Norwegian Safety Investigation Authority

Published June 2021

REPORT Road 2021/02

REPORT ON HEAD-ON COLLISION ON THE E6 ROAD NEAR HAMMER IN SNÅSA MUNICIPALITY ON 2 FEBRUARY 2020

The Norwegian Safety Investigation Authority (NSIA) has compiled this report for the sole purpose of improving road transport safety. The object of any investigation is to identify faults or discrepancies which may endanger road transport safety, whether or not these are causal factors in the accident, and to make safety recommendations. It is not the NSIA's task to apportion blame or liability. Use of this report for any other purpose than for road transport safety shall be avoided.

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This report has been translated into English and published by the NSIA to facilitate access by international readers. As accurate as the translation might be, the original Norwegian text takes precedence as the report of reference.

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REPORT ON ROAD TRAFFIC ACCIDENT

Date and time:	Sunday 2 February 2020 at 10:42
Location:	E6, Hammer, Snåsa municipality, Trøndelag county
Road no, main section (hp), km:	E6, hp 36, km 7,853
Accident type:	Head-on collision
Vehicle type:	Vehicle A: Tractor unit (Volvo FH62 TT) and semi-trailer (Krone SD) Vehicle B: Tractor unit (Scania S500) and semi-trailer (Schmitz SKO 24)
Type of transport:	Goods transport subject to a licence requirement

NOTIFICATION OF THE ACCIDENT

At 20:20 on Sunday 2 February, the Norwegian Public Roads Administration's Traffic Control Centre (VTS) notified the Norwegian Safety Investigation Authority (NSIA) of a road traffic accident on the E6 road near Hammer in Snåsa. The NSIA was informed that two heavy goods vehicles had been involved in a head-on collision and that one of the drivers had been killed. The extent of the other driver's injuries was unknown, and a passenger in one of the vehicles had been taken to hospital in Levanger.

The accident investigator on duty contacted the police to find out more about the accident. The police stated that the road was very slippery at the accident site, and that two persons were presumed dead. The NSIA then decided to deploy personnel to Snåsa that day, and the personnel arrived at the scene at 21:45.

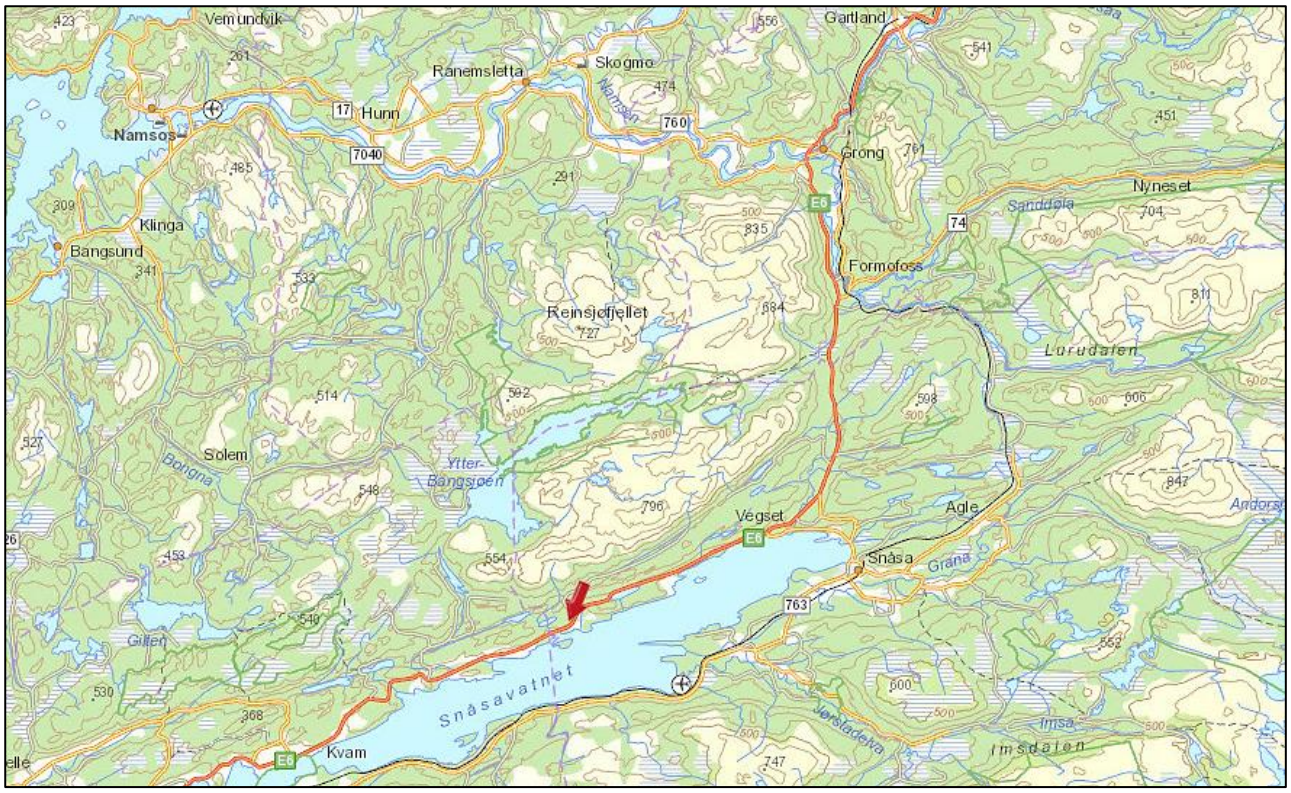

Figure 1: The section of road in question. The accident site is marked with a red arrow. Map: Kystinfo, the Norwegian Coastal Administration

SUMMARY

The accident occurred on the E6 road near Hammer in Snåsa at approximately 10:40 on 2 February 2020, when the driver of a Polish heavy goods vehicle heading south lost control and the vehicle crossed into the opposite lane. The vehicle collided head-on with a Norwegian heavy goods vehicle travelling north on the E6 road. Both drivers were instantly killed in the collision. The vehicles ran off the roadway after the collision, and the tractor unit of the Norwegian vehicle caught fire. A person travelling as a passenger in the Norwegian vehicle managed to escape through a broken window. The passenger suffered some physical injuries in the accident.

At the time of the accident, the road friction was very low at the accident site, also compared with adjacent road sections. Several witnesses who were on the scene shortly before and after the collision have stated that the roadway was *'extremely slippery'*, *'hopeless to walk on'* and *'slippery as soap'*. The NSIA believes developments in the weather and road surface conditions in the area, as well as the road geometry and asphalt surfacing at the accident site, contributed to the accident occurring where it did. The tyres on and the handling characteristics of the southbound vehicle, combined with the driver's choice of speed, also impacted the sequence of events.

The investigation has shown that the salting carried out by the contractor responsible for road maintenance on the day of the accident was incorrect, seen in light of the weather forecast for the area. The saline solution used at the accident site was approximately 25 g/m^2, and the salting method used was the same *'as usual'*. The salting was carried out at 04:30 on 2 February, more or less in the middle of a forecast period of precipitation. The contractor did not check whether the measure was effective, nor were any additional measures implemented at the accident site in the six hours prior to the accident.

