RAIB

Rail Accident Investigation Branch

Rail Accident Report

Derailment of a passenger train at Roudham Heath, Norfolk, 6 February 2024

Report 03/2025
February 2025

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.

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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.

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Summary

At around 20:53 on 6 February 2024, a passenger train travelling at 83 mph (134 km/h) through Roudham Heath, Norfolk, struck two trees which had fallen onto the track. As a result, the train derailed and travelled for around 680 metres before coming to a stop.

One of the 31 passengers on board suffered a minor injury. There were no other injuries to the passengers or staff on the train. The train and infrastructure both suffered damage, and the line was closed for a day while repairs took place.

The two trees were part of a forest adjacent to the railway that is owned and managed by Forestry England. One of the trees, a twin-stemmed pine tree, fell first, landing on and felling an adjacent oak tree. The pine tree suffered from a loss of root anchorage, primarily because it was standing in highly saturated, sandy soil. Because of the way the pine tree had grown and its proximity to the railway, it was more likely to land over the tracks in the event of it falling. Inspections of the trees by Network Rail and Forestry England had not identified any cause for concern, and so no action had been taken to reduce the likelihood of the tree falling.

RAIB's investigation identified that the risk imposed by trees standing in saturated soil was not being effectively managed by either Forestry England or Network Rail. This was an underlying factor to this accident.

There was no significant deformation of the train's cab structure following the collision, and an axle-mounted brake disc on the train engaged with one of the rails which helped to contain the train's path during the derailment.

RAIB has made two recommendations, one addressed to Forestry England and one to Network Rail. Both recommendations ask the respective organisations to review their processes for inspecting and managing trees that are within falling distance of the railway, to consider the effects of high soil saturation levels on the risk of trees falling, and to make any appropriate changes.

Introduction

Definitions

1 Metric units are used in this report, except when it is normal railway practice to give speeds and locations in imperial units. Where appropriate the equivalent metric value is also given. Left and right when used in the report relate to the train's direction of travel.

2 The report contains abbreviations and acronyms, which are explained in appendix A. Sources of evidence used in the investigation are listed in appendix B.

The accident

Summary of the accident

3 At around 20:53 on 6 February 2024, a passenger train travelling at 83 mph (134 km/h) through Roudham Heath, Norfolk, struck two trees which had fallen over the track. The train derailed as a result of the collision, subsequently travelling around 680 metres before coming to a stop.

4 One of the 31 passengers on board suffered a minor injury. There were no other injuries to the passengers or the staff on board. The train and railway infrastructure both suffered damage, and the line was closed for a day while repairs took place.

Context

Location

5 Roudham Heath is an area of mixed woodland in western Norfolk, forming an outlying part of Thetford Forest. The town of Thetford lies around 5 miles (8 km) to the south-west (figure 1). Harling Road station is 2.5 miles (4 km) to the east.

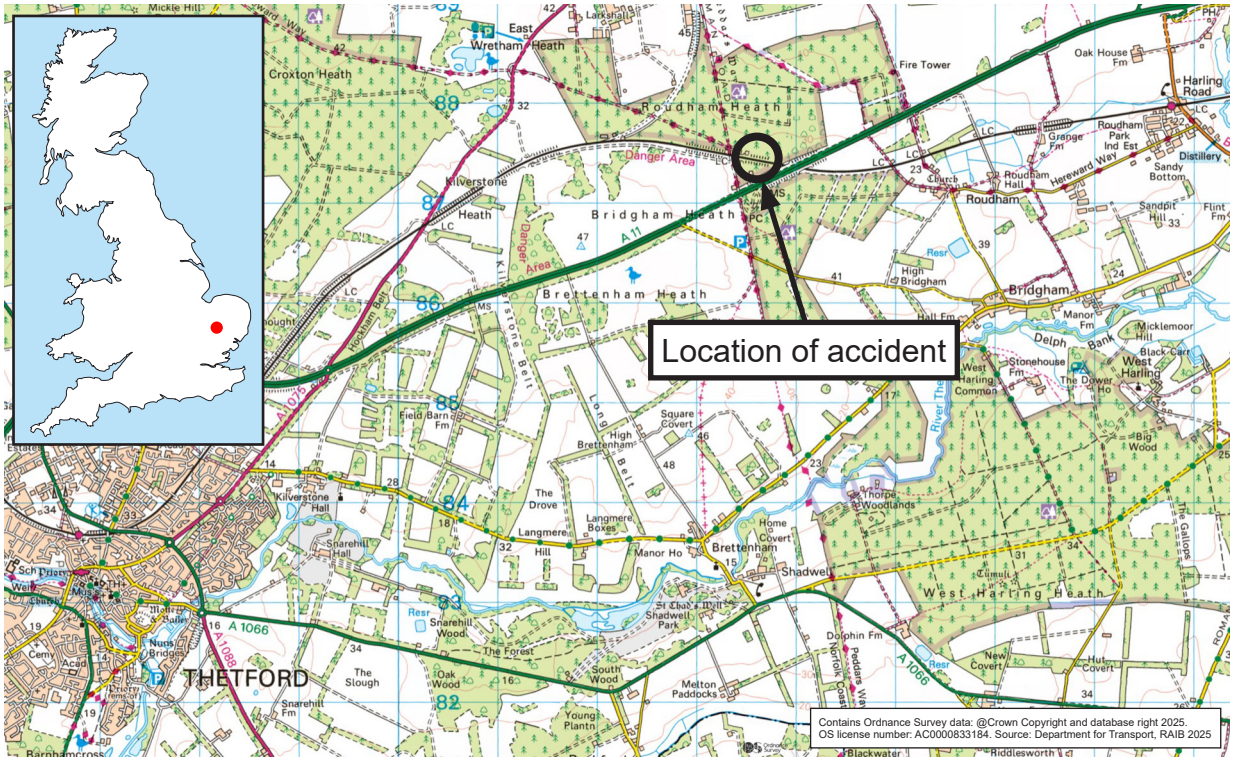

Figure 1: Extract from Ordnance Survey map showing the location of the accident at Roudham Heath.

