

Earthworks, supporting track

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For

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Management of earthworks in the railway environment is not about not about geotechnical engineering!

It is about safely getting passengers and freight from departure to destination, and to achieve this geotechnical and track teams need to work together.



How we manage geotechnical assets in Network Rail

Case Studies

- Catastrophic earthwork failures
- Progressive earthwork failures
- Active management of challenging earthworks

How we will manage challenging earthworks more effectively in the future?

- Better communication
- Improved standards and processes
- Future technology



How we manage geotechnical assets in Network Rail

Earthwork Asset Policy

Management of Earthworks Manual – NR/L2/CIV/086

Reference Documents

NR/L2/CIV/086/Mod01 Earthwork Evaluations

NR/L2/CIV/086/Mod02 Earthwork Assessments

NR/L2/CIV/086/Mod03 Geohazard Assessment

NR/L2/CIV/086/Mod04 Earthwork Interventions

NR/L2/CIV/086/Mod05 Earthwork Mitigations

NR/L2/CIV/086/Mod06 Earthwork Monitoring Strategy Selection and Implementation

NR/L2/CIV/086/Mod07 Selection and Implementation of Operational Restrictions

NR/L2/CIV/086/Mod08 Selection and Implementation of Temporary Restraints

NR/L2/CIV/086/Mod09 Adverse/Extreme Weather Prioritisation

NR/L2/CIV/086/Mod11 Definition of Earthwork Derailment Risk Models

NR/L2/CIV/086/Mod12 Definition of Earthwork Asset Criticality

NR/L2/CIV/086/Mod13 Management of Vegetation on Earthworks

NR/L2/OTK/5201 Management of Lineside Vegetation

NR/L3/CIV/005 Railway Drainage Systems Manual

NR/L3/CIV/006 Handbook for the Examination of Structures

NR/L3/CIV/037 Managing the Risk Arising from Mineral Extraction and Landfill

NR/L3/CIV/038 Managing the potential effects of coal mining subsidence

NR/L3/CIV/065 Examination of Earthworks Manual

NR/L3/CIV/065/Mod02 Definition of Soil Cutting Hazard Index

NR/L3/CIV/065/Mod04 Definition of Soil Embankment Hazard Index.

NR/L3/CIV/065/Mod03 Definition of Rock Slope Hazard Index

NR/L3/CIV/071 Geotechnical Design

NR/L3/CIV/185 Management of Reports of Safety Related Geotechnical Incidents

NR/L3/TRK/1010 Management of responses to extreme weather conditions at structures, earthworks and other key locations

