Rail Accident Investigation Branch

Rail Accident Investigation: Interim Report

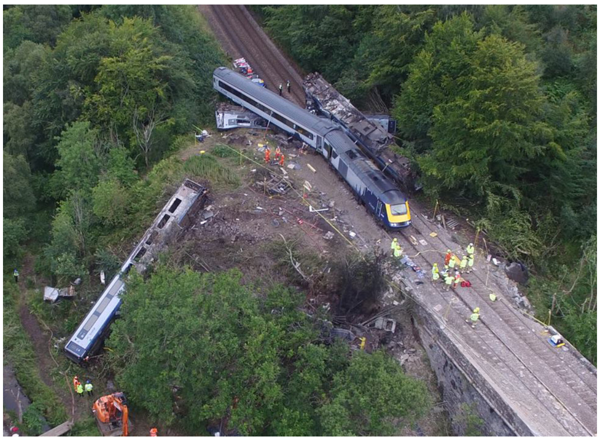
Derailment of a passenger train at Carmont, Aberdeenshire
12 August 2020

Report IR1/2021
April 2021

Note: This interim report contains information obtained as part of the Rail Accident Investigation Branch's (RAIB's) ongoing investigation. It supplements the information published on RAIB's website on 21 August 2020. Some of the information contained in this report may be refined or changed as the investigation progresses.

The purpose of a RAIB investigation is to improve 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.

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



Summary

1 At around 09:37 hrs on Wednesday 12 August 2020, a passenger train collided with debris washed onto the track near Carmont, Aberdeenshire, following heavy rainfall. The subsequent derailment resulted in the death of three people, injuries to the six other people in the train and catastrophic damage.

RAIB’s role and the context of this interim report

2 The Rail Accident Investigation Branch (RAIB) is responsible for conducting independent investigations into railway accidents in the UK. The purpose of its investigations is to improve safety, by establishing the causes of accidents and making recommendations, to reduce the likelihood of similar occurrences in the future or to mitigate their consequences.

3 RAIB is not a prosecuting body; its investigations are focused solely on safety improvement and do not apportion blame or liability. The police and the Office of Rail and Road deal with any contraventions of the law. None of their statutory duties are changed by the RAIB investigation.

4 RAIB’s investigation is running independently of the joint investigation instructed by the Lord Advocate to be carried out by Police Scotland, British Transport Police and by the railway industry’s regulator, the Office of Rail and Road. However, all investigating agencies, and the industry, are co-operating fully with each other.

5 This interim report is based on evidence gathered and analysed to date and explains RAIB’s preliminary findings. Further investigative work may cause some modification to these findings.

6 A final report will be published by RAIB on completion of its investigation. All RAIB investigation reports are available on RAIB’s website.

7 If found necessary, during its investigation RAIB may also issue urgent safety advice and make recommendations to such persons as are appropriate in the circumstances.

Background

Location

8 The accident occurred near milepost 221[1] on the railway between Montrose and Aberdeen. The two-track railway between Laurencekirk (210½ miles) and Stonehaven (225 miles) was opened in 1849 by the Aberdeen Railway Company. From Carmont signal box (219½ miles) the railway runs east-north-east on a curving alignment to follow the Carron Water valley towards the coast at Stonehaven (figure 1).

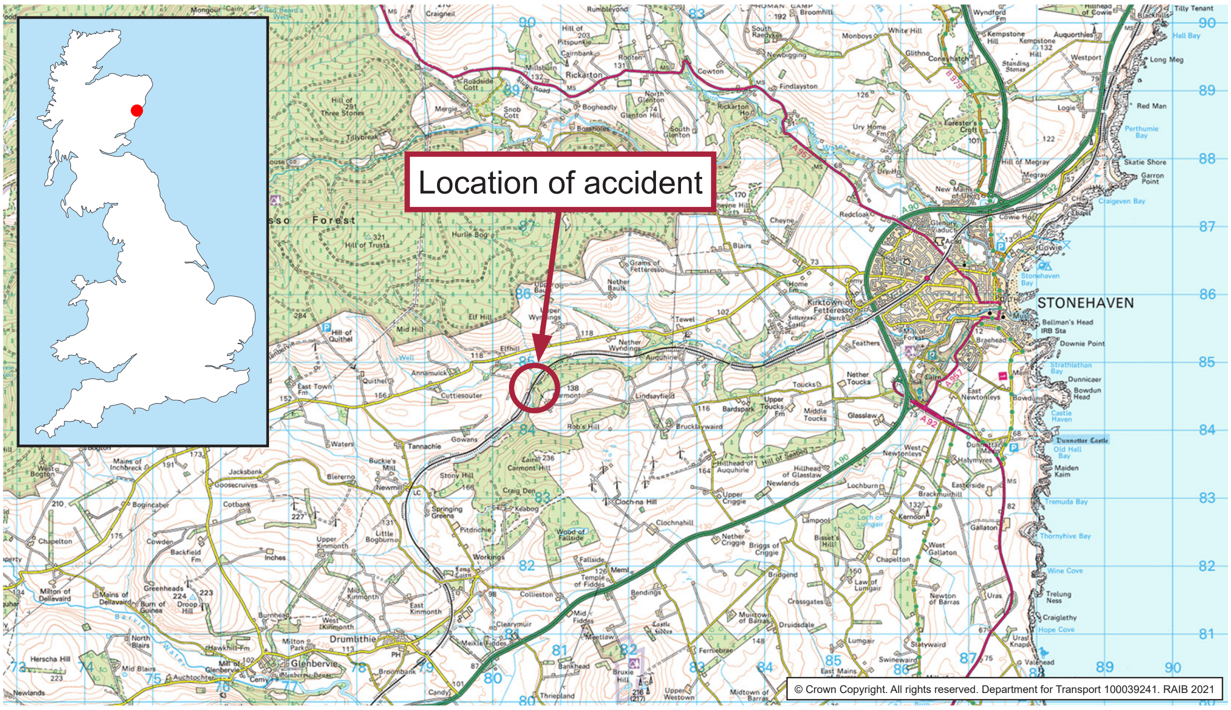


Figure 1: Extract from Ordnance Survey map showing location of accident

9 One and a half miles (2.4 km) north-east of Carmont signal box, the railway is carried 12 metres above Carron Water on a single span masonry arch bridge with parallel wingwalls. Approaching this bridge from the south, the line runs along the west side of a steeply sloping river valley, initially on a left-hand[2] curve of 700 metres radius, which is followed immediately by a right-hand curve which begins about 100 metres before the bridge and becomes progressively tighter until it reaches a radius of 800 metres a short distance beyond the bridge. For most of this length, the railway runs through a deep cutting with a steep cutting face, up to 21 metres high on the left-hand side of the railway. The cutting was excavated through soil (glacial till) and the underlying rock (Carron sandstone). Beyond the top of the cutting, the ground rises away from the railway. The cutting ends about 50 metres from the bridge and the railway runs onto an embankment which starts about 20 metres before the bridge and continues beyond it (figure 2).

[1] Distances on this section of railway are measured from Carlisle, via Perth and a now-closed route via Forfar.

[2] Left and right relate to facing forward on the train involved in the accident as it travelled north and struck the washout.