The investigation has revealed that, prior to the accident, multiple road users notified the Traffic Control Centre (VTS) of challenging road surface conditions on sections of road in the same contract area for winter road maintenance as the accident site. VTS did not communicate these reports to the contractors involved. The NSIA considers that the Norwegian Public Roads Administration (NPRA) should improve its procedures to ensure that reports of road surface conditions in winter are taken into account.

The accident occurred on a section where the road surface conditions were known to be and described in the operations contract as slippery, requiring extra attention during winter. The investigation has shown that the contractors had not drawn up procedures for following up road surface conditions on prioritised sections. The investigation has also shown that the contractors have not fulfilled contractual requirements relating to systematic control of the road network, documentation of work performed and of the winter friction level, as well as the contents of the contractors' *'winter plan'* and *'record of special incidents on the road network'*.

Furthermore, the investigation has identified shortcomings in the NPRA's follow-up of winter road maintenance. Over and above construction meetings, as well as possible spot checks and friction measurements, the NPRA had not established other systematic activities for documenting, following up or quality assuring winter road maintenance. The investigation also found insufficient follow-up of contractual requirements by the NPRA.

Neither the NPRA nor the contractors have performed a systematic assessment and evaluation of winter road maintenance after the accident. In this context, the NSIA would like to see more coherent guidelines for evaluating winter maintenance in light of serious incidents and road traffic accidents. The NSIA believes that the NPRA should increasingly facilitate national learning from winter road maintenance.

The NSIA submits six safety recommendations as a result of this investigation.

1. FACTUAL INFORMATION

1.1 Sequence of events

On Sunday 2 February 2020, at approximately 10:40, a Polish heavy goods vehicle was heading south on the E6 road with a trailer carrying a cargo of fish. The heavy goods vehicle had left Gartland at 10:05 (see Figure 1) and was bound for Maryport, England. In a downward slope towards a right-hand curve before the exit to Østvika, the driver lost control of the Polish heavy goods vehicle, which crossed into the opposite lane (see Figure 2). The vehicle collided head-on with a Norwegian heavy goods vehicle travelling north on the E6 road carrying foods (see Figure 3). This heavy goods vehicle had left Trondheim that morning and was bound for Brønnøysund.

Figure 2: North-to-south view of the section of road where the heavy goods vehicles collided. Photo: Google Maps

Figure 3: South-to-north view of the section of road where the heavy goods vehicles collided. Photo: Google Maps

Figure 4: The scene of the accident. The two heavy goods vehicles involved and their respective directions of travel are shown. Photo: NPRA. Illustration: NSIA

After the collision, the Polish heavy goods vehicle ran off the road from its lane. The tractor unit came to a stop with its front against some trees, and the semi-trailer ended up at an angle of approximately 90° across the road. The Norwegian heavy goods vehicle ran off the road from its lane after the collision, before it overturned and came to rest against some trees in a slope. Both tractor units sustained extensive material damage in the accident. The driver's cab of the Norwegian vehicle caught fire immediately after the collision.

Figure 5: The final positions of the two vehicles involved in the accident. Photo: The police

1.2 Survival aspects

1.2.1 Road users involved

1.2.1.1 *The HGV drivers*

The post-mortem reports concluded that both drivers died instantly as a result of crush injuries and fractures sustained in the collision.

1.2.1.2 *The passenger*

There was a person in the passenger seat of the northbound heavy goods vehicle at the time of the accident. The passenger escaped through a broken window and was taken to Levanger hospital by air ambulance. The passenger sustained some physical injuries in the accident.

The NSIA has been informed that the passenger was wearing a seatbelt at the time of the collision.

1.2.2 Survival space

Investigations have shown that there was no survival space[1] available at the driver's position of either of the two heavy goods vehicles. The two vehicles collided with an overlap of approx. 50–55% at the driver's positions.

1.2.3 Firefighting and rescue work

The points below summarise the firefighting and rescue efforts made:

- The police were notified of the accident at 10:42.
- Three police patrol units were deployed to the accident site in addition to firefighters and ambulance personnel. An air ambulance and Sea King helicopter was also requested.
- Snåsa fire service arrived at 11:10, and was the first of the emergency services to arrive at the scene. Steinkjer fire service and the first ambulance arrived shortly thereafter.
- Firefighters started work to extinguish the fire in the northbound vehicle, and the fire was soon brought under control. They also quickly ascertained that the driver of the southbound vehicle was dead.
- The three police patrol units arrived at 11:17, 11:19 and 11:22, respectively.
- The air ambulance arrived at 11:26.
- The Sea King helicopter was cancelled, as the emergency services at the scene had determined that both drivers had been killed in the accident.

[1] The space available to the driver and passengers inside the passenger compartment after deformation or intrusion of the vehicle body in a collision.

Figure 6: Firefighting and rescue work in progress at the scene of the accident. Photo: Lars Lilleby Macedo

1.3 Damage to vehicles

Both tractor units sustained major damage to the front as a result of the collision (see Figure 7 and Figure 8), and the tractor unit of the northbound vehicle was completely burnt out. The two semi-trailers both sustained the most serious damage to the front left-hand side.

Figure 7: Damage to the tractor unit of the southbound vehicle. Photo: The police

Figure 8: Damage to the tractor unit of the northbound vehicle. Photo: The police

1.4 Other damage

Roadside terrain and crash barriers were damaged when the heavy goods vehicles ran off the road. The southbound and northbound vehicles were carrying fish and food, respectively, and much of their cargo was scattered across the road and roadside terrain as a result of the collision.

Figure 9: The cargo carried by the two vehicles was scattered across the accident site. Photo: The police

1.5 The accident site

1.5.1 Location

The accident took place on the E6 road near Vestre Hammer, by the exit to Østvika and the boundaries between the municipalities of Steinkjer and Snåsa. The accident site (indicated by a blue cross in Figure 10) was directly north of the exit to Østvika, and the accident took place in a right-hand curve viewed in the southbound vehicle's direction of travel.

