

Level 2

Management of Earthworks

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Published and issued by Network Rail, Kings Place, 90 York Way, London, N1 9AG.



Ref:	NR/L2/CIV/086
Issue:	4
Date:	05 September 2014
Compliance date:	01 October 2014

User information

This Network Rail specification contains colour-coding according to the following Red–Amber–Green classification.

Red requirements – *No variations, could stop the railway*

- Red indicates requirements to be complied with and achieved.
- Red requirements are presented in a red box and expressed as a direct instruction.
- Accountability for the efficacy of red requirements lies with the Professional Head/ specification owner.
- Red requirements are monitored for compliance.
- Corrective actions are to be enforced if variations are discovered through functional checks (such as engineering verification visits, audit or operations self-assurance).

Amber requirements – *Controlled variations, approved risk analysis and mitigation*

- Amber indicates requirements to be complied with unless variation has been approved in advance.
- Amber requirements are presented with an amber sidebar and expressed as a direct instruction.
- Accountability for the efficacy of amber requirements lies with the Professional Head/ specification owner, or their nominated delegated authority.
- Amber requirements are monitored for compliance.
- Variations may be permitted. Variations are approved by the process owner or through existing delegated authority arrangements.
- Corrective actions are to be enforced if non-approved variations are discovered through functional checks (such as engineering verification visits, audit or operations self-assurance).

Green – *Guidance*

- Green indicates guidance. This is presented with a dotted green sidebar and with the word 'should' (usually in notes) or expressed as a recommendation.
- Guidance is based on good practice and represents supporting information to help achieve red and amber requirements.
- Guidance is not mandatory and is not monitored for compliance.
- Alternative solutions may be used. Alternative solutions do not need to be formally approved.
- Decisions made by a competent person to use alternative solutions should be backed up by appropriate evidence or documentation.

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1 Introduction

1.1 Purpose

The purpose of this Standard is to define the requirements for managing Earthworks, so that when meeting these requirements there would be no unacceptable risk to the safe operation or performance of rail infrastructure.

This Standard contains requirements supplementary to those given in [NR/L1/CIV/032: The Management of Structures](#).

1.2 Scope

This Standard covers all Earthworks within the Network Rail boundary, and where it is appropriate to do so, slopes outside the boundary that may affect Network Rail infrastructure.

This Standard applies to the following:

1. Network Rail owned or managed¹ Earthworks equal to or greater than 3 metres high - this includes Earthworks lying above a Retaining Wall where the Earthwork component is greater than or equal to 3 metres.
2. Network Rail owned or managed¹ Earthworks (irrespective of their height) whose failure could pose an unacceptable risk to the safe operation or performance of railway infrastructure, for example, those Earthworks which have a history of instability, or are at risk of flooding or water action.
3. Outside Party Slopes (irrespective of their height) whose failure could pose an unacceptable risk to the safe operation or performance of railway infrastructure (section 6.4 only applies). If application of this Standard is not appropriate to such slopes then a suitable bespoke system should be adopted to manage the risk.
4. Earthworks (irrespective of their height) that lie above the portal of a railway tunnel.
5. Approach Embankments to an overline Bridge that are equal to or greater than 3 metres high, except those owned by a Highway Authority, Roads Authority or other competent authority.
6. Nailed or reinforced soil structures whose face angle is less than or equal to 70 degrees to the horizontal.
7. Any Embankment that also acts as a Coastal, Estuarine or River Defence, irrespective of its height.

The requirements of this Standard need not be applied to Earthworks that do not meet any of the above criteria.

This Standard does not apply to:

1. Track support systems.
2. The management of vegetation - other than the factors affecting slope stability: the requirements for managing vegetation are defined in [NR/L2/TRK/5201: Management of lineside vegetation](#).
3. The management of Earthworks drainage - other than the factors affecting slope stability: the requirements for managing the drainage asset are defined in [NR/L3/CIV/005: Railway Drainage Systems Manual](#).

¹ Totally or Shared.

