Rail Accident Investigation Branch

Rail Accident Report

Derailment near Moy, Inverness-shire on 26 November 2005

Department for Transport

Report 22/2006
November 2006

This investigation was carried out in accordance with:

- the Railway Safety Directive 2004/49/EC;
- the Railways and Transport Safety Act 2003; and
- the Railways (Accident Investigation and Reporting) Regulations 2005.

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Contents

Introduction

1 The sole purpose of a Rail Accident Investigation Branch (RAIB) investigation is to prevent future accidents and incidents and improve railway safety.

2 The RAIB does not establish blame, liability or carry out prosecutions.

3 Access was freely given to Network Rail, First Scotrail and Bombardier Transportation staff, data and records in connection with the investigation.

4 Appendices at the rear of this report contain Glossaries explaining the following:

- acronyms and abbreviations are explained in the Glossary at Appendix A; and
- technical terms (shown in *italics* the first time they appear in this report) are explained in the Glossary at Appendix B.

Summary of the report

5 At 07:02 hrs on the morning of 26 November 2005, passenger train 1B08, a 3-car Class 170 *diesel multiple unit* (DMU) operated by First Scotrail, travelling from Inverness to Edinburgh on the Inverness to Perth section of the Highland Line, derailed after encountering a *landslip* in a *cutting* north of Moy in Inverness-shire. The location is shown in Figure 1.

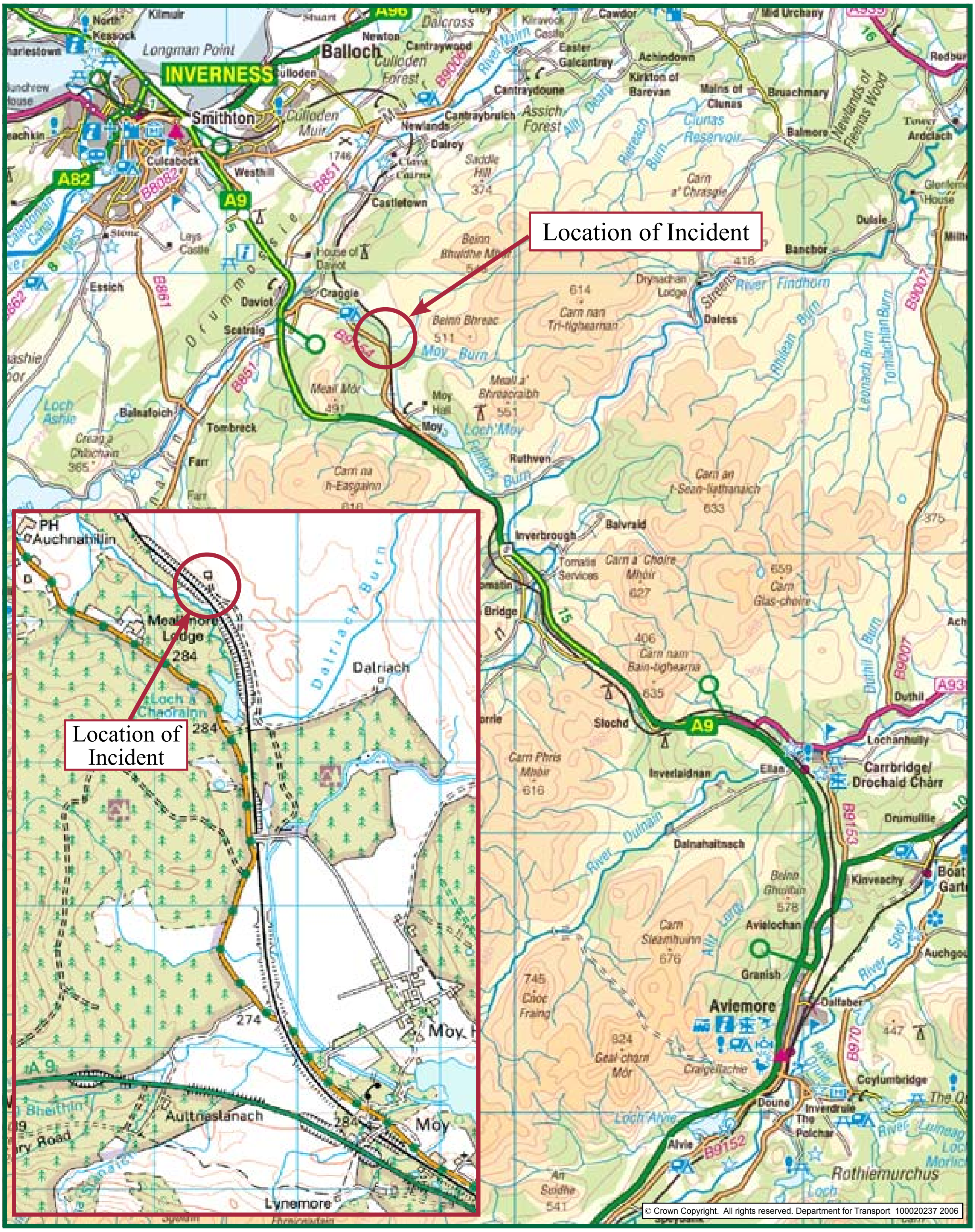

Figure 1: OS map extract showing the location of the incident.

6 All wheels of the leading car derailed to the *down cess*. No wheels of the other two cars were derailed. The derailed train travelled approximately 122 m before coming to rest upright close to the 105 ½ milepost.

7 The impact with the landslip debris, and the subsequent derailment, resulted in damage to the leading vehicle. This was mainly restricted to the front cab, the bogies and the vehicle *underframe* equipment. The impact also caused the release of a ceiling panel in the passenger saloon which hinged downwards and prevented the driver from being able to open the cab-to-passenger-saloon door.

8 Before coming to rest the leading car made a minor glancing impact with the steelwork of *underbridge* 296. There was some minor damage to the track as a consequence of the derailment.

9 The derailment took place on a single-line section. Service operation was restored on the line at 10:50 hrs on 27 November 2005.

10 The immediate cause of the derailment was the train running into material deposited on the track as a result of the cutting landslip.

11 The following factors contributed to the derailment:

- the approach adopted by Network Rail following a forecast of an approaching rainstorm resulted in the forecast being interpreted solely as a flooding risk affecting too localised an area;
- the cutting was not on the 'at-risk' list of *earthworks* used to identify inspection requirements during poor weather.

12 The balance of evidence indicates that the landslip occurred because the groundwater rose to a high enough level to promote a small failure at the cutting slope *toe*, that caused a disruption to flow paths, which resulted in the groundwater rising to a sufficiently high level to initiate a larger deep *rotational failure*. The groundwater level was high because:

- the excessive rainfall during the preceding hours which initiated a watercourse, the flow of which was intercepted by an area of hard standing (Parking Area) located immediately above the cutting slope;
- the lack of adequate drainage on the Parking Area resulting in it acting as a sink and allowing water infiltration into the cutting slope;
- the inadequacy of the drainage on the Parking Area remaining unnoticed.

13 The root cause was that Network Rail did not identify the drainage risks that were imported by the recent building of the Parking Area, located above the *crest* of the failed cutting slope, either during construction or subsequently,

14 The following factors contributed to the failure of the cutting slope:

- snow melt as a result of a recent rise in temperature contributing to the discharge on to the Parking Area;
- soil permeability properties promoting a rapid rise in groundwater level;
- the already relatively high regional groundwater level as a result of the rainfall over the previous 12 months;
- Network Rail being unaware of continued peat extraction on land above the cutting slope and that the land had not been restored to its natural state, and therefore that there was a likelihood of increased run-off from the land;
- lack of need to consult with the Railtrack *earthwork asset steward* when constructing the Parking Area (Railtrack was the predecessor to Network Rail and the owners of the railway infrastructure when the parking area was constructed);
- the decision not to undertake an *Assessment* and not to send a geotechnical engineer to site as part of the Network Rail earthwork management process;
- the general implementation of aerial surveys for the examination of earthworks;
- not undertaking a *Slope Stability Hazard Index* (SSHI) analysis, resulting in there being no standard objective means of comparing the relative risks from different earthworks;
- the lack of a standard process and criteria for undertaking the *Evaluation* phase of the earthworks management process.

15 The only significant train evacuation issue was the lowering of a ceiling panel which prevented driver egress from the cab through to the passenger saloon. This was because of a weakness in the *secondary retention* facility.

16 Recommendations to improve safety are made covering the following areas (paragraph 285):

- improvements to the drainage arrangements near to the site of the derailment;
- review of the procedures for inspection and management of earthworks;
- improvements to Network Rail's procedures and knowledge relating to their own and other parties' activities that could affect the stability of earthworks;
- the procedures for determining the actions to be taken on receipt of a warning of extreme weather and for the identification of earthworks deemed to be 'at-risk';
- modification of the train ceiling panels; and
- investigation of the practicability of fitting features to trains designed to limit the consequence of derailment.

The Investigation

Summary of the incident

17 At 07:02 hrs on Saturday 26 November 2005 train 1B08, the 06:48 hrs Inverness to Edinburgh service, was travelling towards Aviemore on the single-track Highland Line between Culloden and Moy, when it encountered a landslip in a 10 m high cutting north of Moy. The impact with debris from the landslip resulted in the derailment of the leading vehicle in the train.

18 The impact also caused the release of a ceiling panel in the passenger saloon which hinged downwards and prevented the driver from being able to open the cab-to-saloon access door.

Background

Investigation Process

19 The cause of the landslip was determined by investigation of:

- infrastructure condition;
- the earthworks management regime;
- the weather;
- external party land use issues; and
- the slip mechanism.

20 The operational processes for managing the consequences of poor weather were assessed by consideration of the relevant procedures and practices and the actions undertaken.

21 The derailment mechanism and train performance during the collision were assessed by consideration of the:

- consequential damage to the train and track; and
- size and content of the landslip.

The Infrastructure

22 The Highland Line is the main railway line connecting Inverness with the major centres of population in central Scotland.

23 The incident occurred in a cutting just north of the village of Moy at 105 miles 1129 yards. Moy is 20 miles (33 km) north west of Aviemore and 12 miles (20 km) south east of Inverness, close to the A9 road.

24 At this location the line is single track.

25 The gradient at the location is 1 in 60 rising towards Aviemore and there is a *permanent speed restriction* (PSR) of 75 mph (121 km/h).

26 The infrastructure is owned and maintained by Network Rail.

The Train

27 Passenger train 1B08 was formed of a 3-car Class 170 DMU, number 170431.

28 The train was designed and built by Bombardier Transportation. It is owned by Porterbrook Ltd and operated by First Scotrail.

Events preceding the incident

29 The area around Moy had experienced poor weather over the days prior to the incident. There had been a mixture of snow and heavy rain.

30 On Saturday 26 November 2005 passenger train 1B08, the 06:48 hrs Inverness to Edinburgh Waverley, left Inverness on time and travelled towards Aviemore in the *up* direction on the Highland Line.

31 The train was travelling at approximately 56 mph (90 km/h) and carrying 71 passengers and six staff, three of whom were on duty.

Events during the incident

32 At approximately 07:02 hrs the train encountered a landslip in the cutting north of Moy. All wheels on both bogies on the leading vehicle derailed to the right, the down cess. No other wheels were derailed. The train came to rest upright after travelling a further 122 m, Figure 2. (There was found to be timing mis-match between recording equipment fitted on the train; it is possible that the time of encountering the landslip was up to four minutes later).

Figure 2: The derailed train. *(Photograph: First Scotrail)*

33 There was a minor glancing impact with the steelwork of underbridge 296.

Events following the incident

34 At 07:06 hrs the driver of train 1B08 contacted Network Rail *Operations Control* using the *National Radio Network* (NRN) emergency call facility and reported that the train had collided with an obstruction and become derailed. He gave his location as between Culloden and Moy, but was not sure of the exact location. He reported that he had sustained injuries, but was unaware of the number of passengers or whether any of them were injured. He requested immediate full emergency response, adding that an air ambulance would be necessary. The *Duty Control Manager* asked him to make contact again when more details were known about the specific location.

35 Network Rail Operations Control contacted the signaller at Aviemore and informed him of the incident.

36 The Aviemore signaller sent 'six bells' (emergency alarm) to the Inverness Signalling Centre and returned all signals to danger. He then telephoned the signaller at Inverness to inform him of the details of the emergency.

37 The driver contacted the Aviemore Signaller and informed him of the derailment, again not knowing the exact location.

38 On completion of the call from the driver, the Duty Control Manager made an emergency call and was connected to the Network Rail Glasgow exchange operator, he stated that he required emergency assistance. There was a delay in the operator connecting the Duty Control Manager to each of the emergency services in turn. This overall emergency call procedure lasted more than 7 minutes. The Duty Control Manager requested a full emergency response from all services.

39 Because of the delay in being connected to the emergency services, Network Rail Operations Control contacted the Inverness signaller and requested that he directly contact the local emergency services.

40 At 07:08 hrs Network Rail Operations Control informed the *Mobile Operations Manager* of the incident.

41 An off-duty First Scotrail driver travelling on the train went, with the train driver's knowledge, to find out where the train had come to a stand. He soon returned, reporting that the train was at the 105 ½ milepost. The driver arranged for the passengers to be removed from the derailed coach to the rear two coaches.

42 At 07:10 hrs the driver contacted Aviemore Signaller and advised the location of the train. The signaller informed the driver that the emergency services were on their way.

43 At 07:12 hrs the Aviemore signaller informed Network Rail Operations Control and the Inverness signaller of the location. The Inverness signaller passed this onto the Police, with details of the access points, taken from the emergency plan.

44 At 07:16 hrs the driver called Network Rail Operations Control to advise them of the location. There was much discussion about the nearest access point, and the driver agreed to go and find the nearest access location. The driver, accompanied by the off-duty First Scotrail driver, walked forward to verify the access point.

45 At 07:45 hrs ambulance personnel arrived on site.

46 At 07:49 hrs a Network Rail Mobile Operations Manager arrived on the scene and took the role of the *Railway Incident Officer* (RIO).