6 The railway through this area consists of two running lines. The Up Main line is used by trains travelling west towards Ely. The Down Main line is used by trains travelling east towards Norwich. Both lines have a permissible speed of 90 mph (145 km/h) throughout this area.

7 The trees involved in the accident fell from land to the north of the railway, nearest the Down Main line, around 180 metres east of Shadwell level crossing. The railway passes under the A11 dual carriageway 450 metres east of the collision site (figure 2).

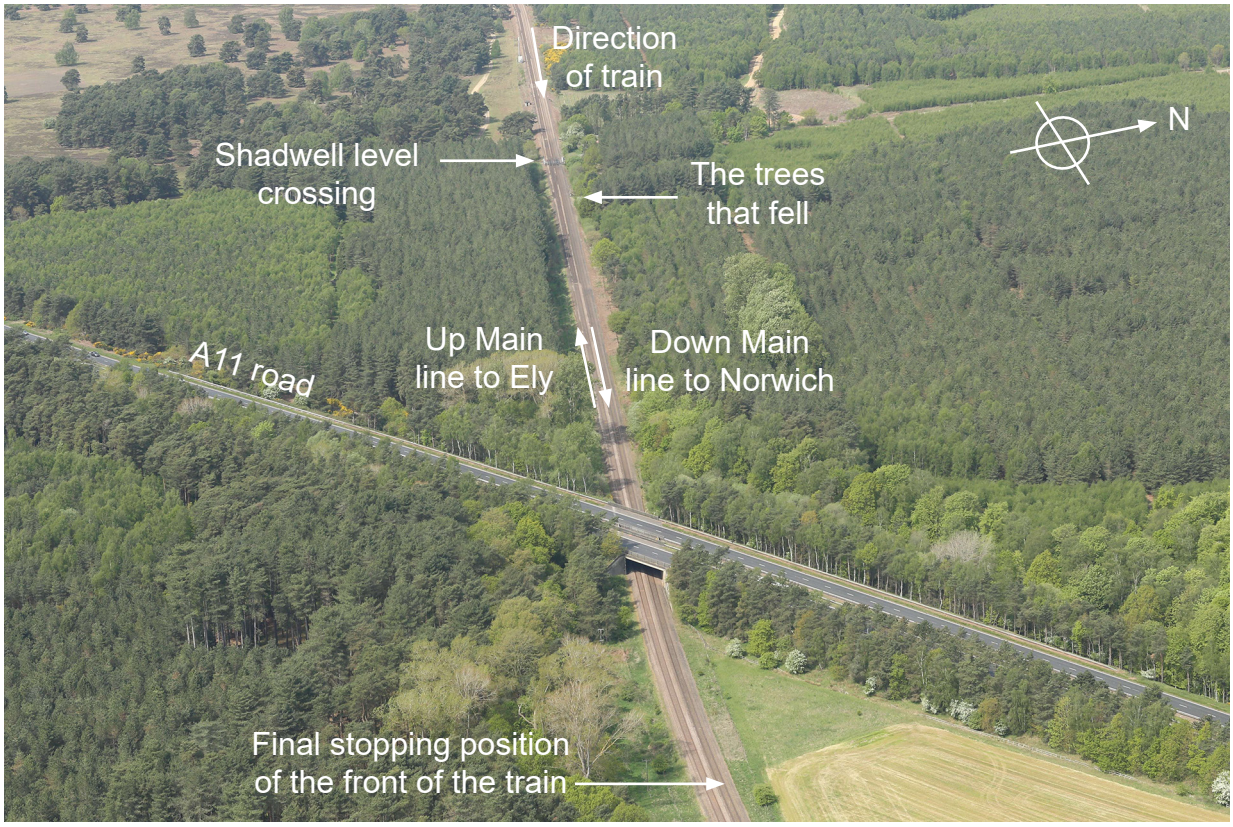

Figure 2: Aerial view showing the area around Roudham Heath (courtesy of Network Rail, with RAIB annotations).

Organisations involved

8 Network Rail owns, operates and maintains the railway infrastructure in this area. It employed the off-track staff that completed the vegetation inspections along the track. The site forms part of Network Rail's Anglia route, which is part of its Eastern region.

9 Forestry England, an executive agency sponsored by the Forestry Commission, owns and manages the land from where the trees fell. It also employed the forester that undertook inspections of Thetford Forest, including the area at Roudham Heath. This whole area forms part of its East England district.

10 East Midlands Railway (EMR) operated the train involved and employed the driver and senior conductor on board.

11 All organisations freely co-operated with the investigation.

Train involved

12 The train involved was a 2-car class 158 diesel multiple unit, reporting number 1L15, which formed a passenger service from Liverpool Lime Street to Norwich, via Nottingham. While the train was fitted with a forward-facing closed-circuit television system (FFCCTV), the footage recovered by EMR did not show any details of the accident as it was too dark (see paragraph 19). The train was fitted with an on-train data recorder (OTDR) which records the train's speed, the operation of its controls, and the functioning of safety systems.

Staff involved

13 The driver of train 1L15 had worked for EMR for 4 years, was competent to undertake their role and had driven the route through the site for around 1 year before the accident.

14 The Forestry England forester that undertook the inspections had over 36 years' experience in various roles at Thetford Forest. They were assessed as competent to undertake forestry inspections.

