Rail Accident Investigation Branch

Synopsis

Derailment of a passenger train at Carmont, Aberdeenshire
12 August 2020

02/2022 Synopsis
March 2022

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This investigation was carried out in accordance with:

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

This is a synopsis of the full RAIB report available at www.gov.uk/raib

Paragraph references in this synopsis, unless prefixed 'S', refer to paragraphs in the full report.

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Preface

The purpose of a Rail Accident Investigation Branch (RAIB) investigation is to improve railway safety by preventing future railway accidents or by mitigating their consequences. It is not the purpose of such an investigation to establish blame or liability. Accordingly, it is inappropriate that RAIB reports should be used to assign fault or blame, or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

RAIB's findings are based on its own evaluation of the evidence that was available at the time of the investigation and are intended to explain what happened, and why, in a fair and unbiased manner.

Where RAIB has described a factor as being linked to cause and the term is unqualified, this means that RAIB has satisfied itself that the evidence supports both the presence of the factor and its direct relevance to the causation of the accident or incident that is being investigated. However, where RAIB is less confident about the existence of a factor, or its role in the causation of the accident or incident, RAIB will qualify its findings by use of words such as 'probable' or 'possible', as appropriate. Where there is more than one potential explanation RAIB may describe one factor as being 'more' or 'less' likely than the other.

In some cases factors are described as 'underlying'. Such factors are also relevant to the causation of the accident or incident but are associated with the underlying management arrangements or organisational issues (such as working culture). Where necessary, words such as 'probable' or 'possible' can also be used to qualify 'underlying factor'.

Use of the word 'probable' means that, although it is considered highly likely that the factor applied, some small element of uncertainty remains. Use of the word 'possible' means that, although there is some evidence that supports this factor, there remains a more significant degree of uncertainty.

An 'observation' is a safety issue discovered as part of the investigation that is not considered to be causal or underlying to the accident or incident being investigated, but does deserve scrutiny because of a perceived potential for safety learning.

The above terms are intended to assist readers' interpretation of the report, and to provide suitable explanations where uncertainty remains. The report should therefore be interpreted as the view of RAIB, expressed with the sole purpose of improving railway safety.

Any information about casualties is based on figures provided to RAIB from various sources. Considerations of personal privacy may mean that not all of the actual effects of the event are recorded in the report. RAIB recognises that sudden unexpected events can have both short- and long-term consequences for the physical and/or mental health of people who were involved, both directly and indirectly, in what happened.

RAIB's investigation (including its scope, methods, conclusions and recommendations) is independent of any inquest or fatal accident inquiry, and all other investigations, including those carried out by the safety authority, police or railway industry.

Synopsis

The accident

S1 At around 09:37 hrs on Wednesday 12 August 2020, a passenger train collided with debris washed from a drain onto the track near Carmont, Aberdeenshire, following very heavy rainfall. The train, reporting number 1T08, was the 06:38 hrs service from Aberdeen to Glasgow, which was returning towards Aberdeen due to a blockage that had been reported on the line ahead. There were nine people on board, six passengers and three railway employees (one of whom was travelling as a passenger).

S2 Train 1T08 was travelling at 73 mph (117 km/h), just below the normal speed for the line concerned. The collision caused the train to derail and deviate to the left, before striking a bridge parapet which caused the vehicles to scatter. Tragically, three people died as a result of the accident:

a) the conductor, Donald Dinnie

b) the train driver, Brett McCullough

c) a passenger, Christopher Stuchbury.

S3 The remaining six people on the train were injured.

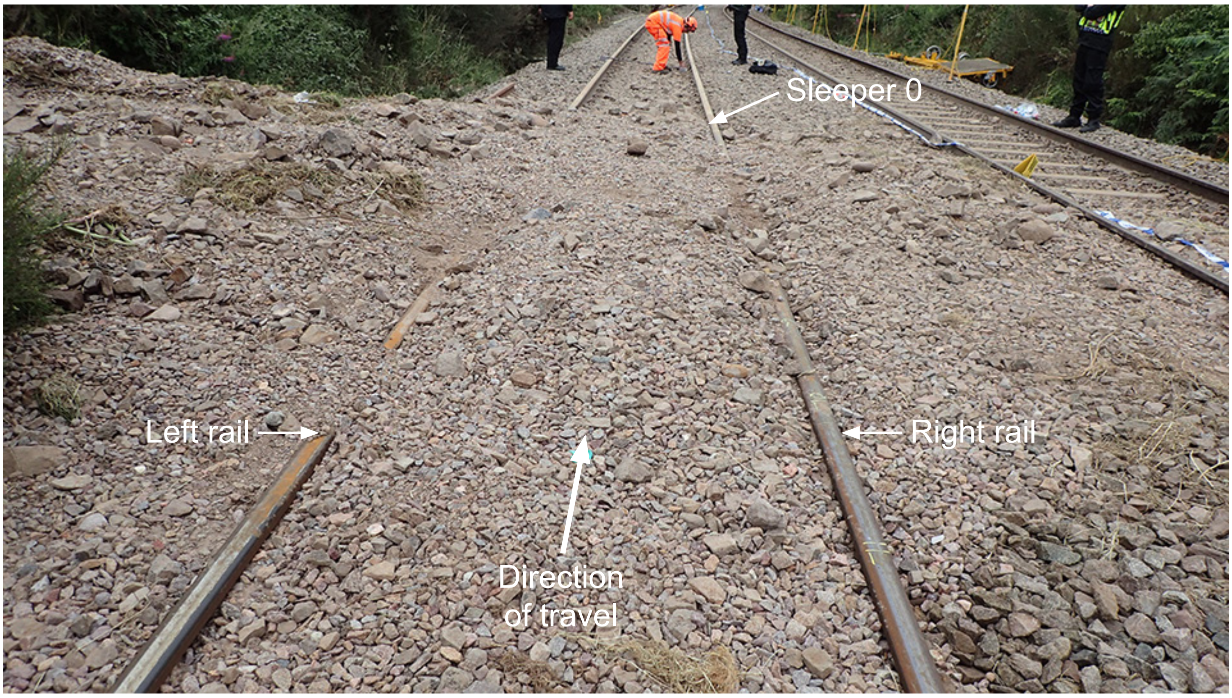
The aftermath of the accident (image taken on 13 August 2020)

What was the immediate cause of the derailment?

S4 Train 1T08 derailed because it struck debris washed out from a 15 metre length of steeply sloping drainage trench. This is evidenced by CCTV images from the train, grooves cut through the debris, the absence of derailment marks on the track on the approach to the debris and marks indicating that the leading wheelset had derailed immediately after the debris field.

S5 The debris mainly comprised gravel with some cobbles and covered the down line for a length of about 10 metres. Estimates made by RAIB after the derailment indicate the maximum depth of debris on the left and right railheads was probably around 170 mm and 135 mm respectively before the train ran through it.

[for details see paragraphs 72 to 81]



Washout debris covering the track

How was the accident investigated?

S6 The Rail Accident Investigation Branch (RAIB) deployed investigators to the site of the accident to commence a full investigation of the circumstances. RAIB is the UK's body tasked with the independent and expert investigation of rail accidents. RAIB was created by Act of Parliament in 2003 and has extensive legal powers to enable it to perform this role. The RAIB's sole objective is to identify the factors that led to the accident and to make recommendations for the improvement of railway safety.

S7 In addition to the investigation by RAIB, parallel investigations are being undertaken by Police Scotland, in conjunction with the British Transport Police; and the UK's rail safety regulator, the Office of Rail and Road (ORR).

The drainage system

S8 The source of the debris that caused the derailment at Carmont was a 'french drain' and the ground immediately surrounding it. This drain had been installed during 2011 and 2012 (the 2011/12 drain) as part of a wider scheme to address a known problem with the stability of the earthworks in this locality. This drain comprised a 450 millimetre (approximately 18 inch) diameter perforated pipe buried in a gravel-filled trench which ran for 306 metres along the edge of a field at the top of a slope that ran down to the railway. The drain then sloped down relatively steeply (at an inclination of 1 in 3) for 53 metres to track level. Catchpits (access chambers, sometimes called manholes) were provided at intervals along the pipe to allow inspection and maintenance of the pipe.

[for details see paragraphs 24 to 27]

What were the weather conditions before the accident?

S9 It rained heavily in the central belt of Scotland and parts of the Grampian mountains during the early hours of 12 August 2020. At around 05:00 hrs this rain began to extend eastwards to coastal areas around Dundee and then moved northwards up the coast, reaching Carmont at about 05:50 hrs. There was then near-continuous heavy rain at this location until about 09:00 hrs. However, it was dry and sunny with broken cloud by the time train 1T08 approached the accident site around 37 minutes later.

