A national assessment of landslide hazard from Outside Party Slopes to the rail network of Great Britain.

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Abstract

In recent years, a number of high profile landslide events have caused disruption, derailments or damage to railway infrastructure in Great Britain. A landslide susceptibility model of the entire railway network was created, designed to give a national overview of potential landslide hazard originating from Outside Party Slopes.

The current assessment was compiled using Geographic Information System (GIS) techniques and desktop modelling to apply a structured analysis of each buffered Earthwork Inspection 5 Chain (^{c}100 m). Data analysed along the network included the BGS GeoSure instability model and newly updated national models for debris flow, earth flow and rock fall, supported by historic landslide data. In order to further focus the Outside Party Slope zone, a buffer of External Natural Geological Influence (BENGI) was created using 5 m Digital Terrain Model. Landslide susceptibility for each Earthwork inspection 5 Chain was categorised using a 'Classification of Hazards on Outside Party Slopes' (CHOPS) score; representing the modelled potential for landslide hazard.

The outputs were combined as a series of matrices to present the CHOPS and Network Rail Derailment Criticality Band interactions. This research will allow further focused analysis of the network, in order to prioritise and direct future investigation and policy decisions.

Keywords: Susceptibility modelling, landslide hazard, asset management, rail infrastructure

Landslide events within Great Britain (GB) (comprising England, Scotland and Wales) are not globally comparable as a catastrophic phenomenon when compared with devastating events widely reported in the media, such as the Sierra Leone landslide in 2017. Neither does GB experience the frequency of events of countries such as Italy (Guzzetti *et al*. 2006). Whilst occasional loss of life is sadly reported (Gibson, *et al*., 2013) the majority of high profile events in GB are the result of impacts to infrastructure, affecting the economy and transport routes (Postance 2017).

GB has, in recent years, experienced a period of wetter than average winters (Pennington *et al*. 2014) and landscape response has included a number of high profile landslides causing disruption to rail travel, train derailments or damage to railway infrastructure. Examples of such high profile cases were documented in the Rail Accident Investigation Branch (RAIB) Landslips Class Report 2012/13, published in 2014 (Department of Transport 2014). Events ranged in size from small wash out failures (St. Bees, Cumbria), through debris flow and train derailment (Stob Coire; Figure 1) to well publicised large failures causing major track damage, longer term, disruption and costly remediation (Hatfield Colliery, South Yorkshire). More recently high profile failures, causing disruption in Lochailort (2016) and derailment at Glen Finann, (January 2018), both in the Scottish Highlands, gained high levels of media and social media interest.

A number of the RAIB investigations identified that landslide material originated from slopes outside of the Network Rail boundary (Department of Transport 2014). Network Rail is responsible for the monitoring and maintenance of all earthwork assets within its property boundary. Earthwork assets within the Network Rail boundary are not included when reviewing outside party slopes. Hazard from Outside Party Slope (OPS), defined as "*A cutting, embankment or natural slope, outside of the Network Rail boundary, owned or managed by an outside party.*" (Network Rail 2017a), has thus been identified as a key priority for strategic Network Rail operating plans under standard NR/L2/CIV/086 "*Outside Party Slopes (irrespective of their height) whose failure could pose an unacceptable risk to the safe operation or performance of railway infrastructure* ...." (Network Rail 2017a). Whilst it is understandable that this is deemed a priority for future management and Route Asset Managers, the reality is that the full extent of the slopes with the potential to affect the rail network is likely to be difficult to access and inspect. The rail network of GB comprises approximately 15,445 km of track, traversing a variety of geological formations and terrains which may be susceptible to future instability.

The British Geological Survey (BGS) has previously collaborated with Network Rail and partners, to model landslide hazards originating from Outside Party Slopes. Previous research has included a detailed regional study of a particular route, detailed Digital Terrain Models and field verification and assessment. This was followed by a feasibility overview of the application of a single landslide susceptibility model derived through a similar methodology in relation to the full network (Freeborough *et al.* 2016). Both projects proved successful on a local and national level, however identified a limitation on data and terrain model scales applied to the national level (Freeborough *et al*. 2016). The current successful methodology builds and evolves on both approaches, employing new and improved spatial modelling for differing landslide types and applying these to the full network at a suitable scale. The final model and underlying data layers were designed to give a national overview of potential landslide hazard to Network Rail senior management and individual regional Route Asset Managers, to allow further more focused analysis of risk to the network.

Susceptibility maps and historical inventory

Landslides can be divided into different types, according to different failure mechanisms, geology and geotechnical properties (Cruden & Varnes 1996; Hungr *et al.* 2014; Figure 2). Whilst the geology and slope angle control the location and failure type of the landslide, the degree of strength lost during failure determines the velocity. The failure stage may involve a kinematic change from sliding to flow or fall, all related to the speed, distance and destructiveness of the landslide. Cruden & Varnes (1996) proposed separate names for the movement mode during each stage of a given landslide. Susceptibility modelling provides the opportunity to identify known characteristics of landslide failures and their associated failure mechanisms, and thus provide key information and identify areas that may have the potential to develop instability.