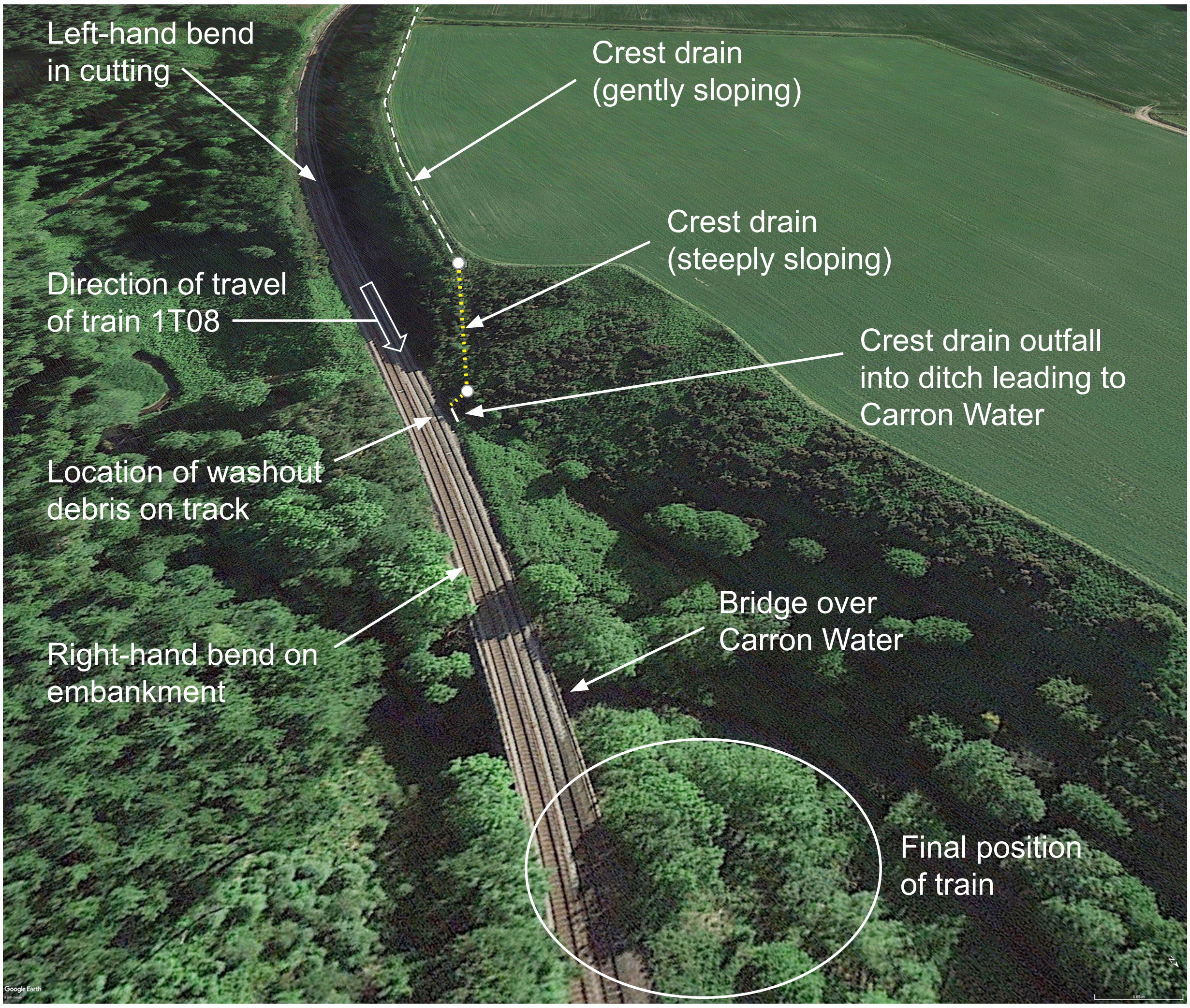


Figure 2: Google Earth image of the site

10 The railway is operated on the absolute block signalling system, using a mixture of semaphore and colour-light signals controlled locally by signal boxes at Laurencekirk, Carmont and Stonehaven (figure 3). At these three locations, and at Newtonhill (the site of a former signal box), there are crossovers which enable trains to transfer from one line to the other. The crossover at Carmont is located immediately south of the signal box.

The train involved

11 The train, the 06:38 hrs service from Aberdeen to Glasgow (which was returning towards Aberdeen at the time of the accident), was a diesel-electric High Speed Train (HST) set consisting of a leading power car, four Mark 3 passenger coaches and a trailing power car (figure 4). The vehicles were originally constructed by British Rail Engineering Ltd and entered service between 1976 and 1980.

12 The most recent modification to the passenger coaches was undertaken between December 2017 and April 2020 by Wabtec Rail Ltd, at its workshops in Doncaster and Kilmarnock, to support ongoing use of the trains by ScotRail and to achieve compliance with legislation covering accessibility for persons with reduced mobility.[3] The work included fitting powered sliding doors to replace the manually operated 'slam' doors which the vehicles had been built with.

[3] https://www.gov.uk/government/publications/accessible-rail-transport/accessible-rail-transport.

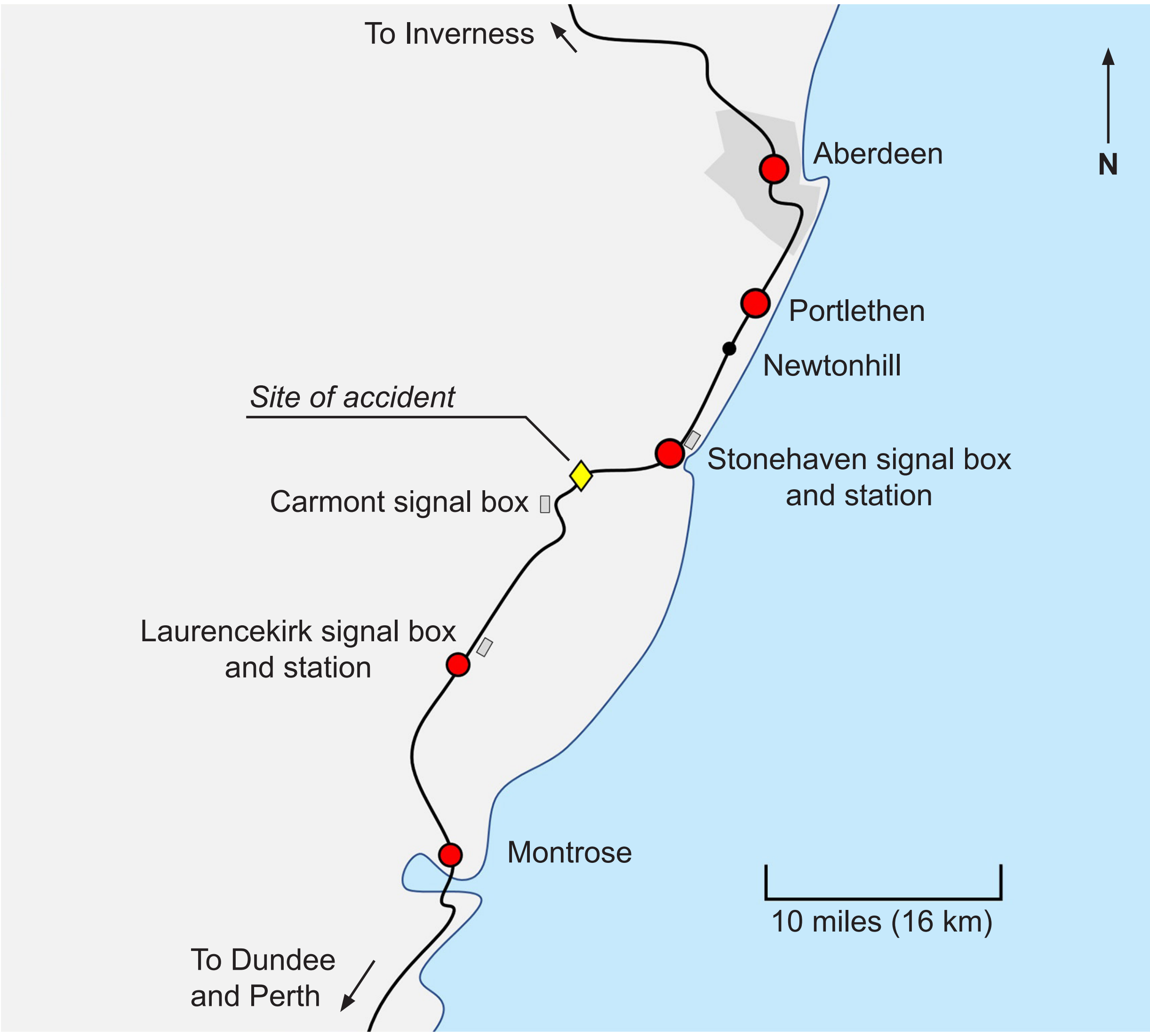


Figure 3: Railway context

Figure 4: A typical ScotRail class 43 HST with Mark III coaching stock (image courtesy of ScotRail)

People

13 There were nine people on the train at the time of the accident - the driver, the train's conductor, six passengers and another conductor travelling to join another train. The driver of the train, the train's conductor and one passenger suffered fatal injuries in the accident. All the other people in the train were injured. The train was lightly loaded because of the local Covid-19 travel restrictions which applied at the time of the accident.

Organisations involved

14 The railway is owned, operated and maintained by Network Rail, which employed the signallers at Carmont, Stonehaven and Laurencekirk signal boxes.

15 The train was operated by Abellio Scotrail Ltd (trading as ScotRail), which employed the staff who were on board at the time of the accident. The vehicles of the train were leased to ScotRail by Angel Trains Ltd, a rolling stock leasing company, and had been modified by Wabtec Rail Ltd, a rolling stock overhauler and maintainer.

16 Carillion Construction Ltd (which has been in liquidation since January 2018) was commissioned by Network Rail in 2009 to design and construct cutting slope remedial works, including a drainage system, for the deep cutting adjacent to the accident site.

17 Ove Arup & Partners Scotland Ltd was commissioned by Carillion to design improvements to the crest and slope drainage and to provide the railway with protection from rock falls.

Weather conditions

18 On 11 August 2020, bands of heavy, locally intense rainfall moved northwards across southern Scotland, the Central Belt and the Grampian Mountains. Similar bands then developed and moved northwards across the Grampian Mountains, but with little rain in eastern coastal areas between Dundee and Aberdeen. By late in the evening, heavy rain was falling on the eastern part of the Central Belt and parts of the Grampian Mountains. Carmont remained dry all day, except for light rainfall totalling 0.5 mm (figure 5).

19 Large amounts of locally intense rain continued to fall in the Central Belt and parts of the Grampian Mountains during the early hours of 12 August 2020. 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 (figure 6). There was then near-continuous heavy rain at this location until 09:00 hrs. However, it was dry and sunny by the time the train approached the accident site.

20 The 51.5 mm of rain which fell in this period at the accident site is almost 75% of the total monthly rainfall (70 mm) for Aberdeenshire in an average August. It caused significant flooding in the surrounding areas (figure 7).