S10 On the morning of 12 August 2020, Met Office analysis of rainfall radar data shows 51.5 mm of rain fell between 05:50 hrs and 09:00 hrs at the Carmont accident site. Based on this amount of rain falling over a 1 km^2 area, the return period for this event is between 100 and 144 years, dependent on the methodology used. This was within a wider area of exceptionally heavy rainfall, described by the Scottish Environment Protection Agency (SEPA) as a rare event, causing severe disruption and significant flooding in central and eastern Scotland on 11 and 12 August 2020.

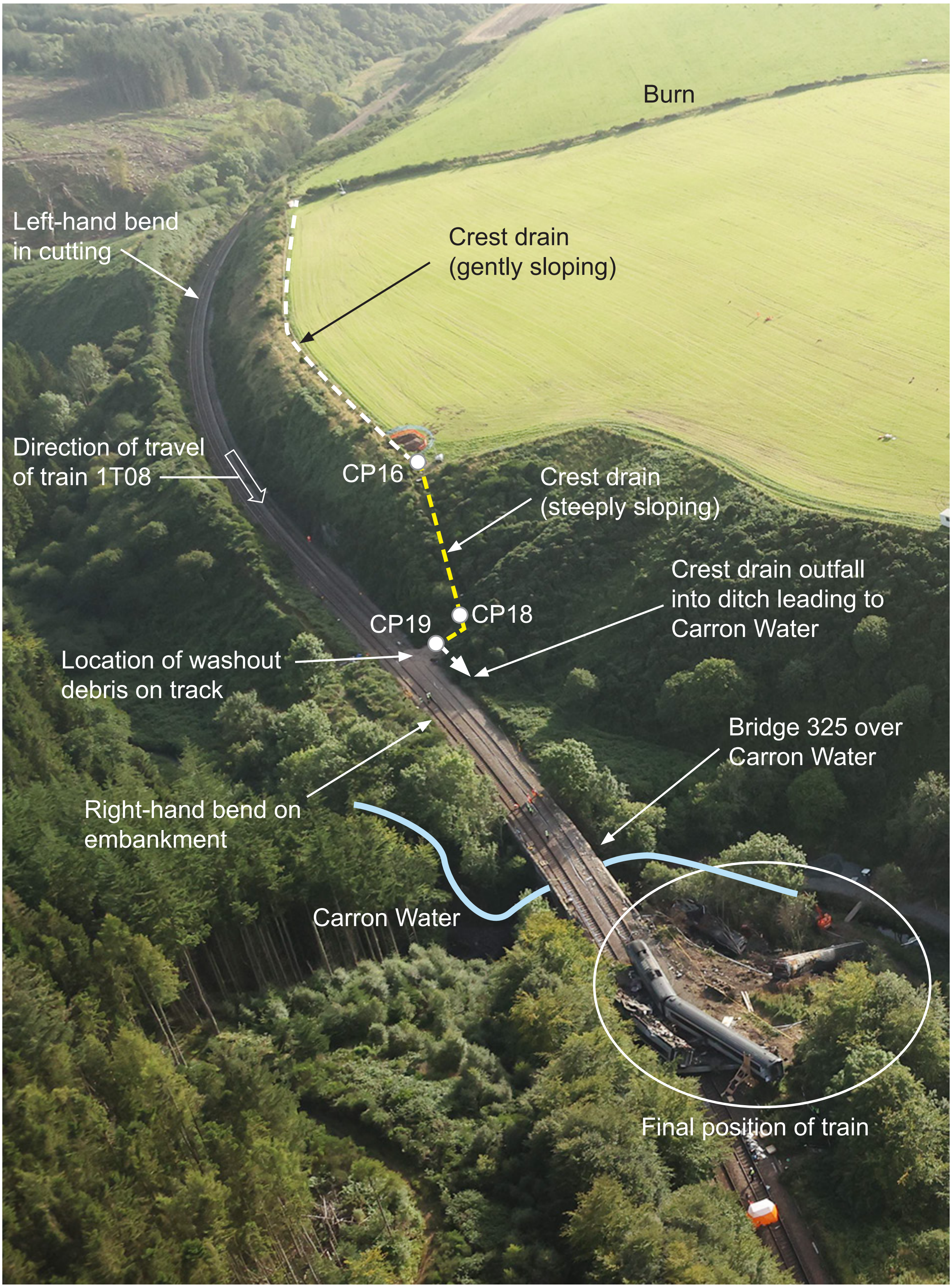
[for details see paragraphs 41 to 43, and 102]

Why was material washed out of the drain?

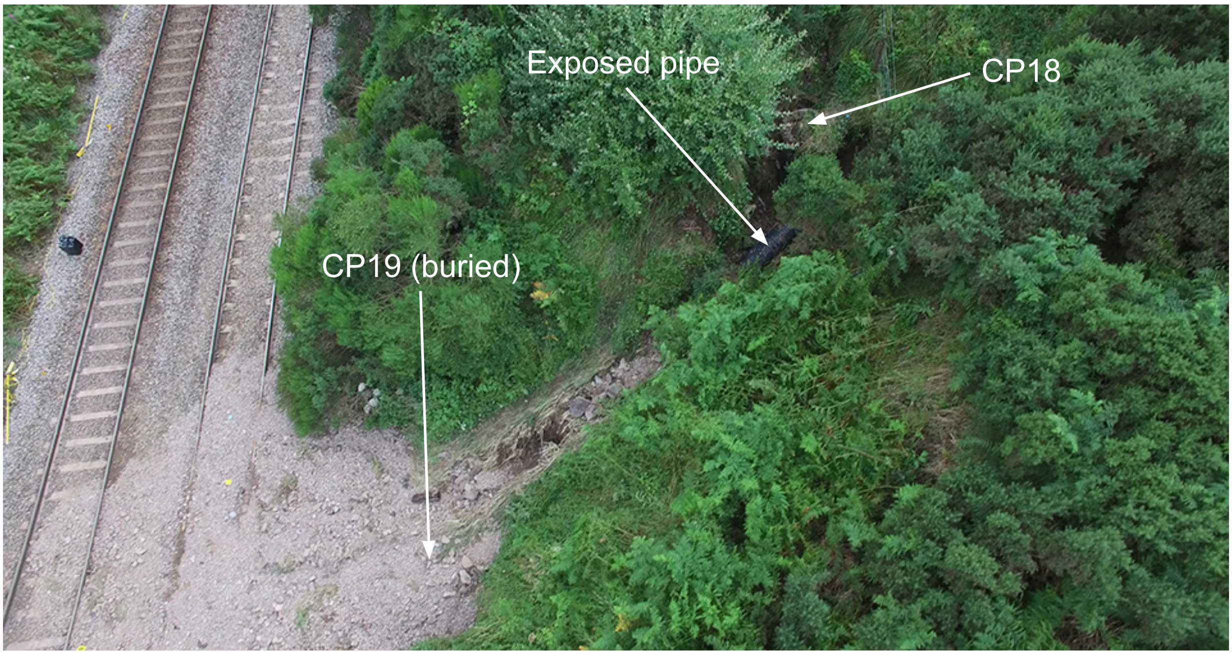
S11 The drainage system at Carmont was constructed during 2011 and 2012. The drainage system was not installed according to the design drawings and a low bund (artificial ridge) was constructed which was not part of the design. Consequently, on the morning of 12 August 2020 surface water flows were concentrated into a short length of the gravel-filled trench, which resulted in gravel and other stony material being washed out of the drainage trench and the area immediately surrounding it.

S12 The trench which contained the drainage pipe was filled with gravel (mainly between 20 mm and 40 mm in size) in accordance with normal practice for french drains. However, the use of this gravel in such a steeply sloping trench increased the likelihood of it being washed away should the water reach the drain as a concentrated flow.

[for details see paragraphs 89 to 113]



Overview of the drainage system (locations marked 'CP' are catchpits)



The washout (locations marked 'CP' are catchpits)

Was the drain correctly designed?

S13 Modelling undertaken by an engineering consultancy firm appointed by RAIB, AECOM, indicated that the design of the 2011/12 drainage system at Carmont would have been capable of safely accommodating the flow of surface water that occurred on the morning of 12 August 2020 without causing gravel to be washed away down the steeply sloping trench towards the track.

[for details see paragraphs 101 to 113]

Was the drain correctly constructed?

S14 The company that was contracted to construct the drain, Carillion, did not undertake construction in accordance with the designer's requirements. Consequently, the drainage system was unable to perform as the designer had intended when it was exposed to particularly heavy rainfall on 12 August 2020. The most significant difference between the original design of the drainage system and the final installation was the construction of a bund running across the slope towards the railway and perpendicular to the 2011/12 drain. This bund, which was constructed outside Network Rail's land, had the effect of diverting a large amount of water into a gully so that it all reached the drain at the same location, thereby increasing the propensity for washout of the gravel infill. RAIB found no evidence that the construction of the bund was notified to Network Rail or the designer.