47 At 07:55 hrs Fire Brigade arrived on site, having been delayed due to the half-mile walk from their nearest known access point. They had been directed to the site after meeting the driver.

48 An engineer (Site Witness), a member of the public who was travelling on the train, was asked whether the condition of the landslip material presented a risk to passengers as they walked by it to the rescuing train. The Site Witness observed and photographed the landslip and surrounding area at around this time.

49 At 08:05 hrs the RIO reported that seven passengers and two staff would need to be taken to hospital. They were airlifted at approximately 09:10 hrs.

50 At 09:21 hrs the rescuing train, sent to assist at the site, was ready to leave the site.

Injuries

51 There were six injured passengers and two injured staff (driver and conductor).

52 Two of the passengers were detained in hospital, one male passenger with back injuries and a female passenger with chest injuries.

53 The driver was 'thrown' forward during the impact with the debris pile and suffered some facial injuries as result of coming into contact with the surround of the cab desk. This part of the cab desk has a smooth edge reducing the severity of injury.

Key Evidence

54 The evidence from the investigation is presented in this section.

<u>Infrastructure Condition (track system)</u>

55 *Track Recording Vehicle* (TRV) six-monthly records over the previous 28 months indicate good track *formation* stability.

56 Track renewal records show that rails were replaced at the site in July 2003. Rail-based plant was used. The work activity involved should not have had any detrimental affect on either the cutting slope or the drainage system, but there are no records of whether this is so or not. No other maintenance was known to be considered necessary or carried out following this.

Infrastructure Condition (drainage)

57 Historical maps and aerial photographs of the site and surrounding area show that the cutting slope lies within the catchment of watercourses which drain into streams running under underbridges 296 and 297. The bridges are located to the south and north of the cutting slope respectively. See Figure 3.

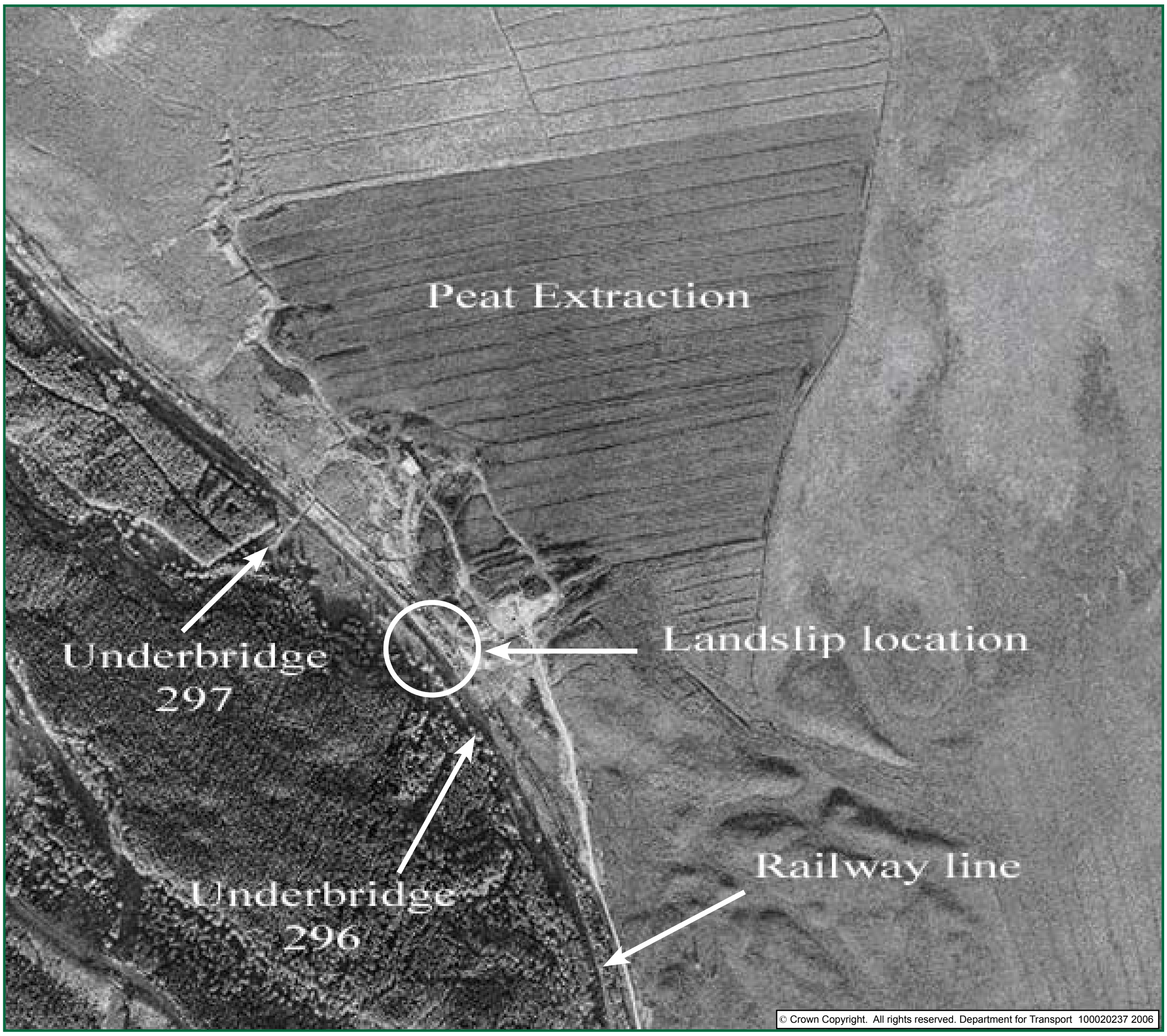

Figure 3: Historic aerial photograph of the site and surrounding area.

58 They also show that the majority of the catchment comprises land on which industrial peat extraction has taken place.

59 These features are shown on the site plan, Figure 4.

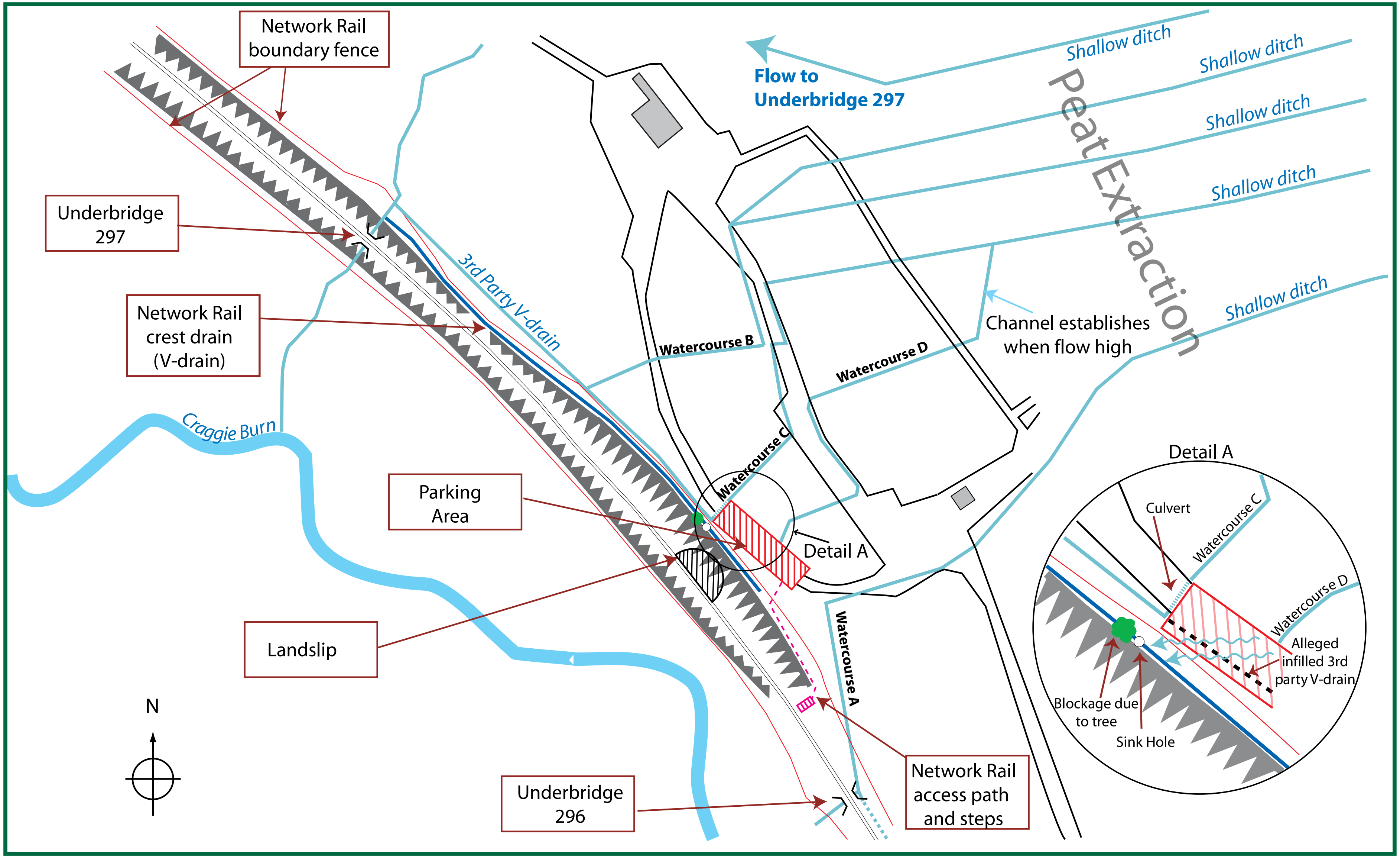

Figure 4: Site plan.

60 A *Special Examination* Report (TSER008/CIV/008) compiled at Network Rail's request by Donaldson Associates (Donaldsons), who was their earthworks and drainage surveying contractor, reported observations regarding the cutting slope after the landslip occurrence. The examination was carried out between 13:20 hrs and 15:30 hrs on 26 November, just six hours after the derailment. The first part of the examination was conducted from a helicopter. An on-foot examination of the site was undertaken later.

61 It reported that the *crest drain* directly above the site of the failure, and also adjacent to the Parking Area (see Figure 4) was covered in snow and pine needles.

62 The site video, made by Donaldsons as part of the Special Examination, recorded the condition of the cutting slope after the landslip and showed evidence of 'tide' marks in the snow indicating that there had been a major discharge of water which had then accumulated on the Parking Area.

63 Some surface water runs off the northern end of the Parking Area. There is evidence that a portion of the run-off then breaches the boundary fence and enters the Network Rail crest drain, as shown diagrammatically on Figure 4 and also on the video image at Figure 5. Just north of this location, a tree was found growing which blocked the drain. No water flowed past the blockage; it was observed to infiltrate into the ground via an apparent 'sink hole' in the drain invert. There was no evidence of ponding due to the blockage or water then overspilling onto the cutting slope. (A portion of the remaining run-off was observed to enter the 3rd party V-drain indicated on Figure 4. Water overflowed from this drain and entered the Network Rail crest drain via an additional breach of the boundary fence north of the tree blockage. However, at this location both drains appeared to be free-flowing and therefore effective in taking the water away from the cutting slope).

Figure 5: Still image from the site video showing water breach through the boundary fence and into the Network Rail crest drain (Image: Network Rail).

64 Site photographs taken by the Site Witness immediately after the incident show a significant amount of water flowing onto the Parking Area (Figure 6). The presence of tide marks in the snow can also be seen again indicating that the flow had been higher.

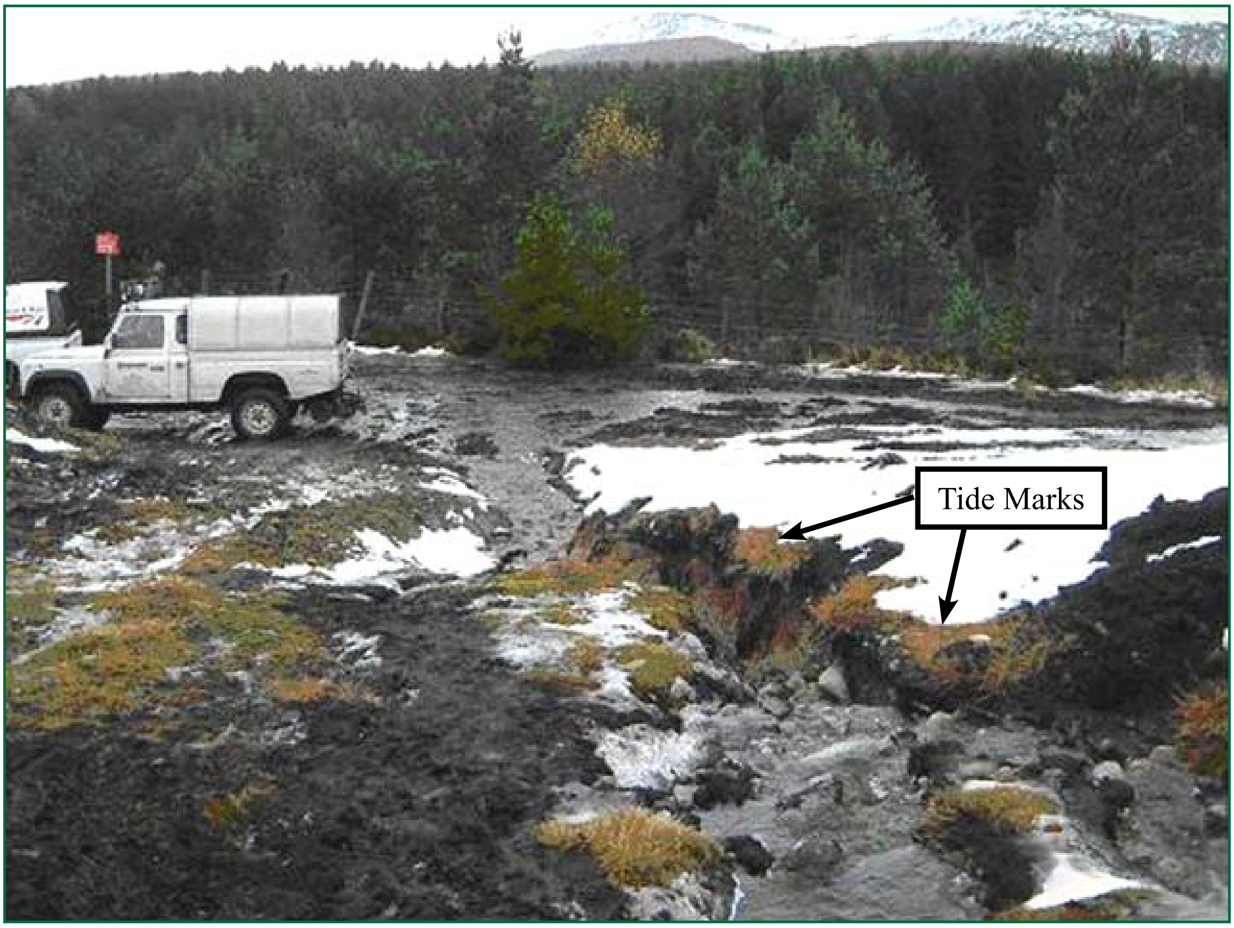

Figure 6: Water observed flowing onto the Parking Area. *(Photograph: Site Witness)*

65 A geotechnical site survey, conducted on 12 January 2006, identified four watercourses, designated Watercourse A, B, C and D, which flow towards of the cutting slope. These are shown on the site plan, Figure 4.