NR/SP/CTM/017 Competence & Training in Civil Engineering

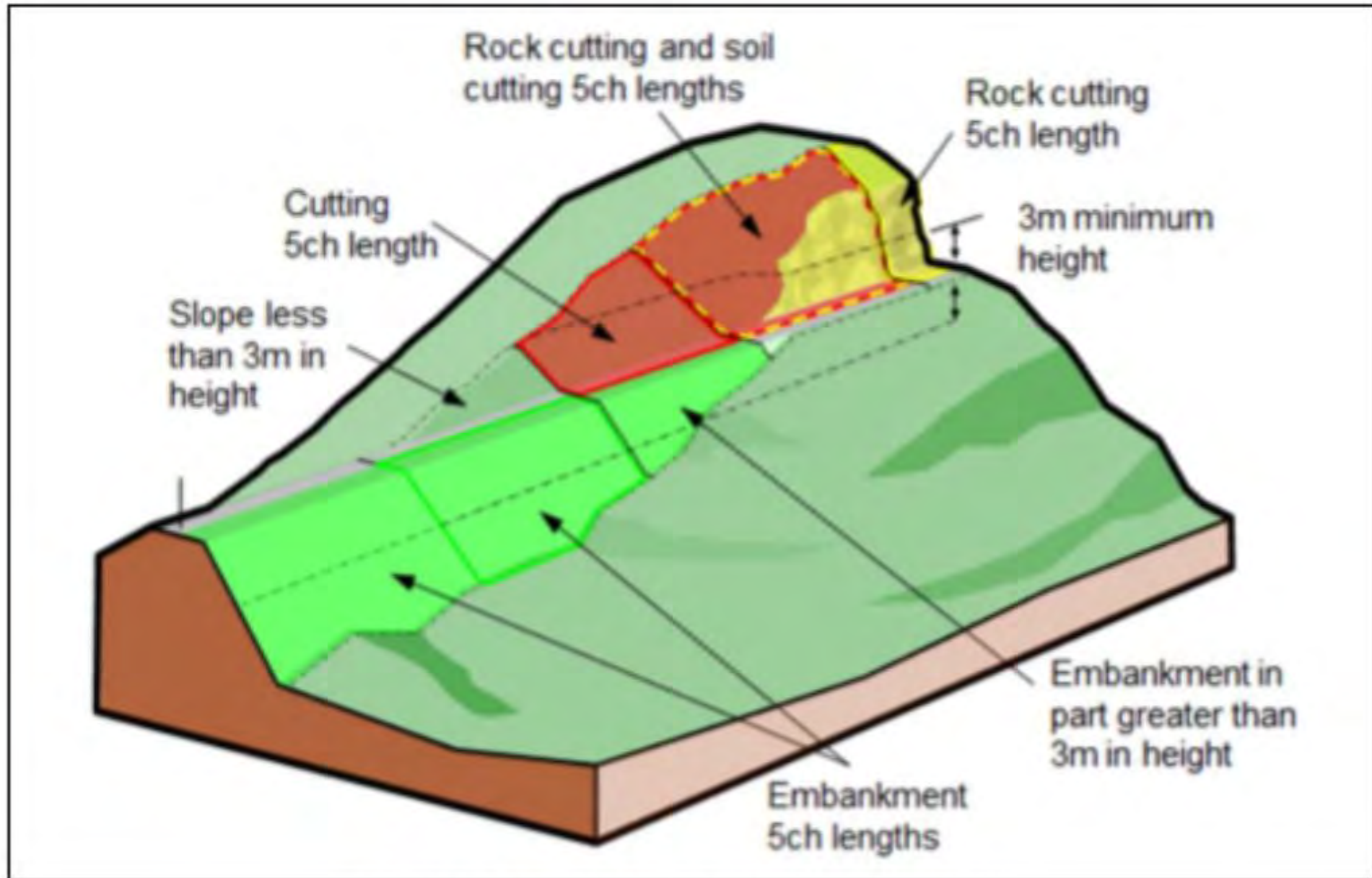