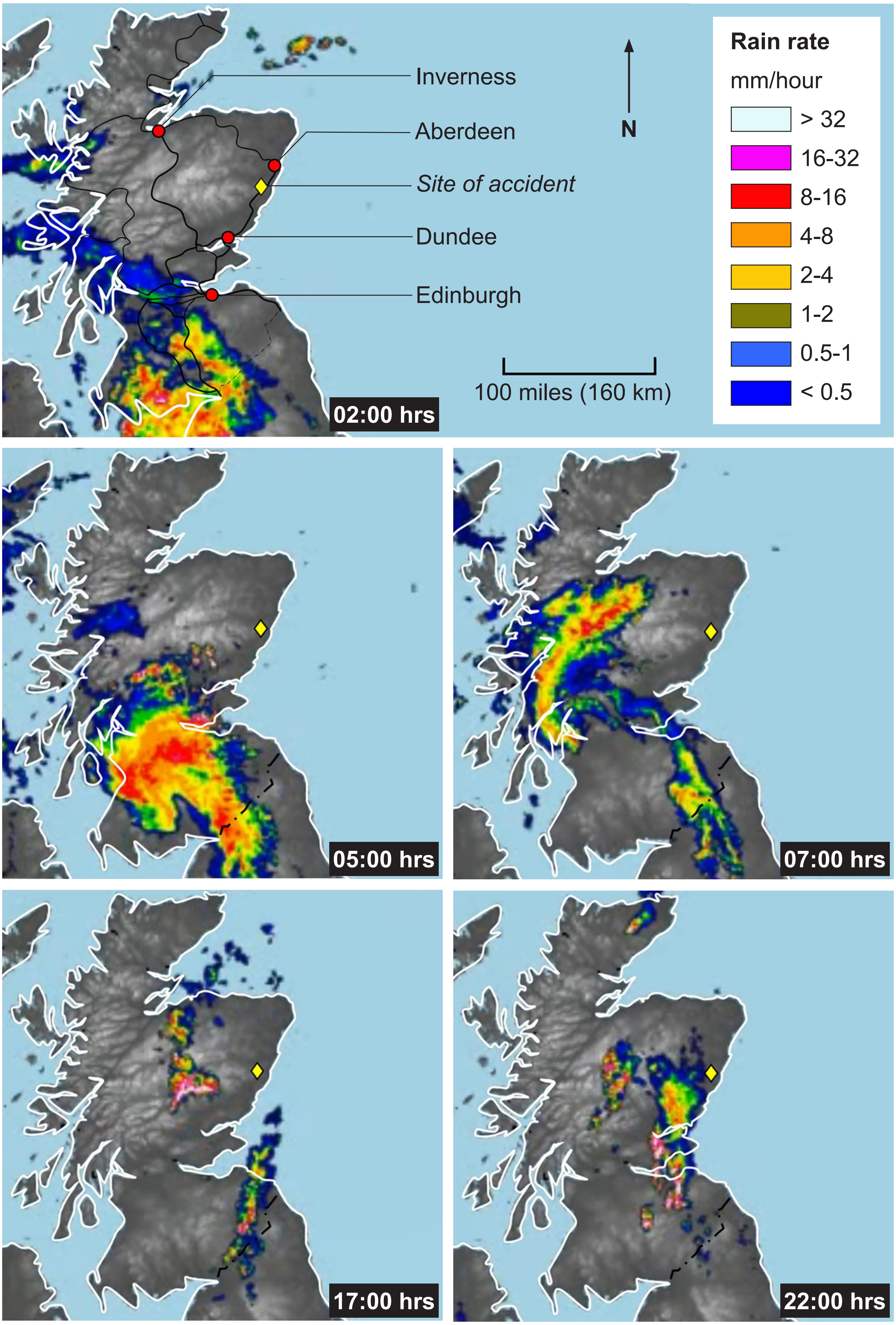


Figure 5: Rainfall - Scotland, 11 August 2020 (courtesy Met Office)

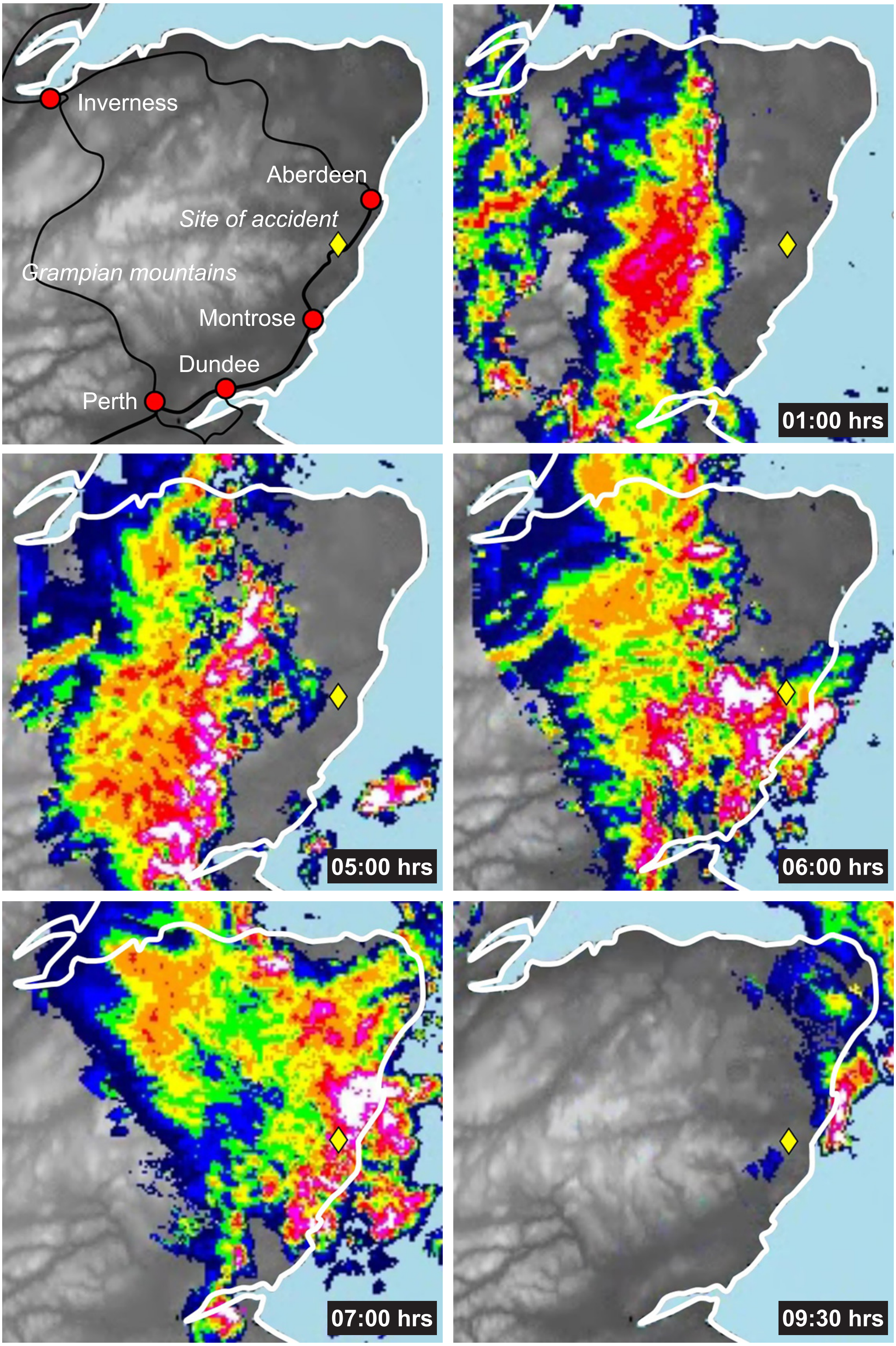


Figure 6: Rainfall - Perthshire, Aberdeenshire and surroundings, 12 August 2020 (key as figure 5)

Figure 7: Conditions on a road near Carmont at 08:39 hrs on 12 August 2020 (image courtesy of Chris Harvey)

History of the works and inspection

Installation of the drainage system

21 The cutting on the west (left-hand) side of the railway has a history of landslips and rockfalls. A landslip in 1915 caused a train to derail in the cutting at a location south of the 2020 accident. At an unknown date, many years before installation of the drain constructed by Carillion, a clay pipe drain had been installed along the cutting crest to intercept water flowing from adjacent land and transfer it to a ditch at track level which leads to Carron Water.

22 Ongoing cutting face instability resulted in Network Rail instructing Carillion Construction Ltd in 2009 to undertake improvement works. Ove Arup and Partners Scotland Ltd prepared a design for these which, in addition to securing slopes on both sides of the railway with rockfall netting, included a new drain running along the top of the cutting, that was intended to intercept water flowing towards the cutting. The new drain was necessary because the existing crest drain was not functioning effectively.

23 The new crest drain ran northwards for a distance of about 340 metres and comprised a 0.45 metre diameter perforated pipe buried in a gravel-filled trench, an arrangement often known as a ‘french drain’. An inlet near the south end captured water from a small burn (stream), which runs along a hedge line towards the railway. The gravel-filled trench was intended to collect water which seeped through the gravel and into the pipe through the perforations (figure 9).

24 Most of the drain sloped gently towards its outfall as it ran along the edge of a field, which rose gently away from the top of the railway cutting. However, as the cutting depth began to reduce, the drain followed the crest and, at the north-west end of the cutting, sloped relatively steeply at an average gradient of about 33% (1 in 3) to track level. Catchpits (manholes) were provided at intervals along the pipe to allow inspection and maintenance of the pipe (figure 8).