66 The following related observations were made:

- Watercourses A and B flow in well-defined channels which then discharge surface water flows away from the cutting slope;
- Watercourse C again runs in a defined channel. It brings the surface water flow close to the crest of the cutting slope. However, the water then passes through a culvert (at the northern end of the Parking Area) and is discharged into a V-drain (which runs north along the outside of the railway boundary) taking the flow away from the cutting slope;
- Watercourse D is only established intermittently and does not run in a defined channel. It discharges water directly onto the Parking Area located above the crest of the cutting slope.

67 The peat extraction on the catchment involved the stripping away of surface heather vegetation.

68 The Parking Area is located directly above the location of the failure. There is no engineered drainage system associated with the Parking Area. It has a permeable surface.

69 There is no drain outfall from the northern abutment of underbridge 296. In comparison, water was seen discharging from the southern abutment.

70 No collector drains were installed to mitigate the effects associated with water flowing over, or falling directly on, the cutting slope.

71 Historic photographs from earthwork Examinations show evidence of ruts on the Parking Area made by vehicle tyres.

72 They also show that there was no flow in Watercourse D on a number of inspection dates.

73 Discussions with the peat extractor indicated that he installed drainage and access tracks along the railway boundary in discussion with the railway. The drainage captured run-off from the peat diggings and directed it southwards to underbridge 296 and northwards to underbridge 297. (The *Territory Earthwork and Drainage Engineer* (TEDE) for Network Rail Scotland has no records of this, but, from post-incident site observations, confirms that the work was undertaken.)

Infrastructure Condition (soil profile)

74 The Site Witness who was present on site immediately after the incident described the *backscar* as 'sweating'. He also found that the debris material was too wet to walk on.

75 Discussion with the engineer undertaking the Special Examination indicated that, at the time of the examination, the debris was firm enough to walk on, but with pockets of water present on the surface.

76 The site video taken at the time of the Special Examination showed the backscar of the failed cutting slope to comprise a cover of between 0.3 and 0.4 m of top soil which is underlain by *glacial till*. No significant wetness can be observed.

77 A fan shaped debris pile was observed spreading out from a slip bowl. This resulted in the deposit of a pile of mixed soil material between 1.5 and 2 m high across the track, Figure 7. The observed landslip is typical of an initial deep rotational failure followed by an *earthflow*.

Figure 7: Debris pile from landslip (the train shown is the one sent to site for rescue). (Photograph: Network Rail)

78 Site photographs taken on 28 November showed significant local variation within the glacial till exposed in the backscar; this included the presence of pockets of sand/gravel in the uppermost 3 m band, Figure 8.

Figure 8: Backscar resulting from the landslip.

Infrastructure Condition (groundwater profile)

79 Groundwater seepage calculations were undertaken to understand the effect that infiltration via the Parking Area would have on the groundwater profile in the cutting slope.

80 Although there is no formal record of the normal groundwater levels in the land above the cutting slope, the presence of the peat would suggest a shallow depth of around 2 m. Since the Network Rail crest drain was found to be dry above the cutting slope, the groundwater level at the crest of the slope was taken to be below the invert of the drain. However, the wet conditions identified locally on the toe of the slope and the lack of a *cess drain* indicate groundwater levels close to the surface at the toe.

81 The above observations were used to define the initial groundwater profile used in the seepage calculations.

82 A range of soil permeability values were used which are considered representative of the type of glacial till found on site. The calculations indicated that, toward the higher end of the range of permeabilities used, the groundwater level would rise rapidly in response to infiltration into the Parking Area. Even towards the lower end of the permeability range, the rate of rise would be significant.

83 Slope stability calculations were undertaken using the results from the groundwater seepage calculations to help understand the landslip failure mechanism.

External Parties (land use)

84 Network Rail company standard NR/SP/CIV/037 (Issue 2, April 2004, Issue 1, August 1999) 'Managing the Risk Arising from Mineral Extraction and Landfill' defines the procedure adopted by Network Rail in managing the risks associated with third party land use. Peat extraction is encompassed by the requirements of this standard. The standard appoints Network Rail's *Mining Engineer* as the single point of contact to receive and evaluate planning applications, *Notices of Approach* and other proposals for mineral extraction and landfill.

85 The Network Rail Mining Engineer (ME) is responsible for evaluating planning applications and reviewing Notices of Approach and generating a mining report indicating the anticipated effects of the mining on the infrastructure. He is to forward this evaluation to the Network Rail nominee, an appropriately qualified engineer having delegated responsibility for part of Network Rail's infrastructure.

86 The ME is required to monitor the stability of Network Rail's infrastructure adjacent to surface mineral workings until restoration in accordance with planning consent is complete. He is to advise the nominee of any instability that may affect Network Rail infrastructure. The nominee is then responsible for identifying and implementing remedial works as necessary. The ME is to maintain an accurate and complete register of ancient mineral workings and current mineral workings.

87 Information from the Network Rail ME indicates that in practice, *Neighbour Notifications* issued under Town and Country Planning procedures alert Network Rail to proposed third party development in the vicinity of railway property. Network Rail is reliant on this notification process for proposed surface extractions, since it is not a statutory consultee on planning applications. On receipt of planning consent such sites are inspected periodically by the *Mining Team* to monitor compliance with planning consent and ensure the stability of railway property.

88 In 1982 planning consent was given for peat extraction adjacent to the railway above the cutting slope. In the 1980s, the British Rail property team was responsible for receiving and responding to Neighbour Notifications in Scotland. However, today there is no reference to peat workings in the region of Moy within the records.

89 In respect of restoration, Condition 5 of the grant of planning consent dated 4 October1982, states:

- 'the applicant shall ensure during the carrying out of peat extraction that areas which are worked out will be left in a satisfactory state, suitably drained, and capable of either afforestation or agricultural use, all to the satisfaction of the Planning Authority,' and ;
- 'during the course of all works shall ensure that any surface run-off from the site shall be suitably contained on the lower slope without detriment to adjoining land or the railway.'

90 In 1996 the Mining Engineer approached all Mineral Planning Authorities in England, Scotland and Wales for details of known surface mineral extractions within 200 m of railway property. Information received from The Highland Council provided details of a planning permission for peat extraction at Dalraich, Moy, the consent for which expired on 1 January 1993; consequently, the site was not inspected by the Mining Team.

91 No subsequent Neighbour Notification or equivalent has been received by the Mining Team for peat workings in the region of Moy. A subsequent enquiry made by the Mining Engineer on 15 February 2006 elicited confirmation that there had been no additional planning consents granted after 1 January 1993.

92 Discussions with the peat extractor indicated that peat extraction activities have been very limited since the 1980s probably being a few hours activity per week.

External Parties (parking area)

93 Discussions with the peat extractor indicated that in 1997 the then railway maintenance contractor constructed a local line access point and, in order to provide an associated parking area, widened the flat area along the boundary fence (outside of the railway boundary) above the cutting in the vicinity of where the landslip occurred. The widened area was surfaced with sub-base material and the drainage ditch that the peat extractor had claimed to have formed (directing water southwards to underbridge 296) was filled in. Network Rail has no records of works associated with the Parking Area construction.

Weather Conditions

94 The site video showed there was significant snow cover on the catchment area.

95 Rainfall data for Freeburn (a gauging station 5 miles to the south east of the cutting slope) showed the total annual rainfall for 2005 to be the highest for the period 1996-2005. However, although data for Coignafearn (a gauging station 9 miles to the south west) showed the total rainfall for 2005 to be amongst the highest for the same period, there had been 4 other years (1998, 1999, 2000 and 2004) when the rainfall had been similar or greater.

96 The hourly rainfall data for Freeburn showed an exceptionally high peak (of 35 mm; assessed as being a 1-in-105-year return period event) between 01:00 hrs and 02:00 hrs in the morning of 26 November 2005. A similar peak was recorded at Coignafearn one hour later. This corresponds with reports of a major storm during the night before the incident. The storm would have been moving south, passing over the cutting slope site within the hour before 01:00 hrs.

97 Temperatures measured at Aviemore, indicated a rise in temperature on 25 November, elevating it above freezing.

98 The wind speed recorded on the A9 at Slochd, some 10 miles (15 km) from the cutting slope, ranged from 3 to 10 knots between early afternoon on 25 November and the early morning of the 26 November. Variable gusts were observed of between 9 and 22 knots.

Slip Mechanism and Content

99 The Special Examination Report (TSER008/CIV/008) compiled by Donaldsons after the derailment reported that the failure left a slip bowl with a backscar some 4 m deep, 11 m wide and having an inclination of 80º (although subsequent discussion with the inspecting engineer indicated an inclination closer to 70º).

100 Slope stability calculations indicated that:

- the cutting slope was marginally stable under normal groundwater conditions;
- a high groundwater level would be needed for the cutting slope to fail in the manner observed;
- a smaller failure at the slope toe would precede the main failure at a lower groundwater level.

101 Site photographs taken after the incident showed the debris pile to contain the remains of several mature coniferous trees. It is evident that these had been rooted on the failed slope and had toppled as result of the landslip. The toppled trees were found with their crowns predominately aligned to the track; the deposited foliage being present in the upper part of the debris pile.

Figure 9: Still image taken from the forward facing CCTV showing the debris pile. *(Image: First Scotrail)*

102 Recordings from the forward facing CCTV on the leading vehicle of the train also confirmed the presence the conifer tree foliage in the upper part of the pile, Figure 9.

103 *Cyclical Examination* Reports compiled by Donaldsons for the cutting slope identified a previous minor failure and areas identified as 'erosion' on the cutting slope - close to the landslip location.

104 A post-incident geotechnical site survey showed evidence of a minor failure just north of the landslip location. (The location of this closely relates to that of one of the 'erosion' areas identified in the Cyclical Examination Reports)

Earthworks Inspection and Management

105 Network Rail's standard RT/CE/S/086 (NR/SP/CIV/086) 'Management of Existing Earthworks' defines the overall process for the identification and mitigation of risks associated with earthworks on their infrastructure.

106 The standard identifies a staged approach involving the key activity steps of *Listing and Identification,* Cyclical Examination, Evaluation and Assessment.

107 Listing and Identification involves capturing details of significant earthworks (meeting defined criteria) on a register.

108 The Cyclical Examination involves a visual inspection of the earthwork 'to record any signs of slope instability'. These examinations are carried out at regular intervals according to the identified condition of the earthwork. Three classifications of earthwork condition are used:

- *Poor*, requiring re-examination in 1 year;
- *Marginal*, requiring re-examination in 5 years, and;
- *Serviceable*, requiring re-examination in 10 years.

The process to be followed is defined in Network Rail standard NR/SP/CIV/065 'Examination of Earthworks'.

109 Evaluation is the appraisal of all relevant information and circumstances relating to the earthwork including its condition, use and location, in order to establish whether actions are required to ensure that the risks posed are acceptable. The actions that may follow an Evaluation include Assessment, monitoring, and carrying out designed remedial works, temporary works and management/maintenance works (for instance in respect of drainage, vegetation etc.). RT/CE/S/086 defines circumstances when an Evaluation needs to be considered. However, it does not define, or give guidance on, the process to be followed when undertaking an Evaluation.

110 Assessment is the determination of the stability of the earthwork by quantitative or qualitative means; this may necessitate site investigation (although this is not prescribed).

111 The standard makes additional requirements for Evaluations to be carried in the event that 'adjacent land is subject to ponding of the surface water', and also when there is a 'change in course of an adjacent watercourse'

112 The standard requires the assessment of *embankments* which are susceptible to instability or damage during flooding in order to decide if a specific management plan is needed in the event of a flood warning. Factors to be considered in the decision are defined. The plan would then define, for instance, the need for monitoring and the criteria for line closure. The standard makes no requirement for similar plans with respect to the general risk of instability of earthworks during heavy rain; or, significantly, with respect to the specific risk to cutting slopes arising from water infiltration during intense rainstorms.

113 Network Rail standard NR/SP/CIV/065 'Examination of Earthworks' (formerly RT/CE/S/065) states, in Section 10, that:
'The Earthworks Examiner shall physically walk over the surface of the…Soil Cutting… by means of traverses between the toe and crest at a minimum of 1 chain intervals. Where access is difficult consideration may be given to using aerial photography to gain information required in the appendices.'

114 Section 12 requires that the Examination shall include the recording of a specific list of observations on field datasheets and survey sheets contained in the appendices of the standard. The recorded observations are then used to calculate the Soil Slope Hazard Index (SSHI) for the earthwork.

115 The SSHI is Network Rail's standardised method of assessing the condition of earthwork with respect to risk of instability. It uses an algorithm which determines the risk of failure against 5 potential failure modes; rotational failure, *translational failure*, earthflow, *washout,* and animal burrowing.

