISH EXECUTIVE DEVELOPMENT DEPARTMENT

WELSH ASSEMBLY GOVERNMENT
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THE DEPARTMENT FOR REGIONAL DEVELOPMENT
NORTHERN IRELAND

Maintenance of Highway Geotechnical Assets

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MAINTENANCE OF HIGHWAY GEOTECHNICAL ASSETS

Contents

1. INTRODUCTION

General

1.1 To assess the condition of highway geotechnical assets, and plan an ordered and cost effective programme of repair and preventative works, it is necessary to have a clear systematic and committed approach to condition inspection and reporting. Such an approach will also allow information on the condition of highway geotechnical assets to be considered as part of the overall assessment of other network assets such as pavements, structures and environmental elements.

1.2 The information will allow Managing Agents and Overseeing Organisations to prioritise and programme maintenance works, and/or consider improvements, where otherwise appropriate. The information should also enable the Overseeing Organisation and Managing Agent to monitor performance by the establishment of benchmark conditions and the setting of Key Performance Indicators.

Background

1.3 The condition of highway geotechnical assets is subject to ageing and requires maintenance.

This document advises on an effective approach to the management of this valuable asset, linked with the introduction (in England) of a data management system and of mandatory requirements for inspection activities and maintenance works.

1.4 The methodology is to support two key objectives:

(i) Tactical Asset Management: To allow the effective management of geotechnical features identified during Safety, Annual or Principal Inspections, Safety Patrols or by third parties. Against each of these features a risk assessment is undertaken so that an appropriate Risk Level can be assigned. The Risk Level is then used to identify and prioritise works needed to mitigate against these features.

(ii) Strategic Asset Management: The determination of geotechnical features actually or, potentially, representing areas of risk and vulnerability for the serviceability of the network is important for strategic management of routes and areas. For example, in being able to assess the impact of Geotechnical Asset condition on other planned activities (including the review of design whole life cost analysis) and in assessing the benefits of carrying out preventative measures before an unacceptable or costly defect arises ie a proactive approach to asset management.

1.5 Geotechnical Assets are one of the principal elements of the highway network. Other principal elements are the road (including the pavement and drainage systems), structures, soft estate and network information. The interaction between these elements can often be complex and is important when considering the maintenance and improvement of the network.

1.6 Highway geotechnical assets principally comprise the subgrade, together with the land within the highway boundary through which the route is formed. This includes cuttings and embankments, and a diverse range of natural geological strata and man made materials, many of which may have been reworked, mixed or modified to render them as suitable engineering materials. These materials may also be supported, strengthened or drained to aid stability or reduce subsidence.

1.7 The maintenance management of highway geotechnical assets is of importance to the Overseeing Organisation in ensuring the safety of road users and preserving the value of the asset.

1.8 The Geotechnical Asset is of increasing environmental value to the network. The value is realised in terms of the habitat it provides for fauna and flora. Its protection is a consideration in the stabilisation and repair of the ageing Geotechnical Asset and in designated areas it will be necessary to undertake habitat and species protection measures before any geotechnical investigations or works are progressed.

Scope and Methodology

1.9 This document details a methodology for the inspection of highway geotechnical assets, the categorisation of geotechnical features, assigning risk levels, and the verification/control of associated investigation, monitoring, design and construction

activities. The inspection and reporting of the condition of Geotechnical Assets will enable information to be considered, potential risks assessed and remedial options to be prioritised alongside the condition of the other principal elements.

1.10 This document does not cover the design of new earthworks, (see HA44 (4)), the widening of existing earthworks (see HA43 (5)), or design methods for the reinforcement of highway slopes (see HA68 (6)). The routine maintenance of pavement and road surface drainage is considered in the relevant Maintenance Manuals (1).

1.11 This document does not cover the inspection and maintenance of structures, including foundations to structures, retaining walls, tunnels, and strengthened earthworks with slopes of between 70^0 and 90^0. These items are covered in Sections 1 and 2 of Volume 3 of the Design Manual for Roads and Bridges (11).

1.12 HA 48/93 'Maintenance of Highway Earthworks and Drainage' is superseded by this Standard which supplements Section 1.9 Volume 2 Trunk Road Maintenance Manual.

1.13 The procedures to be followed for risk management of geotechnical assets are given in HD22.

Mandatory Sections

1.14 Sections of this document which form part of the Standard that the Highways Agency Overseeing Organisations required in the maintenance of highway Geotechnical Assets are highlighted by being contained in boxes. These are sections with which the Managing Agent must comply, or must have agreed a suitable departure from standard with the relevant Overseeing Organisation. The remainder of the document contains advice and guidance, which is commended to all Overseeing Organisations and Managing Agents.

Implementation

1.15 This standard shall be used forthwith for all new management contracts in England for the inspection and maintenance of all Geotechnical Assets on trunk roads including motorways; implementation for existing contracts will be at the discretion of the Overseeing Organisation in consultation with their Geotechnical Advisor. Whilst the general principles of the advice and guidance contained in this document are endorsed, this standard is not mandatory for use in Scotland, Wales or Northern Ireland, and reference as to correct procedural aspects should be made to the respective Overseeing Organisation's maintenance instructions and manuals.

Abbreviations

1.16 The abbreviations below are used in the following sections of this standard:

GA	Geotechnical Adviser
GFR	Geotechnical Feedback Report
GMF	Geotechnical Maintenance Form
GMLE	Geotechnical Maintenance Liaison Engineer
GPIR	Geotechnical Principal Inspection Report
GR	Geotechnical Report
HA	Highways Agency
HAGDMS	Highways Agency Geotechnical Data Management System
MA	Managing Agent
PIF	Principal Inspection Form
PM	Project Manager
PS	Procedural Statement
PSS	Preliminary Sources Study report
RM	Route Manager
TRMM	Trunk Road Maintenance Manual
VFM	Value For Money

2. INSPECTION OF GEOTECHNICAL ASSETS

Personnel

2.1 The Managing Agent (MA) shall appoint a Geotechnical Maintenance Liaison Engineer (GMLE) who shall be responsible for all geotechnical matters carried out by the MA, and who will liaise with the Overseeing Organisation's Geotechnical Adviser and Area Manager. The GMLE shall be a Geotechnical Adviser (Site Investigation Steering Group Reports Institution of Civil Engineers 1993(7)) or equivalent. In addition, the Managing Agent shall submit full details of the qualifications and experience of the proposed GMLE to the Overseeing Organisation for approval when the GMLE is appointed by the MA.

2.2 The GMLE shall be the MA's focal point for the geotechnical aspects of their work and for all matters relating to the inspection and maintenance of Geotechnical Assets, and shall oversee all aspects relating to such assets. The GMLE shall ensure that personnel carrying out Principal Inspections (Sections 2.12 and 2.13) shall be of Geotechnical Engineer or Engineering Geologist (Site Investigation Steering Group Reports (7)) or equivalent.

2.3 Personnel carrying out Annual Inspections (Section 2.10 and 2.11) may not be of Geotechnical Engineer or Engineering Geologist status but shall have sufficient training to enable them to identify defects or potential defects of Geotechnical Assets, and to carry out the inspections to a standard acceptable to the GMLE.

Planning

2.4 The GMLE shall submit a Geotechnical Asset Management Plan to the Overseeing Organisation on appointment and at the end of each financial year. The report shall provide details of the programme of inspections, surveys and works planned for five years with outline costs and details sufficient to allow risk review and prioritisation. The report will allow progress and planning of geotechnical activities to be reviewed with all other infrastructure maintenance activities.

2.5 Personnel trained in working on or adjacent to the highway shall carry out the inspections. The relevant Health and Safety Regulations (13) shall be observed before commencing any inspection.

Type and Frequency of Inspections

2.6 The inspection of geotechnical assets shall comprise Annual Inspections and Principal Inspections, matching the Annual and Five Year Detailed Inspection requirements as set out in TRMM Volume 2, Paragraph 1.9.2. These inspections are in addition to Safety Inspections, such as defined in Volume 2 of the TRMM (1).

Inspection Methodology

2.7 The inspections shall comprise a continuous survey of the whole of the Geotechnical Asset in a safe and cost effective manner.

2.8 Guidance notes for the inspection methodology for the Annual and Principal Inspections are given in Appendix A.

2.9 Whenever possible inspections should be carried out when the ground profile is not obscured with vegetation.

Annual Inspections

2.10 Annual Inspections of Geotechnical Assets shall be carried out to check for any indication of defects such as slips, or incipient slippage of embankment or cutting slopes, subsidence, defective drainage etc. in accordance with the briefing and training given to the personnel carrying out the inspections as required by the

GMLE. Annual Inspections of Geotechnical Assets may be undertaken at the same time as the annual inspection of other assets.

2.11 Geotechnical defect features identified as a result of the MA's routine maintenance activities (including Annual or Safety Inspections), or following other reports and complaints, should initially be recorded in RMMS as Category 1 and 2 Defects, as detailed in TRMM Volume 2, Paragraph 1.1.4 and actioned accordingly. Thereafter, the GMLE shall be informed and a Principal Inspection shall be instructed by the GMLE.

Principal Inspections

2.12 The Principal Inspection shall be recorded using the Principal Inspection Form, (PIF) (Figure 2/1). Any defect shall be reported using the Geotechnical Maintenance Form (GMF) Part A. (Appendix B). Any subsequent geotechnical activities shall be undertaken in accordance with the geotechnical certification procedures described in Section 4.

2.13 The MA shall carry out Principal Inspections on a 5 year cycle such that 20% of the Managed Area is completed per year.

2.14 It is recognised that some areas and geologies experience either fewer or more frequent problems associated with geotechnical hazards than some other areas with different geologies. The frequency of re-inspections may therefore be reduced or increased following appropriate risk assessments and with the approval of the Overseeing Organisation Geotechnical Advisor.

2.15 In England the PIF is compatible with the requirements of the HAGDMS. Two versions of the PIF are provided; one for when using GPS (Global Positioning System) or dGPS (differential GPS) to determine the absolute locations of observations, and the other for when using relative geo-referencing, such as measuring from CHART nodes or marker posts. The former method is recommended.

2.16 Following the first Principal Inspection the information recorded on the PIF need not be repeated in subsequent inspections unless there has been a change in the intervening period.