The earthworks across the GB strategic rail network are broken down into distances of 5 Chains (~100 m), which are referred to as Earthwork Inspection 5 Chains (EI5C). EI5C are used by Network Rail to subdivide the railway corridor into manageable sections that can be examined and assessed. To reflect the two sides of a railway corridor, each EI5C has an Up and/or Down side attributed to it. As this study was requested as a national overview of potential hazard location, a different phenomenon to hazard pathway or potential risk, the highest ranked category present within the length of the buffered EI5C was used as the final rating regardless of percentage coverage. The hazard rating for each Earthwork Inspection 5 Chain was compiled by calculating and recording the percentage of each A (low) – E (high) category contained within the EI5C buffer.

i. GeoSure: Slope Instability (Landslides)

As described in Freeborough *et al*. (2016), a scientifically based 1:50 000 scale assessment of the potential susceptibility to natural slope failure at a location is provided by the national GeoSure: slope instability (Landslides). Data on slope angle, material strength and the known susceptibility to instability of different lithologies, are combined using a multi-criteria and heuristic approach; applying a series of rules against the available data to provide a hazard 'score' at each location (Lee & Diaz Doce 2014). A high susceptibility score of D or E indicates that the ground conditions imply a significant potential for future instability via down slope movement of material (Table 1). The GeoSure Instability Landslides Susceptibility Model Great Britain (Version 7.0) dataset is produced for use at 1:50 000 scale providing 50 m ground resolution. For this study further information on the instability of specific Glacial Till formations was included in the algorithm.

ii. GeoSure Extra: Debris Flow Susceptibility

Areas of potential debris flow hazard are identified in GIS format in the Debris Flow susceptibility model. Debris flows (Hungr *et al.* 2014) are a widespread phenomenon in mountainous terrain and are distinct from other types of landslides as they can occur periodically on established paths, usually gullies and first- or second-order drainage channels (Winter *et al*. 2005) . The mechanism of this particular type of failure is such that potential locations are not as well represented in the GeoSure methodology. Debris flows in GB are most commonly found in upland Scotland but also in parts of Wales and the Lake District. Previous studies have used debris flow susceptibility methodology developed for the landscape of Scotland (Winter *et al*., 2005; Harrison *et al.* 2008). Requiring a national coverage, and with increasing availability of data and improvements in process understanding, the BGS developed a new national product, the Debris Flow Susceptibility Model dataset (Bee *et al.* 2017). The dataset is produced for use at 1:50 000 scale providing 50 m ground resolution, and uses inputs to determine the characteristics of weathering products formed by the underlying geological materials, slope angle, presence of streams, and indications of infiltration potential (Bee *et al*. 2017). A high susceptibility score of D or E indicates that the ground conditions imply a significant potential for future instability via down slope movement of material (Table 1). The model was correlated with an inventory of 2,000 debris flows (Dashwood *et al.* 2017).

iii. Earth Flow

In this research the term earth flow is used as the closest to these types of movement and failures seen on the rail network. Earth flows are mass movements of fine-grained materials that range from rapid earth flows formed in highly sensitive clay deposits to relatively slower earth flows common in fine- grained soils and in some cases, weathered fine-grained rocks such as mudstones (Sharpe, 1938; Varnes, 1978). Glacial Tills are an extremely heterogeneous range of deposits, with variations occurring across the country related to topographic region, nature of the underlying bedrock and depositional processes. Different glacial till (Glacigenic) units have now been identified and the regional variation in behaviour used in this research. Particle sizes distribution can range from clay to boulders. Many tills comprise varying proportions of coarse material in a fine-grained (clay or silt) matrix, whilst others are coarse-grained. Some till units contain beds or lenses of sand and gravel (glaciofluvial deposits) and laminated clay and silt (glaciolacustrine deposits). These beds or lenses can lead to marked variations and local changes in engineering characteristics. Variations in soil properties such as hydraulic conductivity within a till unit may result local increases in pore water pressures at the interface between the coarse-grained and fine-grained material with associated seepage erosion and flowing of material at the surface.

The heterogeneity of glacial till deposits and the subsequent influence of this on landslide susceptibility, was captured in the scoring system for Earth flow which reflects the presence of sand and gravel lenses and in particular laminated clays and silts within the different till deposits. Trenter (1999) emphasises the contribution of glaciolacustrine deposits to instability, due to their lower shear and residual strengths when compared with the bulk of the till unit.

The data on till susceptibility has been combined with a Digital Terrain Model (DTM) and appropriate slope angle categories to create a refined Earth Flow Susceptibility Model. A high susceptibility score of D or E indicates ground conditions with a significant potential for future instability via down slope movement of material (Table 1).

iv. Rock Fall

Detachment of fragments of strong or hard rock from cliff faces is a common phenomenon in many areas of GB. A binary data layer was created indicating the potential presence of susceptible rock. Identification of crags and cliffs using breaks in slope, combined with engineering property data (Dobbs *et al.* 2012) and a Digital Terrain Model (DTM) to create an indicative layer of conditioning factors present within a pixel; indicating present (E) or not (A) for each pixel processing (Table 1). The binary layer does not take into account the process or pathway of a rock fragment (i.e. rolling, toppling, sliding), nor does it include jointing or structural controls which could increase the likelihood of failure.

v. Inventory data and information.

Landslide Inventory information is provided by geological mapping and database sources. Landslide deposits are spatially represented on the BGS published digital 1:50 000 geological maps of Great Britain (DiGMap50) after retrospective digitisation of geological maps. Historically, geological mapping has recorded the location of identifiable landslide deposits as ‘landslip’ on field slips. Due to controlling factors such as: natural landform degradation, minimum-scale mapping rules, and identifiable visible extents, the physical recording of deposit detail and classification on a map is not always captured. The National Landslide Database (NLD) is the most comprehensive inventory of landslide events in GB. The database currently holds information for over 17 000 records (Pennington *et al.* 2015). NLD data are point based, thus new or small event information can be recorded without a corresponding spatially mapped deposit. The underpinning Oracle database is linked to an ArcGIS which displays the NLD landslides as point data.