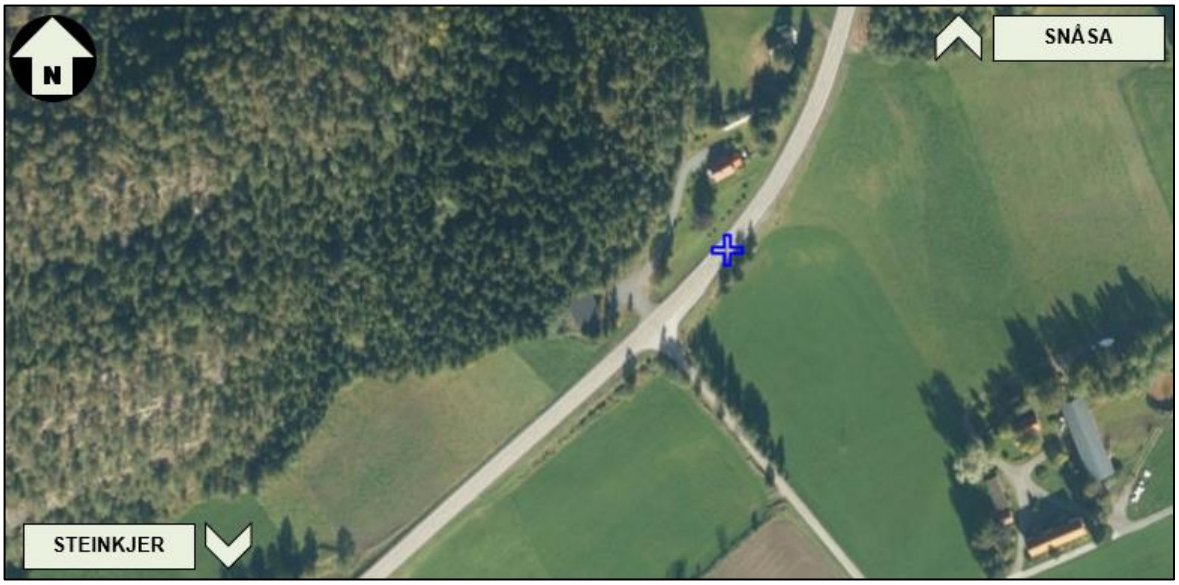

Figure 10: The section of road where the accident occurred. Map: Kystinfo, the Norwegian Coastal Administration

1.5.2 Marks registered at the accident site

Investigations at the accident site found no marks left in the roadway before the point of the collision, but rubber and scratch marks had been left on the asphalt in the northbound lane at the accident site (see Figure 11 and Figure 12). The marks in the roadway were about one centimetre deep.

Figure 11: Marks left (indicated in orange) in the northbound lane. Photo: NPRA

Figure 12: Marks left (indicated in orange) in the northbound lane. Photo: The police

1.5.3 The final positions of the vehicles

After the collision, the southbound vehicle continued out of the road on the right-hand side and ended up across the road with its front against some trees. The northbound vehicle ran off the road and overturned after the collision. The vehicle came to rest on its side against some trees in a tall slope at the side of the road.

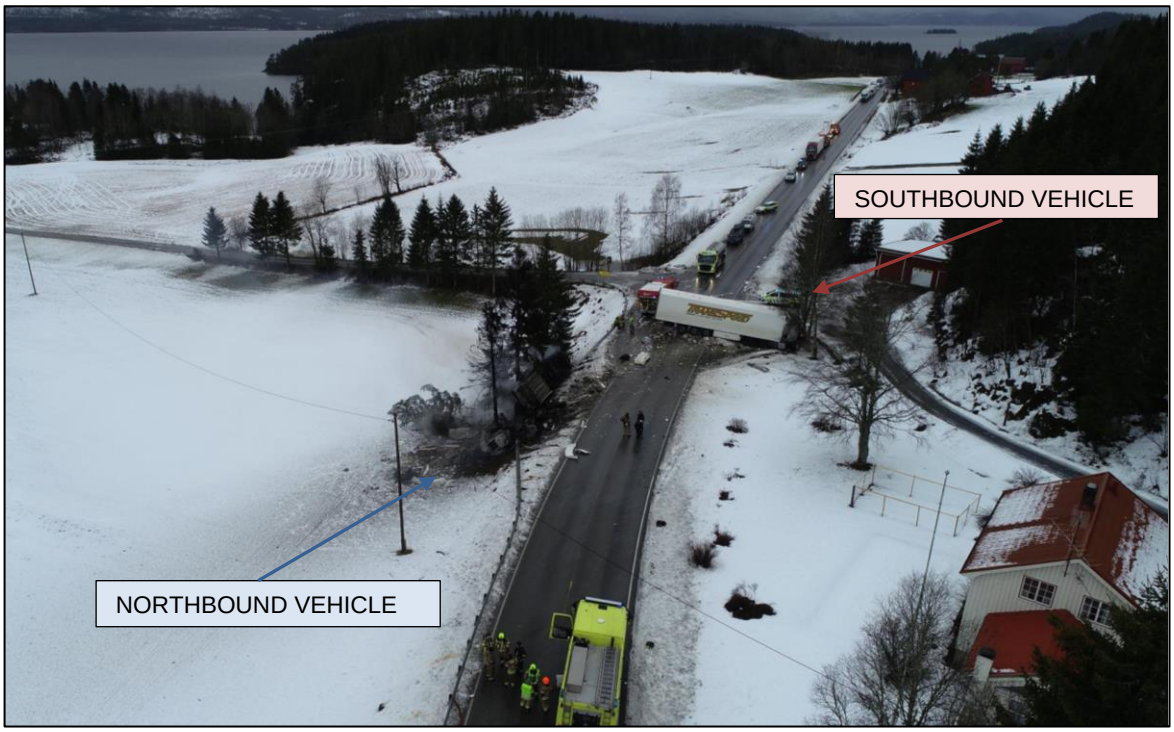

Figure 13: The final position of the two heavy goods vehicles after the collision. Photo: NPRA

1.5.4 Friction conditions

1.5.4.1 *Observations made by the road users involved*

The passenger in the northbound heavy goods vehicle has stated that the driver of the vehicle tested the road friction by braking on the straight stretch just before the accident site, which caused the vehicle to skid a little on the road.

1.5.4.2 *Observations made by witnesses and emergency service responders*

Witnesses who were at the accident site shortly before and just after the crash have informed the NSIA that the road was very slippery.

One of these witnesses was the driver of a passenger car that passed the accident site a few minutes before the accident. The passenger car was heading south on the E6 road and was equipped with studded tyres. The vehicle skidded in the curve, and the driver stated to the police that the road was *'extremely slippery'* for approx. 50–60 meters at the accident site. The slippery section started at the entrance to the curve, seen from the southbound vehicle's direction of travel. The driver did not find the road surface to be slippery before or after the curve. The passenger car passed the northbound heavy goods vehicle about a kilometre before the accident site.

Another witness observed the collision between the heavy goods vehicles from a nearby property. The witness has informed the NSIA that the roadway of the E6 road appeared bare at the time of the accident, but described the road at the accident site as *'hopeless to walk on'*.

Another witness, who crossed the E6 road at the accident site on foot shortly before the accident, stated that conditions were *'slippery as soap'*, with *'clear ice'* on the roadway.

The pedestrian also observed that the surface of a smaller side road, located in the immediate vicinity of the accident site, was ice-covered.

A passenger car arrived at the accident site shortly after the heavy goods vehicles had collided. It was southbound (i.e. driving in the lane in which the Polish heavy goods vehicle had been travelling). The driver has stated to the NSIA that he began to apply the brakes on the way downhill as he was approaching the accident site, but that the road was very slippery. The driver had to drive his car onto the verge of the road to be able to stop. The driver also stated that he did not notice anything remarkable about the road surface conditions on the section of the E6 road before the accident site, and that the roadway appeared bare on the downhill slope towards the site of the collision.