Figure 1-6 Earthworks definition (3D view)



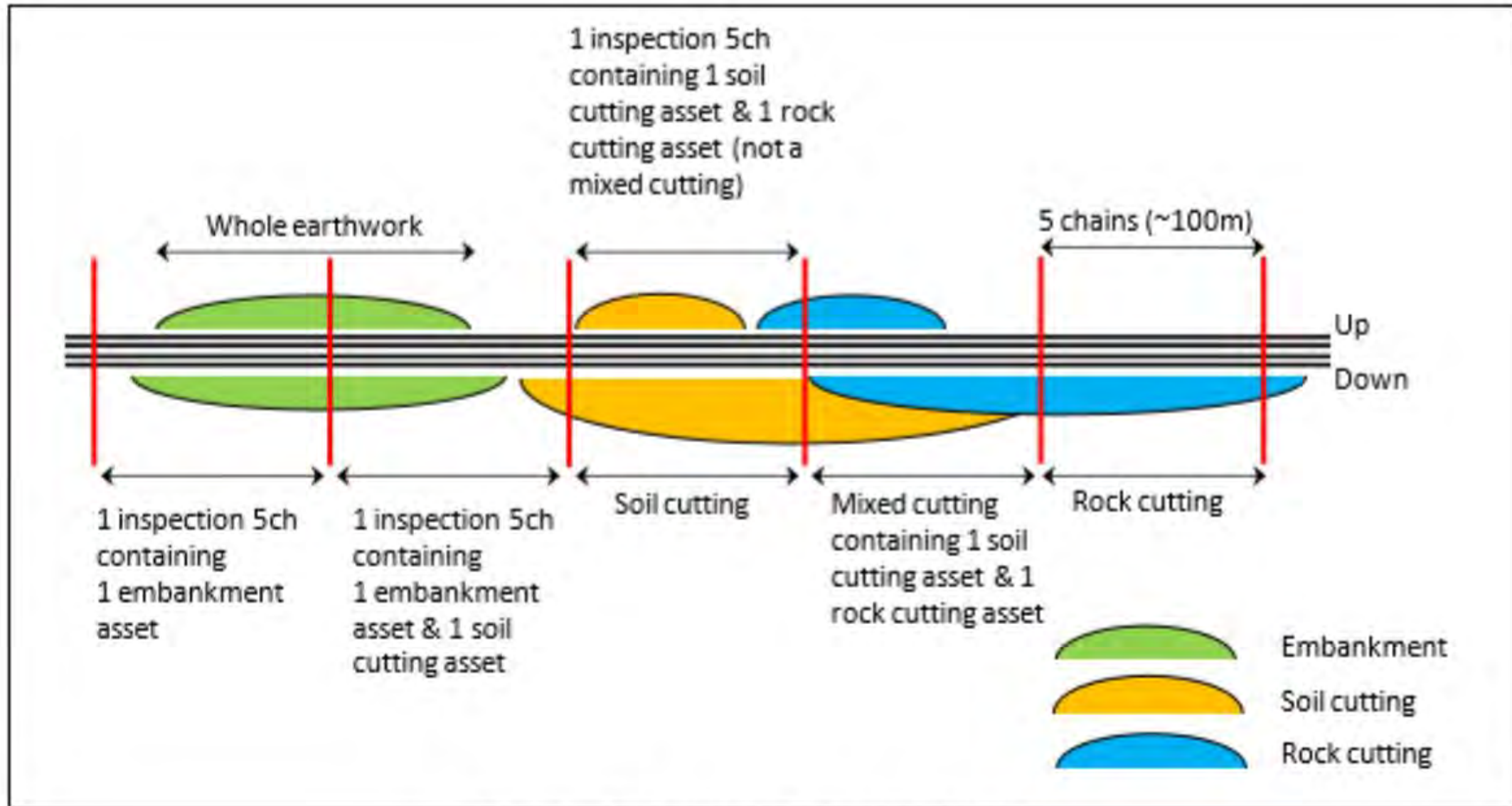
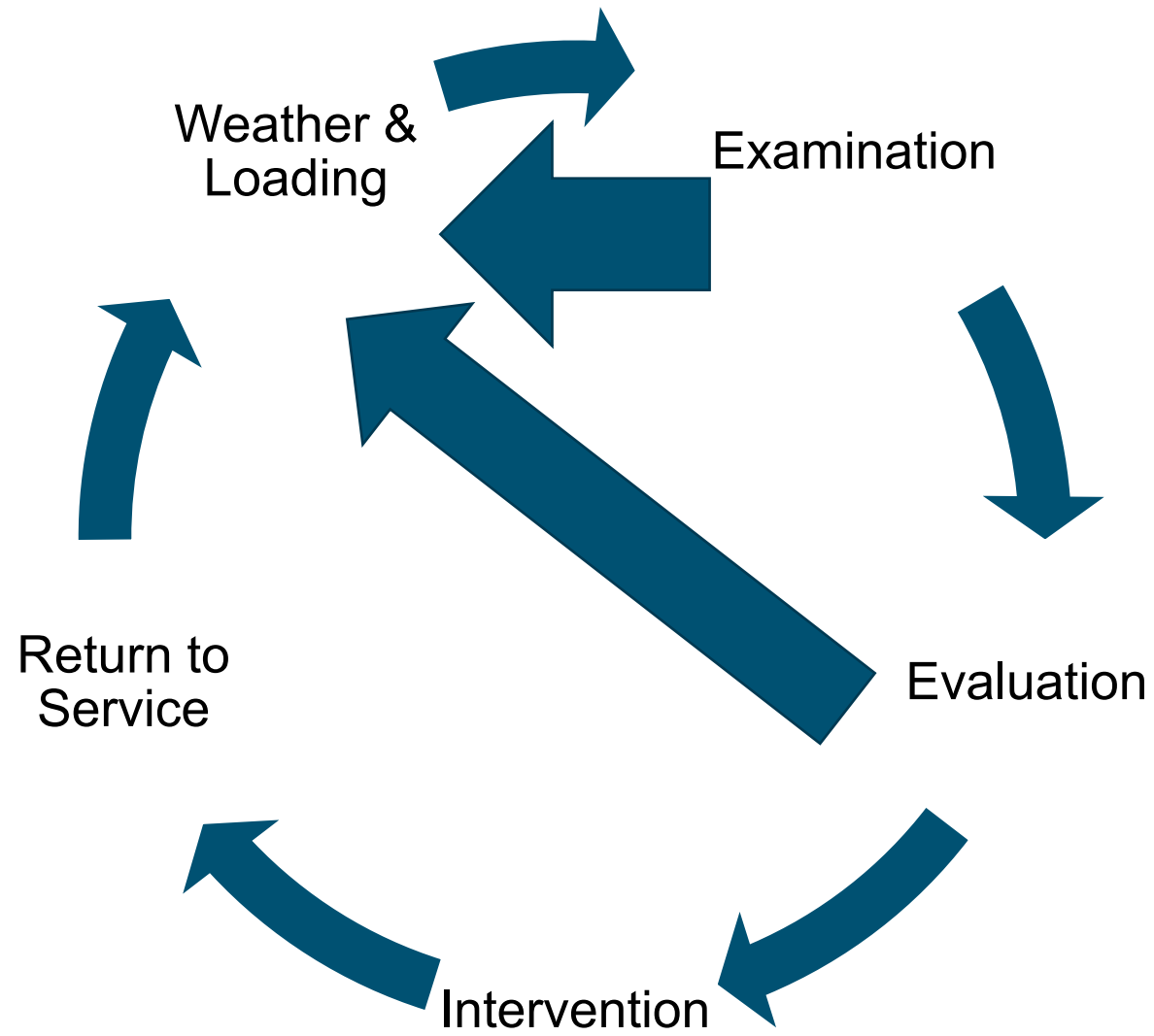