Each NLD event entry has an identification number (NLD ID) and is documented at a minimum index level with information on location, name, and full bibliographic reference (Foster *et al.* 2012a; Pennington *et al.* 2015). The source reference may provide further detailed information which is also included in the record (Foster *et al.* 2012a). The NLD is continually being updated as new events are recorded or reported (Taylor *et al.* 2015). The Network Rail failure reporting standard, NR/L3/CIV/185, (previously CIV028; Network Rail 2017b) dataset of earthwork failures on the rail network was also used to cross correlate and further enrich the NLD information on Outside Party Slope failures.

Using these datasets in parallel, ensured all current BGS records of historic or recent movement, within the 1 km railway corridor, were included in the model as a landslide inventory.

Creation of a terrain guided buffer

Although the model does not address pathway or likelihood of an event affecting the railway, the included data is limited by the creation of a buffer influenced by the geometry of the terrain perpendicular to the railway. Previous studies (Foster *et al.* 2012b) have been carried out using a BGS generated 1 km buffered corridor along the railway, termed 'Wavy Buffer'. The wavy buffer is based on a distance/ catchment rather than assessment of topographical features, 500 m either side of the centre rail line, it is known to overestimate potential hazard. There is no consideration of pathway or slope determination in the processing of the wavy buffer.

The Network Rail property boundary is removed from the OPS model calculation to avoid inclusion of Network Rail owned and managed earthworks (embankments and cuttings), (Arup 2015; Power *et al* 2016) and thus focussing the model on Outside Party Slopes. In order to further focus the potential Outside Party Slope zone, a Buffer of External Natural Geological Influence (BENGI) was created using Ordnance Survey Terrain 5 (OST5) DTM interpretation and a set of terrain rules. The OST5 is a mid-level DTM product from the Ordnance Survey, a United Kingdom national mapping agency, based on a 5 m grid with a typical accuracy of 2 m Root Mean Square Error.

The BENGI was created by Network Rail in collaboration with BGS using OST5 to determine breaks of slope along 1 km cross-sections; 500 m either side of the centre rail line. The methodology created individual cross sections of maximum 500 m either side of the railway at 20 m intervals perpendicular to the rail line (Figure 3a). Spot heights were added at 10 m intervals along each cross-section and connected together to create individual slope profiles. If the angle between two spot heights was greater than 5 degrees this indicated a slope, a change equal to 5 degrees or less was considered to be flat. Benched slopes on the cross sections were automatically detected and removed where the slope direction either side of the bench were identical (cutting, bench cutting, or embankment, bench embankment) and the bench was less than 30% of the slope length. Slopes occurring within 50 m of the Network Rail property boundary and/or 50 m from rail centre line were considered, therefore removing large flat expanses of land and slopes beyond the 50 m limit. A 100 m lateral buffer was applied to each of the cross sections, to generate a polygon that deliberately exaggerates the total amount of land where a slope may be present; to accommodate the fact that the methodology does not model flow path analysis.

Each EI5C has been assigned a final score to represent the potential for landslide hazard termed the 'Classification of Hazards on Outside Party Slopes' (CHOPS) (Figure 3b). The final processing combined the maximum susceptibility model score and inventory data in ArcGIS and was clipped to the BENGI, to assign the CHOPS hazard. Any EI5C determined by the processing to have no Outside Party Slope are classified as CHOPS_U. This provides a national overview of modelled potential landslide hazard from Outside Party Slopes for the full network (Figure 4).

Outputs

The current assessment was compiled based on Geographic Information System (GIS) techniques and desktop modelling to adopt a structured analysis of the network, providing a hazard score for each buffered EI5C. The layers and final results are all scored resulting in a maximum score of the A- E susceptibility schema; the highest final hazard rating being a CHOPS_E. The level of potential hazard is not an indication that a damaging event is going to happen rather an indication of how many causative factors may be present and how severe they are thought to be.

Research carried out by Network Rail (Arup 2015; Powers *et al* 2016) assessing the Earthworks of the strategic network resulted in the refinement in the evaluation of the potential safety consequences of a train derailment at a given location. This is derived through the Common Consequence Tool (CCT) (Arup 2015) and takes into account factors such as train speed, number of tracks at location and track position (potentially increasing the magnitude of the safety consequence should a derailment occur), in addition to distance to obstacles such as body of water, tunnel portal or other significant line-side structure. The CCT aims to provide a consistent means of modelling consequences of derailment for any location; from this is derived Derailment Criticality Band (DCB). The DCB is recorded as a value 1-5; a score of 0 is assigned where no Earthwork has previously been identified. The final information for each EI5C are presented spatially in a series of Environmental Systems Research Institute, Inc. (ESRI) shapefiles, the accompanying attribute table, and numerically in Excel spreadsheet form. The CHOPS score is combined with the Network Rail DCB in a 6 x 5 matrix configuration presenting scientific interpretation of baseline mapping directly in line with stakeholder focussed datasets (Figure 5).

Differences between national and regional context reporting is a key communication point for future focused analysis of the network. When reporting figures in a national versus route context of EI5C scoring, differences arise in potential interpretation of resulting statistics and need to be addressed clearly. When evaluating the national overview, 2.49 % of Wales is reported as CHOPS_ E and 4.08 % in Scotland. On paper this could imply that a greater consideration should be given to Scotland. In comparison, on further examination of information at the regional scale these figure change to 26.24 % for Wales and 23.89 % for Scotland. When combined with the DCB matrix, just two EI5C lengths in Wales are identified as both high hazard potential (CHOPS_E) and high DCB (5), providing a final score of E5. In comparison Scotland identifies fifty-six EI5C with a final score of E5 (Table 2). Further Network Rail analyses will need to focus on the implications of prioritising potentially lower hazard score, but a higher DCB score.