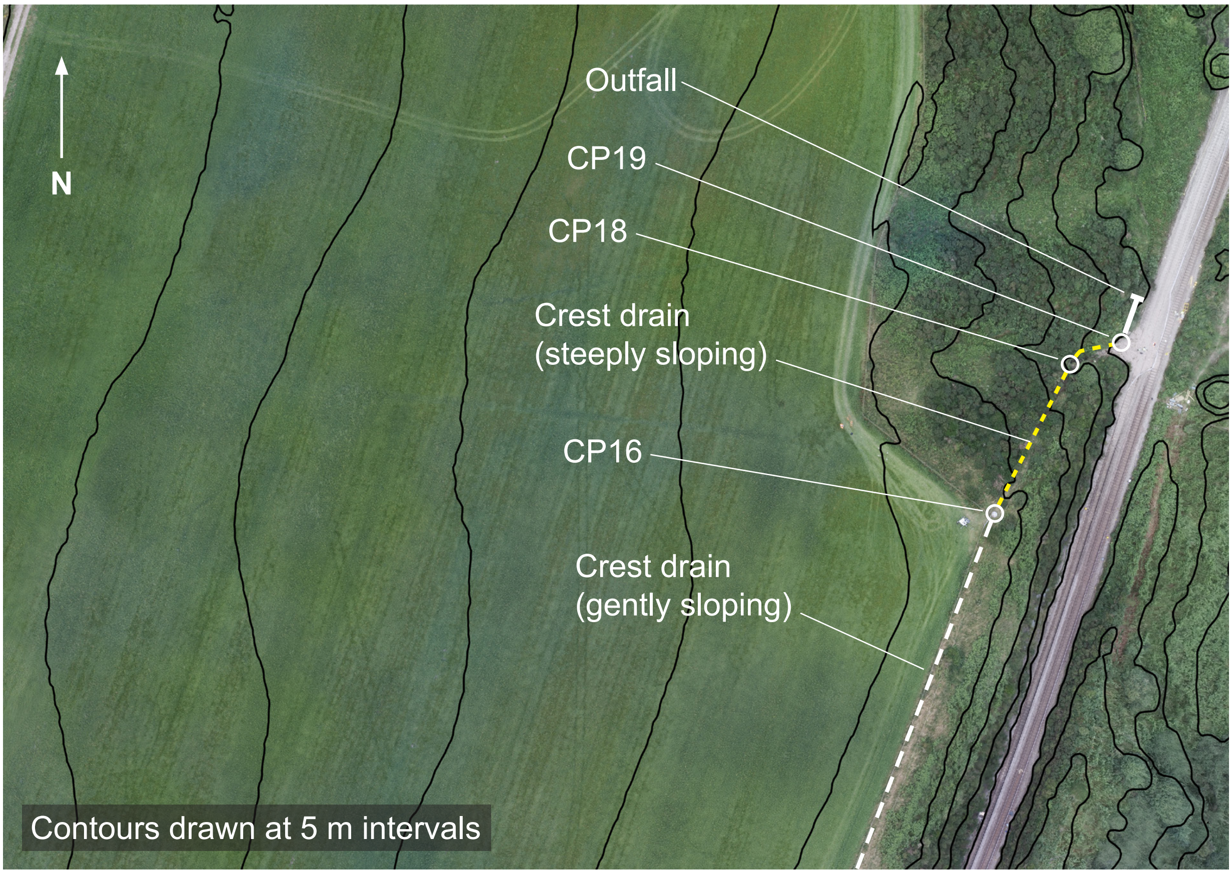


Figure 8: Drainage and initial RAIB survey (contours influenced by vegetation). Only selected catchpits (marked CP with number) are shown.

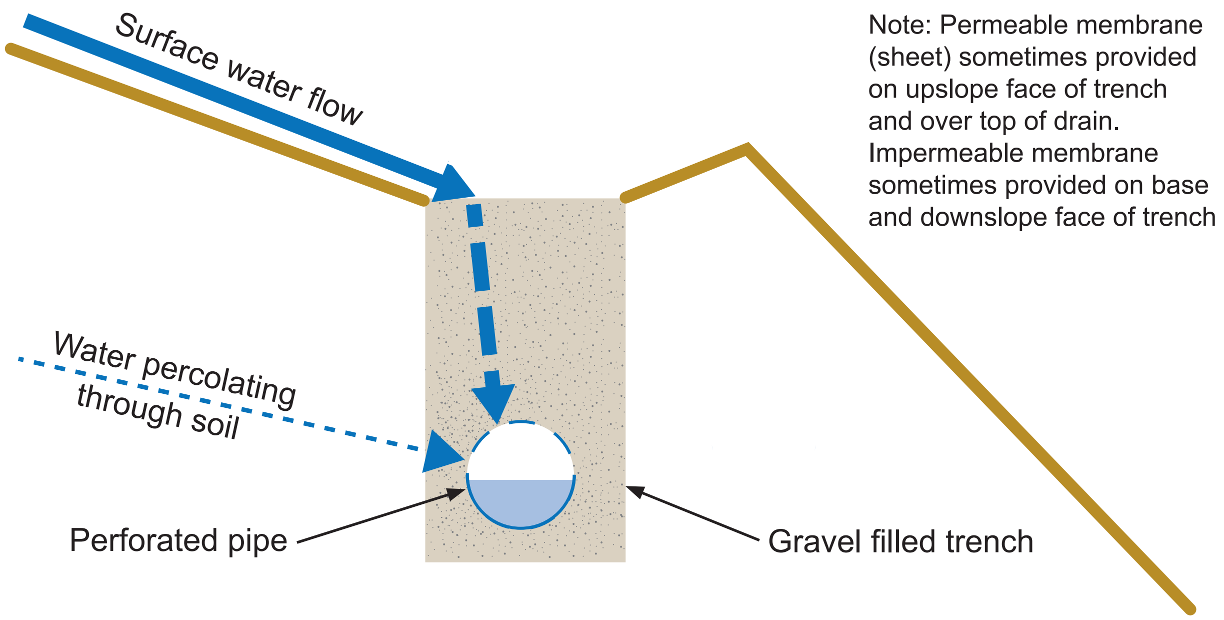


Figure 9: Gravel filled trench

25 A little above track level, the crest drain reached a catchpit, referred to as catchpit 18, located about 15 metres from the railway and near a bend in the pipe, where it changed direction and flowed towards catchpit 19 adjacent to the railway. Beyond catchpit 19, the drain turned to run parallel to the railway for a short distance, until it reached its outfall into a ditch at about track level. This track-side section of the new drain was installed alongside an existing clay pipe track drainage system, which included a catchpit and discharged into the same track-side ditch. The pipework of the crest drain and the track drain were not connected.

Drain inspections

26 The crest drainage system was completed in 2012, but only the section closest to the track, from catchpit 18 to the outfall, was listed on Network Rail's drain maintenance database at the time of the accident. RAIB has found no evidence that the drain upslope of catchpit 18 was inspected between its construction and the accident.

27 On 13 May 2020, two members of Network Rail staff based at Perth maintenance depot carried out a drainage inspection in the Carmont area using a hand-held computer loaded with information from the drain maintenance database, and therefore not including the crest drain upslope of catchpit 18. They inspected the drain downslope of catchpit 18 and did not observe any faults. They did not climb further up the steep gorse-covered slope to seek additional catchpits.

Earthworks inspections

28 Network Rail procedures require routine examinations of cuttings such as that at Carmont, to identify their condition and to trigger appropriate remedial action where needed. The section of cutting in the area of the washout was last examined on 14 June 2020, and this inspection resulted in the slope being assigned a '*low to medium*' likelihood of failure. It was assigned an earthworks hazard category of C on a scale from A (lowest risk) to E. The examiner found no serious issues, such as water flowing over the top of the cutting.

29 A previous examination report, from January 2017, recorded '*drain flowing freely*', based on the examiner seeing water flowing from the outfall at track level. Earthworks examiners are not given any information on drainage arrangements and are not expected to open catchpits. The cutting face was viewed from track level; the examiner did not climb to the top of the cutting and was not required to do so unless they considered this to be practicable and safe.[4]

Track inspections

30 The section of track where the derailment occurred had a planned inspection (a basic visual inspection), which was undertaken overnight on 11/12 August 2020 by an infrastructure technician and a driver travelling slowly in a road-rail vehicle. The inspection report stated that '*no actionable defects*' were found in the area of the accident. A track recording vehicle measured the track geometry through this area on 21 July 2020, and also identified no faults.

[4] Standard NR/L3/CIV/065 issue 6 clause 5.11.

Scour protection works

31 At the base of the bridge which the train travelled over after it had derailed (bridge 325), scour protection works were in progress at the time of the accident to prevent the river eroding away the bridge foundations. This involved work at river level, including installation of a concrete structure on the river bed. The contractor for this work had constructed an access road, which was later used to assist rescue and recovery.

The sequence of events

Events immediately before the accident

32 The heavy rainfall on the night of 11/12 August 2020 caused considerable damage to the railway system in Scotland such that, by 07:00 hrs on the morning of 12 August 2020, the only major route in the central and eastern parts of the country which remained unaffected was Inverness – Aberdeen – Dundee. The area south of Perth was affected by multiple instances of flooding, landslips and signal failures (figure 10). Problems affecting lines in Fife included an incident at a caravan park alongside the railway at Burntisland. A canal had burst its banks and closed the main Edinburgh to Glasgow line at Polmont.

33 On the morning of 12 August 2020, the first two southbound departures from Aberdeen, at 05:06 hrs and 05:36 hrs, left on time and passed through the Carmont area without incident; these were trains 2B12[5] and 1T06 (redesignated as 5T06 as it ran without carrying passengers). Train 5T06 ran to Dundee and, due to weather-related disruption (paragraph 32), was not expected to continue to Glasgow Queen Street, its normal destination. The 05:46 hrs train from Aberdeen to Edinburgh, train 1B07, was cancelled with railway records showing that this was because of '*heavy rain flooding the railway*'. The next departure was train 2B14, the 06:19 hrs service to Montrose, which ran normally to its destination.

34 The train involved in the accident, train 1T08, was the 06:38 hrs service timetabled to run from Aberdeen to Glasgow Queen Street. Because of the weather-related problems south of Dundee, the train was expected to terminate its journey at Dundee on the day of the accident. Train 1T08 departed from Aberdeen on time. The train called at Stonehaven at 06:53 hrs and had passed Carmont signal box when it was stopped by a railway emergency call made by the Carmont signaller, using the GSM-R[6] radio system, in response to a report of a landslip (see paragraph 36). The train stopped about 570 metres before the landslip, which was just north of Ironies Bridge, and subsequently returned northwards (see paragraph 47). Because railway emergency calls are relayed to route control,[7] the signaller's call also informed the route control manager about the Ironies Bridge landslip.

[5] An alphanumeric code, known as the 'train reporting number' is allocated to every train operating on Network Rail's infrastructure.

[6] Global System for Mobile Communications – Railway.

[7] The combined Network Rail/ScotRail route control located at the West of Scotland Signalling Centre in Cowlairs, Glasgow.