Trees involved

15 The tree that almost certainly fell first was a pine tree, which had stood in a plantation which Forestry England reported as having been planted in 1974. The tree was chopped into pieces to facilitate its removal from the railway after the accident, so its exact height is difficult to determine. Measurements of the pieces of tree after the accident suggest it was between 21 and 25 metres tall, similar to the height of neighbouring trees planted at the same time. The base of the pine tree was around 16 metres from the nearest railway line, the Down Main line. Around 8 metres from its base, the pine's main stem split into two distinct stems (known as a bifurcation).

16 The oak tree that was felled by the falling pine tree was older, although its exact age has not been determined. Again, it was chopped into pieces to facilitate removal from the railway. Its height was estimated as being between 15 and 17 metres tall, and it stood around 11 metres from the Down Main line.

External circumstances

17 The weather during the day of the accident was generally windy, with a passing cold front bringing a moderate westerly breeze with gusts up to 25 mph (40 km/h) recorded at local weather stations. At around 18:00, 3 hours before the accident, the wind speed reduced and it began raining heavily, with accumulated rainfall for the day reaching 11 mm by the time of the accident. Based on data from the World Meteorological Organisation, this is approximately one quarter of the average rainfall for the month of February in this area. The predicted conditions on the day were not sufficient to trigger Network Rail's extreme weather process.

18 The site had been subject to more arduous weather conditions during various winter storms in the months leading up to the accident.

19 It was dark when train 1L15 approached the site of the collision. Ambient light levels in the area were low because there are no built-up areas nearby, the nearby A11 dual carriageway is unlit, and there is minimal lighting at Shadwell level crossing.

The sequence of events

Events preceding the accident

20 As Network Rail's extreme weather process had not been triggered by the weather conditions, trains were running as normal on 6 February 2024.

21 At around 18:00, it began raining heavily at Roudham Heath. This heavy rain would continue for around 5 hours.

22 Train 1R88, an EMR service travelling from Norwich to Nottingham, passed through Roudham Heath at around 20:30 on the Up Main line. This was the last train to pass the site before the accident and the driver of train 1R88 did not report any obstruction at this time.

23 At 20:40, train 1L15 departed Thetford station heading towards Norwich on the Down Main line. There were 31 passengers, the driver and a senior conductor on board.

24 At an unknown time between train 1R88 passing through Roudham Heath at 20:30 and the accident at 20:53, the pine tree fell towards the railway, striking and felling the oak tree, resulting in the trees fouling both the Up and Down Main lines around 180 metres east of Shadwell level crossing. Nobody witnessed the trees falling. The pine tree came to rest on top of the oak tree. At the point the trees crossed the Down Main line, the upper branches of the oak tree were just above the rail and the upper trunks and branches of the pine tree were around 2 metres above rail level (figure 3).

Figure 3: The two trees after being struck by the train.

Events during the accident

25 At 20:53, train 1L15 travelled over Shadwell level crossing. The train was accelerating as it traversed the crossing, with its speed recorded as 82 mph (132 km/h) by the OTDR. The driver did not see the trees on the line ahead as it was dark (paragraph 19).

26 While still accelerating, and now at 83 mph (134 km/h), the train struck the trees. The oak tree, having been felled by the falling pine tree, was positioned at rail level and some of its branches were run over by the first wheelset of the train, causing only superficial damage to the obstacle deflector and lifeguards (see paragraph 85).

27 The twin stems of the pine tree were around 2 metres above rail level. As the train collided with them, the lower of the stems impacted the train at the level of its headlight assembly. The upper stem impacted halfway up the driver's windscreen, causing it to crack, although it remained in place. Both stems struck the front of the train's gangway faceplate, deforming its left-hand section (figure 4).

Figure 4: The damage to the front of the train (train shown after being rerailed).

28 The train's leading wheelset derailed to the left, probably due to the left wheel being lifted by the volume of material it had run over, exacerbated by the forces generated by the impact with the pine stems.

29 OTDR data shows that the driver reacted to the collision and derailment by making an emergency brake application.

30 As the train's leading wheelset derailed to the left, the leading left wheel began to contact the sleepers and ballast shoulder, slowing the wheel and steering the wheelset further to the left. The leading left brake disc, mounted on the first axle, came into contact with the left-hand rail. This limited the lateral shift of the first wheelset, with the wheels running along both the ballast and sleepers (see paragraph 86). All other wheelsets remained on the rails.

31 The train travelled for 680 metres from the point of derailment, before coming to a stop. Around 450 metres into this stopping distance, the train passed under the A11 dual carriageway, which is carried on a concrete bridge over the railway.

32 Around 60 metres from the final position of the train, the brake disc that had been in sustained contact with the left rail fractured and fell onto the track. Without the guidance this disc had been providing, the train began to deviate slightly further to the left, with the left-hand wheel leaving the sleeper ends. However, by this point the train was travelling slowly and it came to rest shortly thereafter.

Events following the accident

33 The driver immediately reported the accident to the signaller using the train's cab radio. The driver stated that they had struck a "substantial object" although they were unclear what it was that had been struck. The signaller stopped all train movements in the area to allow the driver to inspect the train. The driver then confirmed that the train had derailed after striking trees.

34 The signaller arranged for the emergency services and Network Rail response staff to attend site.

35 The driver and senior conductor helped to look after the 31 passengers on board. One passenger reported suffering a minor injury, which was treated by paramedics on site. There was a delay in organising a recovery train to convey the passengers on the rest of their journey due to a lack of available trains and staff. The recovery train left site with the passengers at 23:51.

36 Recovery and repair works were undertaken throughout 7 February 2024, the day after the accident. There was some damage to the infrastructure which required components to be replaced. The two trees were cut into pieces to assist with removal. Forestry England staff attended and assisted by dragging the trees away from the railway infrastructure. At the same time, the train was moved to a nearby siding pending recovery by road.