Conclusions

Outside Party Slope hazard identification is a key priority for Network Rail operating plans, however the full extent of network slope is likely to be difficult to access and inspect. This research offers a national overview of the full strategic network. The model is a desk-top tool to aid site prioritisation for the next phase of route investigations and funding. It is not a risk map and should not be used as such. A high hazard score within the model does not necessarily translate to a high risk; there is no interpretation of likelihood, preventative construction or hazard management schemes in place. Nor does the model assess the cost of a hazard being realised or the exposure to assets or people. The hazard score only examines the conditions that leave an area predisposed to a hazard occurring, based on the geological mapping at the location. The data on the models should not be used as a definitive measure of what is at a given a location, but rather as an indication of what may be there. The data are, of course, not intended as a replacement for detailed site-specific studies or Route Asset Manager knowledge. The research and future liaison with Route Asset Managers will enable strategically focused analysis of the network, in order to prioritise and direct future investigation and policy decisions.

This is emerging Research & Development with which the BGS have assisted Network Rail in understanding natural hazards using mapped geology products and digital terrain models. This research has been undertaken as ongoing continuous improvement to understand the potential threats from land beyond the immediate railway infrastructure. The evolution of understanding from natural threats beyond the land owned by Network Rail is a significant step forward. However, the baseline assessment that has been undertaken is not yet ready for immediate integration into the infrastructure owners' policy or standards framework. Further validation, review and consideration are now needed to ascertain the best way of proportionally incorporating potential threats from natural slopes into the already challenging area of geotechnical asset management.

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Figure Captions

Fig. 1. Derailment of train at Stob Coire Sgriodian, Scottish Highlands 28.06.2012, caused by a shallow planar landslide that developed into a Debris flow (©NERC)

Fig. 2. Schematic representation of the classification of landslide type after Cruden and Varnes (1996) (©NERC)

Fig. 3. A schematic representation of the Outside Party Slope final Earthwork Inspection 5 Chain (EI5C) sections using the Buffer of External Natural Geological Influence (BENGI). Any cross section within Network Rail property or a spot of change of less than 5 degrees is excluded from the analysis).

Fig. 4. National output of the Outside Party Classification of Hazards on Outside Party Slopes research, presenting the maximum hazard score for each Earthwork Inspection 5 Chain for Great Britain (©NERC)

Fig. 5. Graphic representation of Classification of Hazards on Outside Party Slopes (A – E) and Derailment Criticality Band (0 - 5) matrices results.

Table 1. *Text descriptions for the A-E hazard ratings of the landslide susceptibility models used in the assessment of the rail network*

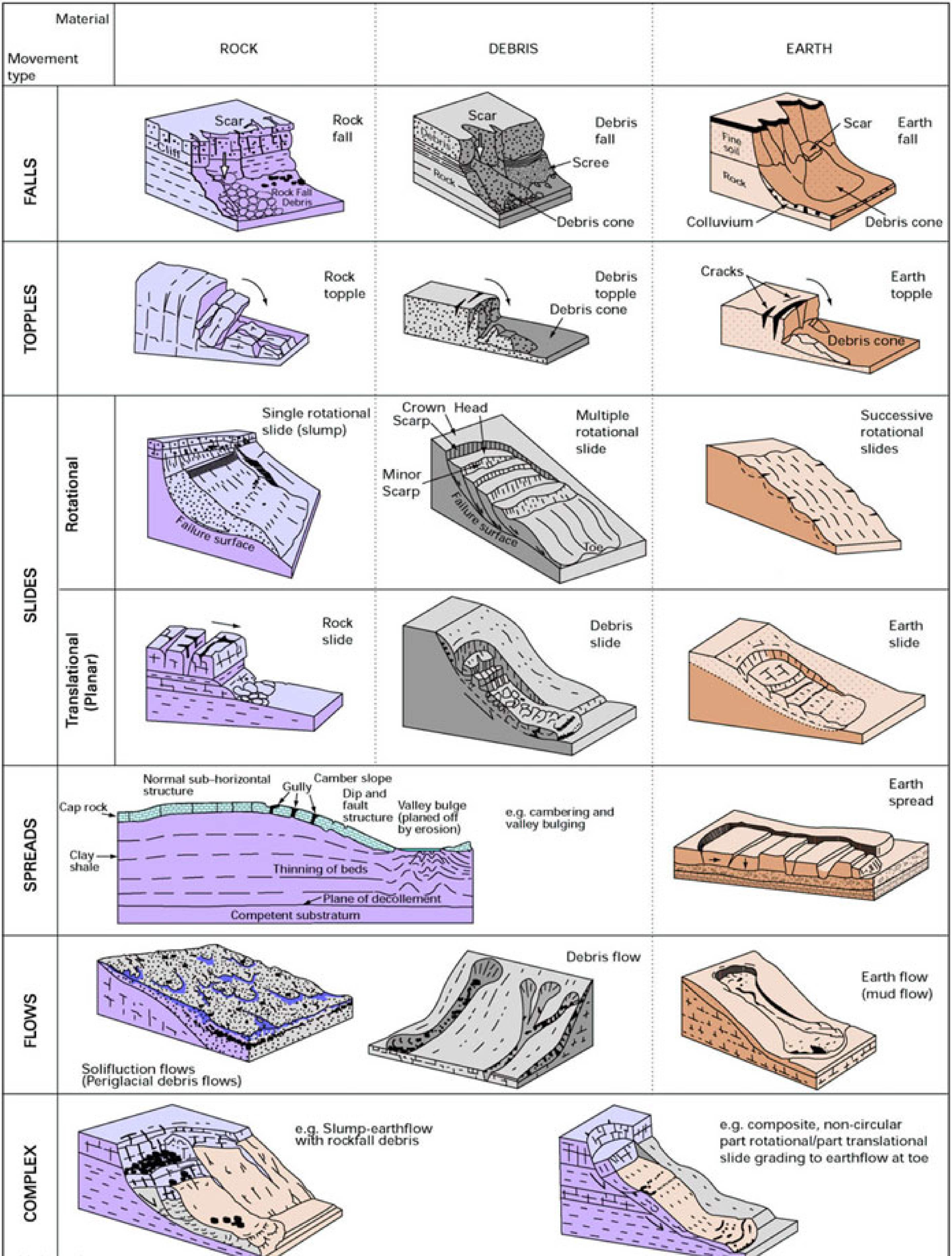
Table 2. *Example data extract showing regional route analysis of final matrices Classification of Hazards on Outside Party Slopes (CHOPS) score (C- E) and Derailment Criticality Band (DCB) (4 and 5).*