Another passenger car also arrived at the accident site shortly after the heavy goods vehicles had collided. This vehicle was heading north (in the lane in which the Norwegian heavy goods vehicle had been travelling). The driver stated to the police that road surface conditions on the E6 road travelling north from Steinkjer were good, but that the accident site was *'very slippery'*. The witness has stated that conditions were such that both he and other witnesses had slipped on the road at the accident site several times.

The police arrived about 35 minutes after the accident. At that time, the police recorded an air temperature of 1.5 °C. There was light rain in the air, and, in places, slush and a thin film of ice on the roadway. The Norwegian Public Roads Administration (NPRA) did not conduct any friction measurements at the site of the accident, as the roadway was bare and wet when NPRA personnel arrived approximately 1.5 hours after the accident.

1.5.4.3 *Reporting of road surface conditions to the Traffic Control Centre*

The Traffic Control Centre's (VTS) log shows that, from midnight on 2 February until the time of the accident, it received three reports of challenging road surface conditions on roads in the area between Verrabotn and Hammer. These reports of slippery road conditions concerned the Fv 6922, Fv 6918 and Fv 762 roads. These road sections are located approx. 100 km, 90 km and 40 km from the accident site, respectively, but fall within the same contract area for winter road maintenance as the accident site (see section 1.13.1). VTS received the last of these notifications at 09:44.

VTS has informed the NSIA that the notifications concerned slippery conditions on county roads located some distance away from the accident site. VTS has also stated that no complaints about slippery conditions were reported on the Verdal–Snåsavannet section of the E6 road, or further north within the contract area, before the time of the accident.

VTS has stated that it did not emerge in communication with the emergency services and other parties involved in dealing with the accident that the roadway at the accident site was slippery. The road surface conditions at the accident site only came to VTS's attention via the media in the afternoon of 2 February.

1.6 Road users

1.6.1 Driver of the southbound vehicle

1.6.1.1 *General information*

The driver of the southbound heavy goods vehicle was 46 years old at the time of the accident. The driver was an employee of the Polish transport company Trans Speed. The employer has informed us that the he had been a professional driver for 20 years and had been employed by the company for about 2 years at the time of the accident. The driver held a driving licence for the categories AM, A1, A2, A, B1, B, C1, C, BE, C1E, CE and T.

The Polish employer has informed the NSIA that this was not the first time that the driver had driven the section of road where the accident occurred.

1.6.1.2 *Transport activities*

A consignment note dated 1 February 2020 was found in the tractor unit in connection with technical examinations of the heavy goods vehicle. The consignment note stated that, on 31 January, a cargo of approx. 14 tonnes of fish was to be transported from Oslo Seafood Center AS in Oslo to Salaris AS in Abelvær in Trøndelag county. The cargo was delivered to Salaris AS on 1 February. The NSIA has been informed that the heavy goods vehicle picked up a cargo of approx. 10 tonnes of fish from Salaris AS in Abelvær on 1 February, to be transported to a fish processing plant in Maryport, England. The consignment was to be delivered on 5 February.

A log book containing information about the driver's transport activities before the accident was found in connection with the NSIA's technical examination of the heavy goods vehicle. The logged transport activities show that the driver apparently arrived at Gartland in Trøndelag at 01:00 on Sunday 2 February, and left Gartland at 10:05 on the same date. The driver then drove southwards for approx. 35 minutes before the accident occurred on the E6 road near Hammer.

1.6.2 Driver of the northbound vehicle

The driver of the northbound heavy goods vehicle was 30 years old at the time of the accident. He was an employee of the Norwegian transport company Kristensen Transport AS. The employer has informed us that the he had been a professional driver for 12 years and had been employed by the company for about 2.5 years at the time of the accident.

The NSIA has been informed that the driver knew the section of road where the accident occurred well.

1.7 Vehicles and cargo

1.7.1 Introduction

Representatives of the NPRA's accident investigation team, scenes of crime officers from the police and NSIA personnel carried out technical examinations of the heavy goods vehicles on 3 February 2020, and relevant findings are described in the following sections.

1.7.2 Southbound vehicle

1.7.2.1 *General information*

The southbound heavy goods vehicle consisted of a triple-axle tractor unit and a triple-axle semi-trailer, both Polish-registered. The heavy goods vehicle was carrying about 10 tonnes of fish at the time of the accident.

1.7.2.2 *Tractor unit*

The tractor unit was a triple-axle Volvo FH 62 TT. The vehicle's unladen weight was 9,756 kg, and its maximum permissible weight was 27 tonnes. The most recent periodic roadworthiness test conducted on the tractor unit was valid until 2 October 2020.

A visual inspection of the brakes on the tractor unit found no defects in undamaged components, while the damage to the vehicle made it difficult to examine the other components.

The tractor unit had studless winter tyres of the type *M+S* (*Mud and Snow*) and *3PMSF* (*Three-Peak Mountain Snowflake*). The front wheels of the tractor unit (front axle) were of the brand *Continental Hybrid HS3*, and had a tread depth of 10–12 mm. These tyres had not been siped,[2] and had only longitudinal grooves. The tractor unit's drive axle (second axle) was equipped with tyres of the brand *Crosswind CWD30K* on three wheels, with a tread depth of 15–19 mm. The tyre was gone from the outside left-hand dual wheel, and the rim was severely deformed as a result of the accident. The rear bogie axle (third axle) was steerable and equipped with single wheels of the brand *Hankook AW02* on both sides. The tread depth of these tyres was 10–11 mm.

The tractor unit's tyres complied with the applicable marking and tread depth requirements. The air pressure in all the tyres was approximately 8 bar, which is within the tyre manufacturers' recommended range.

Damage made it impossible to check the tractor unit's steering. However, the technical examination found dry, greaseless areas on the turntable (see Figure 14).

The following is quoted from the NPRA's report to the police:

> *The fifth wheel of the Polish tractor unit had dry areas without grease. This could have a negative effect on driving round curves on a slippery road surface. Resistance is created against the change of angle between the tractor unit and the semi-trailer. The Polish tractor unit had corresponding dry, greaseless areas on the upper coupler plate around the king pin.*

The NPRA's assessment is that the tractor unit was in good technical condition before the accident.

[2] Cutting thin slits across the tread of tyres for the purpose of improving traction during steering and braking on slippery roads. The outer part of the tyre becomes softer and more flexible, and the contact surface increases.

Figure 14: Pale areas on the turntable where grease is missing. Photo: NPRA

1.7.2.3 *Semi-trailer*

The semi-trailer was a triple-axle Krone SD. The vehicle's unladen weight was 8,167 kg, and its maximum permissible weight was 36 tonnes. The semi-trailer was 14 metres in length and 2.60 metres wide.

The semi-trailer was equipped with brake shoes on all axles. A visual inspection of the brake components identified no defects. Nor were any faults or defects found in the wheel suspension. However, the technical examination found dry, greaseless areas on the upper coupler plate around the king pin (see section 1.7.2.2).