37 The line reopened at 22:00 on 7 February.

Analysis

Identification of the immediate cause

38 Train 1L15 derailed because it collided with two trees that had fallen across the track from outside the railway boundary.

39 The train collided with the two trees, which caused the leading left wheel to derail to the left (paragraph 28). The train then continued for around 680 metres before coming to a stop (paragraph 31).

40 Damage to the sleepers and wheel marks on the rails show that the train derailed immediately after striking the trees. There was no evidence of derailment before the point of collision.

Identification of causal factors

41 The derailment occurred due to a combination of the following causal factors:

a. Two trees, a pine tree and an oak tree, which were located on adjacent land and close to the railway boundary, fell across the track (paragraph 42).

b. The driver had no warning of the obstruction (paragraph 73).

Each of these factors is now considered in turn.

The trees

42 Two trees, a pine tree and an oak tree, which were located on adjacent land and close to the railway boundary, fell across the track.

43 During the time between train 1R88 passing Roudham Heath at 20:30 and the accident involving train 1L15 at 20:53, two trees had fallen across both railway lines. The trees, a pine and an oak, had fallen from an area of land adjacent to the northern boundary of the railway which is owned and managed by Forestry England.

44 An inspection by Forestry England on the day following the accident, 7 February 2024, concluded that neither tree showed signs of disease or decay, which are common signs of a tree that is at risk of falling. This was supported by the observations made by Network Rail and RAIB on the same day. Network Rail and Forestry England cut up the trees into sections to help their removal from the railway. This also involved the felling of a third tree to facilitate access for machinery to drag the larger sections off the railway infrastructure and onto Forestry England land.

45 Following the accident, RAIB engaged the services of an expert arboriculturist to examine the two trees and their natural environment, and to produce a report. The expert visited the site of the collision in April 2024. The expert concluded that the pine tree had almost certainly fallen first and that, as it fell, it collided with and felled the oak tree, resulting in both lying across the railway. Examination of the sections of trees by the expert arboriculturist confirmed the earlier conclusions that neither showed signs of disease or decay.

46 The trees fell across the railway due to a combination of the following:

a. The pine tree suffered from loss of root anchorage (paragraph 47).

b. The pine tree had an offset centre of mass which made it more likely to fall towards the railway (paragraph 57).

c. The trees were within falling distance of the railway (paragraph 60).

d. The pine tree was not identified as being at risk, so no action had been taken to reduce the likelihood of it falling (paragraph 63).

Each of these factors is now considered in turn.

Root anchorage of the pine tree

47 The pine tree suffered from loss of root anchorage.

48 Tree roots broadly perform three functions: anchorage, harvesting of soil water and dissolved nutrients, and the transportation of those nutrients and water to the rest of the tree. Anchor roots provide the majority of the tree's stability, typically extending around 1 to 2 metres from the stem to form a mass known as the mechanically active rootplate (MAR). Harvester roots are very fine and are mainly without bark. Transport roots are much thicker than harvester roots and extend beyond the MAR into the surrounding soil. They provide a means of transporting the nutrients and water absorbed by the harvester roots back to the tree.

49 There are generally three alternative modes of a whole tree toppling:

1. a loss of anchor root integrity inside the radius of the MAR (usually due to decay or by root severing, for example, by cutting during excavation works)

2. root breakage at the edge of the MAR caused by wind loads exceeding the strength of the roots causing them to fracture together with a loss of the soil shear strength, resulting in rootplate rotation

3. a loss of root anchorage, caused by a loss of adhesion between the roots and soil, with a number of the transport roots pulling out of the soil, rather than most or all of the roots fracturing (as per mode 2).

50 Examination of the pine tree by the arboriculturist in April 2024 showed many pulled out transport roots (figure 5), indicating this tree failed by the third mode, due to a loss of root anchorage.

51 The anchorage available to a tree is a function of the adhesion between its roots and the properties of the soil it is situated in. If the loads applied to a tree exceed the available anchorage, then the tree can begin to move, or even topple.

52 The geology at Roudham Heath is typical for this area of East Anglia, being composed of sandy soil over a chalk bedrock. Sand is an inherently non-cohesive soil with poor mechanical properties for tree root adhesion. Excessive water within a non-cohesive soil can reduce its mechanical strength and the ability of a tree root to adhere to it.

Figure 5: The root structure of the pine tree after the accident, showing the many pulled out transport roots.

53 While the site was not flooded on the day of the accident, it had been raining extensively for around 3 hours before the collision occurred. The area where the tree was located is almost entirely flat, so there is little surface runoff during or following rain. Water is usually dispersed from the site by seepage through the soil to the level of the local water table. While there is a drainage ditch between the railway and the site of the two trees, this has a low flow rate due to the local topography.

54 Further evidence of floodwater being a feature of this site, and in various areas in the neighbouring plantations, was found during the post-accident inspection by the arboriculturist in April 2024 (paragraph 45 and figure 6). The plantation between the site of the fallen trees and Shadwell level crossing remained flooded for at least a month after this inspection as shown by aerial images taken by Network Rail in May 2024 (figure 7). Local residents also recalled a similar flood event around February 2021 and many other occasions of localised high water levels. There have been various small-scale projects to install attenuation ponds and pumps to protect the local houses from such events indicating that there is a history of high groundwater levels in the area.

Figure 6: Site conditions during the post-accident inspection in April 2024.

Figure 7: The extent of flooding at the site in May 2024, just over 3 months after the accident. The previous location of the pine and oak trees is indicated (courtesy of Network Rail, with RAIB annotations).