	Susceptibility model hazard rating definition			
Legend	**GeoSure instability: (Landslides)**	**Debris Flow**	**Earth Flow**	**Rock fall**
A	**Slope instability problems are not thought to occur** Slope instability problems are not thought to occur, but potential problems of adjacent areas impacting on the site should always be considered.	**Debris flows are not thought to occur.** This is due to a lack of available slope materials, high drainage rates or low slope angle.	**Earth flow failures are not thought to occur.** Till deposits are not thought to be present *or* till deposits are present but considered not susceptible to failure due to very low slope angles.	Factors contributing to a potential rock fall hazard **are not** indicated as being present within this pixel
B	**Slope instability problems are not likely to occur** Slope instability problems are not likely to occur, but potential problems of adjacent areas impacting on the site should always be considered.	**Debris flows are not likely to occur.** This is either due to a limited availability slope materials, sufficient drainage rates or low slope angles.	**Earth flow failures are not likely to occur.** Low to moderately susceptible till deposits are present, but earth flow type failures are not likely to occur due to controlling slope angles.	-
C	**Slope instability problems may be present or anticipated.** Site investigation should consider specifically the slope stability of the site.	**Debris flows may be present or anticipated.** The combinations of increasing slope angle, poor drainage condition and the presence of available material may increase the potential for failures to occur.	**Earth flow failures may be present or anticipated**. Earth flow failures may be anticipated due to moderately susceptible lithology and potentially controlling slope angles.	-
D	**Slope instability problems are probably present or have occurred in the past.** Land use should consider specifically the stability of the site.	**Debris flows are probably present or have occurred in the past.** The combinations of steep slopes, poor drainage conditions and an increased presence of available material suggest that debris flows are likely to be present at these sites.	**Earth flow failures are likely to be present.** Slopes at this location are particularly susceptible to earth flow failures due to the moderate – high susceptible tills and indicated controlling slope angles.	-
E	**Slope instability problems almost certainly present and may be active.** Significant constraint on land use.	**Debris flows are highly likely to be present.** The heightened combinations of steep slopes, poor drainage conditions and the presence of available material suggest that debris flows are highly likely to be present at these sites.	**Earth flow failures are highly likely to be present.** Slopes at this location are particularly susceptible to Earth flow failures due to the presence of highly susceptible tills and indicated 20 -35 degree slope angle.	Factors contributing to a potential rock fall hazard **are** indicated as being present within this pixel:

Table 1. *Descriptions for hazard ratings of the landslide susceptibility models used in the assessment of the rail network*

Regional Network Rail Route	Hazard rating score (CHOPS and DCB)									
	C3	**C4**	**C5**	**D3**	**D4**	**D5**	**E3**	**E4**	**E5**	**Total extract count**
Anglia	159	91	44	11	5	3	**14**	0	0	327
LNEEM	820	561	308	184	108	43	233	**164**	**106**	2527
LNW	896	748	450	294	135	85	188	**114**	73	2983
Scotland	544	355	180	236	133	59	342	**139**	56	2044
South East	337	75	159	55	12	35	149	27	62	911
Wales	88	33	19	23	16	7	28	23	2	239
Wessex	233	29	15	33	7	0	89	9	2	417
Western	828	368	120	138	71	25	200	**124**	85	1959
Total extract count	**3905**	**2260**	**1295**	**974**	**487**	**257**	**1243**	**600**	**386**	**11407**

Table 2. *Example data extract showing regional route analysis of final matrices Classification of Hazards on Outside Party Slopes (CHOPS) score (C- E) and Derailment Criticality Band (DCB) (4 and 5)*


Material
Movement type
ROCK
DEBRIS
EARTH
FALLS
Scar
Rock fall
Cliff
Rock Fall Debris
Scar
Debris fall
Debris
Scree
Rock
Debris cone
Scar
Earth fall
Fine soil
Rock
Colluvium
Debris cone
TOPPLES
Rock topple
Debris topple
Debris cone
Cracks
Earth topple
Debris cone
SLIDES
Rotational
Single rotational slide (slump)
Failure surface
Crown
Head
Scarp
Minor Scarp
Multiple rotational slide
Failure surface
Toe
Successive rotational slides
Translational (Planar)
Rock slide
Debris slide
Earth slide
SPREADS
Normal sub-horizontal structure
Gully
Camber slope
Cap rock
Dip and fault structure
Valley bulge (planed off by erosion)
Clay shale
Thinning of beds
Plane of decollement
Competent substratum
e.g. cambering and valley bulging
Earth spread
FLOWS
Solifluction flows (Periglacial debris flows)
Debris flow
Earth flow (mud flow)
COMPLEX
e.g. Slump-earthflow with rockfall debris
e.g. composite, non-circular part rotational/part translational slide grading to earthflow at toe