The semi-trailer was fitted with studless winter tyres of the type *M+S* (*Mud and Snow*). All tyres on the semi-trailer were of the brand *Continental Hybrid HT3* with longitudinal grooves. The tread depth was 11–12 mm on the two foremost axles and 6–7 mm on the rear axle. The tyres had not been siped.

The following is quoted from the NPRA's report to the police:

> *The tread depth of new tyres is 15 mm. Siping cuts about 3 millimetres into new tyres, so the tyres in question have not been siped. A tread depth of 12 millimetres without siping reduces friction against ice and snow-covered road surfaces.*

The semi-trailer's tyres complied with the applicable marking and tread depth requirements. The air pressure in all the tyres was approximately 8 bar, which is within the tyre manufacturer's recommended range.

The semi-trailer was loaded with about 10 tonnes of fish in polystyrene boxes, and the NPRA's assessment is that the cargo did not shift before the accident.

The NPRA's assessment is that the semi-trailer was in good technical condition before the accident.

Figure 15: Damage to the Polish semi-trailer, which was carrying fish in polystyrene boxes. Photo: NSIA

1.7.3 Northbound vehicle

1.7.3.1 *General information*

The northbound heavy goods vehicle consisted of a triple-axle tractor unit and a triple-axle semi-trailer, both Norwegian-registered. At the time of the accident, the heavy goods vehicle was carrying approx. 45 m^3 of food from Coop, which corresponds to a weight of about 12,200 kg.

1.7.3.2 *Tractor unit*

The tractor unit was a triple-axle Scania S500. The vehicle's unladen weight was 10,010 kg, and its maximum permissible weight was 28 tonnes. The tractor unit was owned by Scania Finans AB, and hired by Kristensen Transport AS. The tractor unit was first registered in Norway on 11 July 2019, and had therefore not undergone a periodic roadworthiness test before the accident.

The transport company has informed the NSIA that, at the time of the accident, the tractor unit was fitted with studded winter tyres on the front axle and studless winter tyres on the second and third axles. The winter tyres were of the type *M+S* (*Mud and Snow*).

Most of the tyres on the tractor unit were burnt out, but technical examinations showed that the tread of the tyres on the second axle were siped on the three central grooves.

The damage to the tractor unit made it impossible to carry out visual inspections or technical examinations of the brake or steering components. The wheel suspension likewise could not be examined.

The extent of the damage meant that it was not possible to make an assessment of the tractor unit's technical condition before the accident.

Figure 16: Fire damage to the driver's cab of the Norwegian tractor unit. Photo: NSIA

1.7.3.3 *Semi-trailer*

The semi-trailer was of the type Schmitz SKO 24. The vehicle's unladen weight was 9,531 kg, and its maximum permissible weight was 42 tonnes. The semi-trailer was 13.60 metres in length and 2.55 metres wide.

A visual inspection of the brake components identified no defects. A visual inspection of the brake components likewise identified no defects. None of the axles were steerable.

The vehicle had studless winter tyres of the type *M+S* (*Mud and Snow*) and *3PMSF* (*Three-Peak Mountain Snowflake*) at the time of the accident. The tyres on the front and second axles were of the brand *Bridgestone*, while the tyres on the third axles were of the *Double Coin* brand. The tread depth of the tyres was 5.5–7 mm on the two foremost axles and 11 mm on the rear axle. The following is quoted from the NPRA's report to the police as regards the tyres:

> *All the tyres had dense siping and a pattern suitable for Nordic conditions (snow and ice).*

The semi-trailer's tyres complied with the applicable marking and tread depth requirements. The air pressure in all the tyres was approximately 8 bar, which is within the tyre manufacturer's recommended range.

1.8 Road conditions

1.8.1 General information

The E6 road is a European road running from Kirkenes in Norway to Trelleborg in Sweden. It has a total length of 3,058 km, of which 2,578 km are in Norway. A total of 186.5 km of the E6 is in Trøndelag county. This section stretches from the county boundary with Nordland at Nordlandsporten in Namsskogan to the boundary with Oppland county at Svone south of Kongsvoll in Oppland.

The E6 Trøndelag section has national road status and forms part of the main road network. The NPRA is the road owner for the section of road in question (see section 1.17.1).

According to the NPRA's national road database (NVDB), the section of road where the accident occurred had an annual average daily traffic (AADT[3]) of about 2,000 vehicles a day in 2019, with a proportion of heavy vehicles of approx. 23%. The signposted speed limit is 80 km/h.

1.8.2 The accident site

1.8.2.1 *Road geometry*

At the accident site, the E6 road has two lanes separated by a broken centre line. The roadway is marked by enhanced edge lines. The NPRA measured the width of the roadway (between the edge lines) at the accident site to 6.2 metres, and the width of the paved road to 6.8 metres. Crash barriers, consisting of steel beams on steel and wooden posts, are installed along the northbound lane.

Viewed in the southbound vehicle's direction of travel, the horizontal curvature at the accident site forms an approx. 230-metre-long right-hand curve. The accident occurred just under 30 metres past the middle of this curve.

The NPRA carried out a registration of the state of the road on the section where the accident occurred on 7 July 2020,[4] and measurement data from this registration are reproduced in Figure 17. The measurement data registered show that the horizontal curve radius varies through the curve and towards the site of the collision. The horizontal curve radius changes quite a lot at the beginning of the right-hand curve; from a straight section to a curve radius of approx. 500 metres over the first 30 metres or so. The horizontal curve radius then changes less for the next approx. 70 metres until the point where the curvature is greatest (from a curve radius of approx. 500 metres to approx. 225 metres). From this point towards and past the point where the collision occurred, the right-hand curve begins to straighten out towards another straight section.

The measurement data registered also show that the cross slope of the southbound vehicle's lane increases from approx. -2% at the beginning of the right-hand curve to between approx. -4.5% and -6.5% on the final section leading up to the point where the collision occurred. The road's cross slope is consistently below the minimum cross slope

[3] Annual average daily traffic (AADT) – average daily traffic through the year, total for both directions.
[4] The intervals between the registration points were approx. 2 metres.

required,[5] from approx. 40 metres into the right-hand curve for a distance of approx. 100 metres up to the point where the collision occurred (see the distance between EV6 S93D1 m7960 and S93D1 m7860 in Figure 17). The greatest non-conformity in the cross slope is found at around m7945, approx. 90 metres before the point where the collision occurred, where the difference between the measured cross slope and the calculated minimum cross slope is 1.5 percentage points.

The NSIA has also calculated both the longitudinal slope and resultant slope[6] for the right-hand curve in the southbound vehicle's lane. The longitudinal slope of the road is approx. -6% at the beginning of the curve and varies between approx. -5% and -7% on the section up to the point where the collision occurred, where the road begins to level off. The resultant slope varies between approx. 6% and 9% on the section in question,[7] and exceeds the minimum requirement of 2% to ensure drainage throughout the right-hand curve.[8]

1.8.2.2 *Roadside terrain*

The roadside terrain in the northbound direction of travel consists of a field and a clump of trees on the right-hand side and a private property on the left-hand side of the road.