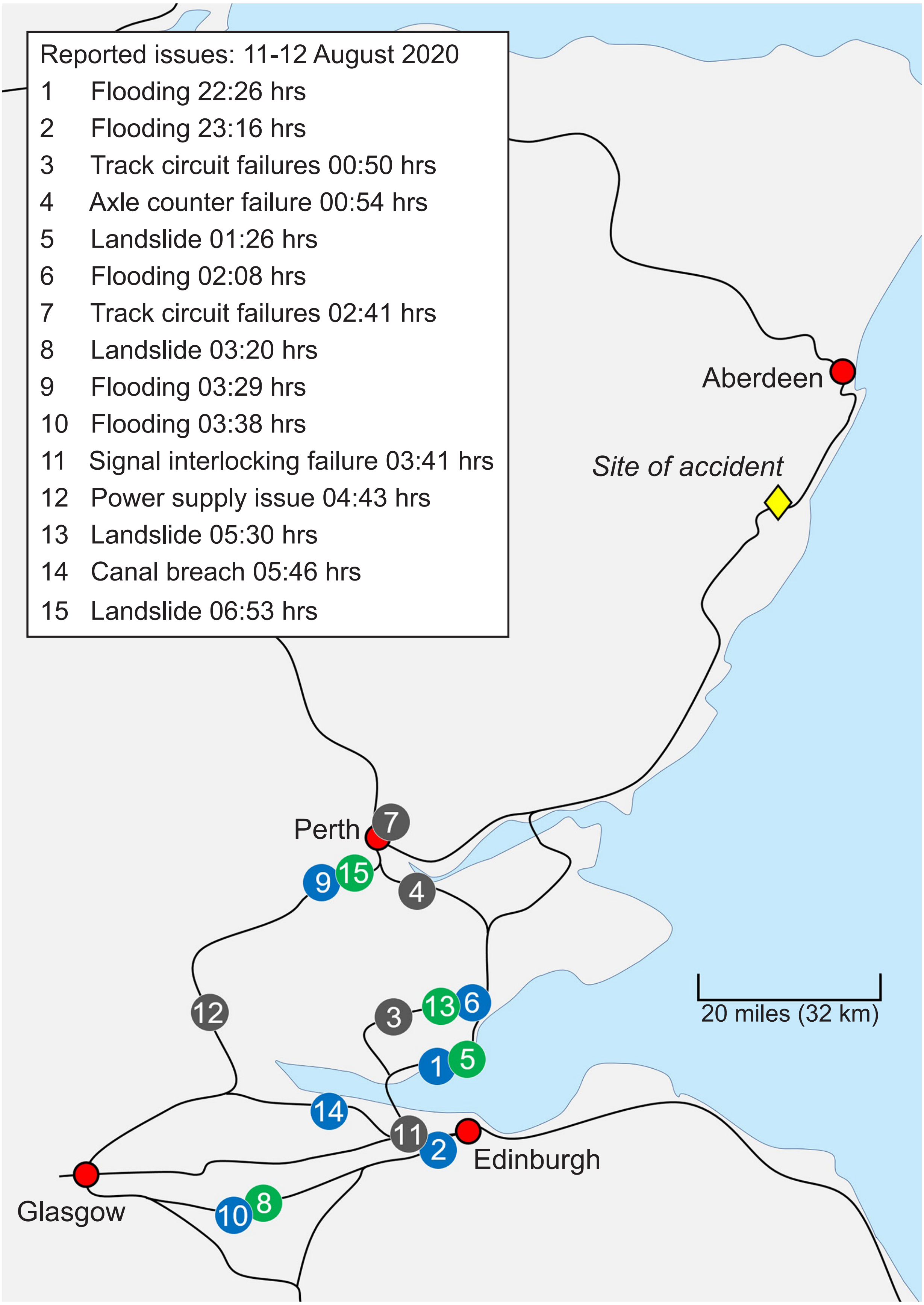


Figure 10: Known infrastructure failures south of Perth at 07:00 hrs on 12 August 2020

35 The first northbound train of the day to pass the accident site was train 1H25, the 05:39 hrs service from Dundee to Inverness (via Aberdeen). This train passed Carmont on time at 06:46 hrs but it encountered floodwater at Newtonhill, in the area of the 230 milepost, 11 miles (18 km) north of Carmont. At 06:57 hrs, the driver made a railway emergency call to the Aberdeen signaller (also relayed to route control) using the GSM-R radio system, and the railway was closed at Newtonhill until the situation could be assessed by Network Rail staff on the ground. Train 1H25 continued on its journey towards Aberdeen.

36 The next northbound train to pass the site was train 2B13, the 06:39 hrs service from Montrose to Inverurie (via Aberdeen). At 07:00 hrs, this train, travelling on the down line,[8] stopped adjacent to Carmont signal box. The driver reported to the signaller that he had seen a landslip affecting the up line at a location he identified as '*Black Bridge*', but which was subsequently found to be a short distance away at Ironies Bridge (these locations are respectively 2.1 km and 1.6 km south of Carmont signal box). The signaller informed the driver of train 1T08 about this landslip by making a railway emergency call (paragraph 34).

37 After the driver of train 2B13 had reported the landslip to the Carmont signaller, train 2B13 resumed its journey towards Aberdeen and passed the accident site at about 07:07 hrs, before reaching Stonehaven station at 07:13 hrs. It was unable to continue any further because of the flooding which had closed the railway at Newtonhill (paragraph 35). The driver saw nothing unusual when passing the accident site.

38 A Network Rail staff member arrived at Black Bridge, and the signaller provided them with protection from train movements, at 08:19 hrs. The staff member went to investigate the landslip which had been reported by train 2B13. He was unable to locate a problem at that location and started to walk north. He found the landslip blocking the up line approximately 550 metres away, close to Ironies Bridge, from where he could see train 1T08 stationary further north on the up line. He also found flooding affecting the down line in the vicinity of Ironies Bridge, and reported this to the Laurencekirk signaller, who informed route control at 08:50 hrs (see paragraph 40).

39 To the south of Ironies Bridge, train 1A43, the 06:00 hrs service from Perth to Inverurie, had been held at Laurencekirk station because of the flooding at Newtonhill. This was to avoid the risk of stranding the train, and its passengers, in a remote location because the next station, Stonehaven, was occupied by train 2B13 (paragraph 37). At 08:28 hrs, the driver of train 1A43 was advised by route control, via the signaller at Laurencekirk, that because of the route blockages further north, the train was to be terminated at Laurencekirk. The train was redesignated as 1Z43, crossed to the up line and departed southwards from Laurencekirk station.

[8] In the Carmont area, the down line is used by trains travelling north from Montrose towards Aberdeen, and the up line is used by trains travelling south. The down line is on the west side of the up line. The area between the two lines is known as the six-foot, and the area immediately outside the two tracks is known as the cess.

40 After travelling about 730 metres (800 yards), the driver of train 1Z43 stopped on seeing a landslip ahead at 210 miles 160 yards. The driver informed the Laurencekirk signaller who passed this information, and information about the flooding at Ironies Bridge (paragraph 38), to route control at 08:50 hrs. This meant that route control staff were now aware of two landslips and two flooding events in the 21 mile (34 km) section of line between Laurencekirk and Newtonhill (figure 11), in addition to the weather-related events elsewhere (paragraph 32, figure 10).

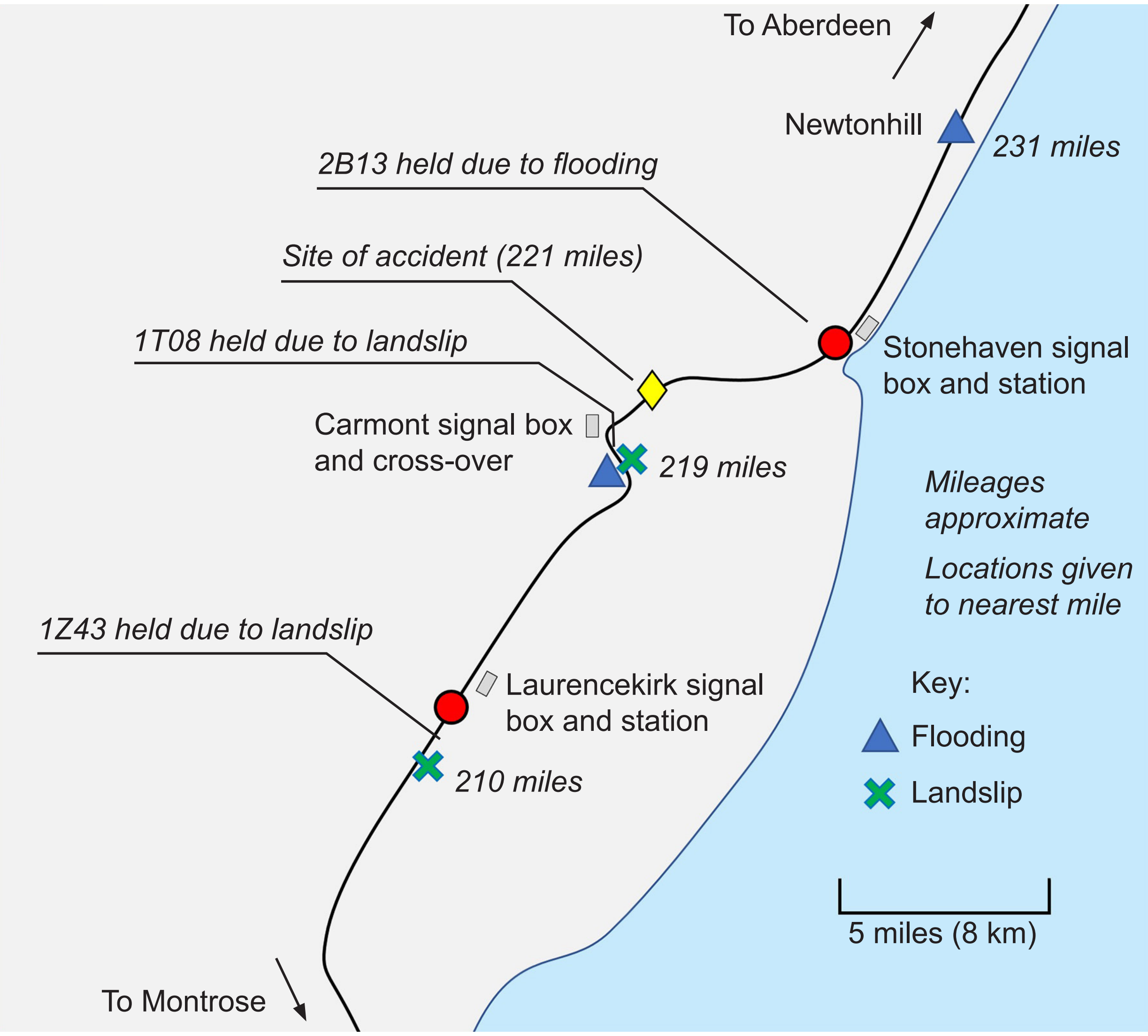


Figure 11: Train positions and known infrastructure failures around Carmont at 09:00hrs on 12 August 2020