2.17 Data collected from the Principal Inspection shall be used to assign Classes of geotechnical feature to the Geotechnical Assets inspected (see Section 3); such Classes shall be indicated on the inspection form. Other actual or potential geotechnical features and hazards (within or adjacent to the highway) shall also be recorded on the inspection form. Following the inspection, the MA shall prepare a Geotechnical Principal Inspection Report (GPIR) for the routes inspected.

2.18 The GPIR shall provide an assessment of the inspections carried out, the problems encountered and a preliminary assessment of preventative and remedial works. The scope of the report shall be as detailed in Appendix C.

Urgent Actions

2.19 Should urgent actions be identified as part of the Annual or Principal Inspections then the GMLE should be contacted immediately, a Class 1A/1B/1C assigned and a GMF Part A completed.

Highways Agency Geotechnical Data Management System (HAGDMS)

2.20 The key management system for the HA Geotechnical Asset is the Geotechnical Data Management System (HAGDMS); this comprises a Geographical Information System (GIS) and linked databases.

The HAGDMS system provides the following facilities:

(i) Mapping interface to scales of up to 1:1250 in urban areas and 1:2500 in rural areas.

(ii) Basic geological mapping on a scale of 1:625,000.

(iii) Databased index of all highways related geotechnical reports held by the HA, their Managing Agents and other relevant organisations.

(iv) Databased index of boreholes and wells held by the British Geological Survey.

(v) A database facility for all Geotechnical Asset inspection and maintenance records.

(vi) Facilities for archiving digital or scanned copies of all geotechnical reports and associated digital documents such as AGS files, CAD drawings or digital photographs.

(vii) Map and text based facilities for searching the report and borehole databases.

(viii) Automated preparation of maps from the inspection records database showing Classes of geotechnical features (reference Section 3) by colour coding. This includes the automated determination of 'at risk' zones in soil slopes.

(ix) Text based facilities to search and query the inspection and maintenance records database to answer technical, financial and planning questions.

2.21 The system will be accessed by all HA Regional Offices, their Managing and Design Agents, and any other authorised parties over the HA Extranet. All user access will be via a web browser interface with appropriate security protection to any Commercial In Confidence material. Figure 2/2 illustrates the structure of the HAGDMS.

2.22 The inspection and maintenance data to be included in the system will comprise:

(i) Principal Inspection Forms for each Geotechnical Asset.

(ii) Plans of each route at a scale of 1:2500, with Classes of geotechnical features identified.

(iii) Geotechnical Maintenance Forms (GMF) Parts A, B and C.

(iv) Geotechnical Principal Inspection Report (GPIR).

(v) Preliminary Sources Study Report.

(vi) The Geotechnical Report, as built drawings, and the Geotechnical Feedback Report.

(vii) The Geotechnical Certificates for each report (see Section 4).

(viii) Index to all other geotechnical reports.

(ix) Index to borehole data.

Further details of the HAGDMS are contained in reference 10.

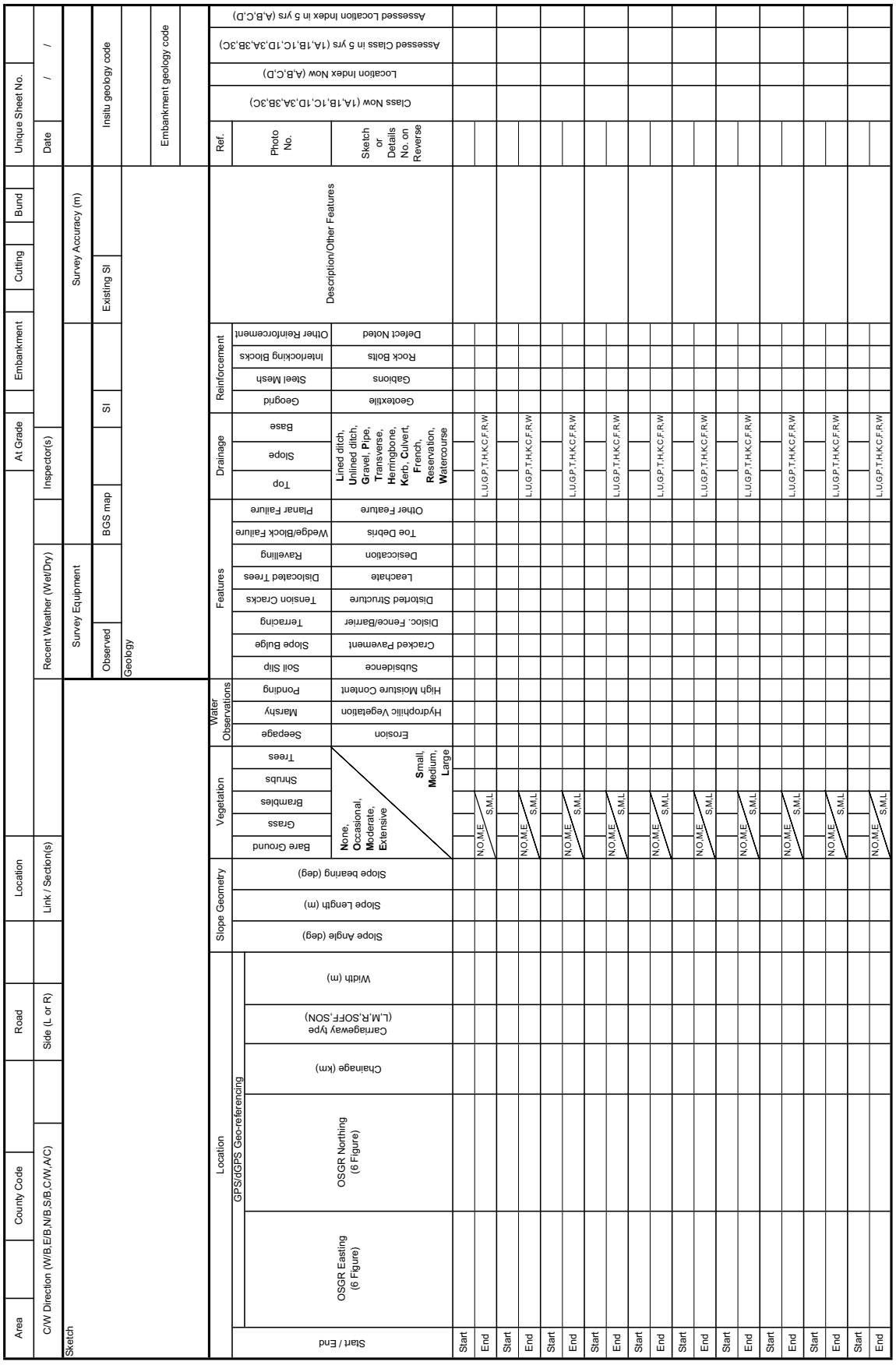

Figure 2/1 - Principal Inspection Form (GPS/dGPS geo-referencing)

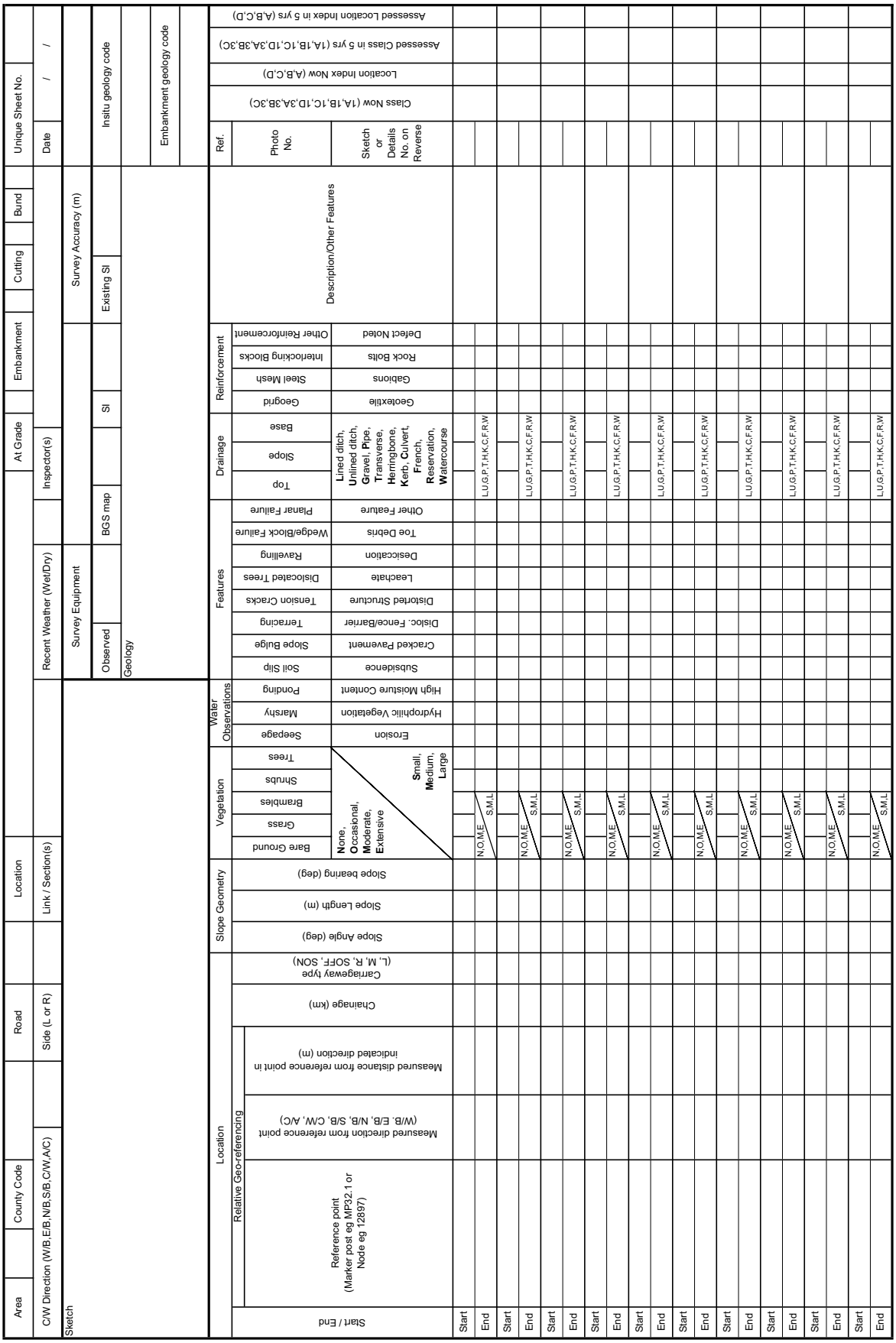

Figure 2/1 (continued) - Principal Inspection Form (relative geo-referencing)