Figure 1-5 Segmentation of earthworks

Earthwork type	Earthworks Hazard Category	Planned examination interval (years)	Permitted examination tolerance (months)
Soil Cutting	A	10	12
	B, C	3	3
	D, E	1	3
Rock Cutting	A	5	6
	B, C	2	3
	D, E	1	3
Embankment	A	10	12
	B, C	5	6
	D, E	1	3





CP5 intervention matrices						CP6 intervention matrices							
Embankments													
Earthworks Asset Criticality Band	5	Examine	Maintain	Maintain	Renew	Renew	Earthworks Asset Criticality Band	5	Maintain	Maintain	Renew	Renew	Renew
	4	Examine	Maintain	Maintain	Renew	Renew		4	Examine	Maintain	Renew	Renew	Renew
	3	Examine	Maintain	Maintain	Refurbish	Renew		3	Examine	Maintain	Refurbish	Renew	Renew
	2	Examine	Maintain	Maintain	Refurbish	Renew		2	Examine	Maintain	Refurbish	Refurbish	Renew
	1	Examine	Examine	Examine	Refurbish	Refurbish		1	Examine	Examine	Maintain	Refurbish	Refurbish
	A	B	C	D	E	A		B	C	D	E		
Earthworks Hazard Category						Earthworks Hazard Category							
Soil cuttings													
Earthworks Asset Criticality Band	5	Maintain	Refurbish	Refurbish	Renew	Renew	Earthworks Asset Criticality Band	5	Maintain	Refurbish	Renew	Renew	Renew
	4	Maintain	Refurbish	Refurbish	Renew	Renew		4	Maintain	Maintain	Renew	Renew	Renew
	3	Examine	Maintain	Maintain	Renew	Renew		3	Examine	Maintain	Refurbish	Renew	Renew
	2	Examine	Maintain	Maintain	Renew	Renew		2	Examine	Maintain	Refurbish	Renew	Renew
	1	Examine	Examine	Examine	Refurbish	Refurbish		1	Examine	Examine	Maintain	Refurbish	Renew
	A	B	C	D	E	A		B	C	D	E		
Earthworks Hazard Category						Earthworks Hazard Category							
Rock cuttings													
Earthworks Asset Criticality Band	5	Examine	Maintain	Maintain	Renew	Renew	Earthworks Asset Criticality Band	5	Maintain	Refurbish	Renew	Renew	Renew
	4	Examine	Maintain	Maintain	Renew	Renew		4	Maintain	Refurbish	Renew	Renew	Renew
	3	Examine	Maintain	Maintain	Renew	Renew		3	Examine	Maintain	Renew	Renew	Renew
	2	Examine	Maintain	Maintain	Renew	Renew		2	Examine	Maintain	Refurbish	Renew	Renew
	1	Examine	Examine	Examine	Refurbish	Renew		1	Examine	Examine	Maintain	Refurbish	Renew
	A	B	C	D	E	A		B	C	D	E		
Earthworks Hazard Category						Earthworks Hazard Category							