55 The windspeed at the time the trees fell was not overly high and should not have been sufficient to blow over the pine tree in normal circumstances. The history of high groundwater, together with the onset of heavy rain before the collision, and the failure mode of the pine tree, suggest the primary reason for failure was the saturated nature of the soil the tree was standing in. As the adhesion between the roots and the soil decreased, the available root anchorage of the tree was reduced to a point that the wind load and self-mass of the tree were sufficient to overcome the tree's ability to remain standing.

56 While the oak tree may have had sufficient root anchorage to support its own weight, it was standing in similar soil conditions to the pine tree. Given the coincident time of failure, it is highly likely that it was struck by the pine tree. Its available root anchorage was then insufficient to support the combination of its own weight and the force imparted by the large pine tree as it toppled.

Likelihood of falling towards the railway

57 The pine tree had an offset centre of mass which made it more likely to fall towards the railway.

58 An aerial image, taken by Network Rail in May 2022, shows the pine tree with its bifurcated stem growing with a bias towards the railway (figure 8). Based on the post-accident inspection of sections of the pine tree, it is believed that this was a characteristic of its growth, and not rotation of the tree about the MAR. Trees will naturally grow to seek out as much light as possible, and the railway corridor offered a clear space for the pine tree to grow towards, away from the proximity of its immediate neighbours.

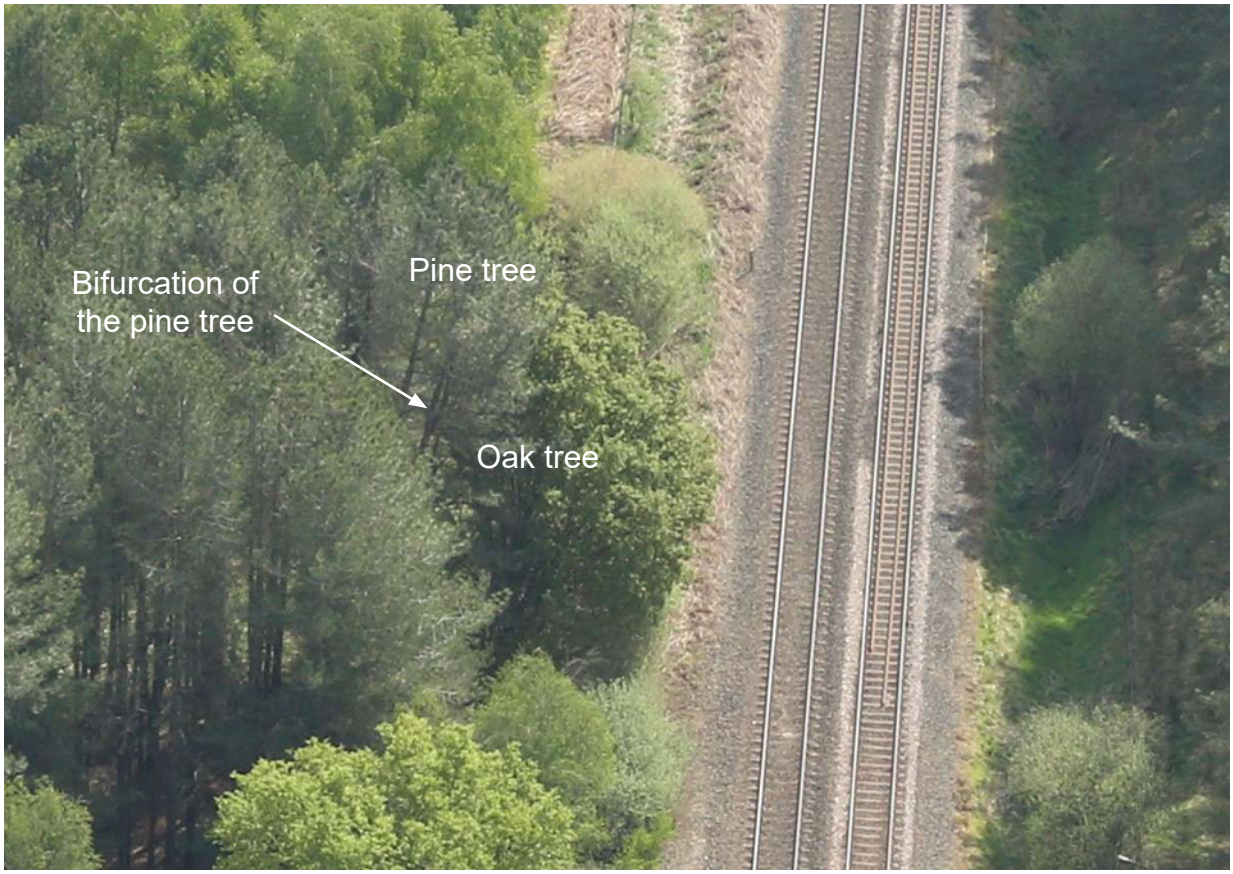

Figure 8: Aerial view taken in May 2022 showing the bias in the growth of the pine tree. The bifurcation of the pine tree is highlighted (courtesy of Network Rail, with RAIB annotations).

59 This bias meant that when the tree fell it was more likely to fall towards the railway, regardless of the direction of any wind load which was applied, especially in moderate wind speeds such as those on the day of the accident (paragraph 55).

Proximity to the railway

60 The trees were within falling distance of the railway.

61 The pine tree, with a height of between 21 and 25 metres (paragraph 15), was sited around 16 metres from the nearest line, the Down Main line. The oak tree, with a height of between 15 and 17 metres (paragraph 16), was sited around 11 metres from the same line. Both trees were tall enough to foul the railway should they fall towards it.

62 Network Rail uses various tools for monitoring trees in proximity to the railway. Network Rail's 'Tree Risk Manager' system correctly identified that both trees had the potential to reach the railway if they were to fall. However, neither of these trees had been identified as being at risk of falling because they were healthy trees.