116 The date after which earthworks examinations on Network Rail's infrastructure are required to comply with NR/SP/CIV/065 is stated as 4 April 2005. (However, the standard had been in development for a number of years prior to the incident and draft versions, containing very similar requirements, were in use within Network Rail).

117 Information from the TEDE showed that Donaldsons was awarded the contract for Cyclical Examination of earthworks within the Scotland Territory in February 2003. This included the cutting slope where the landslip occurred; it was identified as HGL2/YU044.

118 Donaldsons undertook three Cyclical Examinations before the incident. The first examination was undertaken on 5 November 2003. This was undertaken by helicopter aerial survey and not by walking over the slope. The survey was undertaken by a senior geotechnical engineer who flew in the helicopter, acting as *Earthwork Examiner*; landings were made to permit observation of particular interest at ground level.

119 The series of photographs taken on the aerial survey were first viewed in the office by a team of junior engineers working for Donaldsons and associated examination reports prepared. The reports underwent a multi-level review within Donaldsons involving more senior engineers. As part of this process a subjective decision was made regarding the earthwork condition.

120 Donaldsons recognised some of the human factor issues (for instance, loss of concentration and boredom) arising from long periods of photograph observation. The multi-level review process was adopted to mitigate the associated risks.

121 The Cyclical Examination report identified the condition of the cutting slope HGL2/YU044 as Poor and therefore requiring annual re-examination. A second Cyclical Examination was undertaken on 29 November 2004, again identifying the condition as Poor. A third examination, undertaken on 16 November 2005, also identified the condition to be Poor. Both subsequent examinations were carried out using the same aerial survey method.

122 The justification for adopting the aerial survey technique was primarily that, for Cyclical Examinations in Scotland, it offers an appropriate balance between cost and effectiveness. In comparison it was felt that the costs of undertaking all examinations on foot would be disproportionately high compared with the benefit gained.

123 The TEDE did not require the SSHI analysis to be undertaken as part of the Cyclical Examination as he did not consider the calculation algorithm to be reliable at the time because it was under development. However, the base information for the calculation - required by the field datasheets of NR/SP/CIV/065 - was actually collected. Although not used in an SSHI analysis, the base information was used as part of the process that was adopted to decide the earthwork condition (paragraph 119). The same information was not however used as a direct input to the Evaluation. (Although it is recognised there is no requirement in RT/CE/S/086 for this to be considered in an Evaluation, the general intent is to appraise 'all relevant information'.)

124 As the result of not undertaking an SSHI analysis, the Cyclical Examination reports compiled by Donaldsons for the cutting slope present information that only partly fulfils the requirements of Section 12 of NR/SP/CIV/065. Specifically the 'box' provided for the SSHI value is left blank and the field datasheets, which would have allowed its calculation, are omitted. The reports did, however, include diagrams of the observed features (in the form of Survey Sheets required by NR/SP/CIV/065); photographs and comments on a number of identified defects together with recommended management actions were also included.

125 The Cyclical Examination stage is used to identify candidate earthworks which could be at risk of failure; i.e. categorised as Poor. The process results in a large proportion of the number of earthworks being Poor (over 10% in the Scotland Territory). It is the purpose of the Evaluation stage to identify the reduced number of earthworks that are physically at risk and in need of mitigating actions.

126 Evaluation is undertaken by the in-house team reporting to the TEDE (using the Cyclical Examination reports compiled by Donaldsons) in order to determine its criticality with respect to subsequent actions. That a cutting slope is categorised as Poor is, in itself, not an indication of the criticality of the remedial work that may be needed.

127 The Evaluation of the cutting slope resulted in the Earthworks Assessment Engineer (reporting to the TEDE) reviewing, on 11 March 2005, the report from Donaldsons on the examination of 5 November 2003. Documented details were then transferred to the *Batch Summary* (in-house tabular summary of key aspects relating to identified earthworks within the territory) and Network Rail's planned management actions added. It is not evident that any other information sources were used as an input in compiling the Batch Summary.

128 The Batch Summary, used by the TEDE to record the status of earthworks and associated management activities within the Scotland Territory, located HGL2/YU044 on the *up cess* side of the Highland Line between 105 mls 68 yds and 106 mls 39 yds.

129 Network Rail's recorded management actions major on works associated with the condition and maintenance of the existing drainage system on the cutting slope. The actions are similar to those recommended by Donaldsons in their Cyclical Examination report.

130 The Evaluation did not appear to indicate any major concern with regard to the stability of the cutting slope. A drainage engineer, reporting to the TEDE, did visit the site in March 2005. No site records exist regarding the visit; however the TEDE recalls that no specific concern existed with respect to the overall condition of the crest drainage arrangement. As a result no remedial works were considered necessary for 2005-2006. No evidence has been identified that an Assessment was undertaken or considered necessary.

131 Two separate post-incident SSHI analyses were undertaken in accordance with NR/SP/CIV/065, one on the basis of the information available from the existing aerial survey and the other on the basis of information collected from a foot survey undertaken after the incident, under conditions simulating the practical constraints of a typical Cyclical Examination.

132 Comparison of the results from the two analyses indicated that more critical features were observed on the foot survey and that the resulting SSHI scores for the foot survey indicated a Poor condition for 3 out of 5 of the considered failure modes compared to 1 out of 5 from the aerial survey.

Wet Weather Response

133 Information from the TEDE showed that in July 2000, Railtrack issued a memorandum in Scotland implementing an instruction for the patrolling of embankments and cuttings during periods of adverse weather. It was titled 'Embankments and Cuttings – Arrangements During Adverse Weather Conditions'.

134 The instruction includes a *list of 'at-risk' embankments and cuttings* and a set of weather conditions (B, C and D) which are deemed to pose a risk. Weather condition B is defined as 'Heavy Rainfall'. Details of forecasting arrangements are included.

135 The list is used to identify sites requiring inspection when poor weather is forecast. It identifies the forecast area in which the embankment or cutting is located and the weather conditions creating the risk.

136 The instruction also defines the action to be taken according to the inspection findings.

137 The list has been revised in recent years. It now includes reference to Network Rail's defined *weather forecast areas* and *weather warning categories*. Cutting slope HGL2/YU044 was not included on the list at the time of the incident.

138 NR/CS/OPS/021 Issue 2 'Weather - Managing the Operational Risks' describes how Network Rail manages the operational risks arising from adverse and extreme weather events, including the use of weather forecast information.

139 Responsibilities are placed on Route/Area Operations Managers, Operation Safety Managers and Weather Strategy Coordinators to plan and implement arrangements for the management of weather related issues.

140 The standard defines different alert statuses. The Control Duty Manager or Duty Contracts Manager is to interpret forecast information taking into account local conditions and the state of the infrastructure and assign a status of alert for the following four days. The Operations Control is to notify all relevant parties including train operators, maintenance staff and Network Rail's national control.

141 It allows for special weather warnings in Scotland; *Weather Categories* B, C and D. In this standard Weather Category B is defined as a rainfall hazard.

142 It lists the potential consequences of weather hazards, including 'land-slide' and 'slope failure'. Reference is made to other documents for specific procedures to manage these hazards. Included are Railway Group Standards and Network Rail's Control Manual.

143 The Network Rail Control Manual gives guidance to the staff working in Operations Control on the actions to be taken in a variety of operational circumstances.

144 Section C22 defines guidance for 'managing the effects of the weather'. It includes guidance on forecasting arrangements aligned to that in NR/CS/OPS/021 Issue 2.

145 Specific guidance is also given on the actions to be taken following certain types of weather (e.g. wind).

146 Issue 3 was current at the time of the incident. It contained no guidance with respect to any consequence due to rain. Issue 4 has been revised to include guidance on flood risk; guidance on the general risk posed by earthwork instability remains absent.

147 It recommends Operations Control to have a register of 'high-risk' areas that can operationally affect the running of trains in poor weather.

148 The Network Rail Control Manual was developed to standardise the practices used by Operations Control, throughout the country. It replaces the local processes that were previously used.

149 The manual is not currently issued as a formal company standard but plans are in place to do so.

150 Witness evidence showed that the Operations Control works to the weather management process defined in Section C22 of the Control Manual. No additional rules or instructions are adopted. The Control Manual replaced the Regional Safety Manual that was previously used in Scotland.

151 It also showed that Operations Control has a register of 'high-risk' areas related to a number of key weather hazards, for example low rail adhesion. They do not make use of an equivalent list for earthworks which are at risk of failure.

152 *Infrastructure Control* in Scotland is responsible for responding to risks and faults affecting Network Rail owned infrastructure. This includes the risk of earthwork failure.

153 The Infrastructure Control team report into Network Rail's maintenance organisation. Prior to July 2003, they were part of First Engineering who was then sub-contracted to provide maintenance services in Scotland.

154 The Infrastructure Control is co-located with the Operations Control.

155 The Infrastructure Control liaises directly with the Operations Control in response to the forecast of poor weather. Local track maintenance teams are then notified that inspection of known 'at-risk' embankments and cuttings should be considered. The local teams are then responsible for deciding whether and how to respond. Observations from any inspections carried out are fed back; collated information is sent to the TEDE.

156 In executing the above duties, the Infrastructure Control has continued to follow the intent defined in First Engineering's procedure RE/M001/23.

157 RE/M001/23 is no longer under formal change control as it is not a formal Network Rail document. Informal arrangements are in place to manage changes to key information: for instance the addition/deletion of earthworks to the list of 'at-risk' embankments and cuttings that is used. Changes to this list are made by the TEDE.

158 There are no known alternative Network Rail defined procedures to RE/M001/23.

159 First Engineering's procedure RE/M001/23 references the special Weather Categories used by Network Rail in Scotland. It includes a list of 'at-risk' embankments and cuttings and the actions that are expected of the local teams in response to inspection findings; for instance a request for a speed restriction or line blockage. A reporting process is defined together with the means of escalating matters if mitigating actions cannot be decided.

160 Information presented to Network Rail's Formal Investigation showed that, over the days preceding 26 November there had been ongoing communication between Network Rail and the Met Office. At 21:22 hrs on 25 November the Met Office contacted Operations Control to report a weather warning.

161 It also reported that the *Maintenance Delivery Unit Manager* confirmed that a member of staff had attended known sites in Morayshire at 04:00 hrs on 26 November.

162 Voice recordings from the control room showed that the Met Office passed a forecast of 'heavy rain' moving into the 'Elgin to Morayshire areas' to Operations Control.

163 Infrastructure Control called three local maintenance teams to request that known sites be inspected before the first service train of the next day. The message requested the inspection of known flood-sites in the Elgin and Morayshire area.

164 It was agreed that only one of the teams needed to conduct inspections.

165 The other two teams said that they did not cover any sites in the Elgin and Morayshire area. As a result it was agreed that inspections were not required. One of these two teams advised that they covered a known site located at Slochd. The site is around 15 km from the cutting slope near Moy.

Derailment and Subsequent Damage

166 Site photographs taken after the incident showed that the leading vehicle of the 3-car train derailed all wheels to the right, the down cess. The vehicle came to rest in an upright position. Both trailing vehicles remained on the track.

167 Vehicle inspections carried out at the depot in Inverness (28 and 29 November 2005) and also at Bombardier Transportation works in Crewe (2 February 2006) observed the following with regard to damage and debris impact on the leading vehicle:

- damage to the head of the leading coupler and cab valence (more significant on the left hand side);
- deformation of enclosure plates forward of the *obstacle deflector*, deposition of soil, and damage and detachment of equipment fitted underneath the cab; Figure 10 shows the damage to the underside of the leading cab, by contrast Figure 11 shows the underside of the trailing cab which did not directly encounter the debris pile;
- paint distress on the cab and leading passenger *doorway stiffeners* indicating major structural loading;
- deposition of soil and structural damage on underframe mounted equipment toward the trailing bogie (toward the leading bogies the equipment remained relatively clean and undamaged);
- deposition of soil and distortion of a *secondary traction link* on the trailing bogie;
- deformation of the AWS support bracket on the leading bogie indicating that it ran pressed against the inner face of the down cess rail, Figure 12;
- contact marks and corresponding underframe structure damage showing that the coupler connecting the leading vehicle to the following vehicle had been subjected to high lateral forces which caused it to *yaw* to the right hand side; the coupler remained connected.

Figure 10: Underside of leading cab showing damage as a result of encountering the debris pile.

Figure 11 : Underside of trailing cab.