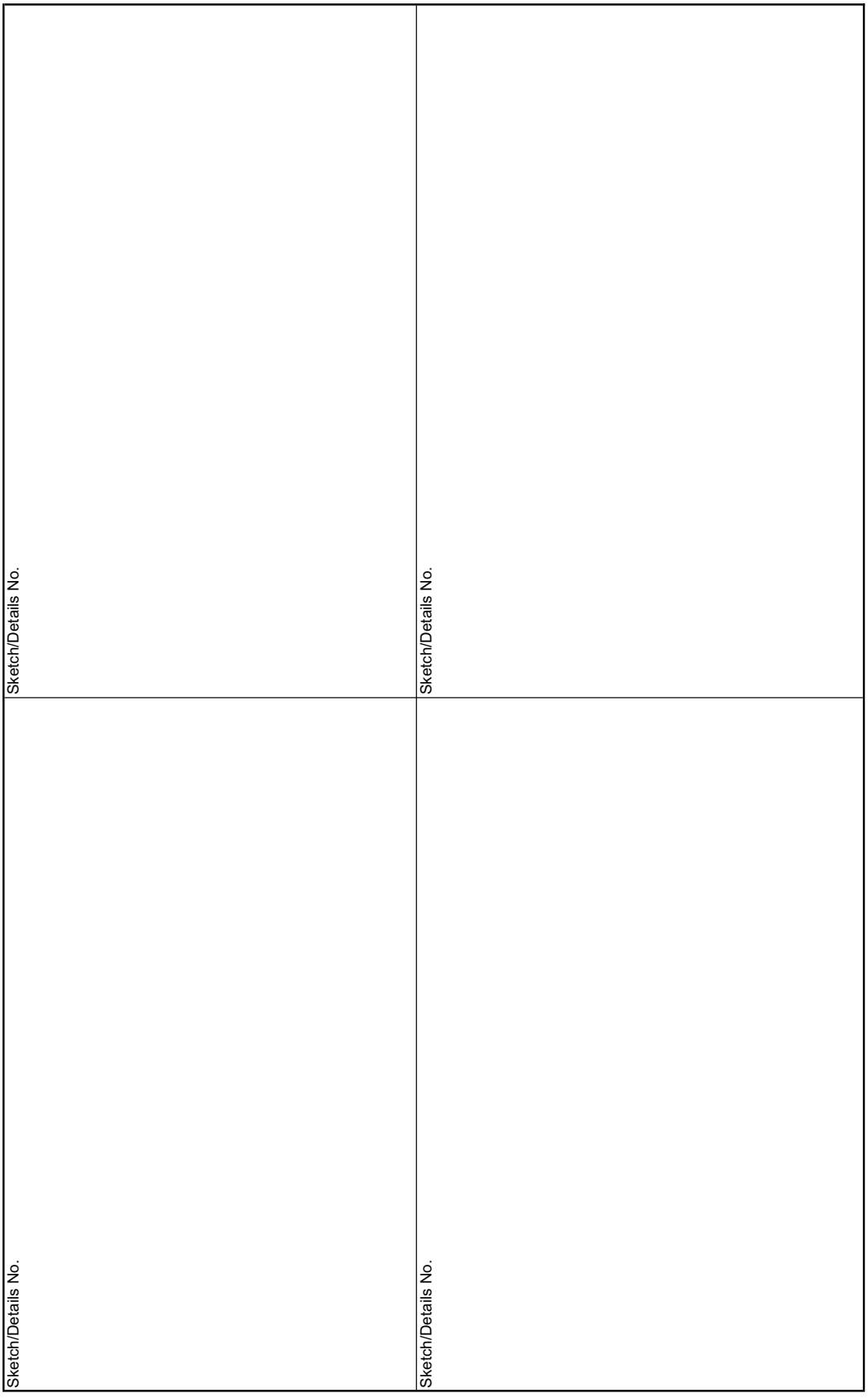

Figure 2/1 (continued) - Principal Inspection Form (reverse)

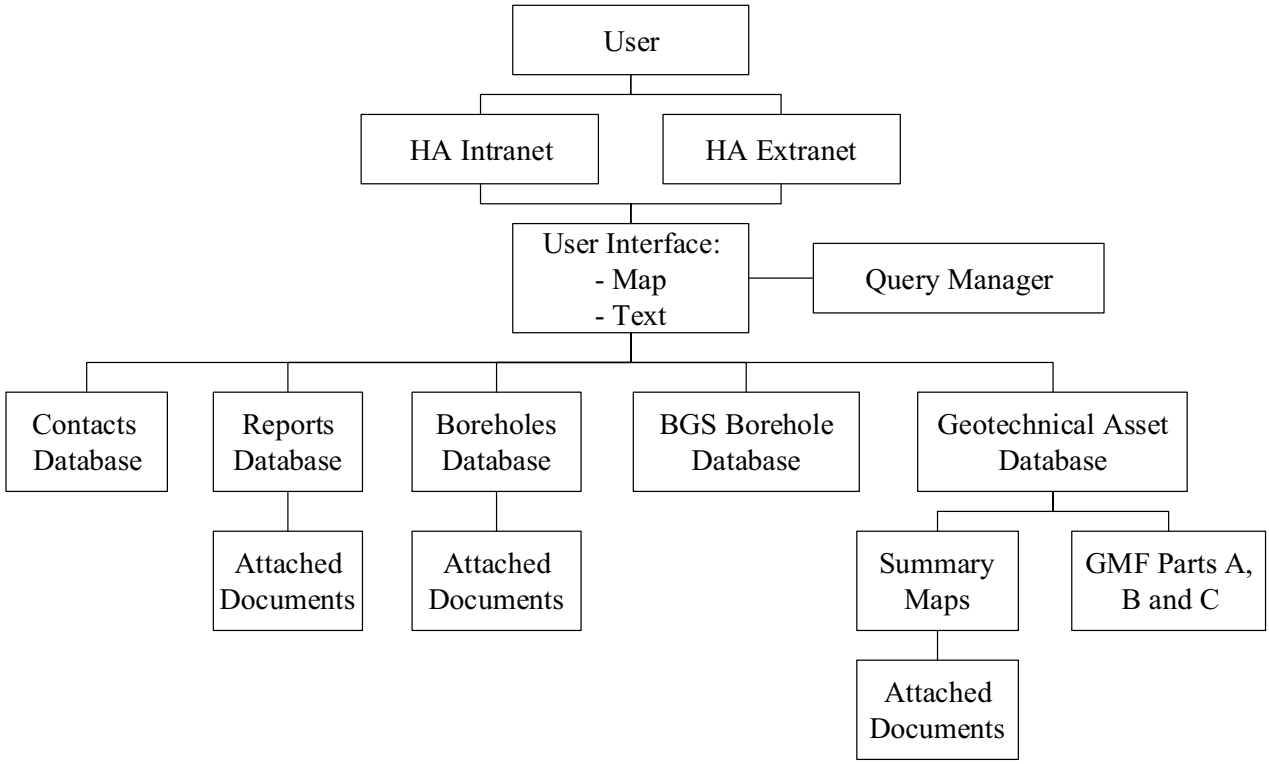

Figure 2/2 - HAGDMS Structure

3. RISK ASSESSMENT OF GEOTECHNICAL FEATURES

Risk Assessment Framework

3.1 A risk assessment is carried out on all geotechnical features identified during a Principal Inspection:

(i) to classify the nature of the feature

(ii) to determine the level of risk to the network

(iii) and hence to determine any actions that may be required.

The methodology is summarised as:

What + Where + When => Risk Level => Action

The components of the assessment are:

(i) Class (What) - A classification of each feature (Section 3.2).

(ii) Location Index (Where) - Giving the location of the feature in relation to the highway or other asset of importance (Section 3.3).

(iii) Timeframe (When) - The period that the assessment applies to (Section 3.4).

(iv) Risk matrix by timeframe (Risk Level) - An assessment of risk level based on the previous three inputs (Section 3.5).

(v) Actions Table (Action) - Indicating the action required and when it should be carried out (Section 3.6).

The process is summarised as:

Class + Location Index + Timeframe => Risk matrix by timeframe => Actions Table

Class

3.2 Three principal Classes of geotechnical feature are defined:

(i) Class 1: Areas of defect.

(ii) Class 2: Areas at risk.

(iii) Class 3: Areas of repair, strengthening and preventative works.

The Classes are subdivided depending on the type of feature as detailed in Table 3.1 below.

(i) Class is determined on the nature of the feature as observed now in the field, and reported on the PIF.

(ii) A subjective assessment is also made of how the feature may deteriorate over the next 5 years, and what Class it may have at the end of that period.