S15 Other differences between the original design and the installed drainage system were probably not causal but nevertheless provide evidence of an absence of control of construction changes. These included:

a) omission of the intended connection from the existing (pre-2010) drainage into the 2011/12 drain at catchpit number 18

b) relocating catchpit 18

c) the lack of geotextile lining to the trench (required to prevent fine soil particles entering the drain and clogging it up) in the area of the washout

d) cutting holes in the side of catchpits on site so that the holes were significantly larger than the pipes passing through them

e) a bend in the pipe not coinciding with a catchpit (about one metre downslope of catchpit 18).

RAIB found no evidence that any of these changes were referred to the designer for consideration.

[for details see paragraphs 114 to 154]

Why was the issue not spotted and corrected during construction?

S16 The contractual arrangements between Network Rail and Carillion meant that Carillion was responsible for the delivery of works in accordance with designs approved by Network Rail, together with amendments agreed through formal processes during the construction phase of the scheme. There is no evidence that changes such as the construction of the bund and omission of the connections from the existing drainage to catchpit 18 were dealt with as part of a formal process. Changes of this type should have been referred to Arup (as the designer). However, its records, supplemented by witness evidence, indicate that no such reference was made.

S17 Network Rail's audit regime at the time of the drain's construction did not include audits likely to detect design modifications implemented on site without proper change control.

S18 Network Rail's project team were probably unaware that the 2011/12 drain was significantly different from that intended by the designer and therefore did not take action. Had they been aware of this, it is possible that the consequent risk would have been recognised and remedial actions taken. Although Network Rail had a project team, they were not required by Network Rail business processes to check that the drain was being installed in accordance with the design. They therefore relied on a contractual assurance process that required Carillion to refer proposed changes to the designer, Arup, for approval.

S19 Preparation and retention of 'as-built' drawings of newly constructed assets are required to assist future maintenance of the asset. Depending on how these are prepared, they can provide an opportunity for the designer to recognise inappropriate design modifications. RAIB found no evidence of any such drawings being submitted to the designer or Network Rail.

S20 It is possible that preparation of as-built drawings would have triggered the transfer of the newly constructed asset to the asset maintenance team. These drawings are generally considered an essential part of the health and safety (H&S) file required by the Construction (Design and Management) Regulations 2007. There is no evidence that this file was prepared for the Carmont project. Furthermore, out of a total of 64 projects sampled by RAIB, more than half were missing any trace of an H&S file. In a sample of eleven drainage projects considered by RAIB, five were not transferred into the asset management system.

[for details see paragraphs 155 to 184 and 287 to 297]

Who knew that the gravel surface of the 2011/12 drain was eroding?

S21 In December 2012, shortly after the drain was completed, but before the associated fencing work was finished, the landowner visited the sloping section of drain following a period of heavy rain. During this visit, he took a photograph of the steeply sloping section of drain upslope of catchpit 18 showing water flowing from a side channel and slight erosion to the gravel surface of the 2011/12 drain. The landowner stated that he passed this photograph to Carillion or Network Rail. No evidence has been found relating to receipt of the image or action being taken in response to it. It is likely that this erosion was visible when Network Rail and Carillion staff inspected the site in March 2013.

S22 It is very unlikely that the slight erosion of the gravel surface would have been immediately recognised as a precursor to a sudden washout affecting railway safety. However, this was clear evidence of a problem requiring action such as repair, monitoring and/or reference to the drain designer. This was a missed opportunity to recognise the effect of the bund on water flows.

[for details see paragraphs 185 to 188]

Why was the issue not spotted and corrected following routine inspections?

S23 Information about the section of the drainage system nearest the track at Carmont was held in Network Rail's infrastructure maintenance database (Ellipse). When construction was completed, the remainder of the Carmont drainage system should have been, but was not, entered into Ellipse to trigger routine inspection and maintenance activities. This did not happen due to non-implementation of Network Rail's procedures for introducing new assets onto infrastructure. It is possible that this was related to the absence of 'as-built' drawings (paragraph S19). Since Network Rail's asset managers were unaware of the upper part of the drainage system, no inspection regime was established (although the lower part of the drain was inspected in May 2020). RAIB found no evidence that Network Rail undertook any inspection of the upper parts of the drainage system in the period between the inspection of the completed works in March 2013 and the accident in August 2020.

S24 The previous rainfall event in December 2012 (paragraph S21) caused drain surface erosion over a relatively small area. Since there may well have been no obvious indication that the defect could suddenly become a significant washout, it is not evident that this extent of damage would have been considered sufficient to trigger remedial action had it been detected by a routine inspection by maintenance teams. Furthermore, it is not possible to determine whether any remedial works would have been sufficient to prevent the washout on 12 August 2020.

S25 The earthwork at Carmont is described by Network Rail as a 'mixed' cutting because it is formed of both soil and rock. RAIB observes that Network Rail's standard relating to the examination of this type of cutting was open to differing interpretations, and so left a potential gap in the management of risk from the soil components of these earthworks. Although it was generally understood by local examiners that it was desirable to traverse the slope of a mixed cutting to view it from the bottom and top, the inability to do so was not always reported to Network Rail.

[for details see paragraphs 275 to 286 and 584 to 598]

Railway operations

S26 Northbound train movements on the section of railway where the accident occurred are signalled from Carmont signal box, which is located near the settlement of Newmill, about 2.4 km (1.5 miles) from the site of the accident. The overall control of the railway, including the response to severe weather, was the responsibility of the Scotland route control room ('route control'), located at the West of Scotland Signalling Centre in Cowlairs, Glasgow. This is an integrated control arrangement staffed by both Network Rail and ScotRail staff.

S27 The train involved in the accident, train 1T08, was the 06:38 hrs service timetabled to run from Aberdeen to Glasgow Queen Street. On the morning of 12 August 2020, it was planned to terminate train 1T08 at Dundee because of obstructions on the line ahead. However, at about 07:01 hrs, just after passing the signal box at Carmont, train 1T08 was instructed to stop due to a landslip obstructing the line ahead that had been reported by the driver of another train.

S28 After the landslip had been reported, Scotland route control decided that train 1T08 should return to Stonehaven to avoid it being stranded remote from a station. This movement required the train to pass from the southbound line to the northbound line via crossover points near to Carmont signal box. Since the points were required to be secured to enable this movement, it was 09:28 hrs before the signaller was able to authorise the train to proceed towards Stonehaven.

[for details see paragraphs 44 to 58]

What did the railway know about the weather conditions on the 12 August 2020?

S29 During the night of 11/12 August 2020, the weather had caused multiple failures and other problems on the railway infrastructure through Scotland's central belt and eastern areas. The cumulative effect of these failures was such that by 05:00 hrs, the only unaffected main route in Scotland was the line from Inverness to Dundee via Aberdeen. During the very early part of the morning, trains operated over this route without encountering weather-related problems.

S30 Shortly before 07:00 hrs, control began to receive information about weather-related issues between Aberdeen and Dundee, and at 07:01 hrs, train 1T08 was brought to a stand near Ironies Bridge south of Carmont signal box, becasue of a landslip that had been reported on the line ahead. There was near-continuous heavy rain in the area around Carmont between 05:50 hrs and 09:00 hrs.

[for details see paragraphs 44 to 58]

Did anyone know about the washout at the site of the accident?

S31 The last train to pass the site of the accident was train 2B13, the 06:39 hrs service from Montrose to Inverurie, at about 07:07 hrs. The driver saw nothing of concern on the journey. Modelling of water flows indicates that the washout probably occurred between 08:15 hrs and 09:00 hrs.

[for details see paragraphs 59 and 254]

Why was the train travelling at just under its normal permitted speed of 75 mph?

S32 At the time there was no written process that required train 1T08 to be instructed to run at a lower speed on its journey between Carmont and Stonehaven following an intense rainfall event, and no such instruction was given by route control or the signaller. Consequently, normal railway rules applied to the train movement.

S33 During the conversation between the driver of train 1T08 and the signaller at Carmont, the signaller stated that the line was 'fine' and that the driver could proceed at normal speed.

S34 The driver then drove the train towards Stonehaven, accelerating to just below its normal speed, as permitted by the railway's Rule Book on a line that was not known to be obstructed.

[for details see paragraphs 246 to 257]

What actions did operations control take in response to the extreme rainfall events on 12 August 2020?

S35 By 09:00 hrs, around 30 minutes before the return journey of train 1T08, four obstructions of the railway within 11 miles (17.7 km) of Carmont signal box had been reported to route control. These were:

- a landslip at Ironies Bridge which had led to train 1T08 being stopped
- flooding at Ironies Bridge
- flooding at Newtonhill (north of Carmont)
- a landslip near Laurencekirk station (south of Carmont).