Reversal of train 1T08

41 As train 1T08 was unable to proceed south beyond Ironies Bridge (paragraph 34), and there was concern about the passengers being stranded, a member of route control staff called the Carmont signaller at 07:18 hrs and asked him to arrange with the signaller at Stonehaven for train 1T08 to return to Stonehaven. This movement involved the train crossing from the up line to the down line at Carmont over the crossover there. This crossover is not equipped with facing point locks, a device which secures points in position and is required on points which are used by passenger trains in the diverging, or facing, direction. For this reason, the railway Rule Book required temporary clamps and scotches to be fitted to the points which make up this crossover before 1T08 could return north.

42 A Network Rail Mobile Operations Manager (MOM) was tasked (at 07:40 hrs) to travel to Carmont with the equipment for temporarily securing the crossover to allow the passage of train 1T08. The MOM, who was based in Aberdeen, experienced considerable difficulty in reaching Carmont, because of the many flooded roads in the area, and arrived there at approximately 08:55 hrs.

43 By 09:17 hrs, the MOM had fitted the necessary clamps and scotches to the crossover points. Arrangements were also made to de-train any passengers from train 2B13, which was still standing at Stonehaven, so that it could move out of the platform to make room for train 1T08. By 09:29 hrs the heavy rain had stopped and the sun was shining at Carmont signal box.

44 At 09:29 hrs, the Carmont signaller used the GSM-R radio system to speak to the driver of train 1T08, standing between the signal box and Ironies Bridge. The signaller authorised the train to return north on the up line as far as Carmont, traverse the crossover and then proceed towards Stonehaven on the down line. The signaller advised the driver to traverse the crossover at '*five miles per hour*', and said that everything was then fine to Stonehaven so the train could run at normal speed to there.

45 As the signaller was not aware of any obstruction on the line, railway rules did not require him to instruct the driver to travel at a speed slower than the maximum normally permitted. If aware of a possible obstruction or other potential problem, a signaller should instruct a driver to proceed at caution, at a speed which will allow the train to be stopped short of any obstruction.

46 The driver then asked the signaller whether train 1T08 would be held at Stonehaven, and the signaller confirmed that was the case, because the line was blocked beyond Stonehaven.

47 The signaller gave the driver permission to make the move, and the driver repeated back the instruction to confirm that he had understood it. Train 1T08 moved off, and passed Carmont signal box at about 09:34 hrs, travelling at 5 mph (8 km/h). After passing over the crossover, the train's speed increased and, as permitted by railway rules, the driver continued to accelerate the train towards 75 mph (121 km/h), the maximum permitted speed at the accident site.

Events during the accident

48 In the area of bridge 325, north of Carmont, heavy rain between 05:50 hrs and 09:00 hrs on 12 August 2020 resulted in gravel from the crest drain, together with stones and soil eroded from the surrounding ground, being washed onto the track. This debris covered the down line at 220 miles 1610 yards. The precise time at which this occurred is not known, but must be between about 07:07 hrs, when the last train before the accident passed this location (paragraph 37), and the arrival of train 1T08 at about 09:37 hrs.

49 Data from the on-train data recorder (OTDR) fitted to the trailing power car shows train 1T08 travelling at about 73 mph (117 km/h), which was less than the maximum permitted speed of 75 mph (121 km/h), as it approached the washout debris. The left-hand curve on the approach obstructed the driver's view of the debris until the train was about 120 metres from it. The train covered this distance in less than four seconds. Although the OTDR records an application of the emergency brake, there was insufficient time for this to have had any significant effect on the train's speed before it struck the debris. When the leading power car struck the debris, it derailed to the left. Its leading end progressively deviated towards the cess as the track curved to the right, and it continued running derailed for around 60 metres until it struck a section of bridge parapet. After destroying more than half the parapet, the power car fell off the bridge and down onto a wooded embankment below, and the driver's cab became detached on impact with the ground.

50 Three of the following five vehicles travelled in different directions beyond the bridge (figure 12). 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 and came to rest on its right-hand side. 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. The behaviour of the train in the derailment and the damage it sustained are described in more detail in paragraphs 71 to 83.

Events after the accident

51 The contractors working on the scour protection project at bridge 325 (paragraph 31) had a small team on site on 12 August 2020 to protect plant and equipment from rising water levels. Two people were standing by the river when they heard a '*loud rumbling noise from above*', and ran as the derailed vehicles fell down the embankment. The contractor's supervisor made a 999 call at about 09:37 hrs.

52 At 09:43 hrs Police Scotland advised route control of a report of a train off the track and on fire between Carmont and Stonehaven. This message was passed to the signaller at Stonehaven, who in turn called the Carmont signaller, and at 09:48 hrs the signallers stopped all further train movements between these locations. Network Rail staff, including the MOM who had been at Carmont signal box, reached the site of the accident at approximately 09:55 hrs, and the emergency services started to arrive at around 10:13 hrs. At 10:15 hrs a conductor who had been travelling to Dundee as a passenger on train 1T08 phoned Carmont signal box from a lineside telephone, having walked along the line from the site of the accident.

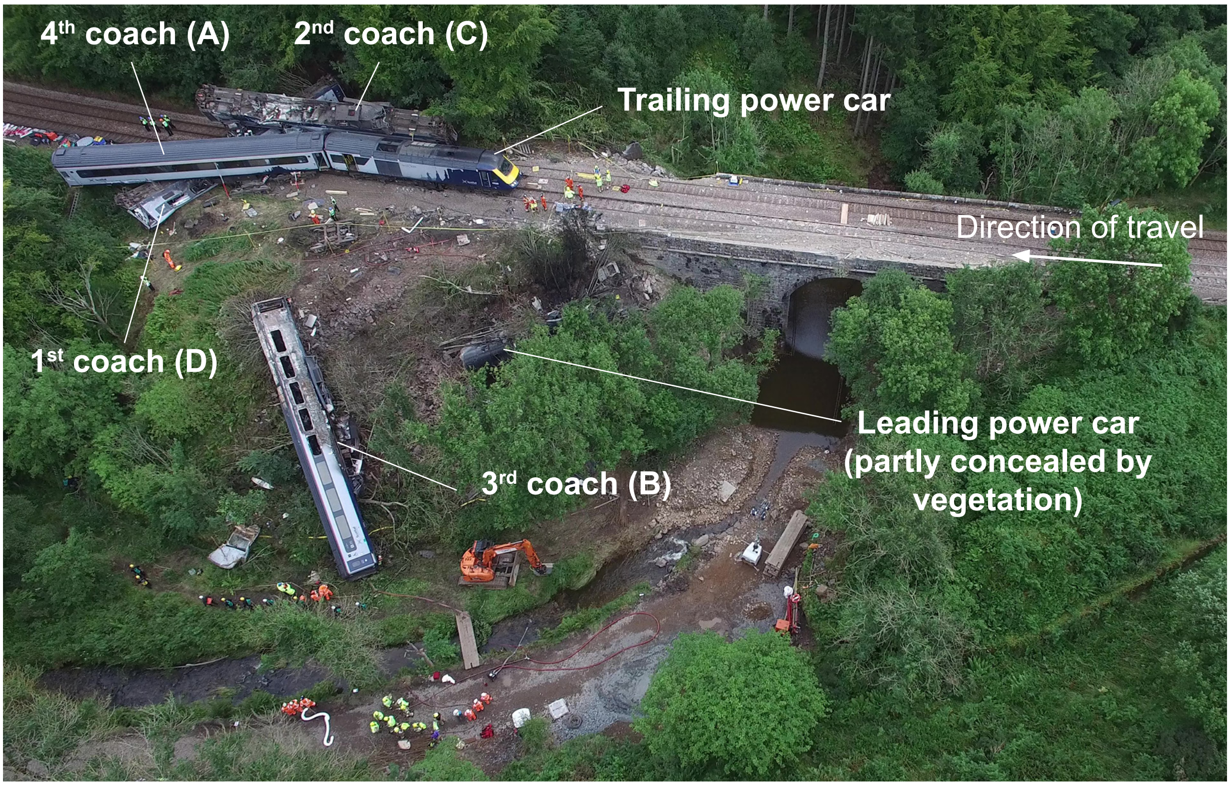


Figure 12: Derailed train

53 The scour protection contractor's staff provided initial assistance to the injured people on the train. They also used a small excavator that was on site to move a portable fuel tank away from the scene, to put water on one of the fires (see paragraph 83) and to place a timber mat across the river to make a temporary bridge. Local residents also responded and provided assistance to injured people and the emergency services.