Figure 6-4 Earthworks intervention matrices for CP5 and CP6

Botley Embankment Feb 2014



Epsom Embankment Dec 2019



Ashmead Embankment October 2019



Ashmead Embankment Feb 2020 / May 2020



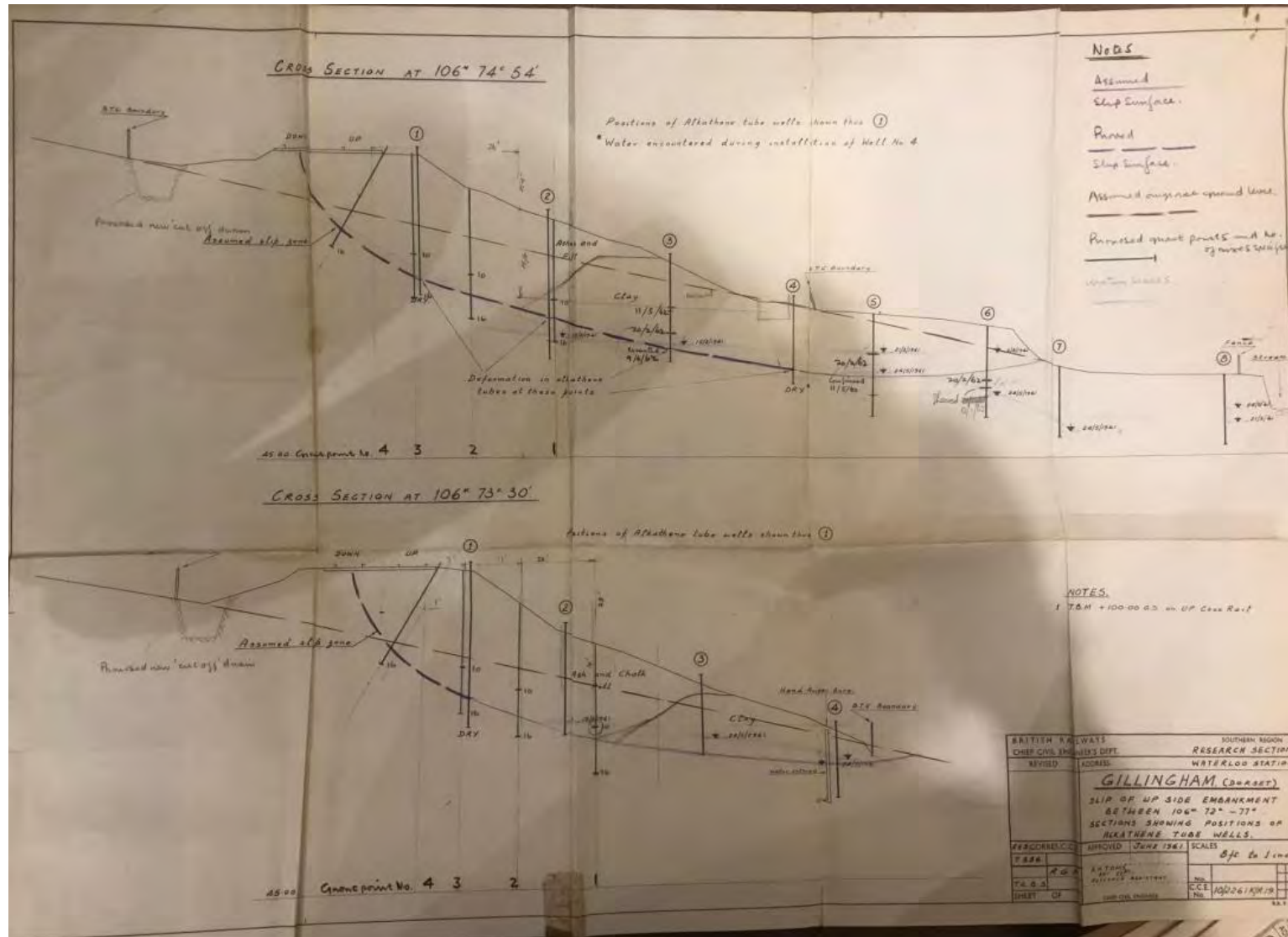
The Street Embankment Oct 2019



Bugley Bridge Embankment Mar 2020



Bugley Bridge Embankment 1961/1962



Bugley Bridge Track Re-alignment June 2021



Willesden High Level Junction May 2019

All Images courtesy of RAIB

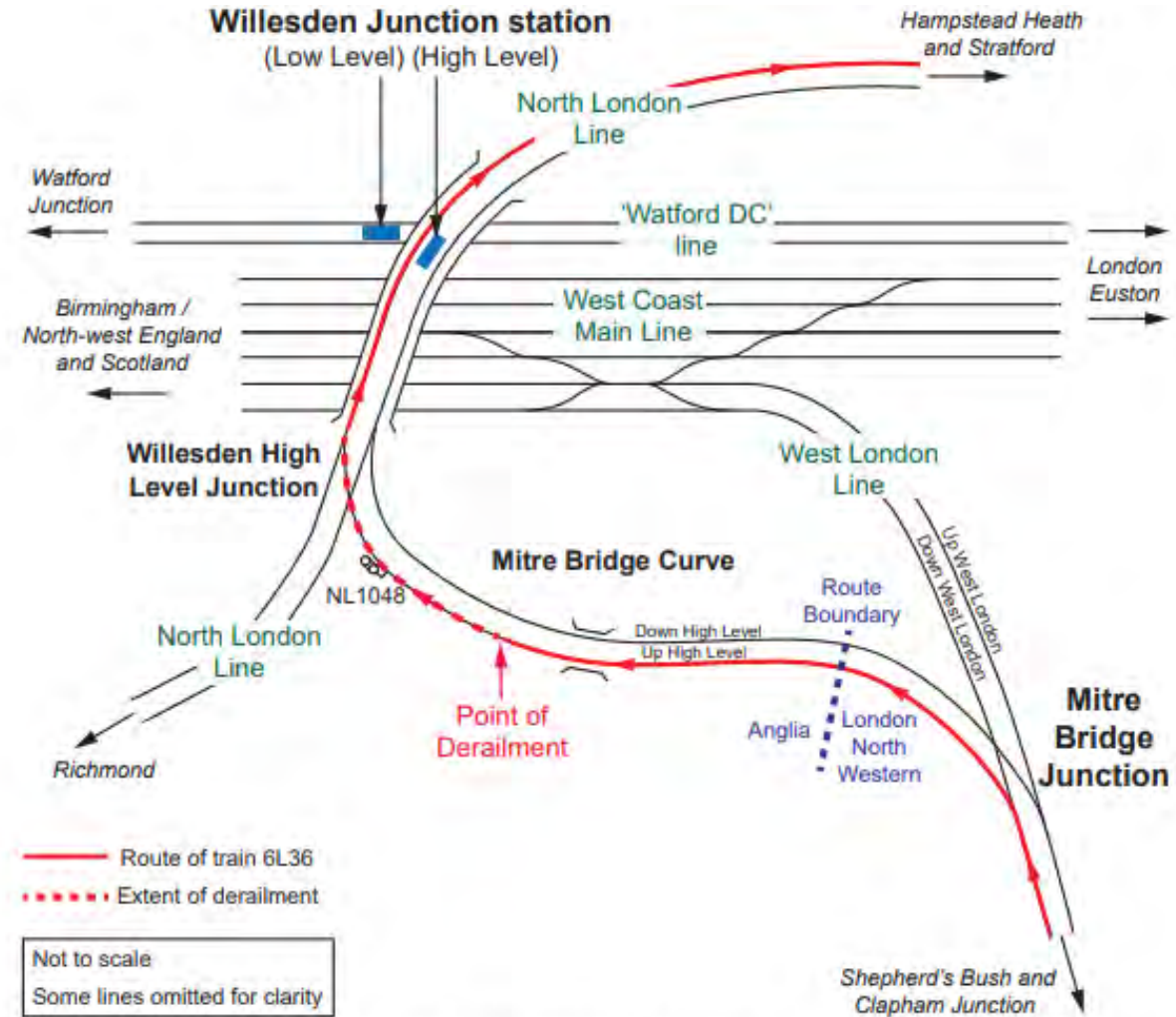
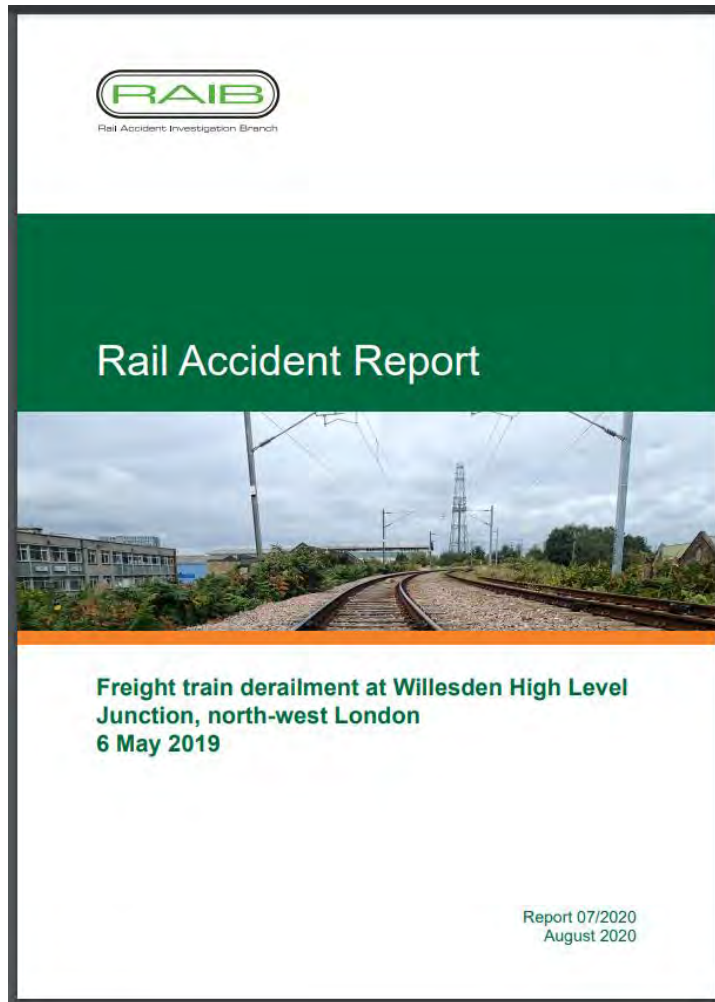