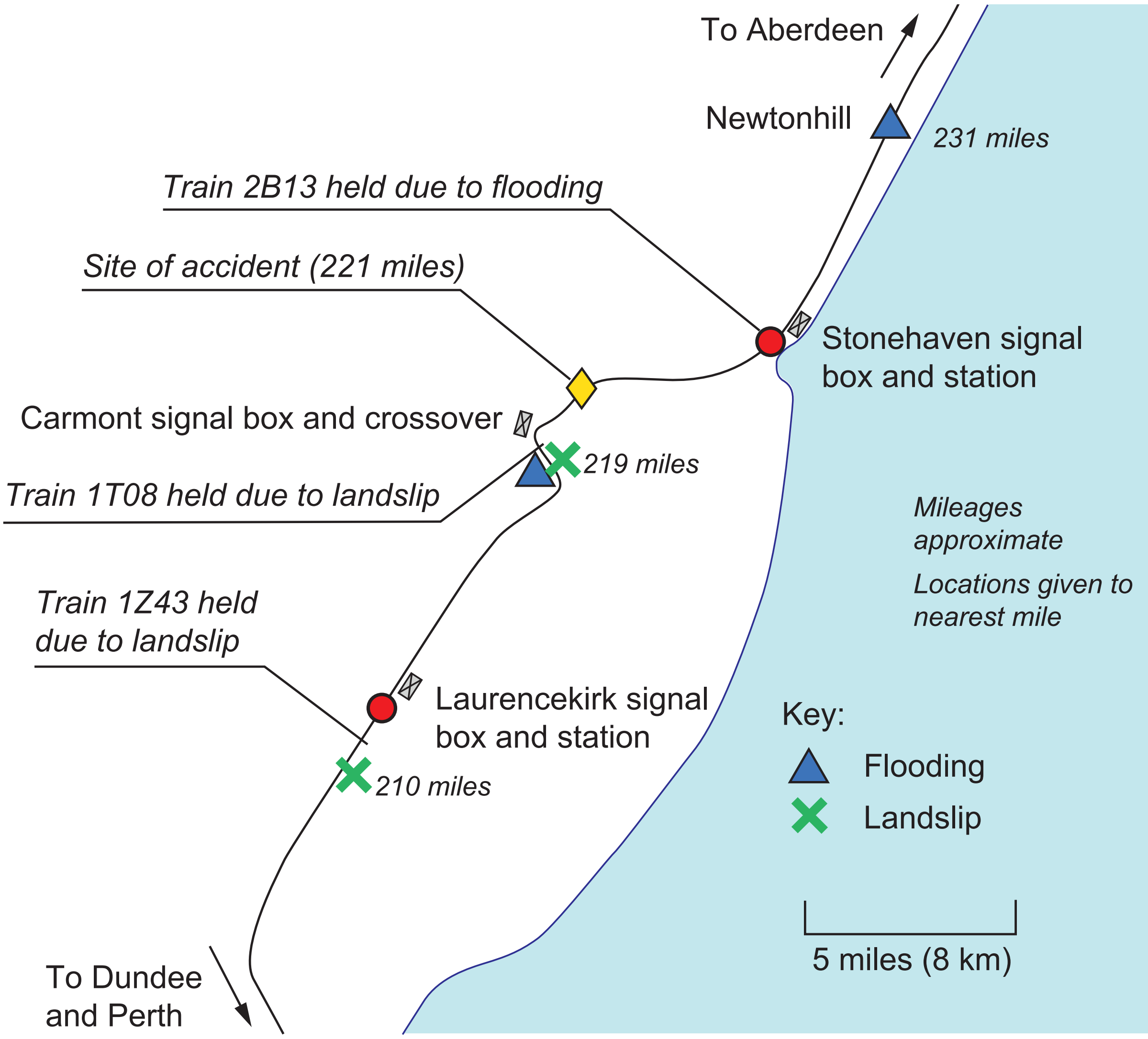
S36 Despite this, no instruction was given to the driver or Carmont signaller that train 1T08 should run at reduced speed or that it should be used to examine the line. At the time, there was no clearly defined process that required any such precaution in these circumstances.

[for details see paragraphs 225 to 235]

Did controllers have the resources, information, procedures and training needed to manage extreme rainfall events of the type that occurred on 12 August 2020?

S37 RAIB found evidence that the Scotland route control team was under severe workload pressure on the morning of 12 August 2020, because of the volume of concurrent weather-related events in Scotland (such as the canal breach at Polmont). However, despite the severe nature of the disruption to Scotland's railway infrastructure, no additional resource had been obtained for the control room and the senior management 'gold command' structure had not been established to relieve the pressure on the controllers.

S38 RAIB's investigation also found that controllers in Scotland, and elsewhere, had not been given sufficient guidance or training to enable them to effectively manage complex situations of the type encountered on the morning of 12 August 2020.



Train positions and known infrastructure failures around Carmont at 09:00 hrs on 12 August 2020

S39 Following previous serious infrastructure failures, in 2015 Network Rail had procured access to a computer tool, the Network Rail Weather Service (NRWS), which was capable of being configured to provide short-range weather forecasts and real-time data on weather conditions. Although the tool was accessible from the control room, this was not used by controllers as a source of information when managing the response to weather-related events. This was because the NRWS had not been optimally configured for use in such circumstances and controllers had not been provided with the procedures or training needed to exploit its full capabilities. The NRWS was also available to the geotechnical asset management team (see paragraphs S45 to S46).

S40 Even if better use of weather data had been combined with knowledge that very heavy rainfall was a known threat to earthworks throughout Network Rail infrastructure (see paragraphs S42 and S43), it is unclear whether controllers would have asked the signaller to caution train 1T08. Beyond certain high-risk locations (a very small proportion of the railway network), Network Rail's national processes did not include the option of imposing precautionary speed restrictions or other mitigation in areas subject to forecast, or actual, extreme rainfall events. This meant that although Network Rail was well aware of the threat posed by extreme rainfall events, such as summer convective storms, neither the controllers nor the asset management team had any 'ready-made' procedural options to mitigate the risk to infrastructure in such circumstances, except at the locations recognised as high-risk.

[for details see paragraphs 189 to 245]

National standards required the convening of an 'extreme weather action team' (EWAT) meeting - how was this requirement applied in Scotland?

S41 Route control practice meant that formal extreme weather action team (EWAT) meetings were not always convened when required by Network Rail's processes, and no such meeting was called on 11 or 12 August 2020 despite forecasts of severe weather. However, even had an EWAT been convened it is considered unlikely that Network Rail would have taken the actions needed to avoid the accident. This is because Network Rail had not established effective arrangements to manage the consequences of extreme rainfall events that endangered infrastructure not identified as being at high risk.

[for details see paragraphs 298 to 317]

Did Network Rail understand that extreme rainfall events might endanger infrastructure that had not previously been identified as being at high risk?

S42 Network Rail's strategy for mitigating the risk of weather-related infrastructure failure was based on the identification of high-risk locations and concentrating risk mitigation measures, such as the appointment of 'watchmen', at these locations. Network Rail did not consider that the drain at Carmont was at risk of washing out during very heavy rainfall.

S43 Network Rail also understood that extreme rainfall events could pose a more general risk to the integrity of earthworks and structures. This understanding is evidenced by minutes of senior management meetings, published responses to previous RAIB investigations and emails between asset managers and route control in the months before the accident.

[for details see paragraphs 195 to 224]

What action was taken by the geotechnical asset managers?

S44 At the time of the accident, Network Rail had a standard that identified the need for consideration to be given to the dynamic assessment of risk should 'significantly heightened rainfall intensity' mean that parts of the railway not identified as high-risk were susceptible to failure.

S45 The geotechnical asset management team had undertaken to monitor the NRWS on 11 and 12 August 2020, and were checking it a couple of times a day, or on notification from control of some real-time incident or feedback of a problem. Reliance on this notification by route control meant there was a significant risk of a train encountering a landslip before route control (and therefore before the geotechnical team) was aware of a problem.

S46 The NRWS, although not configured to do so easily, could have been used to determine when the geotechnical team should initiate precautions outside locations recognised as high-risk (that is beyond sites shown on the geotechnical assets 'at risk' list). However, Network Rail had not established the rainfall thresholds at which this should be done, and it was impractical for the geotechnical team to determine these in real time during an extreme weather event. Such threshold values were introduced after the accident.

[for details see paragraphs 195 to 224]

Risk awareness and management assurance

Did Network Rail appreciate the risk from very heavy rainfall to its earthworks, and associated drainage?

S47 The railway industry's risk assessments had clearly signalled that earthwork/drainage failure due to extreme rainfall was a significant threat to the safety of the railway. However, they had not clearly identified potential areas of weakness in the existing operational mitigation measures.

[for details see paragraphs 374 to 396]

Did Network Rail know that its risk mitigation measures had not been effectively implemented in route control?