54 During the first few hours after the derailment, the emergency services established their presence on site, removed the injured people to hospital and extinguished the fire in coach B.

The RAIB investigation

55 ScotRail notified the accident to RAIB at 10:10 hrs on 12 August 2020. RAIB immediately despatched a team of investigators by air and rail, the first of whom arrived on site at 18:00 hrs. In conjunction with investigators from the police and the Office of Rail and Road (ORR), RAIB began identifying and collecting evidence. This included an examination and survey of the train wreckage, the track, bridge 325, the washout debris, the drain the debris had come from, other drainage features in the area, and the steep slope and field above the railway. Further RAIB staff were deployed to site during subsequent days.

56 Preparations for the recovery and removal of the vehicles began immediately. The need to construct a suitable access road and foundation for cranes to work from meant that it was 7 September 2020 before the first of the vehicles of train 1T08 was removed from the site. All the vehicles were taken to a secure, covered location for detailed examination.

57 The last vehicle was lifted from the railway on 15 September 2020 and the line was formally handed back to Network Rail on 19 September 2020. However, before this date, Network Rail had been able to access parts of the site to plan and begin repairs. The line was reopened for traffic on 3 November 2020, after new drainage had been installed.

58 Investigation of the land above the railway, by RAIB and others, is continuing. Monitoring equipment has been installed and continues to provide data on ground conditions and water flows.

Cause of the derailment

59 The train derailed after colliding with stones washed out onto the track from the gravel-filled crest drain and from the adjacent ground. Post-accident surveys of the track found no evidence suggesting the derailment occurred on the approach to the debris on the track, and verified pre-accident inspections which had found no track defects in this area. RAIB has not found any evidence of a train fault that could have played a part in its derailment.

60 The first evidence that train wheels had deviated from the rails was identified less than one metre beyond the point where the left-hand rail emerged from beneath the debris. The top surface of the rail was scored by the flange of the leading left-hand wheel as it started to derail.

Cause of the washout

61 The washout was caused by unusually heavy rain (paragraph 19) which washed stone from the gravel-filled crest drain near catchpit 18, and from surrounding ground, onto the adjacent track leaving the perforated drainage pipe exposed. Local ground topography directed large amounts of surface water onto the steeply sloping drain in the area from which gravel was washed (figure 8). Although surface water flow alone can dislodge gravel, and stones of other sizes, RAIB is continuing to investigate whether other factors, such as the drainage system's design or the quality of installation, contributed to the displacement of material.

62 The topography of the area around the washout, as recorded by an RAIB aerial survey immediately after the accident, is shown in figure 8. Gravel was missing from the drain to a depth sufficient to expose the buried pipe partially or completely for a distance of about eight metres upslope of catchpit 18 (figure 13). Material was also missing for an additional six metres around and downslope of catchpit 18 (figure 14). Evidence of large surface water flows in this area was shown by detritus caught on a fence and by erosion of channels in the soil immediately upslope of the drain.

63 The colour and shape of the drain fill, as evidenced by gravel remaining in the drain, differed from stones occurring naturally in the surrounding area and represented a significant proportion of the debris on the track. The locally occurring material found on the track was probably washed from the surrounding soil and the slope close to the track. Stones similar to those found in the debris on the track were seen in natural soil exposed in the trench sides in areas where the gravel fill had been washed out.

Figure 13: Drain with gravel washed out upslope of catchpit 18

Figure 14: Drain downslope of catchpit 18

64 It is possible that surface water flows, before the day of the accident, had been sufficient to dislodge gravel from small areas of the gravel-filled drain, sufficient to be seen in the area affected, but with insufficient material washed down for this to be apparent at track level. The lack of an effective drainage inspection regime (paragraph 26) meant that any such indications of future problems upslope of catchpit 18 would not have been detected.

Management of trains in extreme weather

65 Network Rail procedure[9] NR/L2/OPS/021 and associated documents require operational risk arising from extreme weather to be managed using pre-planned mitigations given in an Integrated Weather Management Plan (IWMP), which includes the Adverse/Extreme Weather Plan (A/EWP) containing earthwork-related mitigation. Provision of mitigation given in the IWMP is normally initiated by route control staff calling an Extreme Weather Action Teleconference (EWAT), involving themselves and staff from appropriate maintenance, asset management and train operator teams.

66 In Scotland, the route control manager, located at route control, decided whether to call an EWAT (as part of a broader consideration of weather issues) after reviewing weather forecasts provided by a specialist forecaster shortly before 03:00 hrs each day. The time taken to convene an EWAT and then mobilise the resources needed to implement mitigations in the A/EWP meant that a weather hazard needed to be forecast the previous day if mitigation was to be implemented on a particular morning.

67 Each forecast covered five days, with the first commencing at 06:00 hrs on the day of the forecast. The forecasts considered weather hazards including ‘heavy rain accumulation’ and ‘convective rainfall intensity’, the first reflecting the total amount of rainfall and the second identifying a type of storm sometimes associated with intense (high rate of) rainfall, typically summer storms. Hazards were presented for five areas: Edinburgh, Motherwell, Perth, Glasgow and Highlands (figure 15). Dependent on their severity, the hazards were progressively classified as Extreme (the most significant), Adverse or Aware. The forecaster included a low, medium or high confidence level for each forecast hazard, including instances when no hazard was forecast.

68 Rain-related forecasts received at 02:57 hrs on the morning of 11 August 2020 and at 02:51 hrs on the morning of 12 August 2020 are summarised in Table 1. The ‘heavy rain accumulation’ and ‘convective rainfall intensity’ hazards for 12 August 2020 (the day of the accident) were not forecast the previous day and were given low confidence ratings when predicted on 12 August 2020. The route control manager did not call an EWAT meeting as a result of receiving the weather forecasts on 11 August 2020 and 12 August 2020, as he concluded the forecast weather was not sufficiently adverse to require this.

[9] Procedure NR/L2/OPS/021 ‘Weather – managing the operational risks’; issue 8 June 2019 was applicable at the time of the accident.

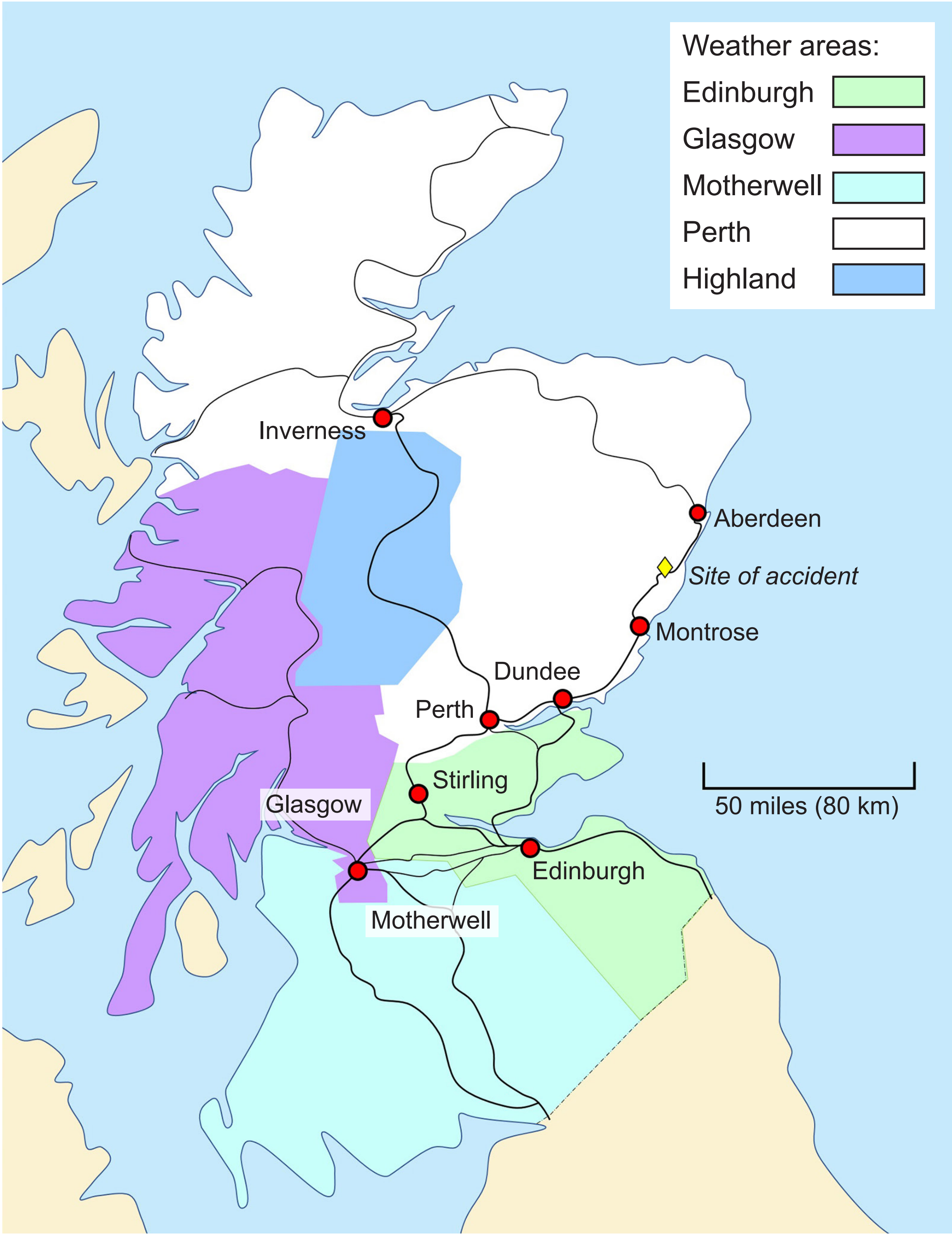


Figure 15: Areas used in Network Rail weather forecasts for Scotland

Forecast issued	Predicted to occur on	**Perth area, incl. accident site** Hazard rating (confidence in brackets)		**Edinburgh, Motherwell, Glasgow and Highland** Number of areas with each hazard rating	
		Heavy rainfall	**Convective rainfall**	**Heavy rainfall**	**Convective rainfall**
11 August	11 August	Extreme (Low)	Aware (Low)	Extreme - 1 Adverse - 2 Aware - 1	Aware - 4
	12 August	No hazard (Low)	No hazard (Medium)	Aware - 2 No hazard - 2	Aware - 2 No hazard - 2
12 August	12 August	Extreme (Low)	Aware (Low)	Aware - 2 No hazard - 2	Aware - 2 No hazard - 2
Other hazards, including lightning in the Perth area, were included in the forecast but are not shown above. Text accompanying the hazard ratings provided some additional information about expected weather conditions.					