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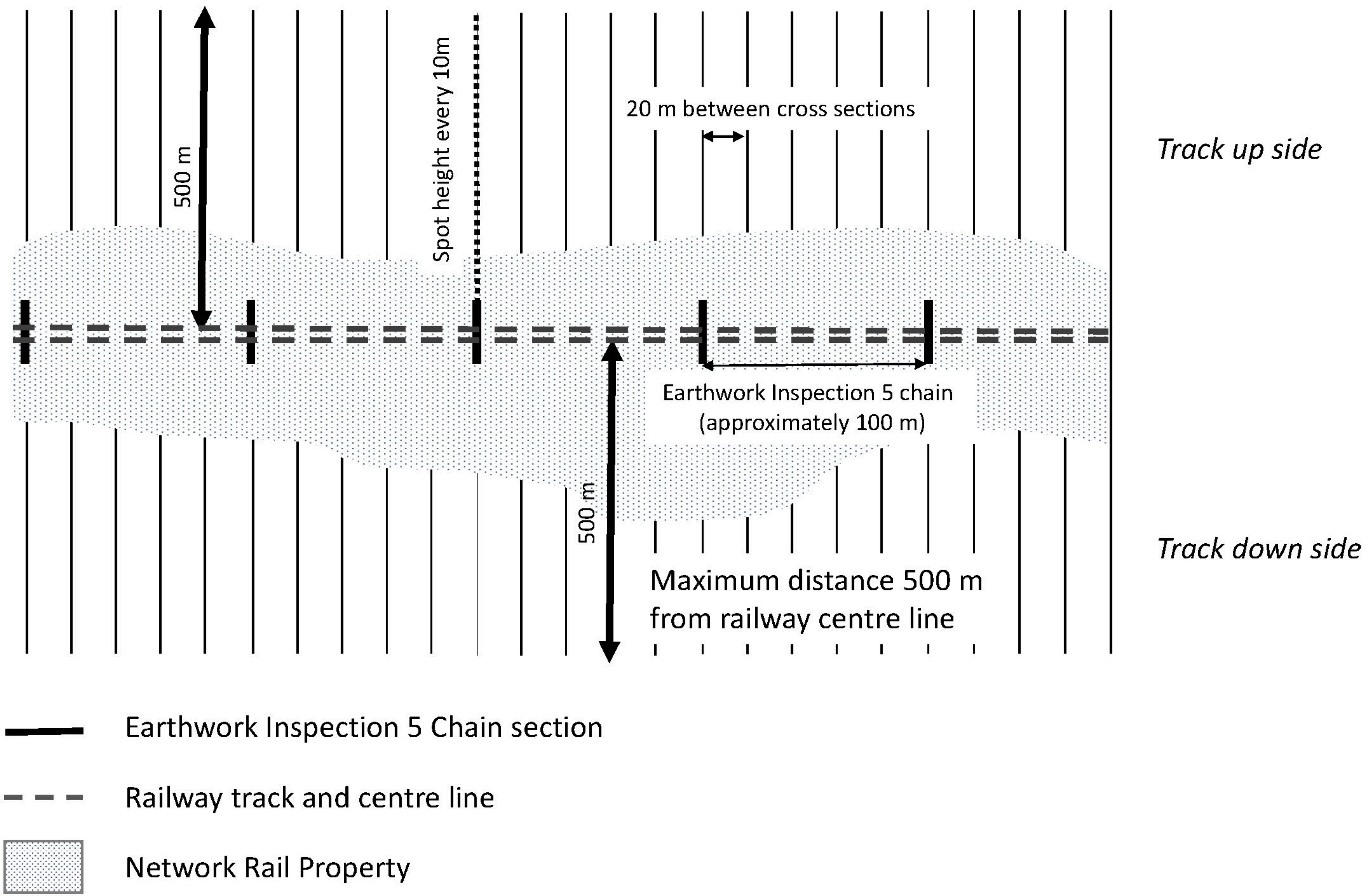