S48 Network Rail's management assurance processes did not highlight the extent of weaknesses in the implementation of extreme weather processes in route controls, or that the controllers lacked the necessary skills and resources to effectively manage complex weather-related situations of the type experienced on 12 August 2020. Consequently, significant areas of weakness in the railway's risk mitigation measures were not fully addressed.

[for details see paragraphs 359 to 373]

Did Network Rail have an effective strategy to mitigate the risk from extreme rainfall events?

S49 Before the accident at Carmont, Network Rail's overall approach to the management of earthwork/drainage failures due to extreme rainfall events was to:

a) Examine, evaluate and risk assess earthworks (taking account of drainage assets).

b) Consider the need for additional works to improve the resilience of earthworks/drainage assets that are considered particularly vulnerable to extreme rainfall events and implement these improvements where appropriate.

c) Inspect and maintain the condition of earthworks/drainage assets, particularly those considered to pose a higher risk to trains.

d) Define appropriate mitigation measures to be implemented in case of extreme weather (at the high-risk sites on the 'at risk' list).

e) Obtain forecasts of weather events, conduct a multi-disciplinary review (known as an EWAT) and trigger implementation of mitigation measures at known high-risk sites.

f) Monitor the situation during the weather event and conduct further reviews as appropriate.

S50 Network Rail's strategy for the management of risk associated with extreme rainfall events had identified the need to implement engineering works to improve the resilience of high-risk assets. However, the operational response to extreme weather events was critically reliant on the identification of high-risk locations and the introduction of additional control measures at those specific locations.

S51 RAIB observed that the success of the overall approach adopted by Network Rail was reliant on the accuracy of forecasting, the reliability of risk assessment, the deployment of sufficient resource and the ability to monitor rainfall events in real-time. In all of these areas Network Rail had yet to meet its own aspirations. The investigation concluded that:

a) Although access to enhanced weather forecasting and monitoring technology had been procured, its capabilities were not being fully exploited by the geotechnical asset management and route control teams.

b) Although risk assessment of earthworks has progressed markedly in the last 20 years, it was, and will always be, an imperfect predictor of failure.

c) The railway has insufficient resource to entirely overcome the potential for infrastructure failure.

S52 Although Network Rail had taken some steps towards implementing modern technology to help monitor weather conditions and better inform operational decision makers, its capability had not been fully exploited before the accident at Carmont. RAIB observes that the roll-out of a technology-based strategy has real potential to manage the risk from extreme rainfall events, provided those who will rely on it are given suitable procedures and training. Such a strategy, coupled to modern communications equipment, would enable train drivers to be instructed to operate at speeds commensurate with the rainfall-related risk in the locality they are passing through. This would benefit the safety of the line (by restricting train speeds, or suspending operations, when necessary) while reducing the need to impose blanket speed restrictions over areas that are not at significant risk.

S53 RAIB's findings regarding the sufficiency of Network Rail's strategy for managing extreme weather events are consistent with those of the Weather Advisory Task Force chaired by Professor Dame Julia Slingo (see paragraph S92). The task force concluded:

'The weather alert thresholds, used operationally to mitigate weather-associated risks and manage safe train operations, require a major overhaul. They need to be dynamic in space and time, to be based on multiple predictors and to reflect the variations in exposure and vulnerability across the network.'

S54 The task force also reflected on the ability of Network Rail to implement effective measures for the management of weather risk:

'Weather pervades many aspects of Network Rail's operations, beyond daily weather alerts, and with a diverse range of needs. There does not seem to be a central core of expertise - an 'authoritative voice' - that can be drawn on to ensure that weather science and data are used correctly and coherently across the organisation. There also seemed to be a lack of coherence on the procurement of expert weather and flooding services combined with a lack of knowledge of existing, external capabilities that could be levered rather than procuring something new.'

S55 RAIB concluded that, despite an awareness of the threat, Network Rail had not sufficiently recognised that its existing measures did not fully address the risk from extreme rainfall events, such as summer convective storms. Consequently, areas of significant weakness had not been addressed.

[for details see paragraphs 335 to 358]

Had sufficient lessons been learnt from previous incidents involving the failure of earthworks and drainage assets?

S56 Since 2009, RAIB has investigated 11 earthwork failures that resulted in debris being deposited on the railway (excluding events triggered by construction work, vegetation and melting snow). In 2014, RAIB published a class investigation covering a range of landslips, many of which were associated with drainage issues.

S57 RAIB's class investigation and other precursor events demonstrated:

- the potential for events to occur at locations where examinations had not identified a high risk of failure
- the likelihood of rain triggering the event
- the importance of providing an effective drainage system.

S58 Network Rail and RAIB concerns were heightened by the landslip just outside the portal of Watford tunnel, Hertfordshire, in September 2016 that caused the derailment of a train and a subsequent glancing blow, inside the tunnel, between the derailed train and a train on the opposite track. Discussions at the meeting of Network Rail's executive committee and the company's Safety, Health and Environment committee in November 2016 covered a range of issues, including:

a) the need to review the earthworks and drainage on the approach to Watford tunnel

b) the use of guard rails to prevent derailed trains from deviating too far from the track at high risk sites such as viaducts, and a need for a review of the strategy and criteria for their fitment

c) more extensive use of satellite images to identify issues on neighbouring land

d) the plans for a risk-based review of cutting slopes at tunnel portals, taking into account drainage and water flows.

S59 Despite an awareness of risk, Network Rail had not completed the implementation of additional control measures following previous events involving extreme weather. In particular, Network Rail had yet to implement an effective strategy to address the general threat to the stability of earthworks during, and following, extreme rainfall events, including those that had not been assessed as being at risk. Furthermore, Network Rail had still to complete actions to enhance the capability of operating staff to manage complex operational incidents.

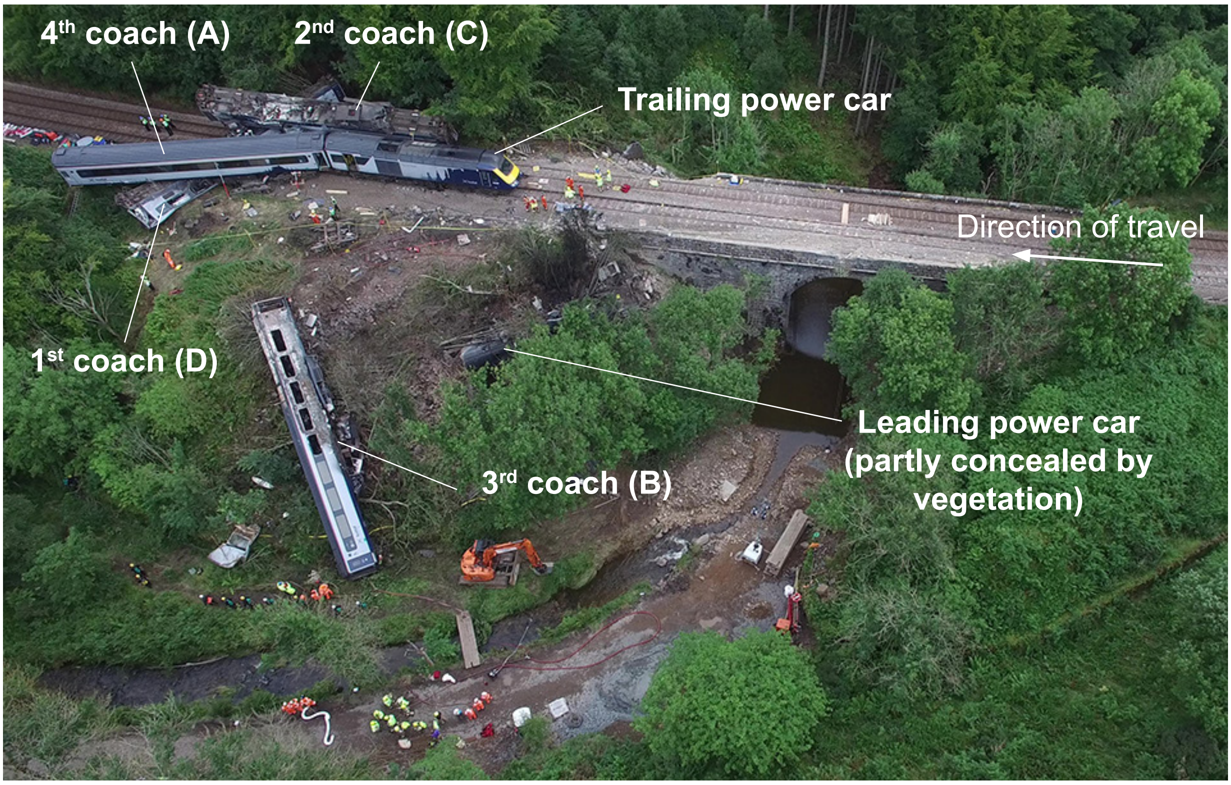
S60 It is possible that better delivery of change in response to safety learning would have resulted in actions that would have prevented, or mitigated, the consequences of the accident at Carmont.