Class	Description of feature	Examples of feature
	Class 1: Areas of defect	
1A	Major soil slip related defects, or combinations of minor soil slope instability indicators which indicate the early stages of a major defect. Such defects trigger Class 2A at risk zones in soil slopes with similar geology and similar or more severe morphology	• A soil slope slip • Major tension cracks in a soil slope • Combination of slope bulge, dislocated trees and minor tension cracks indicative of a major soil slope feature
1B	Major rock slope or non-slip related geotechnical defects. They may be indicative of a vulnerability elsewhere and may trigger Class 2B at risk zones in adjacent or similar areas	• A rockfall from a rock cutting face • Settlement of an embankment due to underlying compressible soils • Contaminated water discharges due to an adjacent landfill site • Mining induced settlement of the carriageway • Solution feature collapse at embankment toe
1C	Major defects which do not trigger at risk zones because they are caused by localised conditions which are not representative of the geological unit elsewhere. May be slip, or non-slip related	• Localised seepage. • Localised ground subsidence of carriageway associated with settlement of a trench excavation backfill • Landslip caused by local excavation into the slope toe
1D	Minor defects which do not trigger at risk zones because of their minor nature. May be slip, or non-slip related	• Minor tension cracks • Dislocated trees • Rabbit burrows • Minor road undulations due to underlying peat • Minor tear in geotextile fabric in a reinforced slope
	Class 2: Areas at risk	
2A	Any soil slope within an earthwork with a similar or more severe morphology than that which occurs at the location of a Class 1A defect or Class 3A repair in a soil slope of the same geology. Such a slope must also be on the same road and within the same Maintenance Area as the 'trigger' Class 1A defect or Class 3A repair. A Class 2A zone is considered to be at risk of future slope instability and is automatically assigned by the HAGDMS	• A steeper and higher soil slope within the same geology as a Class 1A or 3A feature, but which does not currently show any defects
2B	Any part of a soil or rock earthwork considered to be at risk of experiencing geotechnical problems for a reason that is not related to soil slope instability. Such zones are manually assigned, and may be triggered by a Class 1B defect or Class 3B repair	• A section of a cutting in rock which has not yet failed, but which is in similar material to a cutting which has already failed. The assessment will take into account slope height, angle, bedding and discontinuity orientations etc • Earthworks underlain by areas of mining activity but no defects visible at present • Earthworks in the vicinity of a landfill site which may be susceptible to leachate infiltration, but none visible at present
	Class 3: Areas of repair, strengthening and preventative works	
3A	Sections of soil earthworks where previous Class 1A defects have been repaired, or where preventative works have been undertaken to prevent deterioration of a Class 2A at risk zone. Class 3A triggers Class 2A at risk zones in soil earthworks of the same geology with similar or more severe morphology	• Granular slope replacement of a failed cutting, but with no visible current defects • Area of remedial slope drains
3B	Sections of earthworks where previous Class 1B defects have been repaired, or where preventative works have been undertaken to prevent deterioration of a Class 2B at risk zone. Class 3B triggers Class 2B at risk zones	• Sections of carriageway patched or repaired due to mining induced subsidence, but show no current subsidence • Area of remedial rock bolting on a rock cutting face • Collector system installed to intercept contaminated seepage from adjacent landfill, which is operating successfully
3C	Features within earthworks which are unlikely to develop into Class 1 defects and are not considered to be Class 2 at risk zones, but to which particular attention should be given in routine inspections. This Class includes strengthened earthworks and previous Class 1C defects that have been repaired	• Reinforced earth slopes with no current defects • Repaired slip caused by excavation for installation of Variable Message Sign foundation

Table 3.1 Classification of Geotechnical Features

Location Index

3.3 The Location Index indicates the location of the geotechnical feature with respect to the principal assets that are, or may become, affected by a failure. Location Index is defined in Table 3.2.

(i) Location Index is determined for each geotechnical feature as observed now in the field, and reported on the PIF.

(ii) In addition a subjective assessment is made of how the feature may deteriorate and extend over the next 5 years, and hence the Location Index at the end of that period.

Timeframe

3.4 The risk assessment is carried out over two timeframes, based on the observed conditions now, and a subjective assessment of conditions in five years time. The later provides the basis of the proactive approach to maintenance. The Timeframe definitions are givne in Table 3.3.

Location Index	The area that the feature affects	Structures and third party property that the feature affects	Examples of Location Index
A	The running lanes	Critical structures and inhabited buildings	• A rockfall has landed in lane one. • A landslip has encroached on a bridge pier. • A mining subsidence depression has appeared in lane one. • The road is on embankment across an area of peat, the carriageway has suffered severe undulations. • A landslip remote from the carriageway is threatening a house on adjacent property
B	The hardshoulder	Communications links, critical highways furniture and non-inhabited buildings	• A slip in an embankment has undermined the safety fence. • A seepage of leachate from an adjacent landfill is entering the carriageway drainage and is spilling on to the hardshoulder • A landslip on an embankment has severed the motorway telephones cable
C	Adjacent to the highway	Non-critical structures, drainage, non-critical highways furniture	• A series of tension cracks and a slope bulge indicating a small slip about to occur, the verge is sufficiently wide that the hard shoulder will not be affected, but there is a traffic sign that may be disrupted.
D	Remote from the highway	Adjacent land	• A slip in a noise bund separated from the carriageway by a wide verge. • Solution feature depression noted in an adjacent field, but desk study indicates that the susceptible horizon does not extend under the carriageway or adjacent earthworks.

Table 3.2 Location Index

Timeframe	Definition
Now	Class and Location Index of feature as observed in the field now and reported on the PIF
Five years	On the basis of the observations of Class and Location Index of a feature in the field now, a subjective assessment is made of the potential deterioration of the feature, and hence the Class and Location Index the feature may have in five years time

Table 3.3 Timeframe

Risk matrix by timeframe

3.5 Five levels of risk are defined in Table 3/4.

Two matrices of risk level are given below in Table 3.5, one for each of the Timeframes considered. Both provide an assessment of the Risk Level now due to the geotechnical feature. The first matrix uses the Class and Location Index observed now in the field, and reported on the PIF. The second matrix uses the subjective assessment of Class and Location Index in five years time, and provides an indication of the Risk Level now as a basis for the proactive approach to maintenance.

Risk Level	Description
S	Severe
H	High
M	Medium
L	Low
N	Negligible

Table 3.4 Risk Level

Risk Level NOW for observations of Class and Location Index NOW					
Location Index	**Class**				
	1A/1B/1C	**1D**	**2A/2B**	**3A/3B**	**3C**
A	S	H	M	N	N
B	S	M	M	N	N
C	H	M	L	N	N
D	M	L	N	N	N

Risk Level NOW for assessed Class and Location Index in FIVE YEARS time					
Assessed Location Index	**Assessed Class**				
	1A/1B/1C	**1D**	**2A/2B**	**3A/3B**	**3C**
A	H	M	N	N	N
B	H	L	N	N	N
C	M	L	N	N	N
D	L	N	N	N	N

Table 3.5 Risk Matrix by Timeframe

Actions Table

3.6 The required action to be taken now is determined by whichever is the highest Risk Level from either of the two Timeframes considered in Section 3.4 above. The recommended geotechnical actions to be taken are given in Table 3.6 below:

Risk Level	Description	Recommended Geotechnical Action
S	Severe	Remedial action must be undertaken with highest priority and H&S/Traffic Management requirements considered and kept under constant review. Consider VFM of Preventative works on adjacent Class 2 assets and potential impact on other Routine or Capital maintenance activities.
H	High	Remedial action required, timescale to be determined by the Overseeing Organisation Geotechnical Advisor and Overseeing Organisation Area Manager, but within 5 years. Interim monitoring/inspection may be called for and H&S/Traffic Management requirements considered. Consider VFM of Preventative works on adjacent Class 2 assets and potential impact on other Routine or Capital maintenance activities.
M	Medium	Remedial action may not be required but preventative action advisable within 5 years. Review inspection and/or monitoring regime and potential impact on other Routine or Capital maintenance activities.
L	Low	No immediate action required. Review inspection and/or monitoring regime. Consider VFM of Preventative works. Review potential impact on other Routine or Capital maintenance activities.
N	Negligible	No immediate action required. Re-inspect in five years.

Table 3.6 Recommended Geotechnical Action by Risk Level

Examples

3.7 Two examples are given below to illustrate the use of the above Risk Assessment procedure.

Landslip on London Clay embankment

3.8 The Principal Inspection of a 5m high embankment has revealed a series of tension cracks over a 10m length of the embankment, located 2m down from the crest. There is a safety fence, and buried cables for motorway lighting and telecommunications at the edge of the hardshoulder. There are no signs of problems on the carriageway or hardshoulder, and no other signs of instability on the embankment slope. The desk study has indicated that the underlying geology is Glacial Deposits overlying the London Clay and observation of adjacent cutting geology suggests that the embankment fill is likely to be London Clay.

The tension cracks are recorded on the PIF as a minor defect, Class 1D. The defect currently only affects the shoulder of the embankment, and does not affect the safety fence, cables or hardshoulder, the Location Index is therefore given on the PIF as C (Adjacent to highway). For the Timeframe of Now, the Risk Matrix shows the Risk Level to be Medium.

The inspecting engineer assesses that if nothing is done to the defect, then in five years time it is likely to have developed into a landslip affecting the full height of the embankment, and that it is likely to undermine the foundations for the safety fence, and disrupt or sever the cables. It is thought unlikely that the hardshoulder will be affected, and very unlikely that the carriageway will be affected. Therefore, the assessed Class in five years time is 1A (Major soil slope defect), and that because it will affect communications links and critical highways furniture (the safety fence) the assessed Location Index in five years is B. For the Timeframe of Five years, the Risk Matrix shows the Risk Level to be High.

The required Action is based on the highest assessed Risk Level, which is High, for the Five year Timeframe.

The Actions table states that remedial action is required, within five years, on a timescale to be decided by the Overseeing Organisation Geotechnical Advisor and Overseeing Organisation Area Manager.

Contaminant seepage from landfill

3.9 A routine non-specialist highway inspection of a 3m high cutting in Boulder Clay has identified a seepage of foul smelling liquid along a 5m length of slope. The GMLE has been informed, and sent a geotechnical engineer to carry out a Principal Inspection of the feature. Initial visual inspection, and subsequent chemical testing, indicates the liquid to be landfill leachate. The engineer completes a PIF for this single feature. A desk study reveals an old landfill in an infilled brickpit adjacent to the highway. The reason why the seepage is occurring at this one location, and not elsewhere along the cutting, is not obvious from a visual inspection.

On the PIF the feature is assigned a Class 1B, in that it is a Major non-slip defect. The Location Index is given as C as it is adjacent to the highway, but the hardshoulder is not affected. The Risk Level for the Timeframe of Now is therefore High.

The inspecting engineer is of the opinion that the seepage is unlikely to get worse over the next five years, and is unlikely to cause deterioration of the slope. Therefore the assessed Class for five years time remains as 1B and the assessed Location Index remains as C. The Risk Level for the Five year Timeframe is therefore Medium. (A defect that is present Now represents a higher risk than a similar defect which is not present Now, but which is considered likely to develop within the next Five years. Therefore, in the risk matrix the Five year Risk Levels are lower than the corresponding Now Risk Levels.)

The required Action is based on the highest assessed Risk Level, which is High, for the Now Timeframe. The Actions table states that remedial action is required, within five years, on a timescale to be decided by the Overseeing Organisation Geotechnical Advisor and Overseeing Organisation Area Manager.

As a result of the desk study the adjacent parts of the cutting where they are bordered by the landfill are assigned a Class 2B, as they are at risk from similar problems.