Risk of falling trees

63 The pine tree was not identified as being at risk, so no action had been taken to reduce the likelihood of it falling.

64 The trees were subject to two different inspections: one by Forestry England as the trees were growing on its land, and one by Network Rail because of the proximity of the trees to the railway.

65 Forestry England undertakes inspections in line with the guidance document '*Common sense risk management of trees*' published by the National Tree Safety Group, published in December 2011. This guidance suggests that land should be zoned to prioritise the management of risk in areas of high use. It identifies that trees alongside roads and railways present a higher level of risk because of vehicles moving at speed and, as such, should receive an appropriate level of inspection.

66 Forestry England's inspection process designated the site at Roudham Heath as being 'zone 1', its highest risk category. This means that it receives an annual inspection by a competent forester. The inspection process can be done on foot, or by vehicle. It looks at the area as a whole, to identify any trees which are showing signs of distress or evidence of fruiting bodies or fungal growths, both indicators of poor tree health. Any trees that the forester is concerned about are noted, and appropriate actions to address the issue are planned. Forestry England provided records of its inspections at the site for the previous 5 years, including the most recent inspection undertaken on 23 October 2023. Neither of the trees involved in the accident, nor any of the immediately neighbouring trees, were identified as being of concern in any of these inspections.

67 Network Rail inspects trees in line with its business process 'Lineside vegetation management manual', NR/L2/OTK/5201, issue 5 published December 2020. Module 1 of this process states that an inspection plan shall be in place for all lineside vegetation, and this shall include a '*visual assessment of lineside vegetation where it poses a risk to the railway*'. In accordance with the process, all lineside vegetation should receive an on-foot inspection every 3 years and an annual inspection during a train cab ride.

68 Inspections are undertaken by Network Rail employees or specialist contract staff trained to identify whether a tree is dead or suffering from either disease or decay which might lead to failure. Where a tree is on neighbouring land, the inspection is carried out from within the railway boundary and the process does not require any further assessment of such a tree, even if it is in a publicly accessible location. These inspections report hazardous trees by exception; that is, a tree which has not been identified as dead, diseased or decayed would not be reported for further action.

69 Where a tree is found to be at risk of failure, it would be scheduled for remedial work. Where such a tree is identified outside of the railway boundary, then Network Rail would notify the landowner. The contents of this notification include a reminder of the landowner's legal obligations and the potential harm which could arise to the railway if action is not taken.

70 Network Rail's Anglia route had chosen not to undertake on-foot inspections as per NR/L2/OTK/5201 and instead employed an external party who used drones to conduct aerial surveys at the same inspection frequency. This was done because of the volume of inspections required and because tree strikes were seen as a significant risk on the route. The relevant staff within Anglia route had not appreciated that this change of inspection method required a derogation from Network Rail's technical authority (a directorate of Network Rail that, amongst other things, manages its company standards) to vary from the processes laid down in NR/L2/OTK/5201.

71 The most recent inspection of the trees involved in the accident was done in summer 2023 using the drone-based system and the trees were identified as being healthy and at low risk. Because of this, no action was taken to raise any concerns to Forestry England. Inspection of the trees by Network Rail after the accident confirmed that neither tree would have been classed as hazardous if the inspection had been done on foot in accordance with the processes in NR/L2/OTK/5201, instead of using the drone-based system. This indicates that no action would have been taken had a compliant method of inspection method been used.

72 Anglia route stated that its experience with the drone-based system has been positive, with feedback indicating that there has been a significant increase in the number of dead, diseased or decayed trees identified, with the majority of these being on land not owned by the railway.

Warning to the driver

73 The driver had no warning of the obstruction.

74 There were no witnesses to the trees falling. The residential properties next to Shadwell level crossing do not have direct visibility of the site. There are no systems in place at this location that could have detected the falling trees, nor were there any overhead electrification lines which might have alerted railway staff of an issue, had they been damaged. As such, the relevant signaller knew nothing about the fallen trees, and so could not provide any warning to the driver.

75 There is minimal lighting at the level crossing, and the nearby A11 dual carriageway which passes over the railway is unlit. It was overcast and raining heavily. All of this resulted in a site which was very dark. It is not usually possible to stop a train within the distance illuminated by the train's headlights because, unlike road vehicles, trains do not operate on a line-of-sight basis unless specifically instructed to travel at caution, such as when they are examining the line. The FFCCTV footage from the train involved showed no details of the accident as it was too dark. RAIB considers that distinguishing the fallen trees against the general darkness while approaching at over 80 mph, even with the train's headlights, would have been extremely difficult. This understanding is supported by the driver's report that they knew nothing about the presence of the trees until the collision occurred (paragraph 25) and that they were initially unaware as to exactly what they had struck (paragraph 33).

Identification of underlying factor

Risk management of trees

76 The risk of trees in highly saturated soil falling on the railway was not being effectively managed.

77 Both Network Rail and Forestry England had inspected the pine tree which fell first and caused both trees to fall on to the railway (paragraph 63). Neither of these inspections had identified any issues that would suggest the tree was at any immediate risk of toppling.

78 The expert arboriculturist commissioned by RAIB (paragraph 45) noted that, in addition to a reduction in root anchorage, most species of tree growing in flood water are at risk of root asphyxia and, hence, an increased risk of root disease or death. These factors mean that trees in highly saturated soil have an increased risk of falling and, in this case, of fouling the operational railway.

79 There was no process put in place by either Network Rail or Forestry England to understand how this increased risk could be appropriately assessed and managed. The inspections being undertaken on behalf of both organisations were focused on observing the health of the pine tree at that point in time, and were not looking at external factors that may have affected tree health or stability in the future.