1.8.2.3 *Road surface*

The road surface (wearing and binder course) at the accident site consists of stone mastic asphalt, which is a porous type of asphalt that provides good water drainage. It is a hard-wearing type of asphalt whose surface has a good noise-reducing effect, as well as having good drainage characteristics.

Examinations conducted by the Danish Road Directorate[9] show that this type of asphalt is more demanding in terms of winter maintenance, particularly in relation to salting as a compensatory measure to maintain satisfactory friction (see section 1.18.2.2).

The NPRA has informed the NSIA that there has been a lot of wear on the roadway in the area in question, and that stone mastic asphalt was therefore used to reduce rutting. Stone mastic asphalt can generally withstand traffic loads better than asphalt concrete, which is commonly used as a wearing course.

The operations contract describes the road section Hammer–Heimsjøen, which includes the accident site, as a section that is known to be slippery and require extra attention (see section 1.13.5). The road surface on this entire section consists of stone mastic asphalt, while adjacent road sections have asphalt concrete surfaces.

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[5] The minimum cross slope is arrived at through calculations based on the cross slope requirements stipulated in Manual R610 – Standard for drift og vedlikehold av riksveger (‘Standard for operation and maintenance of national roads’) (pages 30–31). The calculations of minimum and maximum cross slope requirements are based on measured horizontal curve radius values.

[6] Resulting slope is a product of the road’s longitudinal slope and cross slope.

[7] The NSIA has used the formula $S_r = \sqrt{e^2 + s^2}$ [m/m], with e being the cant (cross slope) and s the gradient (longitudinal slope), to calculate the resultant slope in the curve. An interval of 20 metres was used to calculate the longitudinal slope.

[8] Norwegian Public Roads Administration. (2019). Manual N100 – Veg- og gateutforming (‘Road and street design’).

[9] Danish Road Directorate (2012). Winter service of porous asphalt. European experience. Technical note 123.

DIRECTION OF TRAVEL – SOUTHBOUND VEHICLE

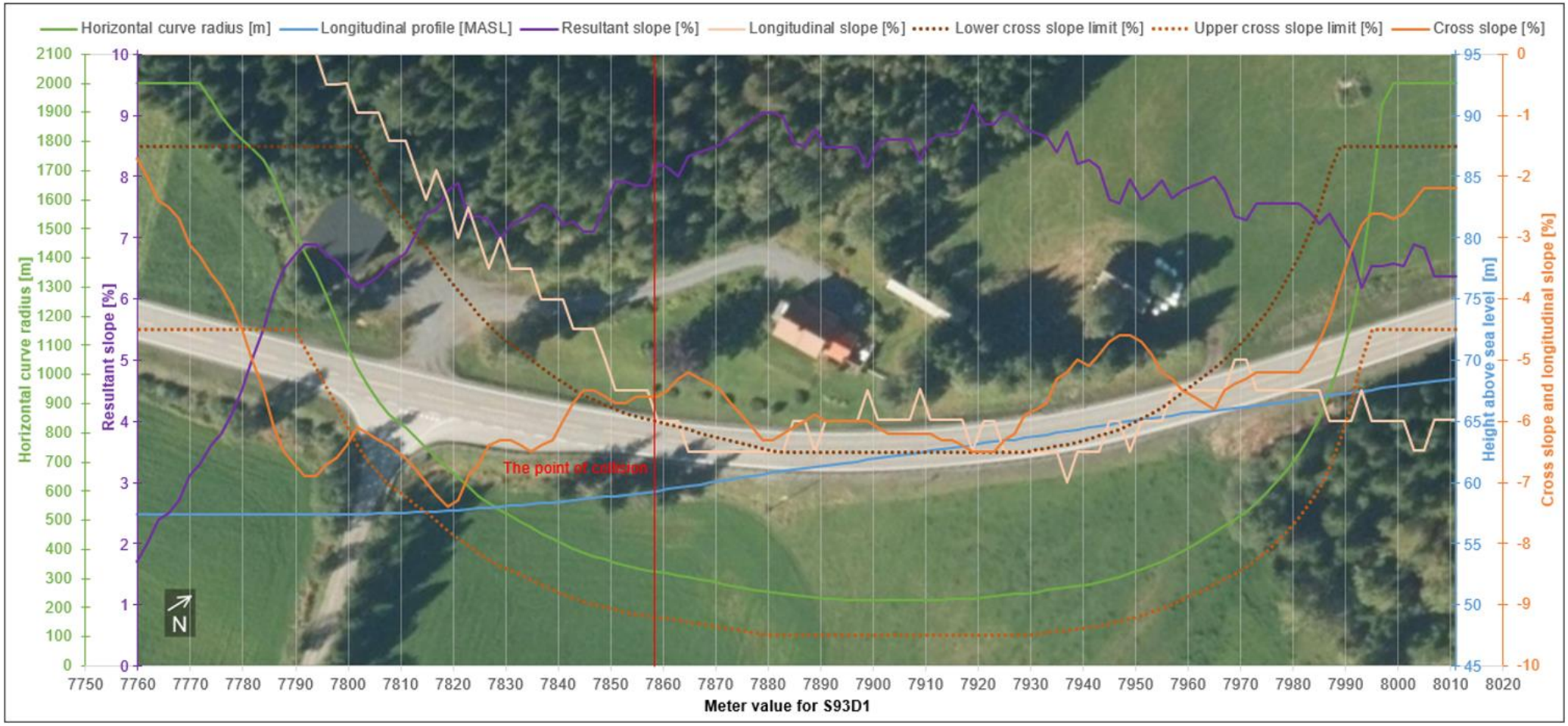

Figure 17: Horizontal curve radius, cross slope, upper and lower cross slope limits, longitudinal slope, resultant slope and longitudinal profile of the southbound heavy goods vehicle's lane and direction of travel. Positive radius values indicate a right-hand curve, and negative cross slope values indicate sloping to the right. Source: NPRA. Overview: © Norwegian Mapping Authority. Illustration: NSIA

1.9 Weather and road surface conditions

1.9.1 Introduction

This description of how the weather developed in the morning of 2 February 2020 is based on data registered by the NPRA's two closest weather stations to the accident site, in addition to statements made to the police and the NSIA by the road users involved and witnesses who were at the scene.

Both the NPRA and the contractors that carry out winter maintenance on the road network have access to weather information from the following sources:

- Halo.met.no (weather service operated by the Norwegian Meteorological Institute).
- Vegvær.no (web-based service operated by the NPRA that contains, among other things, geographically located observations, forecasts and web camera images of the road).
- Weather forecasts at yr.no and storm.no, and on the radio, TV and in newspapers.

Vegvær retrieves and presents data from the NPRA's weather stations, in this case the stations 'E6 Snåsa' and 'E6 Kvam', which are described in section 1.9.3.