4. CERTIFICATION PROCEDURES FOR REMEDIAL WORKS AND PREVENTATIVE MEASURES

Certification Procedures

4.1 The procedures to be followed for the design and implementation of remedial works and preventative measures are described below. The procedures are illustrated on the flow chart in Figure 4/1 for each of the Classes of feature described in Section 3.

Class 1: Areas of Defect

4.2 At each key stage, the defect should be Classified and risk level assessed in accordance with Section 3. Details shall be recorded on a Geotechnical Maintenance Form (GMF) Parts A, B and C as set out in Appendix B. Any subsequent investigation and implementation of remedial works or preventative measures shall be subject to geotechnical certification as described below. In this respect investigation includes site investigation, monitoring and surveys. In certain areas investigation, remedial works or preventative measures to defects, which arise due to common reasons such as similar geologies or due to similar drainage problems may, for reasons of cost and efficiency, be undertaken as a single project. In such cases proposals shall be described in the GR, and works will be subject to the agreement of the Overseeing Organisation Geotechnical Advisor and Overseeing Organisation Area Manager. However, separate Forms A, B and C must be submitted for each defect.

4.3 The GMLE shall submit Part A of the GMF. Part A gives an outline inspection report on the defect and proposals for its investigation. The form requests agreement to proceed with the investigation.

4.4 E-mail notification of a newly completed GMF Part A shall be sent by HAGDMS to the Overseeing Organisation Area Manager (or his nominee) and to the Overseeing Organisation Geotechnical Advisor. The investigation scope is outlined on the Form A, and authority to proceed will be subject to the agreement of all parties, this will be given on-line on HAGDMS, and notified by e-mail to the GMLE.

4.5 The GMLE shall ensure that all pertinent background information is assessed, by the review of available and relevant Preliminary Sources Study reports or by the production of such a report if considered necessary (in consultation with the Overseeing Organisation Geotechnical Advisor). The report shall be in the format set out in HD22.

4.6 The GMLE shall supervise any investigation contracts and shall produce a Geotechnical Report (GR), to cover those investigations, their interpretation, and design of the remedial works or preventative measures. The report shall be in the format set out in HD22.

4.7 A Geotechnical Certificate shall accompany all report submissions as detailed in HD22 Appendix I (2). This certificate will be stored on the HAGDMS.

4.8 The GMLE shall submit Part B of the GMF. Part B outlines the remedial works or preventative measures proposed, working restrictions, dates of work and cost estimates, and seeks agreement to proceed with the works.

4.9 An e-mail notification will be sent to the Overseeing Organisation Geotechnical Advisor and the Overseeing Organisation Area Manager when a Part B form has been completed on-line on HAGDMS, and requires their agreement to proceed. The authority to proceed will be given on-line on HAGDMS, and notified by e-mail to the GMLE, who shall carry out the necessary action.

Minor Works

4.10 Subject to the agreement of the Overseeing Organisation Geotechnical Advisor, the reporting requirements for minor works to defects may be simplified. For such works the content of the Preliminary Sources Study report, and of the GR may be reduced and the reports referenced on the appropriate GMF form. GMF Parts A, B, and C will be required in all cases.

Class 2: Areas at Risk

4.11 The above procedures shall also apply to Class 2 features. GMF Parts A, B and C are required for any investigations, preventative measures or monitoring works carried out. Geotechnical certification as described above and indicated on Figure 4/1 is required. Proposed preventative measures shall be described in the PSS and in further detail in the GR.

Class 3: Areas of Repair, Strengthening or Preventative Works

4.12 Investigation, remedial works or preventative measures are not carried out in connection with maintenance to Class 3 features. The certification procedures described above are therefore not applicable.

Records of Remedial and Preventative Measures

4.13 Records in the form of as-built drawings and GMF Part C shall be prepared for all remedial works and preventative measures carried out. In individual circumstances, and as required by the Overseeing Organisation Geotechnical Advisor, it may be appropriate to produce a Geotechnical Feedback Report and Geotechnical Certificate as set out in HD22. A GMF Part C shall be completed for any investigations or works carried out on any defects and where agreement to the installation of post-works monitoring is required. The monitoring shall be reviewed as part of the next Principal Inspection, or sooner if required by the Residual Risk Assessment. The as-built drawings, or reference to them, together with the GMF forms shall form part of the data to be entered into the HAGDMS as described in Sections 2.20 to 2.22.

Preventative Maintenance

4.14 The inspection and reporting of the condition of highway Geotechnical Assets as required by this Standard, provides an assessment of the likely risk of defects occurring or deteriorating in the future. The identification of such risk, and thus the provision of maintenance prior to defects occurring or deteriorating, as opposed to remediation afterwards, provides a more cost effective and proactive approach to asset maintenance. The costs of such inspection and preventative measures can be significantly lower than associated costs for remedial works. Information sources for possible preventative works solutions are given in Appendix D.

4.15 Proposals for preventative works shall be described in the PSS report and in more detail in the GR. The implementation of such work shall be considered in relation to other works planned or being carried out to the network. GMF Parts A, B and C shall be completed for any investigation and preventative measures carried out.

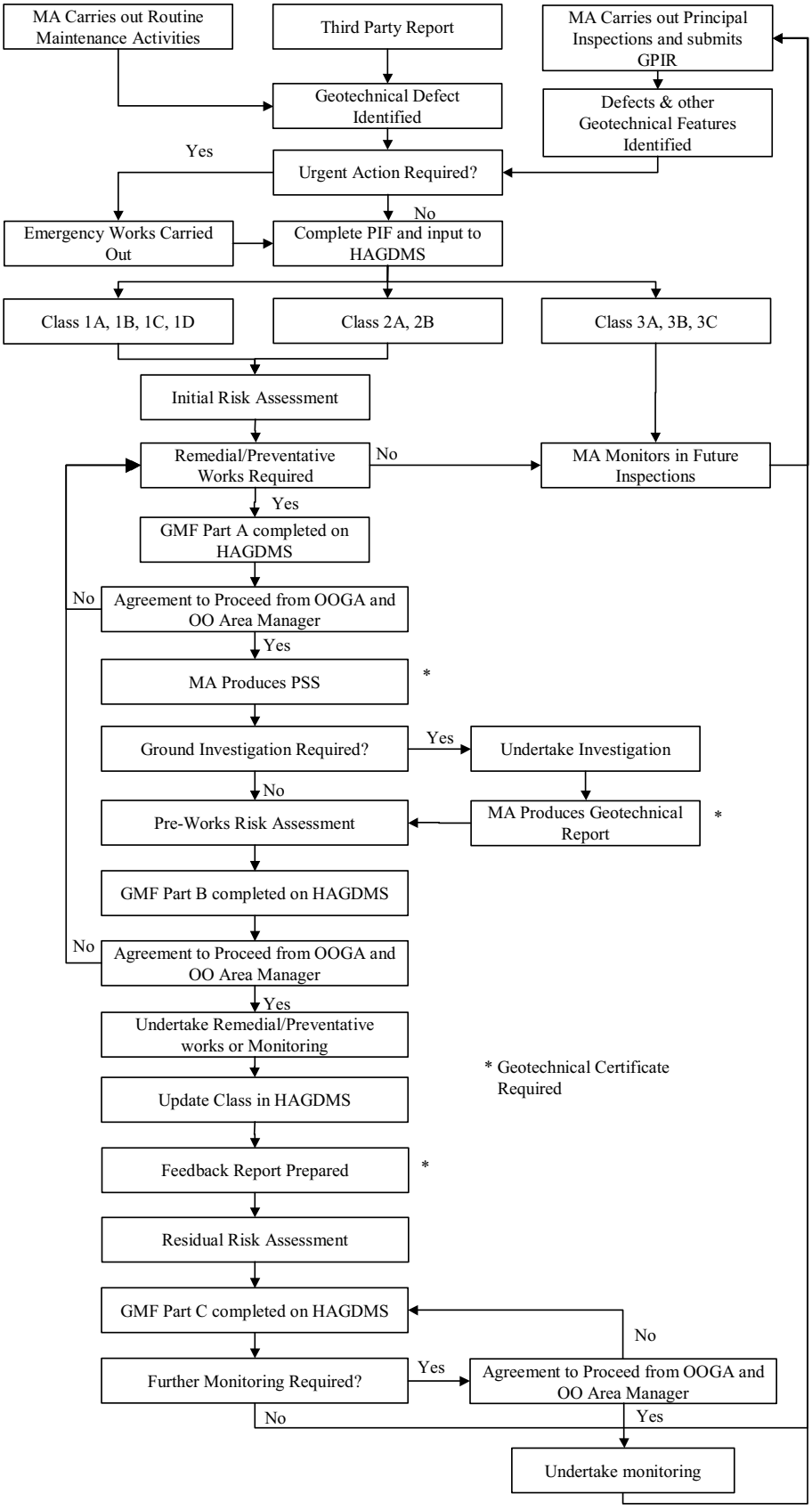

Figure 4/1 - Geotechnical Maintenance Procedures Flow Chart

5. REFERENCES

1. Trunk Road Maintenance Manual (TRMM): Volume 2, Routine and Winter Maintenance Code, Highways Agency, 1996.

2. HD22 Managing Geotechnical Risk. (DMRB 4.1.2).

3. HA44 - Earthworks: Design and Preparation of Contract Documents (DMRB 4.1.1).

4. HA43 - Geotechnical Considerations and Techniques for Widening Highway Earthworks (DMRB 4.1).

5. HA68 - Design Methods for the Reinforcement of Highway Slopes by Reinforced Soil and Soil Nailing Techniques (DMRB 4.1.4).

6. SISG (1993). Site Investigation in Construction. Site investigation steering group. Thomas Telford, London.

   Part 1 Without site investigation ground is a hazard.
   Part 2 Planning, procurement and quality management.
   Part 3 Specification for ground investigation.
   Part 4 Guidelines for the safe investigation by drilling of landfills and contaminated land.

7. TRL 192, Sources of information for site investigation in Britain (revision of TRL Report LR 403) by J Perry and G West, Transport Research Laboratory (1996).

8. BS 5930: 1999, Site Investigations, British Standards Institution.

9. HA Geotechnical Data Management System, User Manual, Highways Agency.

10. Highway Structures: Inspection and Maintenance (DMRB 3.1 and 3.2).

11. CIRIA C550 Infrastructure Embankments - condition appraisal and remedial treatment by Perry, J, Pedley, M & Reid, M (2001).