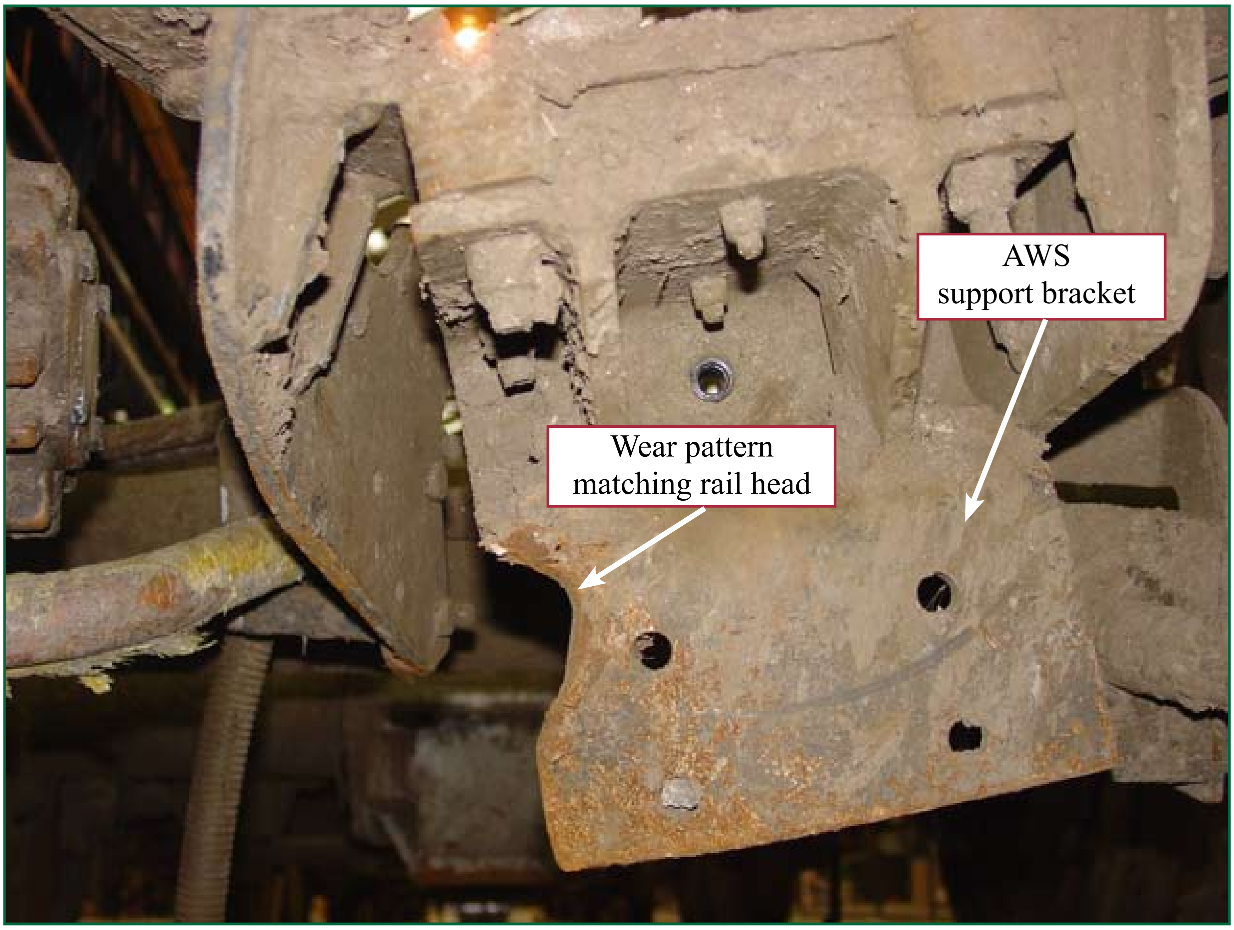

Figure 12: AWS support bracket on leading bogie.

168 Site inspection undertaken on 28 November identified damage to sleepers and *rail fastenings* from less than 1 m past the south end of the backscar. These are consistent with them being run over by a wheel flange. The damage on the sleepers extended to the point at which the derailed wheels had come to rest.

169 OTMR records showed that the train was travelling at 56 mph (90 km/h) and that the driver applied the emergency brake prior to encountering the debris pile. From the data recorded, the estimated train speed on hitting the debris pile was 52 mph (84 km/h).

170 The recording from the forward facing CCTV on the leading vehicle showed that the train encountered the debris pile at 07:02 hrs. It showed the debris pile to be higher on the side of the up cess.

Train Evacuation

171 Site photographs taken after the incident showed that the primary system (key operated budget locks) used to retain the released passenger saloon ceiling panel had been correctly operated. The lanyards which provide secondary retention had also been fitted. However, the metalwork surrounding the holes used to anchor the lanyards had fractured causing the lanyards to break free, Figure 13.

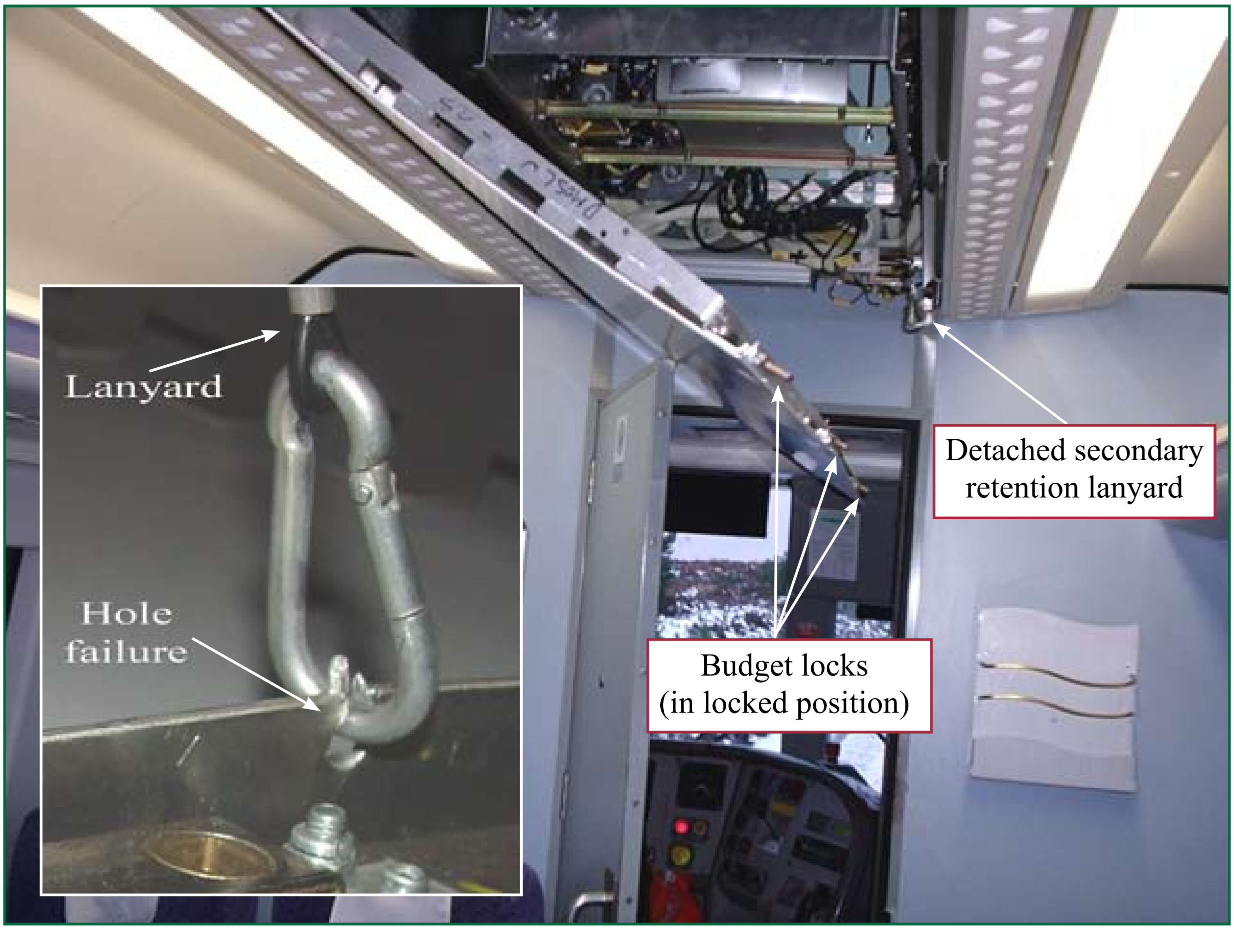

Figure 13: Ceiling panel showing failed secondary retention facility. *(Main photograph: First Scotrail)*

172 After the derailment the driver was unable to gain unaided access to the passenger saloon behind him. This was because the ceiling panel behind the door had lowered during the derailment, preventing the access door from being opened. Assistance from train crew in the saloon was needed to enable access.

Analysis

Infrastructure Condition (track system)

173 The evidence from the TRV records and the post incident site investigations indicate that neither track geometry nor track components contributed to the cause of the derailment.

174 No maintenance had been considered necessary or carried out on the track, drain, structures, earthworks or fencing in the preceding 3 months and therefore the landslip was not initiated by recent changes to the railway infrastructure.

Infrastructure Condition (drainage)

175 The groundwater profile present in an earthwork has a major influence on its ability to resist failure. It is therefore necessary to understand how water may infiltrate into the body of the cutting slope. The key factors influencing this are the drainage (natural and man made) and the permeability of the earthwork.

176 The peat extraction and the installation of roads and hard standing and parking areas have had a significant effect on the natural drainage characteristics of the catchment. In particular, the stripping away of heather vegetation has significantly increased the rate of surface water run-off (paragraphs 58, 67 and 73).

177 Surface run-off is collected by Watercourses A, B, C and D, see Figure 4.

178 Watercourses A and B discharge water away form the cutting slope and do not present an infiltration risk to the slope. Watercourse C takes water toward the cutting slope but its subsequent discharge into a free flowing V-drain means that it too does not present an infiltration risk.

179 Watercourse D has arisen due to natural erosion occurring in the upstream section of Watercourse C. Historic photographs from earthworks inspections show it to provide a flow path which is only evident during excessive rain.

180 Watercourse D directly discharges onto the permeable Parking Area. Some water runs off towards the northern end (a part of which then breaches the boundary fence). However, the majority of the water appears to infiltrate into the ground due to the absence of an engineered drain. The tyre ruts and tide marks on the Parking Area suggest a construction having a natural tendency for the accumulation of standing water. None of the water from the Parking Area flows into the Network Rail crest drain running alongside and to the south of the boundary fence breach, evidenced by the collection of snow and pine needles (paragraph 61).

181 Some of the water which runs off the Parking Area enters the blocked Network Rail crest drain (paragraph 63) which is leaking due to the presence of the observed 'sink hole'. All of this water infiltrates into the cutting slope via the leaking drain. None of the water spills over the crest drain to run down the slope.

182 Watercourse D therefore poses the main risk with regard to infiltration into the cutting slope. None of the engineered drainage systems, on either side of the railway boundary, were effective in managing the discharge from Watercourse D and preventing infiltration into the cutting slope.

183 Additionally, the lack of a *cess* drain, evident by the lack of an outfall in the north abutment of underbridge 296, meant that there was no means of moderating any rise of the groundwater level.

184 The lack of an adequate drainage arrangement on the Parking Area results in it acting as a sink, allowing water to infiltrate into the cutting slope. This is considered to be a cause of the landslip.

185 Earthworks are also at risk from surface water flows. There were no cutting slope collector drains, which are often provided to mitigate the effect of this.

<u>Infrastructure Condition (soil profile)</u>

186 Site investigation and geotechnical observation indicate the cutting slope soil to be glacial till comprising a relatively densely packed mixture of cohesive and granular material. It is made up of relatively equal proportions of clay, silt, sand and gravel with occasional cobbles and boulders.

187 The glacial till is likely to behave as a bound material when in its dense state, but appear granular when loosened. This type of behaviour is consistent with the observed failure mode; that is the soil is of a type which, when bound, exhibits rotational failure, and when granular, earthflow failure.

188 The glacial till is considered to have a relatively high permeability for its type, evidenced by the short time taken for the backscar to dry out, therefore readily supporting water seepage. This permeability is further evidenced by the fact that the debris, which was initially described as too wet to walk on, must have been able to rapidly drain so that it was firm enough by the time of the Special Examination.

189 The gravel pockets identified are likely to promote localised groundwater seepage paths within the cutting slope. It is possible that the infiltration via the ‘sink hole’ identified in the Network Rail’s crest drain is through one of these paths.

<u>Infrastructure Condition (groundwater profile)</u>

190 The groundwater seepage calculations demonstrate that, for permeability values in the upper range (for this type of glacial till), the groundwater profile would rise rapidly in response to infiltration into the Parking Area, Figure 14. Even at the lower end of the range, there would be a significant rise in groundwater level.

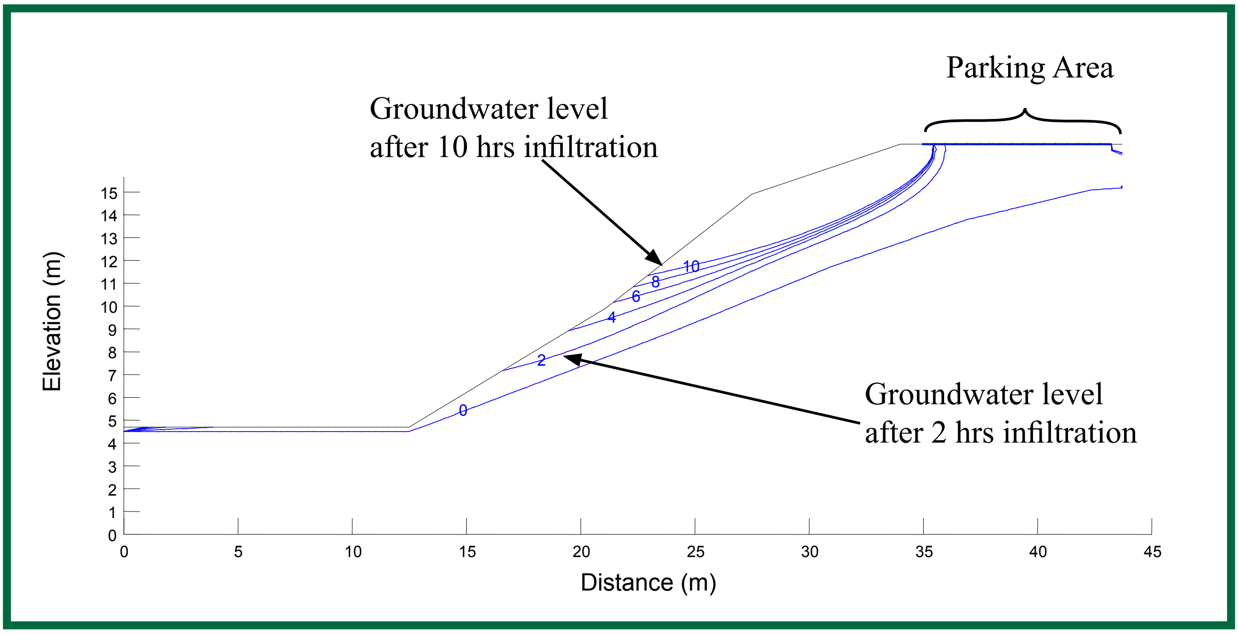

Figure 14: Seepage calculation showing rise in groundwater level in response to infiltration on the Parking Area.