Figure 2: Layout of the railway near Willesden High Level Junction showing the route of train 6L36

Willesden High Level Junction May 2019

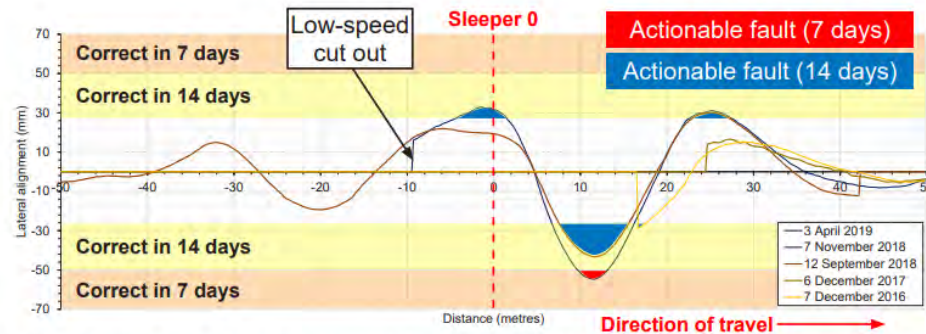


Figure 8: Lateral track alignment recorded on various track geometry measurement train runs prior to the derailment. Locations where low-speed cut out resulted in data loss are highlighted. On 3 April 2019 no lateral track geometry measurement data was recorded in the vicinity of the designated point of derailment, identified as 'Sleeper 0'.

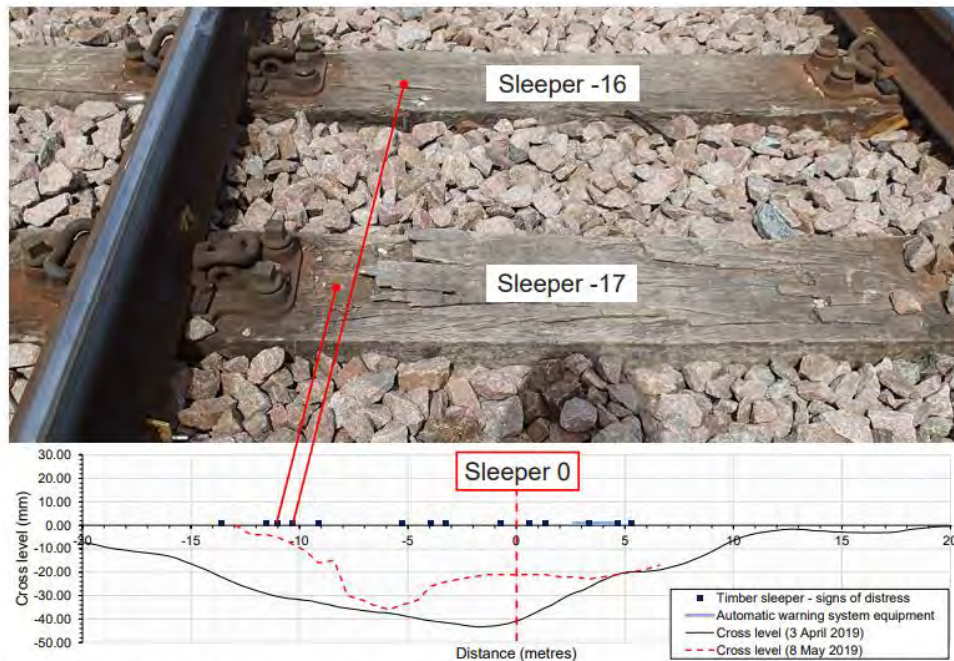


Figure 13: Location of distressed sleepers and automatic warning system equipment close to 0 miles 27 chains compared to cross-level profiles measured on 3 April 2019 and 8 May 2019