4. The management of nailed or reinforced soil structures steeper than 70 degrees, retaining walls and gabion walls. The management of such structures is defined in [NR/L1/CIV/032](#): *The Management of Structures*.
5. The management of Coastal, Estuarine or River Defence works that are not also Embankments. The management of such works is defined in [NR/L1/CIV/032](#): *The Management of Structures*.

This Standard does not cover:

1. Emergency evacuation procedures.
2. Operational health and safety requirements but the safety of site operatives shall be taken into account when planning Examinations, Interventions and Mitigations. In addition the provision of safe access for future maintenance and Examination activities shall be considered during the design and construction of Intervention and Mitigation works.
3. The organisational or commercial responsibilities for delivering the requirements of this Standard.
4. The Examination of an Earthwork: this is covered by [NR/L3/CIV/065](#): *Examination of Earthworks*.

1.3 References

The following referenced documents are indispensable for the application of this specification. For dated references, only the edition cited applies. For undated references, the latest edition of the reference (including any amendments) applies.

CP5 Earthworks Asset Policy

[NR/ARM/M33DE](#): *Definitions for the Reporting of M33 Earthworks Condition Banding*

[NR/ARM/M6DE](#): *Definitions for the Reporting of M6 Earthworks Failures*

[NR/CS/CIV/044](#): *Managing Structures Works (formerly RT/CE/P/044)*

[NR/GN/CIV/203](#): *Evaluation and Assessment of Earthworks*

[NR/GN/CIV/204](#): *Definition of Soil Cuttings Risk Model*

[NR/GN/CIV/205](#): *Definition of Rock Cuttings Risk Model*

[NR/GN/CIV/206](#): *Definition of Embankments Risk Model*

[NR/GN/CIV/207](#): *Definition of Adverse/Extreme Rainfall Prioritisation Procedure*

[NR/GN/CIV/208](#): *Definition of Earthworks Asset Criticality*

[NR/GN/CIV/210](#): *Definition of Soil Cutting Hazard Index (SCHI)*

[NR/GN/CIV/211](#): *Definition of Rock Slope Hazard Index (RSHI)*

[NR/GN/CIV/212](#): *Definition of Soil Embankment Hazard Index (SEHI)*

[NR/L1/CIV/032](#): *The Management of Structures*

[NR/L2/HAM/02201](#): *Management of risk arising from Deferred Renewals*

[NR/L2/OCS/021](#): *Weather - Managing the Operational Risks*

[NR/L2/TRK/5201](#): *Management of line side vegetation*

[NR/L3/CIV/005](#): *Railway Drainage Systems Manual*

[NR/L3/CIV/006](#): *Handbook for the Examination of Structures*



[NR/L3/CIV/028](#): *The management of reports of Safety-Related Events on Buildings and Civil Engineering infrastructure*

[NR/L3/CIV/037](#): *Managing the risk arising from mineral extraction and landfill operations*

[NR/L3/CIV/038](#): *Managing the potential effects of coal mining subsidence*

[NR/L3/CIV/065](#): *Examination of Earthworks*

[NR/L3/CIV/071](#): *Geotechnical design*

[NR/L3/TRK/1010](#): *Management of responses to extreme weather conditions at structures, earthworks and other key locations*

[NR/SP/CTM/017](#): *Competence and Training in Civil Engineering*

2 Roles, responsibilities and competencies

Route Asset Manager

For their respective Route, the *Route Asset Manager (RAM)* is responsible for the following:

1. Implementation of the Earthworks Policy (see *CP5 Earthworks Asset Policy*, or successor).
2. Deciding which, if any, of the requirements given in 4 to 8 of this Standard should be applied to Earthworks.
3. Implementing the requirements identified in 1 and 2 (above) within the defined timescales.
4. Designating those Earthworks to be managed as a Major Structure and devising, updating and implementing the Management Strategy for each of those, see 6.1.
5. The production and updating of those parts of the Adverse/Extreme Weather Plan(s) (see 8.2) which deal with Earthworks.

Earthworks Management Roles

The responsibilities of the following Earthworks Management Roles are defined in [NR/L3/CIV/065](#): *Examination of Earthworks*:

- **Earthworks Examiner (EE)**: The person responsible for carrying out an Examination of an Earthwork.
- **Earthworks Examining Engineer (EEE)**: The person responsible for managing the Examination process.
- **Earthworks Manager (EM)**: The person reporting to the *Route Asset Manager* responsible for managing Earthworks, responsible for the safe management of the Earthworks within a defined geographical area, and has the competency as defined in [NR/SP/CTM/017](#): *Competence and Training in Civil Engineering*.