12. Health and Safety Executive (1992). The Management of Health and Safety at Work Regulations 1992. Health and Safety Executive, London.

6. ENQUIRIES

Approval for this document for publication is given by the undersigned:

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All technical enquiries or comments on this document should be sent in writing to the above, as appropriate.

APPENDIX A. INSPECTION GUIDANCE

A.1.0 Health and Safety

Personnel trained in working on and adjacent to the highway shall carry out inspections. In addition to HA and police requirements the relevant Health and Safety Regulations shall be observed before commencing any inspection. Inspectors must be in possession of a Motorway Pass which conforms to the Motorways Traffic (England and Wales) Regulations 1982 (Exceptions and Relaxations).

A 'Risk Assessment' shall be carried out prior to the inspections for each route. The risk assessment shall include issues relating to the numbers of technical and support personnel required to carry out the inspections such that an adequate complement of personnel are provided to meet the requirements of the Health and Safety Regulations. Traffic management requirements are given in Chapter 8 of the Department of Transport (1991) Traffic Signs Manual and HA Standard TD 49/97 Mobile Lane Closures (DMRB 8.4.4).

A.2.0 Significant Earthworks

Significant earthworks are defined as cuttings, embankments or bunds with a maximum vertical height of greater than or equal to 2.5 metres, or reinforced slopes of any height.

Significant earthworks are bounded by the following:

(i) Over bridges associated with cuttings and under bridges passing under embankments.

(ii) Culverts which extend to over half the height of an embankment.

(iii) Maintaining Agent Area boundaries.

(iv) County Boundaries.

(v) Changes in earthwork geology.

In order to permit the automated calculations and queries in HAGDMS each earthwork can have only one geology, and must be entirely within one County and Maintaining Agent Area. The above earthwork boundaries should be identified before commencing a Principal Inspection.

Earthworks below 2.5 metres in height are not defined as significant earthworks in this standard. However, if a cutting or embankment begins at grade and extends to a vertical height in excess of 2.5 metres then the earthwork should be surveyed as a significant earthwork from its start at grade to its end at grade. There is no minimum height applicable to the inspection of reinforced soil slopes.

A.3.0 At-grade

Lengths of road with no earthworks or where the earthworks are below 2.5 metres in height for their entire length are considered to be at-grade.

At-grade sections are bounded by:

(i) Bridges.

(ii) Maintaining Agent Area Boundaries.

(iii) County Boundaries.

(iv) Changes in geology.

A road in shallow cut and fill (of less than 2.5 metres) on sidelong ground is considered to be at-grade, with the sidelong ground being identified as a geo-hazard.

A.4.0 Annual Inspections

The Annual Inspections typically comprise a continuous survey of all assets on the whole of the network and include a routine general inspection of the Geotechnical Asset. The inspection of the condition of the Geotechnical Asset is only one of many activities during the Annual Inspection. Annual Inspections are undertaken by a trained individual usually not an engineer. The Routine Maintenance and Management System (1996) gives details. Annual Inspections are undertaken on both significant earthworks and at-grade lengths.

The Annual Inspections are generally link and section related, rather than significant earthwork or at-grade length related. An Annual Inspection may lead to a more detailed inspection, a Principal Inspection, if a defect is located.

A.5.0 Principal Inspections

The Principal Inspections are a continuous survey, by a Geotechnical Engineer or an Engineering Geologist (7), of the entire geotechnical asset, comprising all significant earthworks and at-grade lengths.

The most appropriate survey technique(s) should be selected to ensure that the required data is acquired in a safe and cost effective manner. The choice (for example, by foot, slow moving vehicle or aerial) will primarily be a function of:

(i) Nature of the terrain.

(ii) Land area to be covered.

(iii) Disruption to traffic in providing appropriate safety cover for operatives.

(iv) Measurement/recording equipment available.

(v) Variability of topography and geotechnical/ geological features.

(vi) Density and type of vegetation cover.

(vii) Habitat sensitivity.

In the case of significant earthworks the continuous survey would normally be made on foot, at-grade lengths can frequently be surveyed to the appropriate standard from a slow-moving vehicle with periodic stops for walkover inspection.

For significant earthworks the topography of the slope is measured at the following locations:

(i) At the beginning and end of the earthwork, eg adjacent to a structure.

(ii) At any highest or lowest points.

(iii) At any changes in slope inclination/relief.

(iv) At the beginning and end of defects.

(v) At any additional locations necessary to accurately define the slope.

Where defects are being recorded as a single location with a recorded width, the topography of the slope is measured at the mid-point of the defect. Recording of slope topography is not required on at-grade sections, except as required for other reasons, eg the road is on steep sidelong ground.

Details of vegetation, water observations, slip features, and drainage as indicated on the Principal Inspection Form are also recorded with their start and end. Any other features considered to be of note seen during the inspection, such as features outside the highway boundary, instrumentation, emergency telephone positions etc, should be recorded on the Principal Inspection Forms in a descriptive field.

When a defect or potential defect, or other actual or potential geotechnical feature or hazard is located, its position is recorded using geo-referencing. If required, additional details of the feature may be recorded as sketches or notes on the Principal Inspection Forms.

Photographs should be taken of defects and of each reinforced soil structure (e.g. to record vegetation cover on a strengthened earthwork). Other photographs should be taken as necessary.

A.6.0 Reinforced Slopes (Soil or Rock)

All reinforced slopes are considered to be significant earthworks, irrespective of their height. Where a road has been widened since its original construction the toe of the cutting or the crest of the embankment has often been reinforced. Such sections, together with all other reinforced soil slopes, shall be inspected and the relevant sections of the Principal Inspection Form completed, including records to record the topography of the earthwork slopes.

A.7.0 Geo-referencing

Features noted during a Principal Inspection need to have their position accurately referenced within the highway network. This is known as geo-referencing. Geo-referencing is achieved by one of the following methods:

(i) Use of GPS/dGPS to obtain Ordnance Survey Co-ordinates.

(ii) Relative measurement to a known reference point.

(iii) Chainage along the road.

Two versions of the Principal Inspection Form are provided; one for when using GPS/dGPS to determine the absolute locations of observations, and the other for when using relative geo-referencing. The former method is recommended. Both versions of the PIF allow the recording of chainage along the road.

A.8.0 Ordnance Survey Co-ordinates Referencing

Geo-referencing directly to Ordnance Survey National Grid 6 figure co-ordinates can be accomplished through the use of a GPS (Global Positioning System) or dGPS (differential GPS). Trials indicate that hand-held or back-pack dGPS receivers can work to an accuracy better than or equal to that achieved by the relative referencing techniques outlined below. Location co-ordinates obtained by GPS/dGPS can be recorded directly onto the Principal Inspection Form or can be recorded using a digital data capture device.

Use of GPS/dGPS has considerable benefits over other methods of geo-referencing:

(i) Inspectors can obtain geo-referencing information without have to use a measuring wheel in the hard shoulder, thus reducing the health and safety risk.

(ii) There is no reliance on the accuracy and completeness of the reference point databases required for relative geo-referencing techniques.

(iii) Little post-processing of obtained co-ordinates is required.

(iv) Obtained co-ordinates can be checked against mapping in the field to ensure that the recorded locations are in the correct area.

When geo-referencing by co-ordinates, the following information should also be recorded:

(i) Road number.

(ii) Direction of adjacent traffic flow.

(iii) Side of road being surveyed in direction of traffic flow.

(iv) Carriageway type (Link, Main, Roundabout, Slip road off, Slip road on).

Whilst carrying out an inspection, it is advisable to note the position of all potential Reference Points. Such points include nodes and marker posts, but also fixed structures that can later be checked on a map, such as bridges.

A.9.0 Relative Referencing

In order to use relative referencing and to accurately and uniquely define the position of a recorded feature the following information is required:

(i) Road number.

(ii) Identifier of the reference point (e.g. Marker Post number or Link and Section node reference).

(iii) Direction of adjacent traffic flow.

(iv) Side of road being surveyed in direction of traffic flow.

(v) Direction of measurement from the reference point to the feature.

(vi) The distance measured along the highway from the reference point.

(vii) Carriageway type (Link, Main, Roundabout, Slip road off, Slip road on).

Examples of relative geo-references may therefore be:

M23, Node 53369, S/B, L, S/B, 123m, M
or
M4, Marker Post 12.8, W/B, L, E/B, 34m, SOFF

The measurement direction should be relative to the direction of the entire road, not an exact compass bearing at the point being surveyed. Therefore, if a measurement has been made to the due north of a given Reference Point, but overall that carriageway runs to the west, then the measured direction must be recorded as either west or east.

The most suitable Reference Points to use during an inspection are nodes or marker posts. On roads where no marker posts are present then the nodes must be used. On roads where both marker posts and nodes are present, then it may prove most practical to use the marker posts as Reference Points, given that the distance between nodes may be up to several kilometres, and accuracy will be lost when measuring over these distances. Whilst it has previously been noted that there may be up to 15% error in the distance between marker posts, it is also known that there is inaccuracy in the positioning of nodes, and that nodes observed in the field may not be present in the reference point database. Use of Ordnance Survey co-ordinates for geo-referencing is preferred to relative geo-referencing techniques.

A.10.0 Chainage Referencing

Chainage along the road is normally derived by calculation from either of the two above geo-referencing methods, but chainage can be measured directly in the field in some situations. If field measurements of chainage are made, the following information must also be recorded to ensure that the information is unique and unambiguous:

(i) Road number.

(ii) Direction of adjacent traffic flow.

(iii) Side of road being surveyed in direction of traffic flow.

(iv) Carriageway type (Link, Main, Roundabout, Slip road off, Slip road on).

Use of Ordnance Survey co-ordinates for geo-referencing is preferred to use of road Chainage where possible.

APPENDIX B. GEOTECHNICAL MAINTENANCE FORMS (GMF) PARTS A, B AND C

B.1.0 The Geotechnical Maintenance Forms

Geotechnical Maintenance Forms, Parts A, B and C are completed for all Class 1 or 2 features if investigation works and/or remedial/preventative or monitoring works are proposed and/or carried out. The forms are completed for individual features, not groups of features. In this way, a complete history of each feature on which work has been undertaken is recorded.