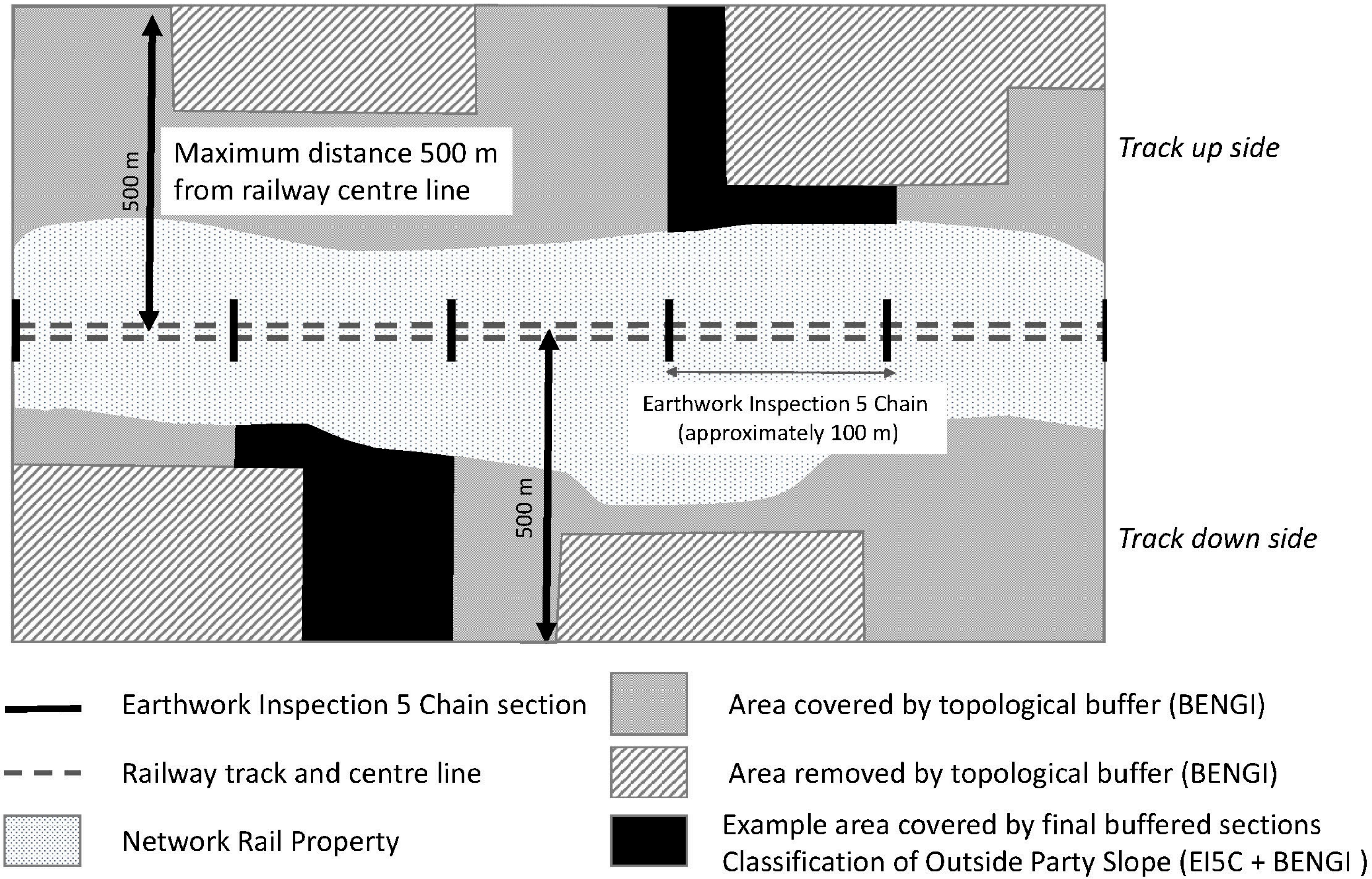
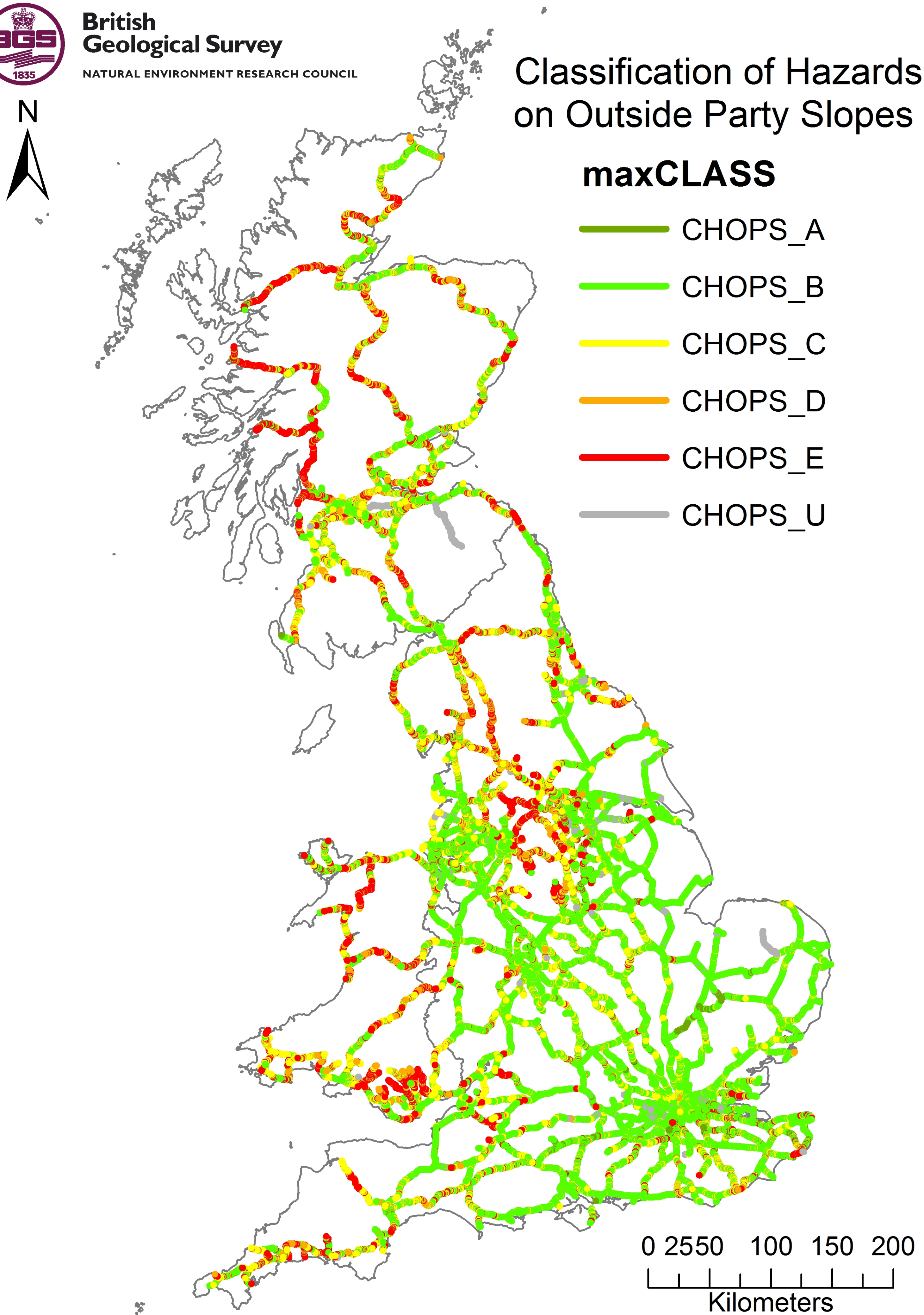