1.9.2 Weather forecasts

The weather forecast for 2 February 2020 is based on two meteograms[10] for Snåsa and Kvam in Snåsa municipality (see Figure 18). The village of Snåsa is located at the north-eastern end of the lake Snåsavatnet, approx. 20.4 kilometres north-east of the accident site. Kvam is located at the south-western end of Snåsavatnet, approx. 17.9 kilometres south-west of the accident site.

The meteograms in Figure 18 show the weather developments forecast for the two areas from approx. 10:00 on 1 February 2020 to approx. 05:00 on 3 February 2020. The weather forecasts were retrieved as they were forecast at 08:00 on 1 February 2020.

The weather forecasts show that the developments forecast for Snåsa and Kvam were fairly similar during this period, with increasing precipitation in the afternoon and evening of 1 February, followed by precipitation through the night continuing on the morning of 2 February. The forecasts also show that somewhat lighter cloud cover was forecast at Snåsa as the morning of 2 February progressed.

The air temperature was forecast to be 1–3 °C through the night and in the morning of 2 February. The forecast dew point temperature was minus 1–1.5 °C.

[10] A meteogram is a graphic representation of the weather forecast for a particular location.

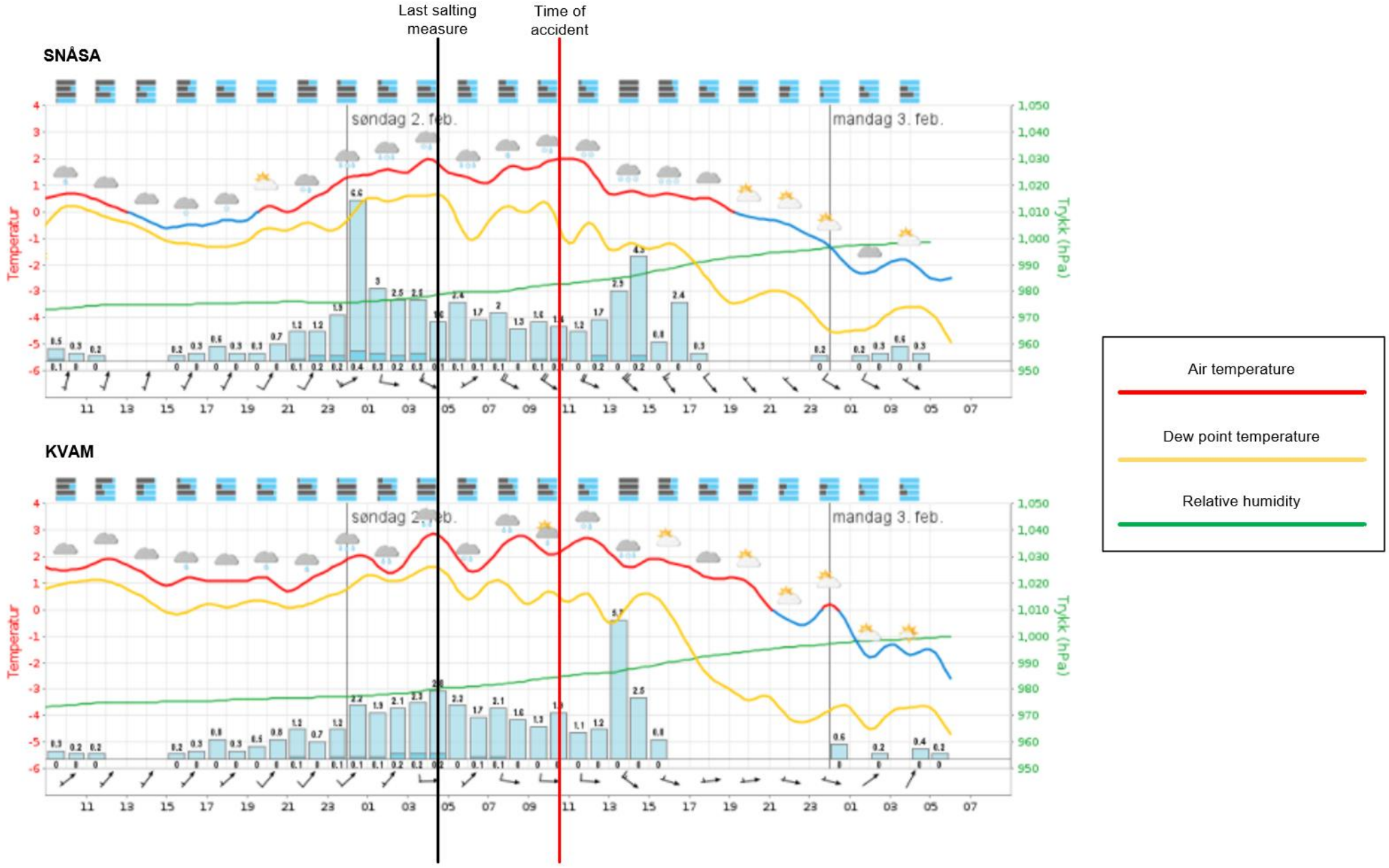

Figure 18: Meteograms for Snåsa and Kvam with the time of the last salting and the time of the accident indicated. Source: Norwegian Meteorological Institute Illustration: NSIA

1.9.3 Recorded weather development

1.9.3.1 *General information*

Data on how the weather developed through the night and in the morning of 2 February 2020 were retrieved from the NPRA's weather stations located in Snåsa and Kvam. These weather stations are located by the E6 road, at distances of 22.4 kilometres (north-east) and 16.6 kilometres (south-west), respectively, from the accident site (see Figure 20).

Measurement data from weather stations must be interpreted with caution, as factors such as precipitation intensity, road surface temperature, air temperature, dew point temperature and wind direction could be subject to local variations.

1.9.3.2 *Weather developments before the time of the accident*

Figure 19 shows the weather developments in the area around the accident site on 2 February 2020, as registered by the NPRA's weather stations 'E6 Snåsa' and 'E6 Kvam'.

Through the night and in the morning of 2 February, both weather stations recorded instances of precipitation, mainly in the form of snow, but also some rain. Both weather stations recorded a period of precipitation at 04:30 – at the same time as the contractor responsible for road maintenance in the area carried out its final salting of the accident site before the accident occurred at 10:42.

The 'E6 Snåsa' station also recorded a period of precipitation at 07:30, followed by a period of dry weather lasting until 14:30. The 'E6 Kvam' station recorded a pause in the precipitation lasting from 05:30 until 13:30.

The 'E6 Snåsa' station has recorded road surface temperatures above 0 °C from 03:00 until 11:00, after which the temperature dropped below 0 °C. The 'E6 Kvam' station has recorded road surface temperatures above 0 °C from 02:00 until 10:00, after which the temperature dropped below 0 °C before rising again to more than 0 °C at 11. At the time of the accident, the two weather stations recorded a road surface temperature of -0.1 °C and 1.0 °C, respectively.