[for details see paragraphs 397 to 452]

The landslip at Watford tunnel, September 2016

The train

S61 The train that derailed at Carmont was a high speed train set (HST) with four coaches and two power cars. HSTs were first introduced into service in the mid-1970s and are generally seen as having a good safety record. Although they pre-date a number of modern standards that are relevant to train behaviour in derailments and collisions, they are authorised to operate on the UK's mainline network. The coaches that formed this particular set had been recently refurbished by Wabtec at its workshops. These works included the provision of power-operated doors.



The derailed train

Why did the train derail when it struck the debris from the washed out drain?

S62 The marks found on the track are consistent with the leading left-hand wheel of the leading power car being lifted up by debris between the wheel and rail and displaced to the left across the head of the rail before falling off the track entirely. At the same time the right-hand wheel dropped into the space between the two rails.

[for details see paragraphs 72 to 81]

What happened to the train after hitting the washout debris?

S63 The curvature of the track at the location of the derailment was a significant factor in the outcome. Once the train derailed at the washout, the front of the leading power car deviated from the track to the left and put the power car on a collision course with the end of the bridge parapet.

S64 The leading power car collided with the end of the parapet, with its centre line slightly to the right of the parapet centre. The collision knocked a substantial amount of masonry from the end of the parapet before the bogie ran along the top of the parapet, skimming off the coping (upper layer) of masonry. Once the power car ran onto the bridge, its left-hand wheels were no longer supported, causing it to veer off the bridge near its mid-span and down to the embankment below. It came to rest on its left-hand side and at an angle with its leading end around seven metres below track level. It is likely that the movement of the leading power car to the left dragged the leading end of the following coach to the left.

S65 Beyond the bridge, other topographical features aggravated the amount of jack-knifing and general vehicle scatter. The first passenger coach came to rest on its roof, almost at right angles to the track. The second passenger coach came to rest overturned onto its roof with its trailing end on top of the first coach and facing the direction of travel. The third passenger coach ran down the steep embankment to the left side of the railway, came to rest on its right-hand side and subsequently caught fire. The fourth passenger coach remained upright and came to rest with its leading end on top of the first coach. The trailing power car remained upright on the down line, still coupled to the rear of the fourth coach.

[for details see paragraphs 454 to 459]

What more could be done to prevent trains derailing when they hit debris on the track?

S66 Lifeguards on rail vehicles are heavy metal brackets fitted immediately in front of the leading wheels of a train. Their purpose is to prevent small obstacles getting under the leading wheels and causing derailment. The HST lifeguards were less robust than those on more modern trains. Although a stronger modern lifeguard might have been better able to move sufficient washout debris out of the path of the leading wheelset, RAIB had insufficient evidence to determine the likelihood that this would have prevented the derailment.

[for details see paragraphs 267 to 274]

What could be done to keep trains closer to the track after they derail?

S67 At the time of the derailment, no guard rails were installed on the approach to and over the bridge at Carmont (although they were added after the accident). The purpose of guard rails is to contain any derailed wheels so that they remain close to the track and do not allow the train to deviate into collision with the infrastructure (for example, tunnel portals and bridge parapets) or trains on adjacent lines. However, to have been effective in containing the lateral deviation of the leading bogie at Carmont, a pair of guard rails would have needed to extend out from the bridge (towards the approaching train) for a minimum distance of around 35 metres. This is considerably further than is required by Network Rail's standard covering guard rails.

[for details see paragraphs 536 to 543]

How were the train's occupants harmed in the accident?

S68 The probable causes of the fatal injuries sustained by the people on the train, were:

- secondary impact of the driver with the cab windscreen and interior as the leading power car struck the embankment below the bridge

- loss of survival space in the leading vestibule of the first coach (where the conductor was standing) as the coach overrode the trailing end of the leading power car while on the bridge
- ejection of the passenger through the open gangway at the leading end of the second coach, probably when it struck the wooded bank after it had traversed the bridge and run off to the right-hand side of the track.

S69 The principal cause of serious injury to three of the survivors was secondary impact with the vehicle interiors. The first two coaches both underwent extreme movements and rolled over onto their roofs before they came to rest. These movements would have subjected passengers to accelerations in the vertical, lateral and longitudinal directions, and would have caused them to come into violent contact with the vehicle interior and/or fall out of their seats on the high side and onto the low side as the vehicles rolled over. The two survivors in the leading coach also received multiple cuts and lacerations and were probably ejected from the vehicle as it came to a rest.

[for details see paragraphs 470 to 480]

How was the train damaged in the accident?

S70 RAIB carried out a detailed examination of the train wreckage to assess its ‘crashworthiness’. Its findings included:

a) The ‘Alliance’ couplers between the vehicles were not able to withstand the forces and relative vehicle movements during the derailment. All the vehicles became uncoupled except at the interface of the last coach and the trailing power car. The uncoupling allowed the vehicles to scatter and roll over and increased the risk of secondary impact with the infrastructure and other vehicles and their bogies.

[for details see paragraphs 502 to 503].

b) The coaches were not fitted with any form of bogie retention in the vertical direction, and this allowed the vehicle bodies to lift off their bogies during the derailment. As a consequence of losing their bogies, three of the coaches were free to slide and roll in an uncontrolled manner (attached bogies tend to resist sliding because they dig into the ballast). The detached bogies also became obstacles in the path of the vehicle bodies, and the second coach probably suffered penetration damage as a result of striking detached bogies.

[for details see paragraphs 504 to 506].

c) Of the 61 main bodyside windows on the passenger coaches, 22 windows were found to be completely broken through (that is, there was no glass left to provide passenger containment) during a post-accident inspection. Most of the windows that were completely broken through were in areas that had suffered significant bodyside damage, or had failed due to the fire that broke out in the third coach. Examination of the interior of the leading coach showed that many large shards of glass had become detached from the inner laminated pane of the window. Both passengers who survived the accident in the leading coach suffered laceration injuries which may have been caused by these pieces of broken glass.

[for details see paragraphs 518 to 527].

Was the condition of the train a factor in the extent of the damage?

S71 The bodyshells of the coaches generally performed well in the accident, resulting in only limited loss of survival space and resisting injurious penetration of passenger spaces during impacts with other vehicles and bogies. However, there was complete loss of survival space in the leading vestibule of the leading coach. The vestibule was protected by four body-end ‘collision’ pillars comprising two gangway pillars either side of the flexible gangway, and two corner pillars next to the doors. All the pillars at the leading end were sheared off at their bases.

S72 Given the age of the vehicles, it was unsurprising that damaged areas of the coach structures were found to have areas of corrosion. RAIB considered whether the extent of corrosion may have significantly affected the way the coach structures deformed and in particular the loss of survival space observed in the leading coach. However, since the forces applied to the collision pillars in the interaction with the leading power car are not known, the investigation was not able to determine whether or not the original strength of the pillars (that is, without any material loss due to corrosion) would have been sufficient to prevent the loss of survival space that led to the death of the train’s conductor.

S73 The coaches involved in the accident had been extensively refurbished in 2019 by Wabtec. Records for corrosion repairs provided by Wabtec indicate some localised corrosion had been identified on the collision pillars on the leading coach, and repairs had been authorised. At that time, there were no formal criteria for judging the tolerability of the corrosion and the extent of repairs that were required in this area. Instead the need for, and extent of, repairs was based on engineering judgment. There are no photographic records of the work actually done and the pillars were too severely damaged in the accident for a meaningful retrospective assessment of this work.

[for details see paragraphs 491 to 501]

How was the driver protected from the impact?

S74 The cab was subjected to severe impact conditions and became detached from the power car. The impact conditions were significantly beyond those in which even modern cabs are designed to provide protection for occupants.

S75 HST driving cabs are not fitted with seat belts or any other secondary impact protection for the driver, and therefore drivers are vulnerable to injurious impact with the desk structure and windscreen in collisions and derailments. In the past, research work has been carried out to examine the feasibility of better protecting train drivers from injury in case of collision. The accident at Carmont has once again highlighted that train drivers are vulnerable to fatal injuries arising from secondary impact with the cab interior in high energy derailments.

[for details see paragraphs 484 to 490]

Would a modern train have behaved differently?

S76 A train built to modern crashworthiness standards (those applicable since the introduction of Railway Group Standard GM/RT 2100 in July 1994) would have had a number of design features that are intended to provide better protection for occupants and keep vehicles in line should they collide with an obstacle or derail. These include:

a) Anti-climb features (either as serrated pads fitted to the vehicle ends or built into the couplers) and energy absorbing vehicle ends to prevent override and consequential uncontrolled structural collapse in collisions.

b) More robust couplers which are better able to resist the forces which couplers are subjected to in derailments, without failure or uncoupling.

c) Bogie retention features, so that in an accident, the bogies remain attached to the vehicle bodies as far as is possible.