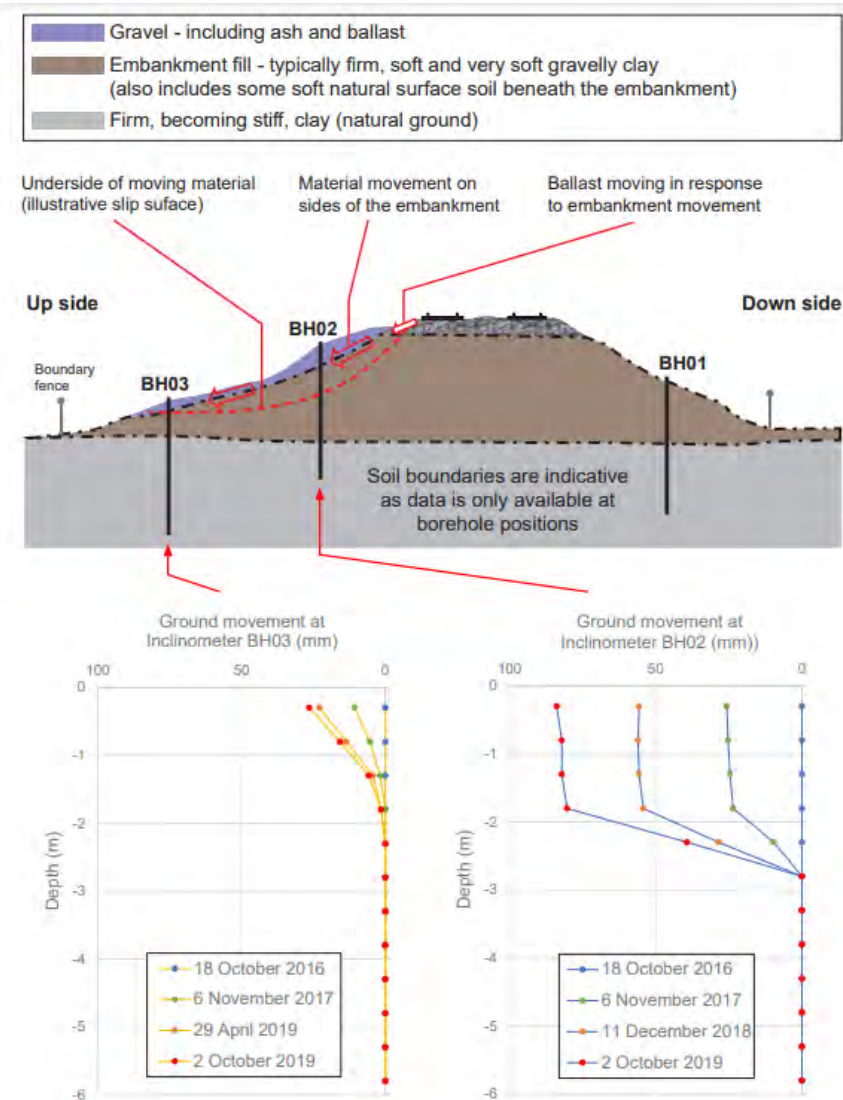


Figure 14: Cross-section of Mitre Bridge Curve embankment showing illustrative slip surface and simplified ground movement. Graphs show how the lateral movement measured at inclinometers BH02 and BH03 varied with borehole depth.

Barrow upon Soar Dec 2012

All Images courtesy of RAIB

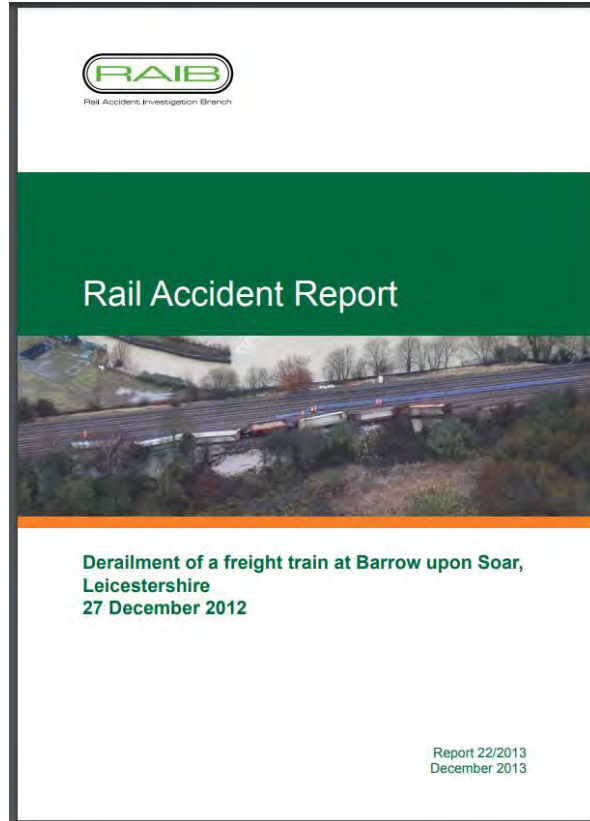


Figure 2: Aerial view of the accident site (photograph courtesy of Network Rail)



Figure 7: The rearmost wagon and loss of support under the cess rail of the Up Slow line

Barrow upon Soar Dec 2012

All Images courtesy of RAIB



Figure 13: Drainage from the foot of the embankment to the River Soar (photographs courtesy of Network Rail)