80 In addition, the flooding at Roudham Heath was only apparent at isolated times (paragraph 54). Although Forestry England was aware that high groundwater issues were occasionally experienced at this location, these may not have been fully appreciated by those undertaking periodic inspections for either organisation if inspections had not taken place when the water level was high.

Factors affecting the severity of consequences

Performance of the cab structure during the collision

81 There was no significant deformation of the cab structure as a result of the collision.

82 Following the recovery of the train to an off-site facility, an inspection was undertaken by RAIB and EMR to assess the damage sustained by the train during the collision and subsequent derailment.

83 Minor damage was evident to various places on the front and underside of the train, in keeping with the train running derailed. The gangway faceplate was deformed in two places, where it had been struck by the two primary stems of the pine tree (paragraph 27 and figure 4). The impact with these stems had also cracked both windscreens, but they remained in place with no penetration into the driving cab. There was also a small crack to an internal cab desk panel.

84 Further inspection of the train was undertaken by EMR as part of the repair process, which included the removal of the gangway faceplate. This showed that there had been no deformation of the load-bearing structure of the train's cab. Crucially, this confirms that there had been no reduction to the internal volume of the cab environment and hence no compromising of the driver's survival space.

85 The train was fitted with an obstacle deflector (a device mounted to the body of the leading vehicle of a train which is intended to reduce the risk of a derailment from a collision with a large obstacle) and lifeguards (which are mounted on the leading bogie to prevent small obstacles getting under the leading wheels). The small branches of the oak tree were able to go under these components, which only received superficial damage from them, but the combined volume of these branches was still sufficient to derail the train.

Containment of the derailment

86 An axle-mounted brake disc on the train helped to contain the derailment.

87 Each wheelset on a class 158 train is fitted with two axle-mounted brake discs (figure 9). Marks on the rail, sleepers and ballast showed the path that the leading wheels of the train took after the derailment, tending to steer to the left as the left wheel engaged with the sleepers and ballast. These marks are consistent with the movement to the left being limited by the engagement of the left-hand brake disc with the left-hand rail (paragraph 30). This prevented any further lateral movement away from the track centreline, which, unrestrained, could have resulted in the train moving further off the tracks or potentially striking the abutment of the A11 dual carriageway overbridge. Around 60 metres before the train came to a stop, the brake disc broke, eliminating the lateral restraint, and the train began to move slightly further from the track centreline (figure 9).

Figure 9: The train's final stopping position beyond the A11 bridge and the sleeper marks made during the derailment (left) and the remains of the axle-mounted brake disc following the train being rerailed (right).

Previous occurrences of a similar character

88 On 27 December 2023, a high speed train (HST) collided with a tree at Broughty Ferry, Dundee, while travelling at 84 mph (135 km/h) (RAIB report 13/2024). The tree had fallen from a public park located next to the railway. The tree had previously been sheltered by three other trees which had been felled in the days before the accident. The increase in exposure, combined with the heavy rain and winds on the day, resulted in the tree falling. The collision caused significant damage to the HST's leading driving cab.

89 On 10 July 2010, an HST collided with a tree at Lavington, Wiltshire, while travelling at 90 mph (145 km/h) (RAIB report 08/2011). The tree involved had fallen across the two railway lines at the location from land outside the railway boundary. The collision caused significant damage to the HST's leading driving cab.

90 Previous RAIB investigations have featured instances of unintentional guidance provided by axle-mounted and underframe fixtures, including:

a. the derailment of a passenger train at Moy on 26 November 2005 (RAIB report 22/2006)

b. the derailment of a passenger train at Barrow-upon-Soar on 1 February 2008 (RAIB report 18/2008)

c. the derailment of a passenger train at Watford Tunnel on 16 September 2016 (RAIB report 11/2017).

Summary of conclusions

Immediate cause

91 Train 1L15 derailed because it collided with two trees that had fallen across the track from outside the railway boundary (paragraph 38).

Causal factors

92 The causal factors were:

a. Two trees, a pine tree and an oak tree, which were located on adjacent land and close to the railway boundary, fell across the track (paragraph 43). This causal factor arose due to a combination of the following:

i. The pine tree suffered from loss of root anchorage (paragraph 47).

ii. The pine tree had an offset centre of mass which made it more likely to fall towards the railway (paragraph 57).

iii. The trees were within falling distance of the railway (paragraph 60).

iv. The pine tree was not identified as being at risk, so no action had been taken to reduce the likelihood of it falling (paragraph 63).

b. The driver had no warning of the obstruction (paragraph 73).

Underlying factor

93 The risk of trees in highly saturated soil falling on the railway was not being effectively managed (paragraph 76, **Recommendations 1 and 2**).

Factors affecting the severity of consequences

94 Factors that positively affected the consequences of the event were as follows:

a. There was no significant deformation of the cab structure as a result of the collision (paragraph 81).

b. An axle-mounted brake disc on the train helped to contain the derailment (paragraph 86).

Previous RAIB recommendations relevant to this investigation

95 The following recommendations, which were made by RAIB as a result of its previous investigations, have relevance to this investigation.

Derailment and subsequent collision at Watford Tunnel, RAIB report 11/2017, recommendation 3

96 In August 2017, RAIB published an investigation report into the derailment and subsequent collision at Watford Tunnel. In this accident, the derailment was contained by features on the leading axle of the train, and the following recommendation was made:

The Rail Delivery Group (RDG), in conjunction with RSSB, should:

a. commission research into the ways in which guidance can be provided to derailed trains. This should include consideration of:

- *how the design of bogies and bogie mounted equipment can assist in limiting the lateral deviation of passenger trains during a derailment;*
- *practice in other countries (eg Japan);*
- *how specially installed infrastructure features can achieve the same effect at high risk locations;*
- *potential design requirements for the retention or enhancement of such features on new trains or infrastructure; and*
- *the potential benefits and drawbacks of such measures.*

If such features, whether existing or additional, are shown to have a net beneficial effect in reducing risk by limiting lateral deviation, RDG/RSSB should:

b. share this information with the relevant Standards Committees; and

c. record and disseminate the design requirements with a view to their incorporation into future standards.