191 The above discussion regarding the soil profile indicates that the glacial till did have a relatively high permeability. There may have been some lower permeability areas. However, the evidence of gravel pockets indicates supplementary seepage paths which would have also aided a rapid rise.

192 The wetness on the face of the backscar immediately after the incident - it was observed as 'sweating' by the Site Witness - is further evidence that the groundwater profile had risen to a high level.

193 The permeability of the soil in promoting a rapid rise in the groundwater profile is contributory to the landslip.

194 The water entering the cutting slope via the blocked and leaking crest drain would have added to the rise.

External Parties (land use)

195 The primary relationship between Network Rail and third parties regarding mineral extraction is via the ME, as explained in paragraph 85.

196 The continued peat extraction was not subject to the procedure described in NR/SP/CIV/037, since it should have ceased prior to the process first being adopted.

197 In 1996, the ME was made aware that peat extraction had been undertaken and that planning consent had expired. It was mistakenly assumed that the extraction activity had ceased and that the land had been restored. No action was therefore taken to visit the site and assess whether the workings had been left in an acceptable condition. If a visit had been undertaken the fact that the land had not been restored would have been identified, potentially prompting the need to assess the local drainage arrangements.

198 British Rail was a statutory consultee for planning applications, but this arrangement was not transferred to Network Rail following railway privatisation. Notwithstanding this, Network Rail is informed about changes of use to neighbouring land on an irregular basis. The manner in which they were informed of the consent for peat extraction at Moy is uncertain. If Network Rail was a statutory consultee for planning permission within the vicinity of the railway it would ensure that they are made aware of changes that may have an impact on their infrastructure. (Although on this occasion it would have made no difference as the planning consent had expired.)

199 Network Rail was therefore unaware of the continued peat extraction and therefore the likelihood of increased run-off from the land because it had not been restored. This is considered to be contributory to the landslip.

External Parties (parking area)

200 There are no records concerning the construction of the Parking Area.

201 Whilst it is recognised that no evidence can be found to support the claim (paragraph 93) that a drain taking run-off flow southwards to underbridge 296 was filled in as a result of the widening of the Parking Area, it is evident that there is no engineered drain to prevent water infiltrating into cutting slope.

202 There appears to have been no requirement for the contractor widening the hard standing area to consult with the engineer responsible for the cutting slope. If consultation and/or approval had been required then the need for additional drainage should have been identified. The lack of need for consultation with the earthwork asset steward regarding the construction of railway installations is considered contributory to the landslip.

Weather Conditions

203 The regional groundwater profile is influenced by medium to long term rainfall patterns. It is normal practice to consider the effects of average rainfall over periods of 12 months or more. The rainfall data (paragraph 95) for the region would therefore suggest that the regional groundwater profile at the cutting slope would have been relatively high (but not necessarily the highest that it had been for many years).

204 The already high regional groundwater profile at the cutting slope is considered contributory to the landslip.

205 The rainfall data indicates that the catchment experienced an intense one hour period of rainfall six hours prior to the derailment, establishing Watercourse D (paragraph 96).

206 Rain would also have fallen directly on the cutting slope, adding to the saturation of the top soil.

207 The high intensity rainfall from the storm is causal to the landslip.

208 There was a general rise in temperature on 25 November 2005, elevating it above freezing. This would have initiated thawing conditions so generating flows of melt water which added to surface run-off due to the storm.

209 It would also have generated melt water from snow present in the trees rooted on the cutting slope. This would have fallen directly on the cutting slope, adding to the saturation of the top soil.

210 The rise in temperature during the presence of significant snow cover is considered contributory to the landslip.

211 According to the Beaufort scale, the local wind was varying between Force 1 ('Light Air') and Force 3 ('Gentle Breeze'). Force 3 is considered indicative of leaves and twigs in motion. By comparison, whole tree motion is not anticipated until Force 7. It is considered that the wind had no significant bearing on the toppling of trees or the stimulation of motion sufficient to initiate an event from which the failure of the cutting developed.

The Slip Mechanism and Content

212 The slope stability analysis undertaken indicates that the slope is stable, albeit only marginally, during normal conditions.

213 Evidence from the Special Examination indicates that a deep failure occurred, similar in nature to a rotational failure. The slope stability analysis shows that a failure of this magnitude would require a high groundwater level, see Figure 15.

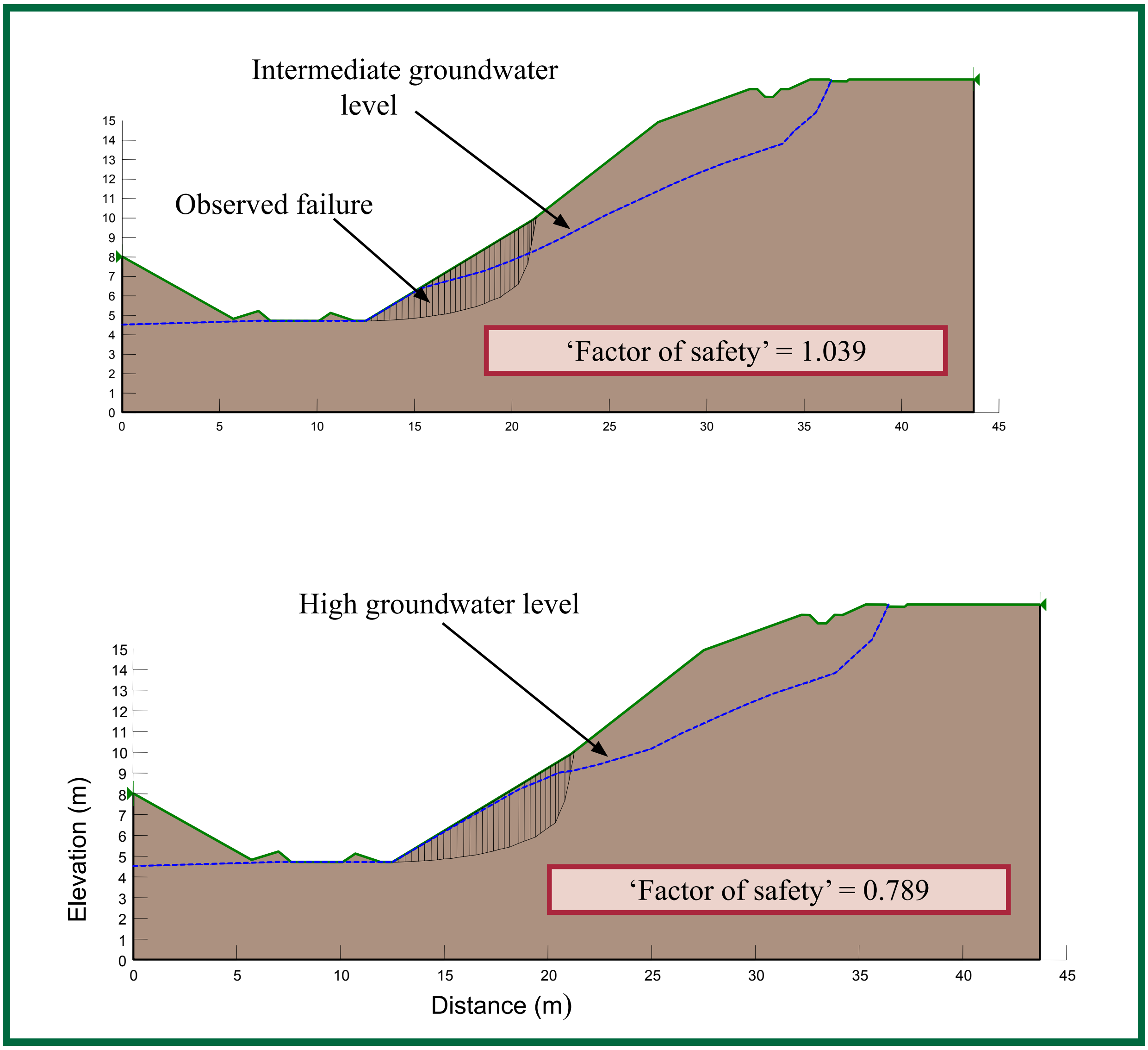

Figure 15: Slope stability calculation for the observed failure with assumed high and intermediate groundwater levels. Factor of safety of less than 1 indicates instability.

214 The seepage analysis undertaken demonstrates that infiltration from water collecting on the Parking Area would result in a significant rise in groundwater level on the slope surface. The Parking Area would have been flooded as a result of the intense rainfall and surface run-off.

215 The slope stability analysis indicates that as the groundwater level rises, a small rotational failure would be expected at the toe of the cutting slope before the groundwater level reached a height sufficient to result in a failure of the magnitude observed. This is shown in Figure 16. Additionally, the predicted small failure would not have exhibited the steep backscar found at the site.

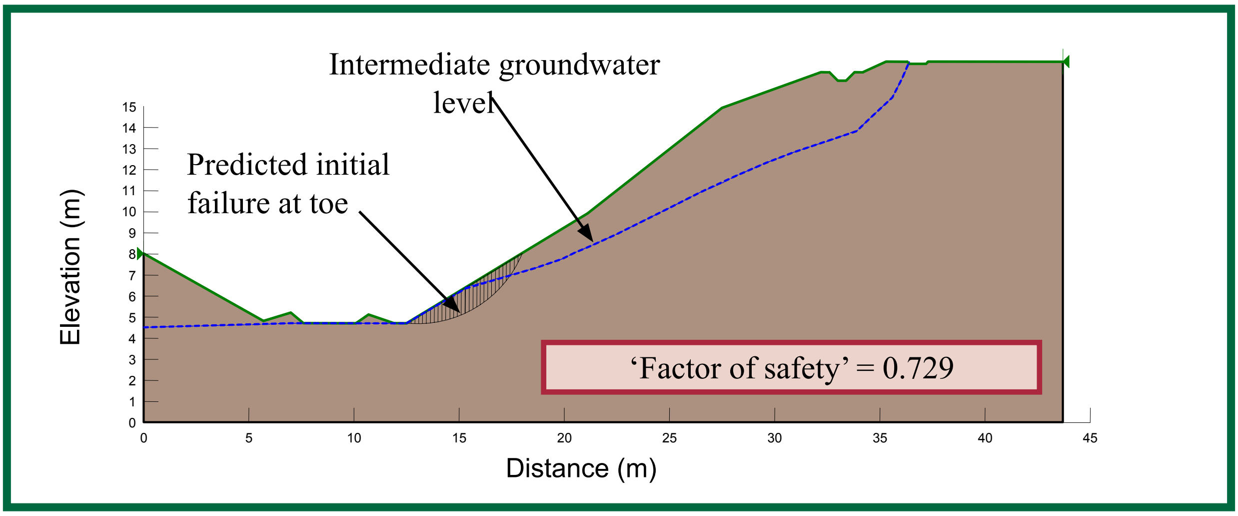

Figure 16: Slope stability calculation indicating likelihood of a small failure on the cutting slope toe at an intermediate groundwater level.

216 This small slope failure resulted in a disruption of the groundwater flow paths and allowed surface water to enter the ground via tension cracks. These two effects resulted in a further rise in the groundwater profile over the lower slope, fully saturating it and causing the loss of any previous stabilising suction pressures. The groundwater level continued to rise.

217 When the groundwater level reached a sufficient height it initiated a deep complex rotational type failure mechanism. During the initial stages, whilst bound, the earth moved as competent solid blocks. However, the movement - due to the saturated nature and low fines content - caused the material to became unbound and experience a rapid loss of strength; as a result, the mechanism developed into an earthflow.

218 The soil continued to flow across the cutting until it reached the toe of the opposite cutting slope. Once the flow movement stopped the water within the material was able to drain leaving a mixture of granular and cohesive material on the track up to a height of between 1.2 and 1.5 m. The orientation (crowns predominantly toward the track) of the trees remaining within the debris pile, indicates that the only obstruction that they may have presented to the train would have been their upper branches and light foliage, Figure 17.

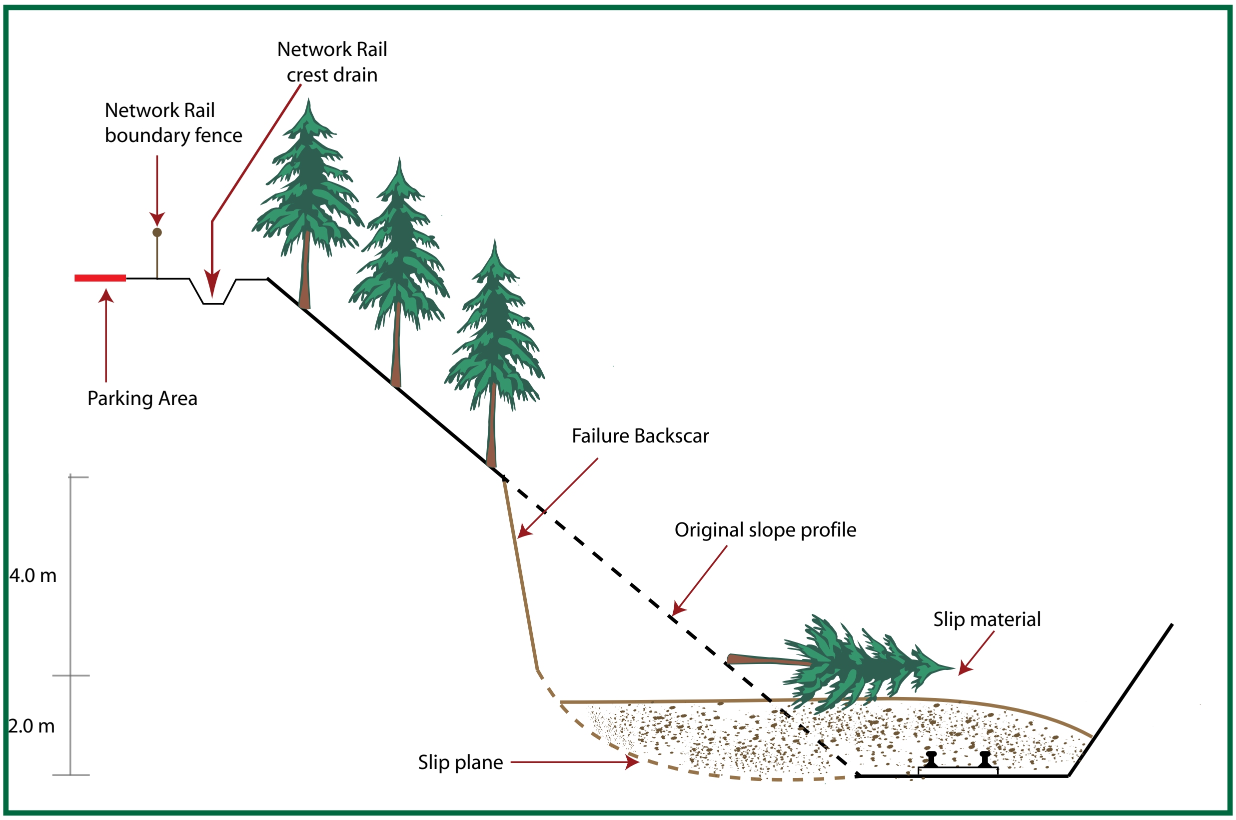

Figure 17: Observed landslip.