Those appointing persons to positions with responsibility or delegated duties to deliver one or more of the requirements of this Standard are responsible for checking that appointees are competent and that they understand their responsibilities. Where applicable, the relevant requirements are set out in [NR/SP/CTM/017](#): *Competence and Training in Civil Engineering*.

Those appointed to positions having the responsibility or delegated duty to deliver one or more of the requirements of this Standard are required to:

1. Have the competency, skill, knowledge and experience necessary to undertake their duties commensurate with the form, type and complexity of the Earthwork(s) being managed.

2. Be aware of their responsibilities.
 3. Understand why and be able to judge when urgent action is required to maintain safety.
- Appointments, responsibilities and duties are to be documented.

3 Definitions²

Adverse/Extreme Weather

A period of weather that is outside the normal range that can result in scour, storms, flooding, high tides, desiccation or high groundwater levels, increasing the likelihood that an Earthwork may fail, suffer performance loss or experience accelerated degradation. It includes periods of prolonged and/or intense rainfall, prolonged dry and/or hot periods and periods of repeated freezing and thawing.

Adverse/Extreme Weather Plan (A/EWP)

A procedure produced in accordance with [NR/L3/TRK/1010](#) covering the actions to be taken in the event of Adverse/Extreme Weather. The plan includes a register of Earthworks that are assessed as vulnerable to failure, performance loss or to experience accelerated degradation in the event of Adverse/Extreme Weather.

Asset Criticality score

A numerical score that represents the likely magnitude of the safety consequence should an Earthwork fail. It has the following components (see Table 1):

- **Likelihood of derailment:** An algorithm is applied to each Earthwork asset to assess the likelihood that a failure of the Earthwork would derail a train. The algorithm is different for each asset type (Soil Cutting, Rock Cutting and Embankment) and considers factors such as the size of the failure, whether it would affect the track, and in the case of cuttings, the hardness of the failed material. These algorithms are defined in [NR/GN/CIV/204: Definition of Soil Cuttings Risk Model](#), [NR/GN/CIV/205: Definition of Rock Cuttings Risk Model](#) and [NR/GN/CIV/206: Definition of Embankments Risk Model](#).
- **Consequence of derailment:** The Common Consequence Tool (CCT) algorithm is applied to each Earthwork to assess the likely number and seriousness of the injuries should a train be derailed. The algorithm is the same for all asset types and considers factors such as the train speed, the number of passengers, whether the train is likely to collide with a lineside structure or another train, or to fall down an Embankment.

The parameters required and the CCT algorithm used to determine the Consequence of derailment, the combination of this with the Likelihood of derailment algorithms, and the division of the resultant scores into the Earthworks Asset Criticality Bands are defined in [NR/GN/CIV/208: Definition of Earthworks Asset Criticality](#).

- **Earthworks Asset Criticality Band (EACB):** The range of possible Asset Criticality scores for each Earthwork type is segmented into five bands designated 1, 2, 3, 4 and 5 termed the Earthworks Asset Criticality Band (EACB). The EACB can be related to the likely safety consequence of an Earthwork's failure. Band 1 has the lowest consequence, and band 5 has the highest consequence. The bands 1 to 5 are the same for each Earthwork type (Soil Cutting, Rock Cutting and Embankment) although the quantitative consequences for a given band vary between the Earthwork types.

² Definitions flagged with an asterisk are not used in the body of this Standard but are required for completeness to understand subsidiary and related documentation.

Earthwork type	Asset Criticality score		Asset Criticality band
	Likelihood of derailment	Consequence of derailment	
Soil Cutting	Soil Cutting risk model	Common Consequence Tool (CCT)	EACB (1,2,3,4 or 5)
Rock Cutting	Rock Cutting risk model		
Embankment	Embankment risk model		

Table 1 Asset Criticality scores and bands

Bridge

A structure of one or more spans greater than or equal to 1.8 metres, whose prime purpose is usually to carry traffic or services over an obstruction or gap.