The forms exist principally in electronic format, on-line in HAGDMS. If paper versions are printed off from HAGDMS at any time, these shall be stamped "uncontrolled" and will remain secondary to the electronic version.

The three forms are used as follows:

B.1.1 GMF Part A (Initial Proposals)

GMF Part A (see Figure B/1) is used to notify Class 1 defects requiring investigation and/or remedial works or for which emergency remedial works have been carried out. It is also used for Class 2 at-risk zones requiring investigation and/or preventative measures to prevent a Class 1 defect developing. It requests agreement to proceed with the ground investigation.

GMF Part A includes an initial risk assessment section.

B.1.2 GMF Part B (Defect Remedial Works Proposal)

GMF Part B (see Figure B/2) provides feedback on investigations carried out as outlined on the GMF Part A, and describes proposed remedial/preventative works or monitoring measures. It requests agreement to proceed with the works.

It includes a pre-works risk assessment to allow revision of the perceived risk level in the light of ground investigation data and desk study information.

B.1.3 GMF Part C (Remedial or Preventative Works Feedback and Monitoring Proposals)

GMF Part C (see Figure B/3) provides feedback on remedial or preventative works carried out as outlined on GMF Part B. It also includes proposals for, and seeks approval of, further monitoring (if required).

GMF Part C includes a risk assessment to record the likely level of residual risk following the works undertaken.

B.2.0 The Process

The procedure for completion, distribution and approval of the forms is as follows:

(i) The forms are completed on-line and are associated to the relevant observation held within the Geotechnical Asset Database of the HAGDMS. New forms are created from with the HAGDMS, and links to the completed forms are via the relevant record in the Geotechnical Asset Database.

(ii) Each Form must be approved by the GMLE.

(iii) The Forms must be completed in sequential order. Before a Part B form can be completed, a Part A form must be in place and fully approved. Likewise, a Part C form cannot be completed until a Part B form is completed and approved.

(iv) When each form is completed an email notification is sent to those within the Overseeing Organisation that must action, agree or otherwise be made aware of the form (the form itself is not emailed). The email notification is automatically generated, and provides a direct link to the form on HAGDMS.

(v) The recipients of the notification email view the form on-line. If they are required to agree/ disagree with the proposed actions they record their comments and apply their electronic signature on-line. At the completion of this process an email is automatically generated and sent to the form originator to advise that the proposed actions have been agreed or disagreed.

(vi) The system automatically tracks the submission/ agreement process. If a form is not agreed/ disagreed within a given period of time, stated on the form, then a reminder email is automatically sent.

Geotechnical Maintenance Form: Part A

Initial Proposals

Area: Road: Unique defect ID:

Initial Risk Assessment

	Risk Level Now	Assessed deterioration in 5 years:	Risk Level in 5 Years:
Defect Class:			
Location Index:			
Risk Level:			

Nature and likely cause of defect:

Comments:

Emergency works: ○ Carried out ○ Proposed

Emergency works details:

Emergency works cost: £

Proposed investigation:

Proposed investigation date: Proposed investigation estimated cost: £

Proposed remedial or preventative works:

Proposed remedial or preventative works estimated cost: £

MA Geotechnical Liaison Engineer Signature: Add Electronic Signature

Date Part A sent: Date agreement required by:

OO Geotechnical Advisor technical agreement in principal: ○ Agreed ○ Not Agreed

OO Geotechnical Advisor Signature: Add Electronic Signature

Date: Comments:

OO Agreement to proceed with investigation: ○ Agreed ○ Not Agreed

OO Area Manager Signature: Add Electronic Signature

Date: Comments:

Figure B/1 - Geotechnical Maintenance Form Part A

Geotechnical Maintenance Form: Part B

Remedial/Preventative Works Proposal

Area: Road: Unique defect ID:

Preliminary Sources Study completed: ○ Yes ○ No

Geotechnical Certificate submitted: ○ Yes ○ No

Geotechnical investigation completed: ○ Yes ○ No

Summary of investigation findings:

Actual investigation cost: £

Geotechnical Report completed: ○ Yes ○ No

Geotechnical Certificate submitted: ○ Yes ○ No

Pre-Works Risk Assessment

	Risk Level Now	Assessed deterioration in 5 years:	Risk Level in 5 Years:
Defect Class:			
Location Index:			
Risk Level:			

Proposed remedial works/preventative measures/monitoring:

Working restrictions (access, traffic management, night working etc):

Proposed date of works: Proposed works estimated cost: £

Comments:

MA Geotechnical Liaison Engineer Signature: Add Electronic Signature

Date Part B sent: Date agreement required by:

OO Geotechnical Advisor technical agreement in principal: ○ Agreed ○ Not Agreed

OO Geotechnical Advisor Signature: Add Electronic Signature

Date: Comments:

OO Agreement to proceed with works: ○ Agreed ○ Not Agreed

OO Area Manager Signature: Add Electronic Signature

Date: Comments:

Figure B/2 - Geotechnical Maintenance Form Part B

Geotechnical Maintenance Form: Part C

Remedial or Preventative Works Feedback and Monitoring Proposals

Area: Road: Unique defect ID:

As-built drawings completed: ○ Yes ○ No
Geotechnical Feedback Report completed: ○ Yes ○ No
Geotechnical Certificate submitted: ○ Yes ○ No
Has the HAGDMS GAD record been updated: ○ Yes ○ No

Works carried out:

Difficulties encountered:

Date works completed: Works actual cost: £

Residual Risk Assessment

Identification of residual risk:

	Risk Level Now	Assessed deterioration in 5 years:	Risk Level in 5 Years:
Defect Class:			
Location Index:			
Risk Level:			

Requirements for further monitoring:

Proposed date of monitoring: Proposed monitoring estimated cost: £

Comments:

Form C: ○ Issued for information only ○ Approval required

MA Geotechnical Liaison Engineer Signature: Add Electronic Signature

Date Part C sent: Date agreement required by:

OO Geotechnical Advisor technical agreement in principal: ○ Agreed ○ Not Agreed

OO Geotechnical Advisor Signature: Add Electronic Signature

Date: Comments:

OO Agreement to proceed with monitoring: ○ Agreed ○ Not Agreed

OO Area Manager Signature: Add Electronic Signature

Date: Comments:

Figure B/3 - Geotechnical Maintenance Form Part C

APPENDIX C. FORMAT OF GEOTECHNICAL PRINCIPAL INSPECTION REPORT

C.1.0 Title Sheet

Clearly indicating the name and section of the road together with the title (Geotechnical Principal Inspection Report), details of the authorship, and the version and date of the report.

C.2.0 Contents

Contents of all volumes listed in the front of each volume with the contents of the particular volume highlighted.

1.0 Introduction

The scope and objectives of the report, together with the limits of the area covered shall be described.

2.0 Site Description

The geography, topography, hydrology, geomorphology, man-made features together with the historical development of the area shall be described. A description of the activities of adjacent landowners shall be included.

3.0 Geology

A description of the basic geology of the area by reference to published data including geological maps and memoirs shall be made. A description (if known) of any earthwork materials used in the works, together with a description of other construction materials which may affect the geotechnical assets shall be included.

4.0 Inspection Methodology

The method of inspection, data acquisition capture and reporting shall be described.

5.0 Background Data

A list, together with the results of enquiries made, of all data sources used for geotechnical, historical and other general information relevant to the area (Ref. TRL Report 192 and BS5930). A brief assessment of the information obtained shall be included.

6.0 Potential Hazard Areas and Constraints

Include full details and describe potential geotechnical and geoenvironmental hazards and constraints, which may affect either geotechnical assets and/or the other principal elements of the road infrastructure. Include description of groundwater and drainage problems. Provide further details of particular geoenvironmental and possible contamination issues, which may be evident from the results of sections 2 and 5. Include details of any ecological or environmental constraints. Cross-reference the location of the hazard areas to the 1:2500 layout drawings (Ref. section 2.20 of this Standard) included in HAGDMS.

7.0 Inspection Results

Include a summary and description of the inspection results, cross referenced to the Principal Inspection Forms or such other forms used for data acquisition. Provide a summary of the number, type and length of Classes of defects, describe the presentation of the results on the 1:2500 scale drawings (Ref. section 2.20 of this Standard) included in the HAGDMS.

8.0 Further Investigation

An outline description of what (if any) further investigation or monitoring is proposed together with a reference to the requirements of geotechnical certification procedures shall be included.

9.0 Proposed Remedial Works

Provide outline proposals for proposed remedial works to Class 1 defects similar to the content of the Preliminary Engineering Assessment in a Preliminary Sources Study Report (HD22).

10.0 Proposed Preventative Measures

As the content of section 9 for remedial works, but giving proposals for Class 1 defects and Class 2 areas at risk.

Data Sources and References

A full list of all data sources and key references shall be included.

List of Tables

Provide a summary sheet of the geotechnical assets cross-referenced to the Principal Inspection Forms, giving details of the type of geotechnical assets, the location and Class of defects.

List of Figures

Location Plan
Geological Map

Photographs/Sketches

Provide a photograph or sketch of each Class 1 defect giving a brief description, location and cross-reference to the Principal Inspection Form.

Appendix A: Drawings

Include drawings as described in Section 2.20 of this Standard.

Appendix B: Principal Inspection Forms

Include Principal Inspection Forms or similar forms used for data acquisition.

APPENDIX D. ADVICE ON THE MAINTENANCE OF HIGHWAY GEOTECHNICAL ASSETS

D.1.0 Geotechnical Hazards

D.1.1 Land, which is actually or potentially unstable, arises from natural processes. Often it is caused or accelerated by human activities.

D.1.2 Many hazards can be avoided or reduced by proper precautions. These include adequate site investigations, the design of works to accommodate known hazards, and appropriate preventative and remedial maintenance works.