97 In response to this recommendation, the Rail Safety and Standards Board (RSSB) launched project T1143, titled '*Devices to guide derailed trains*'. On 3 February 2022, the Office of Rail and Road (ORR) informed RAIB that this recommendation was closed.

Derailment of a passenger train at Carmont, 12 August 2020, RAIB report 02/2022, recommendation 12

98 In March 2022, RAIB published the investigation report into the derailment of a passenger train at Carmont, Aberdeenshire. RAIB concluded that, if the train involved had been fitted with bogie-mounted equipment to prevent significant lateral deviation, the train would have been more likely to have remained close to the track and so avoided the particularly destructive sequence of events triggered by striking a bridge. RAIB made the following recommendation:

RDG and Network Rail, in conjunction with RSSB, should consider and incorporate all relevant learning from the Carmont accident into the assessment of rolling stock and infrastructure design features that can provide guidance to trains when derailed. Particular features to be taken into account include:

a. the risk of derailment from relatively small landslips and washouts

b. position of track relative to adjacent ground on which derailed wheels may run (that is, features that can affect the deviation of a derailed train)

c. proximity to features with the potential to increase the consequence of an accident (bridge parapets, tunnel portals etc)

d. topography likely to increase the extent of vehicle scatter.

The above-mentioned assessment should then be used to develop a systemic, risk-based strategy for the provision of additional measures for the guidance of derailed trains that takes into account the appropriate balance between infrastructure-based mitigation and vehicle-based mitigation. The strategy should also include a plan for implementation of changes to the appropriate industry standards.

99 In response to this recommendation, RSSB created project T1316 titled '*Assessing the case for rolling stock and infrastructure design features that can provide guidance to trains when derailed*'. This project integrated the output from project T1143. Project T1316 was still ongoing at the time of publication of this report. The accident at Roudham Heath further reinforces the importance of this work and the details of the accident were shared with the steering group for project T1316.

Actions reported as already taken or in progress relevant to this report

Actions reported that address factors which otherwise would have resulted in an RAIB recommendation

100 The details of this accident were shared with the T1316 steering group. As research is being undertaken within the industry, no further recommendation regarding train-mounted devices for derailment containment or guidance has been made.

Other reported actions

101 Network Rail Anglia route and Forestry England representatives met following the accident to understand how they could improve collaboration. Actions from the meeting included a commitment to improve the cross-referencing of survey results, co-ordination of remedial work and the establishment of ongoing communication between local staff.

102 Network Rail's Anglia route reported that it is planning to apply for a formal variation to the on-foot inspections required by NR/L2/OTK/5201.

103 Network Rail's technical authority is developing an aerial survey system to assist with the lineside inspection of trees. The system known as digitised lineside inspection uses data produced from equipment on board aircraft to survey the railway corridor. The data is supplemented by light detection and ranging scans and hyperspectral imaging which is processed by software to identify dead, diseased or decayed trees. Network Rail states that use of aerial survey techniques allows the survey to better incorporate trees on neighbouring land which are within falling distance of the railway.

Recommendations

104 The following recommendations are made:[1]

1 *The intent of this recommendation is that Forestry England better understand and manage the risk of trees in saturated ground falling from its land onto the railway.*

Forestry England should review its processes for the inspection and management of trees that are within falling distance of the railway, to consider the effects of high soil saturation levels on the risk of a tree falling. Based on the outcome of this review, it should then implement any appropriate changes to its processes for the inspection and management of trees (paragraph 93).

2 *The intent of this recommendation is that Network Rail better understand and manage the risk of trees in saturated ground falling onto the railway.*

Network Rail should review its processes for the inspection and management of trees that are within falling distance of the railway, to consider the effects of high soil saturation levels on the risk of a tree falling. Based on the outcome of this review, it should then implement any appropriate changes to its processes for the inspection and management of trees (paragraph 93).

[1] Those identified in the recommendations have a general and ongoing obligation to comply with health and safety legislation, and need to take these recommendations into account in ensuring the safety of their employees and others.

Additionally, for the purposes of regulation 12(1) of the Railways (Accident Investigation and Reporting) Regulations 2005, Recommendation 1 is addressed to Forestry England and Recommendation 2 is addressed to the Office of Rail and Road, to enable them to carry out their duties under regulation 12(2) to:

(a) ensure that recommendations are duly considered and where appropriate acted upon; and

(b) report back to RAIB details of any implementation measures, or the reasons why no implementation measures are being taken.

Copies of both the regulations and the accompanying guidance notes (paragraphs 200 to 203) can be found on RAIB's website www.gov.uk/raib.

Appendices

Appendix A - Glossary of abbreviations and acronyms

Abbreviation / acronym	Full term
EMR	East Midlands Railway
FFCCTV	Forward-facing closed-circuit television
MAR	Mechanically active rootplate
ORR	Office of Rail and Road
OTDR	On-train data recorder
RSSB	Rail Safety and Standards Board

Appendix B - Investigation details

RAIB used the following sources of evidence in this investigation:

- information provided by witnesses
- information taken from the train's OTDR
- site photographs and measurements
- weather reports from nearby weather stations
- a specialist arboriculture report commissioned by RAIB
- a review of documentation provided by Forestry England
- a review of documentation provided by Network Rail
- a review of documentation provided by EMR
- a review of the rail industry investigation report prepared by Network Rail
- a review of previous RAIB investigations that had relevance to this accident.

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