219 This mode of failure is consistent with the trees falling forward down the bank – i.e. due to the earthflow. A pure rotational failure would have resulted in them falling backwards against the bank.

220 Additionally, this mechanism supports the landslip happening on this particular day, recognising that the regional groundwater level was probably not significantly higher than it had been during previous wet periods. (The snow melt and extreme rainfall event would have resulted in significant water ingress via the tension cracks, further increasing the groundwater level.)

221 In summary, the seepage and slope stability analysis undertaken indicates that flooding of the Parking Area resulted in a rise in groundwater level that was sufficient to cause a small slope failure at the slope toe which led to conditions sufficient to initiate the larger failure.

222 It should be appreciated that although there are several pieces of evidence that support this mode of failure and none that contradict it, engineering geology phenomena are complex and largely unseen and therefore there will always remain a degree of uncertainty as to the precise failure mode

223 There is some evidence of previous minor failures on the cutting slope. It is uncertain whether these are of the same nature as the small slope toe failure described previously.

Earthwork Inspection and Management

224 Cyclic Examinations undertaken on HGL2/YU044, the earthwork comprising the failed cutting slope, identified its condition to be Poor.

225 However it is important to appreciate that the Cyclic Examination is used to identify earthworks which could be at risk of failure. It is the purpose of the Evaluation to identify the reduced number earthworks that are physically at risk and therefore in need of mitigating action.

226 To enable an accurate Evaluation and the correct course of management action to be adopted it is vital that the evaluating engineer has all of the information to understand the importance of individual and detailed failure indicators. The quality of the information flowing through the inspection and management process is therefore key to ensuring suitable priority is given to individual cuttings. In the case of earthwork HGL2/YU044, even though the cutting slope was classified as Poor, no action was taken to address the weaknesses of the earthwork and the associated drainage.

227 The Cyclical Examinations undertaken did not fully comply with NR/SP/CIV/065. Although compliance with the standard was not mandated on the relevant dates of all three examinations, it was widely adopted as best practice, indeed RT/CE/P/030, the predecessor to RT/CE/S/086 makes reference to the applicability of its forerunner, RT/CE/S/065.

228 The examinations were non-compliant on two main counts. Firstly, the general adoption of aerial surveys for Cyclical Examinations of soil slopes in the Scotland Territory, and secondly the full SSHI methodology was not adopted.

229 It is recognised that there are a number of potential benefits in using aerial surveys for conducting Cyclical Examinations in Scotland. In addition to cost benefit, it alleviates the problems associated with the many sections of line where red zone working is prohibited, and access points are remote. It also enables a more senior and experienced geotechnical engineer to directly observe the earthwork. Foot surveys are generally undertaken by more junior staff, the observations of which are reviewed by senior engineers. (However, by necessity, the latter approach tends to reinforce the collection and recording of a broad spectrum of raw data, avoiding the temptations of filtering through subjective assessment.)

230 It is further recognised that NR/SP/CIV/065 allows for consideration to be given to using aerial photography to gain information where access to the slope is difficult.

231 However, the comparison of post-incident SSHI analyses indicated that aerial surveys maybe less effective in identifying critical features and subsequent stability assessment may indicate vulnerability to fewer failure modes.

232 In Scotland aerial photography is the preferred choice and, it is acknowledged, that in some parts it may be the only practicable means of examination. However there does not appear to have been any formal evaluation of the risks/cost benefit of adopting this approach. The potentially reduced level of detail collected by aerial survey is likely to have contributed to the landslip.

233 Network Rail's introduction of the SSHI approach to identifying Poor and Marginal earthworks provided objective criteria for assessing their condition. This allowed for a more consistent approach to the Examination, and also resulted in standardised data being available throughout all phases of the earthworks management process. The approach adopted in Scotland relied largely on the experience of the engineer in the helicopter. It is recognised that the speed of coverage by this approach allows for a more experienced/qualified engineer to undertake the survey. However, greater reliance is placed on subjective observation and interpretation which could restrict the quality of the raw data recorded and ultimately, the information available for consideration at the Evaluation stage.

234 Not undertaking an SSHI analysis, resulting in no standard means of being able to objectively compare the relative risk from different earthworks, is also likely to have contributed to the landslip.

235 Not fully adopting the SSHI methodology (nor, correspondingly, considering the base survey data collected for its calculation) reduced the amount of useful information which could otherwise have been available for the Evaluation.

236 The report from the Examination was reviewed by the team reporting to the TEDE and the conclusions transferred to the Batch Summary sheet. While NR/SP/CIV/065 describes a detailed process for the collection and analysis of data in the Examination phase, there is no formal process or criteria (for instance, with respect to the information that should be considered) to support the Evaluation phase. This lack of criteria and the reduced amount of information considered, resulted in this phase of the overall process being of limited value. This is evidenced by what appears to be a simple read across of the recommendations from the Cyclic Examination report to the Batch Summary. The lack of process associated with the Evaluation phase is contributory to the landslip.

237 A number of failure indicators are identified in the Cyclic Examination reports. However, the information on the Batch Summary and the decision to send a drainage engineer to site suggests that concern centred only on the condition of the Network Rail crest drain. It is considered that if a decision had been made to undertake an Assessment of the cutting slope (and to send a geotechnical engineer to site as part of the process) it is highly likely that the slope's condition would have led to identification of the inadequacy of the drainage associated with the Parking Area (paragraph 184). This would have raised the need for remedial works.

238 The inadequate drainage of the Parking Area going undetected is causal to the landslip.

239 The decision not to undertake an Assessment, and not send a geotechnical engineer to site as part of the Assessment process, is considered to be contributory to the landslip.

240 If the Cyclic Examination had included a fully compliant SSHI analysis, more information would have been readily available to support the decision of whether to conduct an Assessment, the need for a site investigation, and also what to observe.

Wet Weather Response

241 Control arrangements for managing the operational risks associated with weather reports are (and were formerly) split in Scotland between Operations Control and Infrastructure Control. The two functions are co-located in a single control room.

242 The procedures and guidance used by Operations Control have changed in recent years; local processes have been replaced by new national equivalents. Of relevance is the Network Rail Control Manual and the company standard for the management of weather hazards (NR/CS/OPS/021) (paragraphs 138 to 147). Neither of these gives specific guidance on managing earthwork instability risks in poor weather. (NR/CS/OPS/021 makes reference to a number of earthwork related standards but these have either been withdrawn or are in the process of being so. It does not reference the current Network Rail standard RT/CE/S/086, 'Management of Existing Earthworks').

243 It is probable that specific guidance on earthworks risk, which may previously have been available to Operations Control, was lost as a result of this change.

244 Infrastructure Control is organisationally independent of Operations Control. They have their own processes and guidance and, significantly, do not use the Control Manual.

245 They have continued to adopt processes developed by First Engineering. These include a weather management process (RE/M001/23) which uses a list of 'at-risk' embankments and cuttings to identify sites for which inspections should be considered; the overall approach is similar to that of the previous process in Scotland (paragraph 133).

246 The weather reporting aspects of the processes used by both control functions are consistent; they both use the standard Network Rail terminology for weather forecast area and warning category (including special Scotland Weather Categories B, C and D).

247 The evidence in paragraphs 133 to 159 and the analysis above shows that there is not a single formal set of procedures or guidance for managing the operational risks posed by earthworks instability during poor weather. Despite this, in practice, the local working arrangements and processes adopted by the individual Operations and Infrastructure Control teams combine to provide a pragmatic alternative. Furthermore, this alternative is aligned with earlier instructions that were formally adopted in Scotland.

248 The list of 'at-risk' and embankments and cuttings is now managed by the TEDE. Comparison shows that there is no significant difference between the current issue (August 2006) and that in the First Engineering specification RE/M001/23 (dated 30 July 2001).

249 The risk of failure posed by earthwork HGL2/YU044 near Moy was not considered sufficient enough for it to be included on the list of 'at-risk' embankments and cuttings.

250 The omission of the cutting slope from the list of 'at-risk' embankments and cuttings is contributory to the derailment.

251 Network Rail standard RT/CE/S/086 implies that the risk of flooding needs to be taken into account when compiling such a list (paragraph 112). However, it makes no similar requirement with respect to the type of water infiltration risk observed at Moy. If such requirements were developed and included in RT/CE/S/086, better guidance would be available in the future for establishing and managing such lists.

252 Over the days preceding 26 November there had been ongoing communication between Network Rail and the Met Office and at 21:22 hrs on 25 November the Met Office called Operations Control to advise of a weather warning in the Elgin and Morayshire area. Infrastructure Control then called the local track maintenance teams to request the inspection of known sites in the areas that they cover.

253 None of the communication calls used the defined Network Rail forecast terminology, neither for the weather warning category nor the forecast area. The warning of 'heavy rain' moving into the 'Elgin to Morayshire areas' was passed onto the local track maintenance teams as a request to inspect only known flood-risk sites located within the Elgin and Morayshire area. The ensuing discussions showed that clarification was needed to decide whether the inspection request was applicable to the area they covered.

254 It was decided that no inspections were required by the team covering the identified 'at-risk' site at Slochd (a site close to Moy). A decision was made, following an agreed consensus, that the team did not cover any known sites in the notified area.

255 Both the site at Slochd and cutting slope lie in Network Rail forecast area SC6. Elgin lies inside area SC7, but is close to the boundary with SC6. Morayshire straddles the boundary. It is likely therefore that the forecast was strictly applicable to both forecast areas. If the forecast had been requested, on this occasion, to be reported and communicated using the defined terminology, it might have been identified as applying to a wider geographical area.

256 Similarly, if the defined weather warning terminology had been used, it may not have been interpreted solely as a flooding risk.

257 The approach adopted by Network Rail after the conversation with the Met Office resulted in the forecast rainstorm being considered on too narrow a basis both in terms of its consequence and the area to which it applied.

258 The failure to consider that the rainstorm could generally affect the stability of 'at-risk' cuttings and embankments near Moy is contributory to the derailment.

259 If the forecast had been reported as a Weather Category B warning affecting both areas SC6 and SC7, then information would have been available to directly use the list of 'at-risk' embankments and cuttings. This would have identified the need to inspect known 'at-risk' sites in the vicinity of Moy.

260 In spite of the above, it is recognised that the need for site inspections was agreed in a timely manner and that the request was made to complete these before the first service train of the next day. Furthermore inspections were made; these all related to known problem sites in the Morayshire area.

261 The above contributory factors (paragraphs 250 and 258) work together. If the effect of the weather warning had been considered on a wider basis, and if the cutting slope at Moy had been included on the list of 'at-risk' embankments and cuttings, then action could have been taken to identify the landslip before the passage of 1B08.

262 It is noted that a number of the processes involved in the managing the response to wet weather are not formally adopted. This is likely to limit the degree to which implementation can be mandated or audited.

Derailment

263 All the wheelsets on the leading vehicle derailed to the down cess. The two following vehicles remained on the track. Damage to the sleepers and rail fastenings showed that the derailment occurred within 1 m of the southern extremity of the landslip.

264 The deposits of soil and stone, and damage observed on the underside of the cab structure indicate that soil accumulated in front of the obstacle deflector. Paint distress on the solebar stiffeners under both the cab and leading passenger doorways suggest that the soil accumulation provided vertical support under the cab. This would have tended to unload the wheels on the leading bogie.

265 That more damage was observed on the up cess side of the front of the vehicle is consistent with the debris pile being higher on that side (paragraph 170). The differential in height would have been likely to result in a lateral force being applied to the front of the vehicle in the direction of the down cess.

266 This combination of wheel unloading and applied lateral force is significant as it would have promoted derailment of the leading bogie. That the leading bogie derailed to the down cess, gives additional weight to the probability that the above mechanism initiated the derailment.

267 The damage profile found on the AWS support bracket fitted to the leading bogie suggested that it been in running contact with the *four foot* face of the down cess rail. It is probable this would have contributed in guiding the derailed bogie and hence limiting its deviation from the track.

268 A relative lack of soil debris on the leading bogie, and the forward part of the vehicle underframe behind it, shows that the obstacle deflector shielded parts of the vehicle immediately behind it. It also suggests that it had been effective in reducing the height of the debris pile to be encountered by the rear of the vehicle.

269 Damage and soil on parts of the underframe mounted equipment in front of the trailing bogie indicates that these subsequently came into contact with the remains of the debris pile. The damage on key items of equipment suggest that this contact resulted in establishing a second vertical support point, this time in front of the trailing bogie. This, would have helped unload the wheels on the trailing bogie, which would have been drawn into derailment by the preceding bogie running derailed.

270 Damage on the coupler connecting the leading vehicle to the second vehicle, and that it remained connected, suggests that it would have helped in guiding the rear of the vehicle, hence assisting in the reducing the consequences of the derailment.

271 The presence of only light upper branches in the path of the train indicates that the toppled trees did not contribute to the derailment.