Coastal, Estuarine and River Defence

For the purposes of this Standard an engineered Embankment type structure that protects railway infrastructure against erosion or flooding by tidal or non tidal waters. It includes protection works, which protect land against erosion and encroachment by such waters but which perform no flood defence role; and defences, which protect against flooding or attack by such waters. For examination purposes such defences shall be treated as an Embankment.

Deteriorating Earthworks

Any Earthwork that on Examination has a Hazard Index score with an increased value is considered to be a Deteriorating Earthwork.

- **Degraded D or E:** An Earthwork that on Examination continues to have an Earthworks Hazard Category of “D” or “E” in accordance with [NR/L3/CIV/065](#) but the value of the Hazard Index score has increased.
- **New D or E:** An Earthwork with a Earthworks Hazard Category of “D” or “E” in accordance with [NR/L3/CIV/065](#) which, at the time of previous Examination, had an Earthworks Hazard Category of either “A”, “B” or “C” or a newly identified Earthwork with a Earthworks Hazard Category of “D” or “E” at first Examination.

Earthwork

An Earthwork is a Cutting, Embankment, or Natural Slope segment up to 5 chains long lying within the Network Rail boundary that is equal to or greater than 3 metres high, or if less than 3m high whose failure could pose an unacceptable risk to the safe operation or performance of railway infrastructure. The term excludes the track formation, blanketing and ballast etc. and also geosynthetics that form an integral part of the track supporting system. An Earthwork comprises either the Up or Down side of the railway, with the two sides being separated by an imaginary line along the centre of the track(s).

Cutting

An excavation that allows railway lines to pass at an acceptable level and gradient through the surrounding ground. Categorised as:

- **Soil Cutting:** A Cutting composed entirely or predominantly of soil, very weak or weak rock and may include supporting structures such as retaining or gabion walls.
- **Rock Cutting:** A Cutting composed entirely or predominantly of moderately weak or stronger rock, and may include local support, such as dentition, bolting, and netting. In situ rock slopes exposed below track level in areas of sidelong ground are also included.

- **Mixed Cutting:** A Cutting composed of both soil and rock, either one component overlying the other, or interbedded. For management purposes the soil and rock components are examined and recorded separately.

Embankment

A construction that allows railway lines to pass at an acceptable level and gradient over low-lying ground or ground that is susceptible to flooding composed entirely of soil or rock fill.

Natural Slope

Sloping ground that has been formed by natural processes. For the purposes of examination a Natural Slope sloping towards the track is considered as a Cutting, and a Natural Slope sloping away from the track is considered as an Embankment.

Approach Embankment

An Embankment oblique to the railway on the approaches to a bridge over the railway or a level crossing.

Approach Cutting*

A Cutting oblique to the railway on the approaches to a bridge under the railway

Tunnel portal*

The opening structure to a tunnel providing entry/exit. Any Earthwork existing over the tunnel portal is recorded against the Up Earthwork inspection 5 chain at the tunnel portal, as follows:

- **Soil Cutting above tunnel portal:** A Soil Cutting existing over a tunnel portal structure, oblique to the railway.
- **Rock Cutting above tunnel portal:** A Rock Cutting existing over a tunnel portal structure, oblique to the railway.

No earthwork

5 chain lengths of route on one side of the railway positively verified as not containing an Earthwork as defined above, lying within the Network Rail boundary. Categorised as follows:

- **At grade:** Level ground not requiring any substantial Earthwork to allow railway lines to pass at an acceptable level. Any Embankments or Cuttings present are less than 3 metres in height.
- **Tunnel:** 5 chain lengths of route entirely enclosed within a tunnel structure.
- **Viaduct:** 5 chain lengths of route elevated above ground level on an extended bridge structure.

Earthworks failure

Earthwork slope in a state of collapse, for example; rock fall, soil slip, slide or flow in an Embankment, Cutting or Natural Slope. The full definition of an Earthworks failure is given in [NR/ARM/M6DE](#): *Definitions for the Reporting of M6 Earthworks Failures*.