S77 The refurbished HST that derailed at Carmont was designed and constructed before these standards came into force. While it is not possible to be certain about what would have happened in the hypothetical situation with different rolling stock in the same accident, RAIB considers it more likely than not that the outcome would have been better if the train had been compliant with modern crashworthiness standards.

[for details see paragraphs 528 to 535]

Would the consequences have been worse if more people were on the train?

S78 Because of the COVID-19 pandemic, there were only nine people on train 1T08 on the morning of 12 August 2020. ScotRail estimated the number of passengers that would have been on train 1T08 in normal times to be between 25 and 50 (three and six times greater than on the day of the accident). The circumstances of the accident and the resulting movements of the vehicles was such that, with normal passenger numbers, the casualty toll would almost certainly have been significantly higher.

[for details see paragraphs 460 and 461]

What caused the fires in the leading power car and the third coach, and were people endangered?

S79 Post-accident examination of the fuel tank of the leading power car showed it had been ruptured during the accident, and the absence of other readily combustible material indicates that fuel from this tank sustained the fire. Although the investigation did not establish the precise mechanism by which the fire started, it is possible that damage to the fuel system sustained during the accident may have given rise to diesel fuel being spilled or sprayed; this fuel could have ignited on hot surfaces, or as a consequence of arcing or sparks from damage to electrical systems.

S80 The third coach caught fire after coming to rest on the embankment flank with its right-hand side on the ground and sloping downwards so that its leading end was lower than its trailing end. The fire was not apparent to witnesses until around 11:00 hrs (approximately 90 minutes after the accident). Since no one was trapped in the interior of the coach the fire did not endanger human safety.

S81 The fire in the third coach originated in the batteries beneath the floor of the coach and almost certainly was caused by an electrical fault that arose due to the extent of damage to the underframe of the coach. The subsequent spread of the fire was a consequence of the coach coming to rest on its right-hand side on the slope, with its trailing end uppermost. This orientation meant that the fire naturally extended across the underframe and grew towards the trailing end of the coach. A rectangular hole in the floor on the left-hand side, designed to allow air from the air conditioning system into the passenger compartment, was the likely route of the fire into the coach's interior.

[for details see paragraphs 544 to 558]

Fire damage in the third coach

RAIB's conclusions

Immediate cause

S82 Train 1T08 derailed because it struck washout debris (paragraph 72).

Causal factors

S83 RAIB's investigation concluded that had the drainage system been installed in accordance with the design, it is highly likely to have safely accommodated the flow of surface water on 12 August 2020. However, as installed, the drainage system was unable to do so (paragraph 91). This occurred because:

a) The gravel in the drainage trench was vulnerable to washout if large flows of surface water concentrated onto a short length of drain (paragraph 100, **Recommendation 3**).

b) Carillion did not construct the drain in accordance with the designer's requirements (paragraph 114, **Recommendation 1**).

S84 RAIB also identified the following possible causal factors:

a) Network Rail's project team were probably unaware that the 2011/12 drain was significantly different from that intended by the designer and therefore did not take action. Had the team been aware of this, it is possible that the consequent risk would have been recognised and remedial actions taken (paragraph 160, **Recommendation 1**).

b) Network Rail's processes that were intended to ensure a managed transfer of safety-related information from constructor to infrastructure manager were ineffective. Had this managed transfer taken place in accordance with Network Rail's processes, it is possible that the divergence between the design intent and the asset that had been delivered would have been noted and remedial action taken (paragraph 179, **Recommendations 1 and 2**).

c) No action was taken by Network Rail or Carillion when water flow in gully 1 caused slight erosion to the gravel surface of the new drainage trench before the works were completed. This was a missed opportunity to recognise the effect of the bund on water flows, and is therefore considered to be a possible causal factor in this accident (paragraph 185, **Recommendation 1**).

S85 With regard to railway operations, RAIB identified the following causal factors:

a) Network Rail did not have suitable arrangements in place to allow timely and effective adoption of additional operational mitigations in case of extreme rainfall which could not be accurately forecast (paragraph 189, **Recommendations 6 and 7**).

b) Although aware of multiple safety-related events caused by heavy rain, route control staff were not required to, and did not, restrict the speed of train 1T08 northwards from Carmont to Stonehaven (paragraph 225, **Recommendations 6 and 7**).

c) The signaller and driver were not required to, and consequently did not, restrict the speed of train 1T08 to below that normally permitted (paragraph 246, **Recommendation 6**).

Consideration of other issues

S86 The following issues cannot be completely discounted as factors in the Carmont accident, but the available evidence is insufficient to consider them to be causal. In other circumstances, they could have been a factor in an accident.

a) The HST lifeguards were less robust than those on more modern trains. Although a stronger modern lifeguard may have been better able to move sufficient washout debris out of the path of the leading wheelset to prevent the derailment, RAIB had insufficient evidence to determine the likelihood of this happening (paragraph 267, **Recommendation 14**).

b) Network Rail's process for initiating the inspection and maintenance of new drainage works had not been correctly applied. Consequently, it is likely that the upper section of the 2011/12 drainage system had never been inspected since its completion. Although RAIB has found no evidence to suggest that such an inspection would have changed the outcome, this cannot be entirely discounted. Whether or not relevant to the accident, the absence of proper inspection of a safety critical asset is of great concern (paragraph 275, **Recommendations 1**).

c) Neither RAIB or Network Rail could find any trace of the health and safety file for the Carmont drainage works. There is evidence that Network Rail's processes related to the creation and management of health and safety files were not being correctly applied in Scotland and elsewhere in the UK (paragraph 287, **Recommendation 1**).

d) Custom and practice in Scotland's route control meant that extreme weather action team (EWAT) meetings were not always convened when required by Network Rail's processes, and no such meeting was called on 11 or 12 August 2020 despite forecasts of severe weather. However, even had an EWAT been convened it is considered unlikely that Network Rail would have taken the actions needed to avoid the accident (paragraph 298, **Recommendations 6 and 7**).

Underlying factors

S87 RAIB's investigation identified the following underlying factors:

a) Network Rail's management processes had not addressed weaknesses in the way it mitigated the consequences of extreme rainfall events (paragraph 318). The underlying reasons for this were:

   i. Despite an increasing awareness of the threat, Network Rail had not sufficiently recognised that its existing measures did not fully address the risk from extreme rainfall events, such as summer convective storms. Consequently, areas of significant weakness had not been addressed (paragraph 336, **Recommendations 6 and 10**).

   ii. Network Rail's management assurance processes did not highlight the extent of any areas of weakness in the implementation of extreme weather processes in route controls, or that the controllers lacked the necessary skills and resources to effectively manage complex weather-related situations of the type experienced on 12 August 2020. Consequently, significant areas of weakness in the railway's risk mitigation measures were not fully addressed (paragraph 359, **Recommendation 8**).

   iii. The railway industry's risk assessments had clearly signalled that earthwork/drainage failure due to extreme rainfall was a significant threat to the safety of the railway. However, they had not clearly identified potential areas of weakness in the existing operational mitigation measures (paragraph 374, **Recommendation 6 and 10**).

b) Despite an awareness of the risk, Network Rail had not completed the implementation of additional control measures following previous events involving extreme weather and the management of operating incidents. It is possible that better delivery of change in response to safety learning would have resulted in actions that would have prevented, or mitigated, the consequences of the accident at Carmont (paragraph 397, **Recommendation 9** and Margam report recommendation 6).

Examination of consequences

S88 When considering the consequences of the accident RAIB considered:

- the circumstances of the derailment, speed, local topography and proximity to a bridge (paragraphs 454 to 459)
- the structural damage to the vehicles (paragraph 462 to 469)
- the unusually low number of people on the train because the accident occurred during the COVID-19 pandemic (paragraphs 460 and 461).

S89 The crashworthiness of the vehicles involved in the derailment (paragraph 481 to 483), and the severity and cause of injuries suffered by those on the train (paragraphs 470 to 480) were examined by RAIB. The findings are presented in the following sections of the report:

a) driver's cab (paragraphs 484 to 490, **Recommendation 17**)

b) structure of the coaches and the effect of corrosion (paragraphs 491 to 501, **Recommendation 18**)

c) couplers and absence of bogie retention on the coaches (paragraphs 502 to 506, **Recommendation 19**)

d) vehicle interiors and bodyside mounted folding tables (paragraphs 507 to 517, **Recommendation 16**)

e) window breakage (paragraphs 518 to 527, **Recommendation 15**)

f) comparison with modern rolling stock (paragraphs 528 to 535, **Recommendation 19**)

g) guidance of derailed vehicles (paragraphs 536 to 543, **Recommendations 12 and 13**)

h) fire causation and effects (paragraphs 544 to 558, **Recommendation 20**)

i) evacuation of survivors and emergency egress (paragraphs 559 to 565, no recommendation).