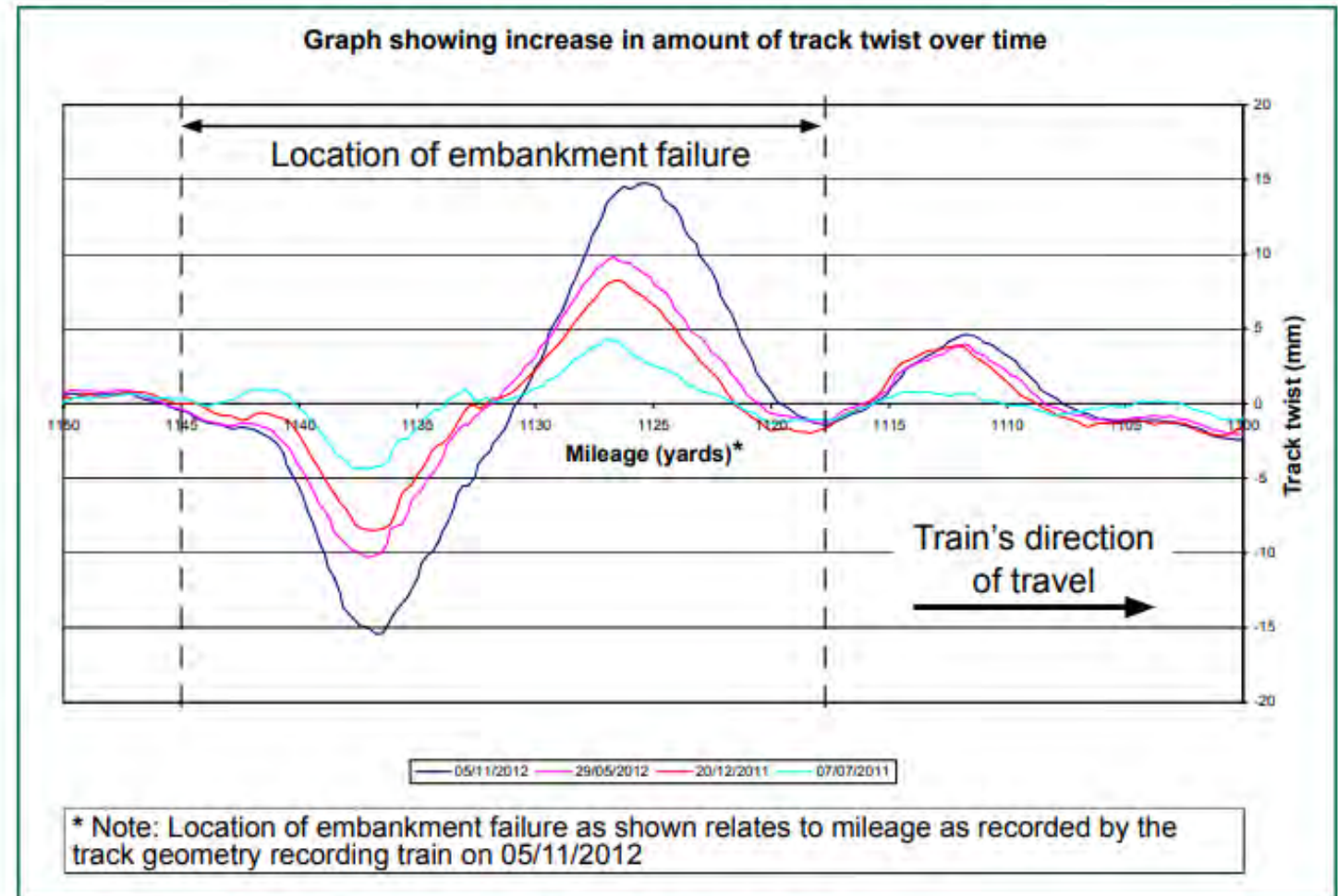


Figure 15: Track twist at the point where the embankment failed

Summary of case studies

	Rapid Failure	Geotech Prior Knowledge	Pway Prior Knowledge	Track Recording	Detected by	Operational Restriction	Response
Botley	Yes	No	No	Yes	Rough Ride	Line closed	Reactive
Epsom	Yes	No	Yes	No	Points lost detection	Line Closed	Reactive
Ashmead	No	Yes	Yes	Yes	TQ/Rough Ride	Speed Restriction/Line Closed	Planned/Accelerated/Reactive
The Street	No	Yes	Yes	Yes	TQ/Rough Ride	Speed Restriction	Accelerated
Bugley Bridge	No	Yes	Yes	Yes	TQ/Rough Ride	Speed Restriction	Active Management
Willesden	No	Yes	Yes	No	TQ	None	Planned/Reactive
Barrow upon Soar	No	No	Yes	Yes	TQ/Rough Ride	None	Reactive



Future Improvements

Better Communication

Both Earthwork & Track standards are being updated to mandate a regular meeting between Geotech & Track Maintenance teams, with a formal process to establish a management plan for problematic sites.

Better Process

Risk assessments for locations where track recording does not collect and process data (low speed cut out)



Future Improvements

Better Tools

Machine learning applied to TQ data to flag earthwork failure precursor signals in the data (At proof of concept stage).

Better Tools

Machine learning applied to Lidar data collected at time intervals to identify mass movement in earthworks (At proof of concept stage).