Earthwork height

The height of a Cutting, at a particular section, is the difference between the level of its crest and the lowest level of the ground at its toe (such as the level of the cess or the bottom of an open ditch). The height of an Embankment, at a particular section, is the difference between

the level of the top of a sleeper and lowest level of the ground at its toe (including the bottom of an open ditch if present).

Earthworks Intervention matrix

The main types of Intervention available to manage the safety risk posed by a portfolio of Earthwork assets are presented as layers overlaid on the Earthworks Safety Risk Matrix. Different matrices are defined for each Earthwork type (Soil Cutting, Rock Cutting and Embankment).

Earthworks Measures

Two quantitative measures are reported to assess the performance of the Earthworks management process, namely:

- **Earthworks Reliability Measure:** The number of Earthworks failures as a rolling five-year annual average, defined in [NR/ARM/M6DF: Definitions for the Reporting of M6 Earthworks Failures](#).
- **Earthworks Sustainability Measure:** The average condition score for all examined assets, defined in [NR/ARM/M33DF: Definitions for the Reporting of Earthworks Condition Banding](#).

Earthworks Safety Risk Matrix

The magnitude of the safety risk of each Earthwork asset can be represented by the asset's position on a 5x5 Earthworks Safety Risk Matrix which is defined by axes of the Earthworks Hazard Category and the Earthworks Asset Criticality Band.

Earthwork segmentation

For the purposes of management, Earthworks are divided into 5 chain (approximately 100m) segments. The terminology adopted is illustrated in Figure 1.

- **Earthwork asset:** A segment of Earthwork (Soil Cutting, Rock Cutting or Embankment) up to 5 chains in length on one side of the railway.
- **Earthwork inspection 5 chain:** A 5 chain length of the network on one side of the railway that may contain one or more Earthwork assets of similar or different Earthwork type. Defines the lateral extent of the Examination of all Earthwork assets within it.
- **Whole Earthwork:** The full (unsegmented) length of an Earthwork of a given construction type (Soil Cutting, Rock Cutting or Embankment) on one side of the railway composed of one or more adjacent Earthwork assets.

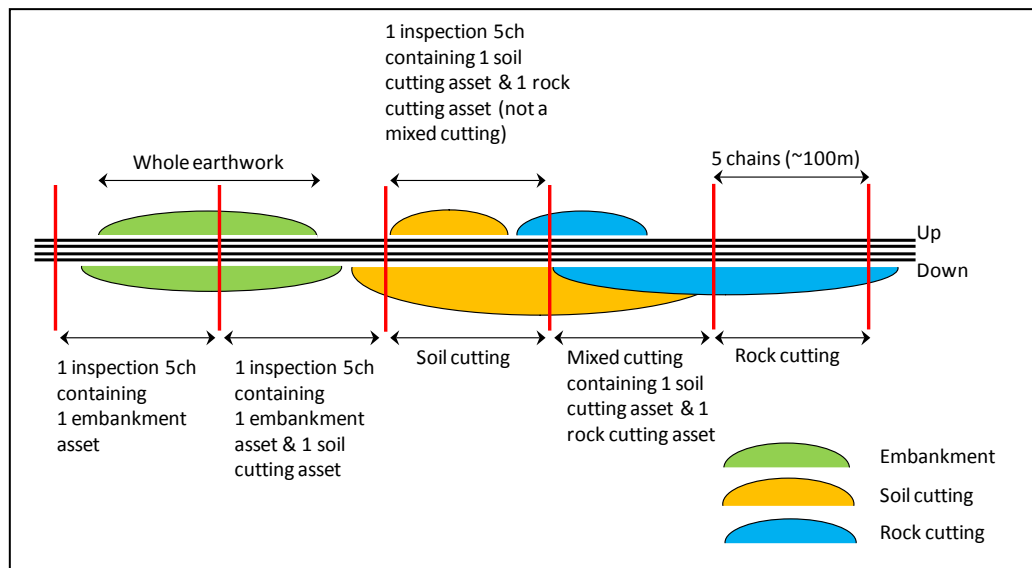


Figure 1 Segmentation of Earthworks

Evaluations, Assessments and Reviews

- **Earthworks Manager Review:** A review of an Earthwork's Examination. This review may be due to recommendations raised by the EE and/or EEE or due to an improvement in Earthworks Hazard Category.
- **Evaluation:** An appraisal of all relevant information regarding the stability, condition, use and location of an Earthwork, to determine the actions required to maintain acceptable levels of safety and performance.
- **Geotechnical Assessment:** The qualitative or quantitative determination of the stability or the safe load carrying capacity of an Earthwork. A Geotechnical Assessment might draw on the findings of a Site Investigation.