Table 1: Rain related hazards in weather forecasts (for areas shown in figure 15)

69 It is unlikely that calling an EWAT would have avoided the accident because the A/EWP did not require any mitigation to be applied at or near the site of the accident. The same applied to the locations of the two landslips and two sections of flooded track located in the Laurencekirk to Newtonhill area (figure 11). The A/EWP only required mitigation at locations which Network Rail considered as particularly vulnerable to extreme weather; it contained no provision for other areas of the railway.

70 At the time of the accident, Network Rail had no formal procedure requiring an immediate review of operating restrictions after the occurrence of multiple weather-related events, such as those in the Laurencekirk to Newtonhill area that were known to route control staff at 09:00 hrs on the morning of the accident.

The derailment and its consequences

71 When the train struck the washout debris, the leading bogie of the leading power car derailed to the left (cess) side of the track, followed by the trailing bogie within a few metres. The leading bogie progressively drifted towards the cess as it approached the bridge. None of the following vehicles appear to have derailed at the landslip. By the time the power car reached the bridge, its leading end was displaced so far to the left that it struck the bridge parapet, demolishing it and, as a result, deviating even further to the left of the track. Near the middle of the bridge, the leading power car became detached from the first passenger coach. During the detachment, the first passenger coach climbed over the trailing right-hand side of the power car, which caused substantial structural damage to the vehicle ends involved in this interaction. The power car then fell off the bridge and down onto the embankment below. The leading bogie of the first passenger coach followed the leading power car onto the embankment.

72 The first passenger coach and following vehicles continued over and beyond the bridge. The first three coaches then jack-knifed in sequence, each becoming uncoupled from the adjoining vehicles, shedding all their bogies and rotating in different directions in the horizontal plane. The first passenger coach (D) rotated to the left (anticlockwise) and came to rest on its roof and almost at right angles to the track. The second coach (C) rotated to the right, ran through some trees and collided with the bank on the cess side of the up line. It then spun round further and came to rest upside down having rotated almost 180 degrees so its trailing end was on top of coach D.

73 The third coach (B) rotated to the left, ran down the steep embankment and came to rest on its right-hand side at an angle of 130 degrees to the track. The fourth coach (A) continued upright on its bogies, until it struck debris from the other vehicles near coach D, and was lifted up and to the left of the track, coming to rest on top of the leading end of coach D. The trailing end of Coach A remained coupled to the trailing power car, which stayed upright.

74 As a result of the derailment and damage to the vehicles, the train driver, the conductor in coach D and a passenger in coach C all suffered fatal injuries. The six other occupants of the train suffered injuries, some serious.

75 The leading power car and all four passenger coaches suffered substantial damage, with the extent of the damage reducing progressively towards the rear of the train.

76 On the leading power car, the driver's cab became completely detached when the vehicle collided with the bank, and the roof, right-hand body side, trailing end, bogies and underframe were substantially damaged.

77 The first passenger coach (D) suffered severe damage to the leading vestibule, roof, and body sides over the leading half of the vehicle, which resulted in significant loss of survival space in that area. The collapsed roof and bodysides also caused substantial disruption to the interior furniture, light fittings and trim panels in that area, but the seats and tables remained attached. Almost all the windows in the leading half of the vehicle were broken through.

78 The second coach (C) sustained damage to the leading vestibule, and localised penetration damage to the trailing left-hand side, most likely as a result of impacts with detached bogies. There was also penetration of the trailing right-hand side. Four windows along the left trailing side were broken through. The coach retained its survival space and the interior furniture remained in place except within a localised area at the trailing end where the seats had been pushed into the aisle by damage to the left-hand body side.

79 The third coach (B) sustained substantial damage to the right-hand body side, roof and underframe equipment, and some damage to the leading vestibule. All the windows on the right-hand side and most of those on the left-hand side were broken through. Coach B later caught fire, which resulted in most of the vehicle's interior being burnt.

80 The fourth coach (A) suffered substantial damage to the leading vestibule and localised damage to both body sides, and the leading bogie pivot and underframe equipment were severely damaged. Several windows were also shattered but not broken through. The interior remained intact.

81 The trailing power car did not suffer any significant damage.

The fires in the derailed vehicles

82 Evidence from witnesses as well as from the on-train CCTV shows that the leading power car was visibly on fire immediately after it came to rest. The likely cause of the fire was the spillage of diesel fuel from the ruptured fuel tank, onto hot engine parts.

83 Coach B subsequently caught fire. Witnesses state that coach B was not visibly on fire until well after the emergency services had arrived. Witness evidence specifically mentions the fire on coach B as being near the battery compartment. No-one was in Coach B at the time of the accident, and no-one was injured as a result of either fire.

Actions already taken by the rail industry

84 Following the accident, on 18 August 2020 Network Rail issued an emergency instruction to signallers relating to the operational procedures for reporting and managing services during heavy rainfall events which cause water levels to rise on or near the railway, or where there is a potential for damage. On the same day the company issued an emergency instruction on the management of earthworks during adverse and extreme weather that required Route Directors to arrange for dynamic assessment of risk to operational management at times of significantly heightened rainfall intensity.

85 In September 2020 Network Rail issued document NR/OPS/GN/012 issue 01 'Network Rail Operational Guidance to Route Control during periods of adverse/extreme rainfall'. This document sets out revised actions which route controls are to take in the event of extreme rainfall. These are assessed by dividing the railway into sections and carrying out a risk assessment for each section, taking account of issues including typical weather conditions, the number of risk sites and condition of drainage. Application of mitigation is partly guided by assessing the potential effect of rainfall, taking account of both the amount of rain and, using soil moisture data, the ability of soil to absorb this rather than cause it to flow over the ground surface. The new process also introduced guidance on thresholds for the amount of convective rainfall which requires consideration as a risk factor.

86 The company has also stated that it intends to establish additional precautionary measures for operating trains and managing earthworks during adverse and extreme weather.

87 Amendments to the railway Rule Book,[10] which came into force in December 2020, were described in the associated railway operating notice as introducing clearer instructions for dealing with damage to structures or earthworks, and any unusual flows or pools of water that could cause damage.

[10] Published by RSSB, a not-for-profit company owned and funded by major stakeholders in the railway industry and which provides support and facilitation for a wide range of cross-industry activities. The company is registered as 'Rail Safety and Standards Board' but trades as 'RSSB'.

Expert review committees

88 Network Rail has commissioned two external reviews by committees headed by independent experts. One deals with Network Rail's management and understanding of the implications of its historic earthworks; the second deals with the implications of climate change. RAIB recognises the importance of these issues to safe management of the railway, and continues to investigate possible overlaps between these issues and the derailment at Carmont.

Areas of ongoing investigation

89 The main areas being considered by RAIB as part of its ongoing investigation are:

- The railway's responses to severe weather events and weather-related infrastructure failures
- The competence and training of operational staff to deal effectively with such events
- The railway's management systems and decision-making processes at times of wide-spread disruption caused by severe weather and/or multiple instances of infrastructure failure
- The railway's use of weather data to help it manage events such as:
  - major winter storms, which can often be forecast with relatively high certainty
  - localised events, such as intense summer storms, for which details cannot be forecast with confidence, but which may be apparent from real-time weather monitoring.
- In respect of the Carmont drainage system:
  - the actual behaviour of the drainage system and a comparison of this with the intended behaviour; an investigation strand which includes analysis of relevant ground and groundwater data, collection of additional ground and groundwater data and mathematical modelling
  - the validation and approval of the drain design methodology, design data, and design output
  - the way in which the drain was constructed and actions taken in response to issues identified during construction and the quality of installation
  - the intended and actual post-construction inspection processes and reasons for any differences.
- In respect of the train and the mitigation of derailments:
  - causes of the fires, particularly the fire in coach B
  - possible effects of fire on the way in which windows broke
  - causes of the injuries sustained by the people on the train
  - crashworthiness of rail vehicles in high energy accidents
  - the performance of devices fitted on trains to displace obstacles on the track
  - devices to mitigate risk in the event of derailments at high-risk locations.

- The likely effect of climate change on the type of weather event that caused the accident at Carmont, and its relevance to the future management of railway drainage
- Underlying management factors, including the development and validation of standards relating to risk management of extreme weather events
- The railway industry's responses to previous RAIB recommendations
- Recommendations for the improvement of railway safety.

Rail Accident Investigation Branch

Date: 19/04/2021

This interim report is published by the Rail Accident Investigation Branch, Department for Transport.

Any enquiries about this publication should be sent to:

RAIB
The Wharf
Stores Road
Derby UK
DE21 4BA

Email: enquiries@raib.gov.uk
Telephone: 01332 253300
Website: www.gov.uk/raib