D.1.3 The principal geotechnical hazards which affect Highway Geotechnical Assets, and which may also affect the other principal assets of the network may therefore be summarised as including:

i) Instability in natural and man made slopes of soil, rock, and fill.

ii) Weak and compressible strata

iii) Adverse groundwater conditions due to changes in the groundwater regime, or to defective drainage, and which may influence material behaviour.

iv) Scour and erosion from adjacent watercourses, and from temporary flooding.

v) Instability associated with active or ancient dissolution features, for example, in calcareous rock formations (particularly chalk) but also those containing salt and gypsum.

vi) The instability of former mine workings or mine entries affecting the land surface.

vii) Subsidence due to current or future mining.

viii) Instability and subsidence due to landfill.

ix) Ground and groundwater chemistry and the potential adverse effects on construction materials (e.g. sulfate attack on buried concrete, including the thaumasite form of sulfate attack).

x) The effect of potential leachate from adjacent landfill, and minewater issues following the cessation of pumping.

xi) Highway drainage acting as a conduit for the migration of leachate from landfill sites.

xii) Expiration of the design life of soil nails, geogrids or other engineering materials or works.

xiii) The destabilising effect of animal burrows.

xiv) The destabilising effects that can result from vegetation, or the removal of vegetation.

xv) Instability resulting from changes in loading, or any other changes from the original design assumptions.

D.2.0 INFORMATION SOURCES

This appendix provides a list of key bibliography and reference sources relevant to the maintenance of highway geotechnical assets and to geotechnical hazards that may affect the other principal elements of the network. In addition an index of useful web sites where searches may be undertaken for other related material as well as a check for the most up to date information.

Information sources are provided on the following topics:

D.2.1 Earthworks

British Standards Institution BS 6031: 1981. Code of practice for earthworks.

CIRIA C550 Infrastructure Embankments - condition appraisal and remedial treatment by Perry, J, Pedley, M & Reid, M (2001).

Design Manual for Roads & Bridges Volume 4: Geotechnics & Drainage, Section 1, Earthworks

Perry J (1989). A survey of slope condition on motorway earthworks in England and Wales. Department of Transport, TRRL Report RR 199, Transport and Road Research Laboratory, Crowthorne.

Reid J M and Clark G T, (2000). A whole life cost model for earthworks slopes. TRL Report 430, Transport Research Laboratory, Crowthorne.

Vaughan PR. (1997). Assumption, prediction and reality in geotechnical engineering. Geotechnique, 44. pp 573 – 609.

Potts DM, Kavacevik N and Vaughan PR (1997) Delayed collapse of cut slopes in stiff clay. Geotechnique, Vol 47, No. 5. pp953-982.

D.2.2 Strengthened Earthworks

British Standards Institution BS 8006: 1995. Code of practice for Strengthened/reinforced soils and other fills.

Design Manual for Roads & Bridges Volume 4: Geotechnics & Drainage, Section 1, Earthworks.

D.2.3 Rock Slopes

Geoffrey Walton Practice (1988). Handbook on the hydrogeology and stability of excavated slopes in quarries for the Department of Environment. London, HMSO.

Hoek E and Bray J W (1981). Rock slope engineering. 3rd Edition Institution of Mining and Metallurgy.

Hudson J A (1989). Rock mechanics principles in engineering practice. CIRIA.

McMillan P and Matheson G D, (1998). Rock slope hazard assessment: a new approach. In Geohazards in Engineering Geology, Geological Society, London, Engineering Geology Special Publications 15, pp 177-183.

McMillan P, Nettleton I M and Harber A J, (1998). Rock Slope Remedial and Maintenance Works. In: Transport Research Laboratory Annual Research Review 1998. Transport Research Laboratory: Crowthorne, Berkshire, UK. P. 24-31.

McMillan P, and Matheson G D, (1997). A two stage system for highway rock slope risk assessment. TRL Scotland.

D.2.4 Pavements

Design Manual for Roads & Bridges Volume 4, Section 1, Earthworks.

Design Manual for Roads & Bridges Volume 7: Pavement Design & Maintenance, Sections 1-5, inclusive.

D.2.5 Site Investigation

British Standards Institution BS 5930: 1999, Code of practice for Site Investigations.

SISG (1993). Site Investigation in Construction. Site investigation steering group. Thomas Telford, London.

Part 1 Without site investigation ground is a hazard.
Part 2 Planning, procurement and quality management.
Part 3 Specification for ground investigation.
Part 4 Guidelines for the safe investigation by drilling of landfills and contaminated land.

Transport Research Laboratory (TRL) 192, Sources of information for site investigation in Britain (revision of TRL Report LR 403) by J Perry and G West, Transport Research Laboratory (1996).

D.2.6 Mining

Arup Geotechnics (1992). Mining instability in Great Britain: Summary Report Arup Geotechnics, Newcastle upon Tyne. (*Note: Database is now maintained by the British Geological Survey and Peter Brett Associates)*

Department of the Environment, Transport and the Regions (DETR). Minerals Planning Guidance Notes (MPGs). Treatment of Disused Mine Openings and Availability of Information on Mined Ground. MPG12

Healy P R, & Head, J M (1984). Construction over abandoned mine workings. CIRIA Special Publication NO. 32. CIRIA, London.

National Coal Board (1975). Subsidence engineers' handbook.

D.2.7 Dissolution Features

Applied Geology Limited (1993). Review of instability due to natural cavities in Great Britain. Applied Geology Limited, Royal Leamington Spa. (*Note: Database is now maintained by the British Geological Survey and Peter Brett Associates)*

McDowell P W, & Poulsom A J, (1996). Ground subsidence related to dissolution of Chalk in Southern England. Ground Engineering, March 1996, pp29-33.

Thompson A, Hine P D, Greig JR, & Peach D W (1996). Assessment of subsidence arising from gypsum dissolution (with particular reference to Ripon, North Yorkshire) – Summary Report. Symonds Travers Morgan, East Grinstead.

D.2.8 Ground and Groundwater Chemistry

Building Research Establishment (BRE) (2001). Concrete in Aggressive Ground Conditions, Special Digest 1 (SD1).

Thaumasite Expert Group, Department of the Environment, Transport and the Regions (DETR), (1999). The thaumasite form of sulfate attack: risks, diagnosis, remedial works and guidance on new construction.

Reid J M, Czerewko M A, Cripps J C and Hiller D M, (2000). Sulfate specification for structural backfills. TRL Report 447. Transport Research Laboratory, Crowthorne

D.2.9 Environmental Considerations

Colwill D M, Peters C J and Parry R, (1985) Motorway Run-Off - The Effect of Drainage Systems on Water Quality. TRRL Research Report 37. Transport Road Research Laboratory, Crowthorne.

Coppin N J, & Richards I G (1990). Use of vegetation in civil engineering. CIRIA B10.

European Community (1990). Directive on the protection of groundwater against pollution caused by certain dangerous substances. 80/68/EEC. Official Journal No. L20.

Greenwood J R, Morgan P R C & Short J, (1996). Bio-engineering: a field trail at Longham Wood cutting, M20 Motorway. CIRIA SP 128.

Highways Agency. Design Manual for Roads and Bridges Volume 10: Environmental Design and Management.

Highways Agency. Design Manual for Roads and Bridges. Volume 11: Environmental Assessment.

Institution of Civil Engineers (1995). Vegetation and Slopes: stabilisation protection and ecology. Edited by D H Baker, Thomas Telford, London

D.2.10 Contaminated Land

British Standards Institution BS 10175: 2000. Code of practice: Investigation of Potentially Contaminated Sites.

Contaminated Land (England) Regulations 2000 (SI 2000/227). DETR

Environment Act 1995 (Commencement No.16 and Saving Provision) (England) Order 2000 (S.I. 2000 No. 340 (C.8)). DETR

Health and Safety Executive (1992). The Management of Health and Safety at Work Regulations 1992. Health and Safety Executive, London

D.2.11 Foundations and Retaining Structures

British Standards Institution BS 8004:1986, Code of practice for Foundations. BSI, London.

British Standards Institution BS 8002:1984, Code of practice for Earth Retaining Structures. BSI, London.

British Standards Institution BS 8081:1989, Code of practice for Ground Anchorages. BSI, London.

Littlejohn G S, (1997). Ground anchorages and anchored structures. Thomas Telford, London.

Highways Agency. Design Manual for Roads and Bridges. Volume 2, Highway Structures: Design (Substructures & Special Structures) Materials, Sections 1 & 2.

Lord J A, Twine D, & Yeow H (1994). Foundations in chalk. CIRIA PR11.

O'Reilly M P, Bush D I, Brady K C and Powrie W, (1999). The stability of drystone retaining walls on highways. Proceedings of the Institution of Civil Engineers, Municipal Engineer, 133, No 2. June 1999.

Tomlinson M J, (1994). Pile design and construction practice, 4th Edition, Spon.

Tomlinson M J, (1995). Foundation design and construction, 6th edition, Longman.

D.2.12 Drainage

Manual of Contract Documents for Highway Works: Specification for Highway Works (MCHW 1& 2): 500 Series, and Highway Construction Details (MCHW 3): B & F Series.

Design Manual for Roads & Bridges Volume 4: Geotechnics & Drainage, Section 2, Drainage

Trunk Road Maintenance Manual Volume 2 (TRMM Vol.2): Routine and Winter Maintenance Code – Chapters 1.5, 1.6 & 1.7

Routine Maintenance Management System (RMMS) – Chapters 2.5, 2.6, 2.7, 3.5, 3.6 & 3.7.

Farrar DM & Brady KC (2000). Drainage of earthwork slopes: a review. TRL Report 454. Crowthorne, Transport Research Laboratory.

D. 2.13 Case Histories

Institution of Civil Engineers (1985), Failures in Earthworks, Proceedings of the symposium on Failures in Earthworks organized by the Institution of Civil Engineers. Thomas Telford, London.

Institution of Civil Engineers (1995). Vegetation and Slopes: stabilisation protection and ecology. Edited by D H Baker, Thomas Telford, London

D. 2.14 Web Sites

Association of Geotechnical and Geoenvironmental Specialists www.ags.org.uk

British Board of Agreement www.bbacerts.co.uk

British Cement Association www.bca.org.uk

British Standards Institute www.bsi-global.com

British Geological Survey www.bgs.ac.uk

Construction Industry Research & Information Association www.ciria.org.uk

Geopages (link withdrawn)

Geotechnical & Geoenvironmental Software Directory www.ggsd.com

Highways Agency www.highways.gov.uk

Institution of Civil Engineers www.ice.org.uk

International Organisation for Standardisation www.iso.ch

National Assembly of Wales www.wales.gov.uk

Northern Ireland Executive www.nics.gov.uk

Stationary Office www.tsonline.co.uk

Scottish Executive www.scotland.gov.uk

The Geological Society www.geolsoc.org.uk

Transport Research Laboratory www.trl.co.uk

World Road Association (PIARC) www.piarc.lcpc.fr