See Appendix A for details of the above processes.

Examinations and Inspections

- **Asset Identification Inspection:** An inspection of a 5 chain section of the network to determine whether there are any Earthwork assets present.
- **Cyclical Examination:** A regular Examination of an Earthwork to identify and record signs of instability carried out in accordance with [NR/L3/CIV/065](#).
- **De-vegetation Inspection:** An inspection of an earthwork following Examination to confirm the de-vegetation requirements of [NR/L3/CIV/065](#) have been complied with.
- **EEE Examination Check:** An independent re-examination of an Earthwork by the *Earthworks Examining Engineer*.
- **EEE Examination Approval:** A review of an Examination report for completeness and correctness. (See 5.2.2)
- **Rapid Response Examination:** A Special Examination required to a prescribed timescale following an Incident when the safety of the operational railway may be at risk: the notification for such an Examination is provided by Network Rail Control.
- **Reconnaissance Inspection:** A site visit undertaken to determine the requirements (if any) for works required to enable an Examination to be undertaken.

- **Special Examination:** An Examination of an Earthwork undertaken outwith the defined frequency of a Cyclical Examination carried out in accordance with [NR/L3/CIV/065](#). The scope of the Special Examination may be similar or different to that of a Cyclical Examination.

See Appendix B for details of the above processes.

Examination season

Earthworks Examinations are generally carried out when the Earthworks are less obscured by vegetation between October and the following March.

Hazard

The potential to do harm: this includes ill health and injury; damage to property, plant, products or the environment; production losses; and increased liability.

Hazard Index score

A numerical score that represents the statistical likelihood that an Earthwork may fail. An algorithm is applied to the parameters observed in an Earthwork Examination to obtain a numerical score for each Earthwork asset. The scoring algorithms are different for each Earthwork type (Soil Cutting, Rock Cutting and Embankment), see Table 1.

- **Soil Cutting Hazard Index (SCHI):** The Hazard Index score assessed for each Soil Cutting asset following systematic Examination. The parameters required, the algorithm used to determine the score and the division of the scores into the Earthworks Hazard Categories are defined in [NR/GN/CIV/210: Definition of Soil Cutting Hazard Index \(SCHI\)](#).
- **Rock Slope Hazard Index (RSHI):** The Hazard Index score assessed for each Rock Cutting asset following systematic Examination. The parameters required, the algorithm used to determine the score and the division of the scores into the Earthworks Hazard Categories are defined in [NR/GN/CIV/211: Definition of Rock Slope Hazard Index \(RSHI\)](#).
- **Soil Embankment Hazard Index (SEHI):** The Hazard Index score assessed for each Embankment asset following systematic Examination. The parameters required, the algorithm used to determine the score and the division of the scores into the Earthworks Hazard Categories are defined in [NR/GN/CIV/212: Definition of Soil Embankment Hazard Index \(SEHI\)](#).

Earthworks Hazard Category (EHC)

The range of possible Hazard Index scores for each Earthwork type is segmented into five categories designated A, B, C, D and E and termed the Earthworks Hazard Category (EHC). The EHC can be related to the statistical likelihood that the asset may fail. Category A is statistically least likely to fail, and category E is statistically most likely to fail. The categories A to E are the same for each Earthwork type (Soil Cutting, Rock Cutting and Embankment) although the failure probabilities for a given category vary between the Earthwork types.

Earthwork type	Hazard Index score	Hazard Index category
Soil Cutting	SCHI	EHC (A,B,C,D or E)
Rock Cutting	RSHI	
Embankment	SEHI	

Table 2 Hazard Index scores and categories