Train Evacuation

272 The ceiling panel adjacent to the cab was released during the derailment, preventing the driver from being able to open his door and gain unrestricted egress into the passenger saloon.

273 The forces involved in the derailment were sufficient to overcome the integrity of two retention systems. Had only the first failed the ceiling would have lowered to a position which would have enabled the door to be opened.

274 The failure of the second system was due to fracturing of the metal frame into which securing holes for the retaining lanyards were drilled.

Conclusions

<u>Derailment</u>

275 The immediate cause of the derailment was the train running into material deposited on the track as a result of the cutting landslip.

276 In addition, the following factors were contributory to the derailment:

- the approach adopted by Network Rail following the forecasting of the approaching rainstorm resulted in the forecast being interpreted solely as a flooding risk affecting too localised an area;
- the cutting was not on the 'at-risk' list of earthworks.

277 The leading vehicle remained upright after derailing and did not deviate significantly from the track. It is likely that secondary guidance provided by a bracket on the leading bogie (not designed for this purpose) assisted in this.

278 The balance of evidence indicates that the landslip occurred because the groundwater rose to a high enough level to promote a small failure at the slope toe, that caused a disruption to flow paths, that resulted in the groundwater rising to a sufficiently high level to initiate a larger deep rotational failure. The groundwater level was high because:

- the excessive rainfall during the preceding hours, which initiated Watercourse D, the flow of which was intercepted by the Parking Area;
- the lack of adequate drainage on the Parking Area resulting in it acting as a sink and allowing water infiltration into the cutting slope;
- the inadequacy of the drainage on the Parking Area was unnoticed.

279 In addition, the following factors were considered contributory to the failure of the cutting slope:

- snow melt as a result of a recent rise in temperature contributing to the discharge on to the parking area;
- soil permeability properties promoting a rapid rise in groundwater level;
- the already relatively high regional groundwater level as a result of the rainfall over the previous 12 months;
- Network Rail was unaware of the continued peat extraction and that the land had not been restored to its natural state, and therefore the likelihood of increased runoff from the land;
- lack of need to consult with the Railtrack earthwork asset steward when constructing the parking area;
- the decision not to undertake an Assessment and not to send a geotechnical engineer to site as part of the Network Rail earthwork management process;
- the general implementation of aerial surveys for the Cyclical Examination of earthworks (not compliant with RT/SP/CIV/065), resulting in the identification of fewer critical features and a reduction in the ability of a subsequent SSHI analysis (if it had been undertaken) to indicate all of the failure mechanisms for which the cutting slope was at risk;

- not undertaking an SSHI analysis (not compliant with RT/SP/CIV/065), resulting in no standard objective means of comparing the relative risks from different earthworks;
- the lack of a consistent process and criteria for undertaking the Evaluation phase of the earthworks management process.

Train Evacuation

280 The only significant issue was the release of a ceiling panel which prevented driver egress from the cab through to the passenger saloon. This was due a weakness in its secondary retention facility.

Actions already taken or in progress

281 Network Rail has repaired the cutting slope. The failed material was excavated and removed. A gabion retaining wall, comprising stone filled wire baskets, was constructed in the cess. This was backfilled with suitable rock in order to support the failed slope.

282 Minor works have been undertaken to clean out and re-instate the existing Network Rail crest drain.

283 As part of the Cyclical Examination of earthworks, Network Rail Scotland now requires that an SSHI analysis is undertaken for all cutting slopes identified as Poor.

284 Bombardier Transportation has undertaken structural testing of the ceiling panel. By re-positioning the attachment hole, the strength of the secondary retention facility is greatly improved. The implementation of this modification is being reviewed with train owners and operators.

Recommendations

285 The following safety recommendations are made[1]:

1 Network Rail should take actions either to prevent infiltration of water through the Parking Area or to install an engineered drainage system capable of managing the water which is expected to run on to it. The capacity of any drainage shall take into account the changes in surface condition due to the development activity on the surrounding land (paragraph 184).

2 Network Rail should repair the blocked and leaking crest drain and ensure that it is fully functional (paragraph 181).

3 Network Rail should review their procedures to address the issues identified below and implement the resulting changes to their operations:

a) water infiltration risks on land adjacent and above cutting slopes. Ensure that these risks, which will include issues such as areas of permeable and semi-permeable land on which surface run-off could collect, are identified and managed (paragraph 278);

b) introduction of new works by Network Rail alongside the railway or change of use of existing works, both of which may import risk with respect to earthwork stability (either during construction, transition, or subsequently). The TEDE should be consulted and should determine any mitigating action and ensure its implementation. For example, relevant risks could be those associated with a detrimental change in ground loading or drainage conditions (paragraph 202);

c) unknown active or dormant surface extraction activities on land above the level of any track and within the boundary Network Rail have assessed may import risk. Ensure there are no such unknown activities that may import risk (paragraph 199);

d) lack of definition and process break-down in the earthworks Evaluation process that may lead to problems in determining which of the candidate earthworks identified by the Examination process are physically at risk of failure and in need of action. Ensure the review defines the key process stages and gives sufficient guidance to a suitably competent engineer (for example with regard to the information to be considered and decision criteria to be used) to ensure the objective, consistent and repeatable identification of such earthworks (paragraph 236);

continued

[1] Responsibilities in respect of these recommendations are set out in the Railways (Accident Investigation and Reporting) Regulations 2005 and the accompanying guidance notes, which can be found on RAIB's web site at www.raib.gov.uk

e) lack of a formal process and guidance that leads to problems in identifying the earthworks to be inspected when adverse or extreme weather is forecast. The review needs to consider the weather forecasting arrangements (for example, the geographical area to which any forecast applies), the reporting and communication process, and the actions to be taken to ensure the safe operation of trains. It should ensure an integrated response by operations and infrastructure controls, and should be adopted nationwide (paragraph 258);

f) the lack of guidance in classifying earthworks for inclusion in the 'at-risk' list for adverse or extreme weather warnings. The guidance should, on a regular basis, import the latest knowledge from the earthworks management process into the 'at-risk' classification process. The guidance should also enforce regular review and update of the 'at-risk' list. Appropriate consideration should be given to earthworks which are prone to failure due to water infiltration during intense rainstorms (paragraph 250).

4 The Scottish Executive and the Department for Communities and Local Government in England and Wales should ensure that Network Rail becomes a statutory consultee for planning applications for developments in the vicinity of the railway (paragraph 199).

5 Network Rail should review their existing internal processes and ensure that the TEDE is included in statutory consultations for planning applications for surface extraction developments in the vicinity of the railway (paragraph 199). The output of this recommendation is dependent on any actions arising from recommendation 4 above.

6 Network Rail should review the risks and benefits of undertaking earthworks Cyclical Examinations by aerial survey compared to foot surveys. The review should identify the mitigating actions needed to control any risks identified. If Network Rail intend to extend their use of aerial surveys to general use, conditions for this should be included in NR/SP/CIV/065. Their review should recognise the impact of aerial surveys, irrespective of specific or general use, on downstream process steps in NR/SP/CIV/065 and assess any mitigation measures necessary to ensure fitness for purpose. For example, SSHI weightings might need to be different if data collection is by aerial survey (paragraph 232).

7 Network Rail Scotland should ensure that processes are in place to assure that NR/SP/CIV/065 is fully adopted for undertaking earthworks Cyclical Examinations. This should include:

- full compliance with the SSHI analysis process (paragraph 234);
- justification for using aerial surveys and definition of attendant risk mitigation (paragraph 232).

continued

8 Bombardier should identify all vehicles manufactured with a similar method of secondary retention to that of unit 170431 and inform relevant train owners and operators of the risk of failure identified in this report (paragraph 272 and 274). Bombardier should modify all new rolling stock under manufacture, and the design for future rolling stock, to mitigate this risk.

9 All rolling stock owners should identify rolling stock in their ownership with a similar method of secondary retention to that of unit 170431 and carry out modifications to mitigate the risk identified in this report (paragraph 272 and 274).

10 As part of their research into 'Whole train dynamic behaviour in collisions and improving crashworthiness' (project T188), RSSB should consider the practicability of design elements on the bogie that limit the degree of deviation from the track following derailments (paragraph 267).

286 Recommendations 3 a) and 3 d) have equivalence to those similarly made as result of RAIB's investigation into the derailment at Oubeck North near Lancaster on 4 November 2005.

Appendices

Glossary of abbreviations and acronyms — Appendix A

AWS	Automatic Warning System
DMU	Diesel Multiple Unit
ME	Mining Engineer
NRN	National Radio Network
OTMR	On Train Monitoring Recorder
PSR	Permanent Speed Restriction
RAIB	Rail Accident Investigation Branch
RSSB	Rail Safety and Standards Board
SSHI	Slope Stability Hazard Index
TEDE	Territory Earthworks and Drainage Engineer
TRV	Track Recording Vehicle

Glossary of terms — Appendix B

Assessment	The determination of the stability of an earthwork taking into account the physical condition of the earthwork.
Automatic Warning System	A system used to give advance warning to drivers of a signal aspect, a temporary speed restriction or a permanent speed restriction.
Backscar	The surface within an earthwork that is left exposed following a landslip.
Batch Summary	Document used in Scotland to record the status of earthworks and associated management activity.
Cess	The area either side of the railway immediately off the ballast shoulder.
Cess Drain	A drain running in the cess, parallel to the running rails providing a means of removing water from the track system.
Crest	The top of a cutting slope.
Crest Drain	A drain provided at the top of a cutting slope to collect water flowing from neighbouring land and direct it to an engineered drain or natural sink.
Cutting	An excavation that allows railway lines to pass through surrounding ground at an acceptable level and gradient.
Cyclical Examination	Regular visual examination of an earthwork to identify and record signs of slope instability.
Diesel Multiple Unit	Train with a diesel power supply distributed along its length.
Doorway Stiffeners	Part of the vehicle body designed to strengthen the area around the door aperture.
Down	In the direction away from London (generally).
Down Cess	The cess located on the left hand side when travelling in the down direction.
Duty Control Manager	Duty person responsible for Operations Control.
Earthflow	A landslip resulting from slow to rapid flow of saturated soil and debris in a semi viscous, highly plastic state.
Earthwork	An embankment, cutting or natural slope.
Earthwork Asset Steward	Engineer with the responsibility for the management of earthwork structures within Network Rail (or Railtrack).
Earthwork Examiner	Person who is competent to examine the condition of earthworks.
Evaluation	An appraisal of all relevant information and circumstances relating to an earthwork including its condition, use and location to establish whether action is required to ensure that the level of safety and serviceability of an earthwork remain acceptable.

Formation	Material provided between the ballast and the subgrade to either increase or reduce the stiffness of the subgrade or to prevent overstressing.
Four Foot	The area between the inner running faces of a pair of rails.
Glacial Till	Geological deposit consisting of mixture of clay, sands and rocks of varying size.
Infrastructure Control	Function within Network Rail responsible for responding to risks and faults associated with Network Rail infrastructure (sometimes referred to as Infrastructure Fault Control).
Landslip	A slide of a large mass of dirt and rock down a mountain or cliff.
List of 'at-risk' embankments and cuttings	List used by Network Rail in Scotland to identify those earthworks which could be at risk of failure during poor weather.
Marginal	The mid risk categorisation (between Poor and Serviceable) of an embankment, cutting or natural slope in accordance with RT/CE/S/065
Maintenance Delivery Unit Manager	Person with responsibility for the delivery of infrastructure maintenance.
Mining Engineer	Network Rail's engineer with responsibility for monitoring extraction activities likely to affect the railway.
Mining Team	Team with responsibility to inspect extraction works.
Mobile Operations Manager	Person responsible for management of Network Rail operations activities in the field.
National Radio Network	A network wide radio system.
Neighbour Notifications	Process for notifying neighbours of any new planning application that may affect them.
Notice of Approach	A statutory notification by a mineral operator to carry out mining works adjacent to Network Rail's infrastructure or property.
Obstacle Deflector	A device fitted to the front of trains to encourage any obstacles on the track to move sideways in the event of a collision.
On Train Monitoring Recorder	A data recorder fitted to traction units, collecting information about the performance of the train.
Operations Control	An office within Network Rail that monitors, reports and makes decisions on a day-to-day basis on the operation of the railway within a defined area (sometimes referred to as Route Control).
Permanent Speed Restriction	A section of line where the permissible maximum speed is less than the linespeed.
Poor	The highest risk categorisation of an embankment, cutting or natural slope in accordance with RT/CE/S/065.

Rail Fastenings	General name for devices that are used to rigidly fix rails to sleepers.
Railway Incident Officer	A person, usually a Network Rail employee, who represents the industry at the scene of a significant incident.
Rotational Failure	Earthwork failure resulting in a cut surface of circular or near-circular form.
Secondary Retention	An independent means of restraining a piece of equipment should its primary mounting fail.
Secondary Traction Link	A rod used on a train to transmit forces due to traction and braking between the bogie and the vehicle body.
Serviceable	The lowest risk categorisation of an embankment, cutting or natural slope in accordance with RT/CE/S/065.
Slope Stability Hazard Index	Quantitative method for determining the failure risk of an earthwork.
Special Examination	An examination of and earthwork undertaken outwith the defined frequency of a Cyclical Examination, where there is concern regarding stability.
Toe	The bottom of a cutting slope.
Track Recording Vehicle	A train fitted with equipment to automatically measure the condition of the track.
Translational Failure	Earthwork failure mechanism resulting in a cut surface which is parallel to the slope.
Territory Earthworks and Drainage Engineer	Asset steward for all earthworks in Network Rail within a defined geographical area.
Underbridge	A railway bridge under which a road, river, canal or similar passes.
Underframe	The underneath of the train body to which equipment is attached.
Up	Direction towards London (generally).
Up Cess	The cess located on the left hand side when travelling in the up direction .
Washout	Damage of an earthwork due to erosion arising from surface water flow .
Weather Forecast Area	Defined geographical area used by Network Rail for weather forecasting and reporting purposes.
Weather Warning Category	Classification used by Network Rail to define weather events which are deemed to be of risk to the railway.
Yaw	The rotation of the train or bogie in the horizontal plane.

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