500 m
Spot height every 10m
20 m between cross sections
Track up side
Earthwork Inspection 5 chain
(approximately 100 m)
500 m
Track down side
Maximum distance 500 m
from railway centre line
Earthwork Inspection 5 Chain section
Railway track and centre line
Network Rail Property



Maximum distance 500 m
from railway centre line
500 m
500 m
Track up side
Earthwork Inspection 5 Chain
(approximately 100 m)
Track down side
Earthwork Inspection 5 Chain section
Railway track and centre line
Network Rail Property
Area covered by topological buffer (BENGI)
Area removed by topological buffer (BENGI)
Example area covered by final buffered sections
Classification of Outside Party Slope (EI5C + BENGI)

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL



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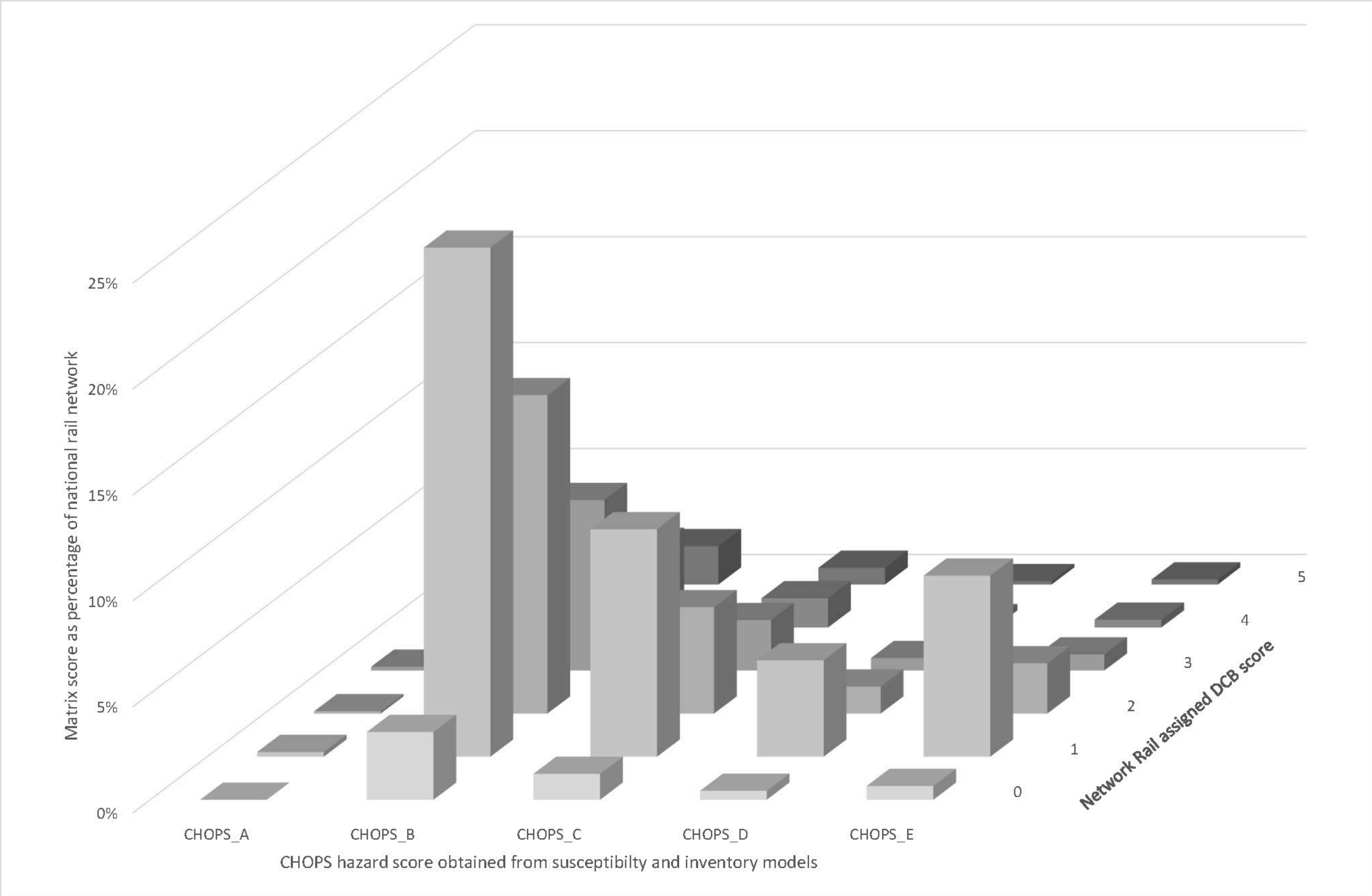

25%
20%
15%
10%
5%
0%
Matrix score as percentage of national rail network
CHOPS_A
CHOPS_B
CHOPS_C
CHOPS_D
CHOPS_E
CHOPS hazard score obtained from susceptibilty and inventory models
0
1
2
3
4
5
Network Rail assigned DCB score