Additional observations

S90 Although not linked to the accident on 12 August 2020, RAIB observes that:

a) Railway industry processes for the operation of route proving trains were poorly defined and inconsistent (paragraph 566, **Recommendation 11**).

b) Use of the GSM-R radio system by ScotRail staff would have broadcast emergency information to other railway staff more quickly (paragraph 577, **Learning point 1**).

c) Network Rail's standard relating to the examination of mixed cuttings was open to differing interpretations, and so left a potential gap in the management of risk from soil components of mixed slopes. Although it was generally understood by local examiners that it was desirable to traverse the slope of a mixed cutting to view it from the bottom and top, the inability to do so was not always reported to Network Rail (paragraph 584, **Recommendations 4 and 5**).

What actions has industry already taken?

S91 The actions that the railway industry has reported taking include:

- A new drainage system, with improved capacity, and with features intended to prevent another washout, was installed to replace the 2011/12 system.
- Guard rails were fitted on both up and down lines on the approach to bridge 325 when the track was re-laid after the accident. The protection includes gathering rails and, on the down line, extends beyond the site of the washout.
- Network Rail stated that, before the accident at Carmont, its project teams had started to review historical projects (up to 10-years old) in Scotland to ascertain whether a health and safety file, if required, had been accepted by the National Records Group (NRG) and stored appropriately; and this process is continuing.
- NR Standard NR/L2/INI/02009 was updated and reissued. This update is intended to strengthen the management of technical queries raised during construction and the process for controlling changes to the design.
- Network Rail introduced expanded drain design requirements in December 2018 which, in addition to enhanced requirements relating to selection of design methodologies, requires consideration of impacts on other assets, such as earthworks and track, during extreme events.
- Scotland's Railway has established a permanently-staffed weather desk position. Network Rail has informed RAIB that suitably qualified people have been recruited to cover this position, which is responsible for monitoring weather conditions and advising controllers on the necessary precautionary actions.
- A process requiring blanket speed restrictions in areas without earthworks on the 'at risk' list was implemented, where considered necessary by Network Rail, throughout its network in September 2020. This process included enhanced use of weather data, including an improved capability to identify convective rainfall which can be difficult to predict until shortly before it falls.
- Network Rail has implemented a number of process changes that are designed to improve the way that it manages its response to recommendations.
- Network Rail has also reported that it is implementing a programme of level 2 audits to check the correct implementation of risk controls that have been introduced in response to RAIB recommendations.
- RSSB has also launched project T1269, 'Development of a system risk model for extreme rainfall events'. The project aims to develop a whole system risk model for these extreme rainfall events. RSSB has also commenced a project to assess the effectiveness of blanket speed restrictions in managing and mitigating risks from trains running into trees or landslips (reference T1252). This considers the effectiveness of current UK practice regarding weather-related speed restrictions, and alternative approaches to such speed restrictions that have proved effective in other countries.
- ScotRail has stated that it intends to change training for conductors working on HSTs so that it will include entering the driving cab and locating the GSM-R equipment.

[for details see paragraphs 619 to 631]

S92 Following the accident at Carmont, and in the light of the likelihood that climate change will exacerbate this risk still further, Network Rail decided to commission two task forces to advise on the ways that it could improve its understanding of earthworks management and potential improvements to its mitigation measures. Lord Robert Mair CBE FREng FRS, a geotechnical expert, led an earthworks management task force to advise Network Rail on how it can improve the management of its earthwork portfolio. Dame Julia Slingo FRS, former chief scientist at the Met Office, led a weather action task force with the objective of better equipping Network Rail to understand the risk of rainfall to its infrastructure.

S93 Neither task force was asked to investigate the accident at Carmont in any detail. However, their findings will inform Network Rail's ongoing asset management and operational mitigation strategies. The work of the task forces therefore complements that of RAIB which relates more closely to the specific factors that contributed to the accident at Carmont.

[for details see paragraphs 632 to 637]

RAIB's safety recommendations

S94 RAIB has made 20 recommendations for the improvement of railway safety. These are all addressed to the UK's safety authority, the Office of Rail and Road. For each recommendation, RAIB has identified the party or parties that RAIB considers require to take action if the intent of the recommendation is to be met (the 'end-implementers'). Carillion are not identified as an end-implementer since the company is in liquidation.

Rec No.	FINDING	End-implementer	AREA OF RECOMMENDATION [for details see paragraph 638]
1	The drain was not installed as designed	Network Rail	Management of civil engineering construction activities
2	As-built information was not handed over to the maintainer	Network Rail	Ensure that all new works are incorporated into inspection and maintenance regimes
3	The gravel in the drainage trench was washed out when subjected to concentrated flows on a short length	Network Rail	Enhanced design processes for new drainage to ensure that the risk of such washouts is minimised
4	The upper parts of the earthworks at Carmont were not examined	Amey and Network Rail	Review of how earthwork examination processes for 'mixed cuttings' are being implemented

Rec No.	FINDING	End-implementer	AREA OF RECOMMENDATION [for details see paragraph 638]
5	Incomplete earthwork examinations were not notified to Network Rail	Network Rail	Evaluate the adequacy, and ways of improving the clarity, of the relevant standard
6	Network Rail's operational procedures did not adequately address extreme and volatile rainfall events such as summer convective storms	Network Rail	Improved processes for implementing mitigations for weather-related risks
7	The route control room was unable to effectively manage the situation in Scotland on the morning of 12 August 2020	Network Rail	Improve the capability of route control rooms to effectively manage complex, widespread and unusual incidents
8	Scotland's integrated control room had not been subject to adequate audit, monitoring or review	Network Rail	Improve management assurance of route control functions
9	The learning from previous events had not been applied effectively	Network Rail	Identify and address the obstacles to effective implementation of lessons learnt from investigation of accidents and incidents
10	Network Rail's engineering risk analysis assessed operational risk mitigation measures as being 'optimal' – the investigation reveals this not to be the case	Network Rail	Risk assessment of the mitigating control measures that relate to failures of earthworks and drainage
11	Lack of clear and consistent rules about the operation of route proving trains	Network Rail assisted by RSSB and the Rail Delivery Group (RSG)	Clarify the arrangements to be applied for the operation of route proving trains
12	The derailed HST did not stay close to the track after it derailed	RDG and Network Rail, in conjunction with RSSB	Assessment of measures to provide improved guidance to derailed trains
13	The derailed HST did not stay close to the track after it derailed	Network Rail	Review of standards applying to the installation of guard rails at higher risk locations
14	The leading wheels of the HST lifted clear of the rail when running in a relatively shallow debris field	Owners of HST power cars	Investigate the feasibility of strengthening the lifeguards on HST power cars to better protect the wheels from obstacles

Rec No.	FINDING	End-implementer	AREA OF RECOMMENDATION [for details see paragraph 638]
15	Glass in the windows of the HST broke into long and potentially dangerous shards	RSSB	A review of current train glazing standards to minimise the risk of lacerations
16	The bodyside mounted folding tables had sharp edges when folded down	Angel Trains, in conjunction with ScotRail (Note: this recommendation may also apply to owners of vehicles with similar tables)	Modify bodyside mounted folding tables to reduce the risk of injury to passengers in case of accident
17	Protection of train drivers remains a safety concern	RSSB	A review of previous research on fitting secondary impact protection for train drivers (for example, seatbelts and airbags)
18	No clear criteria for the extent of corrosion that is permissible in safety critical areas of rolling stock	Owners of mark 3 coaches and other rolling stock susceptible to significant levels of corrosion	Establish criteria for the allowable extent of corrosion in safety critical areas of rolling stock
19	The damage to the HST was very extensive. A significantly higher casualty toll would have been likely if the train had been heavily loaded with passengers	Operators of HSTs, in consultation with rolling stock owners	Assessment of the additional risk to vehicle occupants associated with the lack of certain modern crashworthiness features on HSTs, and the development of industry guidance for assessing and mitigating the risk associated with the continued operation of HSTs and other types of main line passenger rolling stock designed before the introduction of modern crashworthiness standards in 1994
20	The fire in coach B was associated with the batteries	RSSB	Investigation of alternative designs of batteries and their casings which offer improved fire properties

What happens next to RAIB's recommendations?

S95 The action of formally addressing the recommendations to the safety authority (ORR) enables it to discharge its duty of ensuring that the end-implementer considers the recommendation and where appropriate takes action in response to the recommendation. The safety authority or the public body is then required to report back to RAIB on the details of the consideration and the action taken or planned, or the reasons why no measures are to be taken to implement the recommendation.

Learning point

S96 RAIB has identified the following important learning point:

1 Railway staff are reminded that, if available and they are trained to use it, GSM-R radio is normally the most appropriate way to communicate urgent safety information to signallers.

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