The 'E6 Snåsa' station has recorded dew point temperatures above 0 °C from 04:00 until 09:00, after which the temperature dropped below 0 °C. The 'E6 Kvam' station has recorded dew point temperatures above 0 °C from midnight until 19:00. At the time of the accident, the two weather stations recorded a road surface temperature of 0.4 °C and 1.0 °C, respectively.

From 04:00 until 11:00, the 'E6 Snåsa' station recorded air temperatures of 0.8–1.8 °C. The 'E6 Kvam' station recorded air temperatures of 1.0–2.8 °C during the same period. At the time of the accident, the two weather stations recorded air temperatures of 1.2 °C and 2.5 °C, respectively.

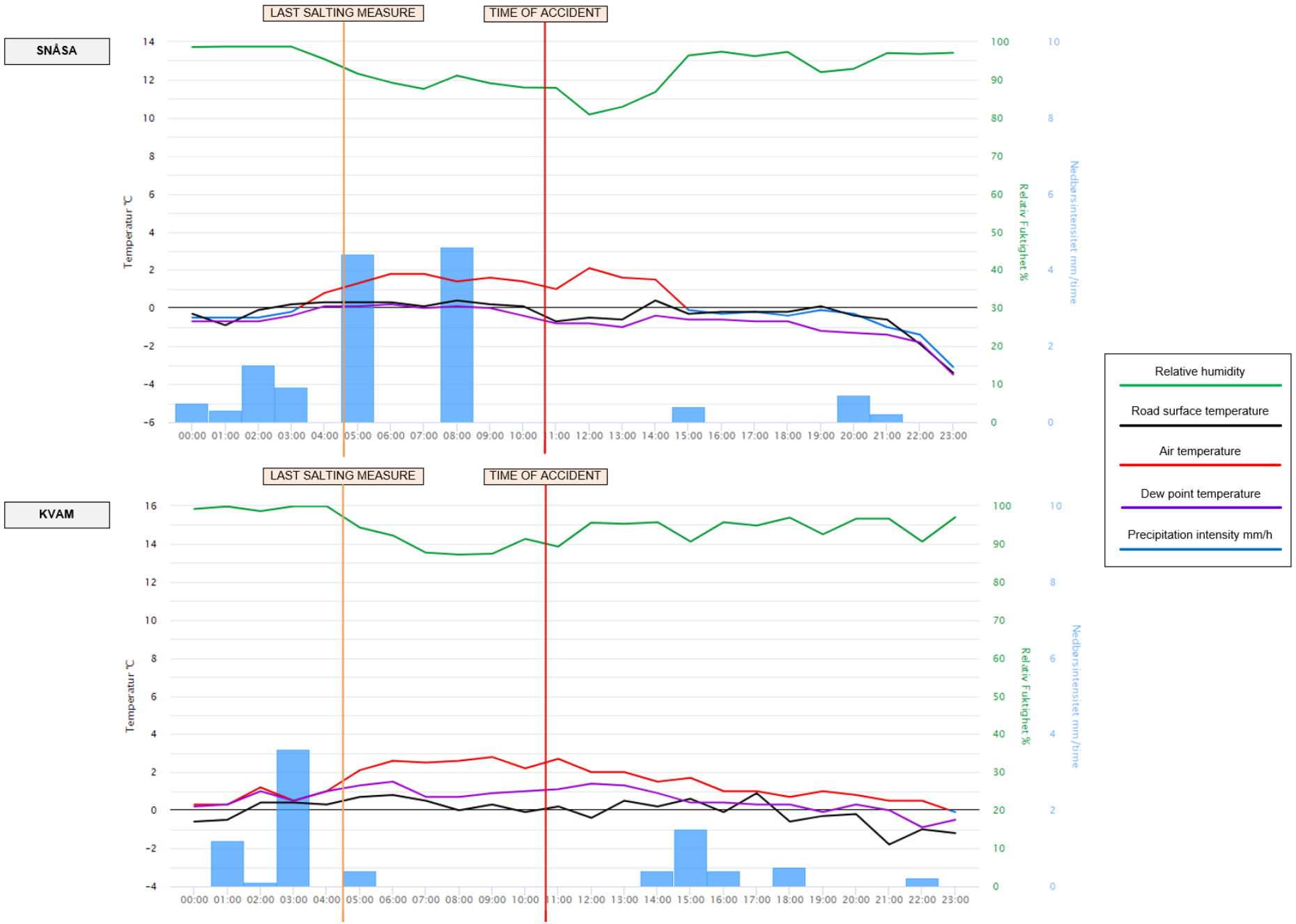

Figure 19: Data from the weather stations 'E6 Snåsa' and 'E6 Kvam' showing the relevant weather developments on 2 February 2020. Source: Vegvær.no. Illustration: NSIA

1.9.4 Visual registrations of weather and road surface conditions

1.9.4.1 *General information*

The NPRA has installed web cameras along the Norwegian road network for the purpose of giving users an impression of driving conditions such as queues, weather and road surface conditions. The cameras are also intended to give those responsible for winter maintenance of the road network information about whether the roads need to be cleared of snow, salted or gritted.

Most of the cameras are located at weather stations along the road network and do not register measurement data in the form of weather and climate data, but record images of weather and road surface conditions at the place in question at given times. Figure 20 shows the locations of the cameras closest to the accident site. They are installed at the weather stations 'E6 Snåsa' and 'E6 Kvam', and record pictures every ten minutes.

Figure 20: Locations of the web cameras closest to the accident site. Source: NPRA. Illustration: NSIA

Visual registrations of weather and road surface conditions via web cameras will show the relevant weather developments, but only in the area in question. The accuracy of these data must therefore be interpreted with caution, as factors such as precipitation intensity could be subject to local variations.

1.9.4.2 *Visual registrations from the weather station 'E6 Snåsa'*

The web camera images show precipitation in Snåsa between 04:10 and 05:20.

Figure 21 shows web camera images from Snåsa from the time between 06:00 and 13:00 on 2 February. The images clearly show precipitation from 07:30, followed by the cloud cover clearing up from approx. 08:40. The images show clear weather at the time of the accident. The clear weather continued until 13:00, after which the sky clouded over and a period of precipitation followed from 14:10.

Figure 21: Web camera images from the weather station 'E6 Snåsa' from the period between 07:40 and 12:27. Source: NPRA

1.9.4.3 *Visual registrations from the weather station 'E6 Kvam'*

The web camera images show that there was precipitation at Kvam through the night.

Figure 22 shows web camera images from Kvam from the time between 06:00 and 13:00 on 2 February. The images show that there was precipitation at Kvam in the morning, followed by a period of dry weather until 10:10. The images then show precipitation again at Kvam at 10:10, about half an hour before the accident occurred. The images show dry weather at the time of the accident. There was precipitation from 11:10 to 12:00, followed by a dry period lasting until 13:00.

The camera at Kvam does not show the sky, only the road. The images show small amounts of ice and/or snow in the road from approx. 07:30 and as the morning progressed.

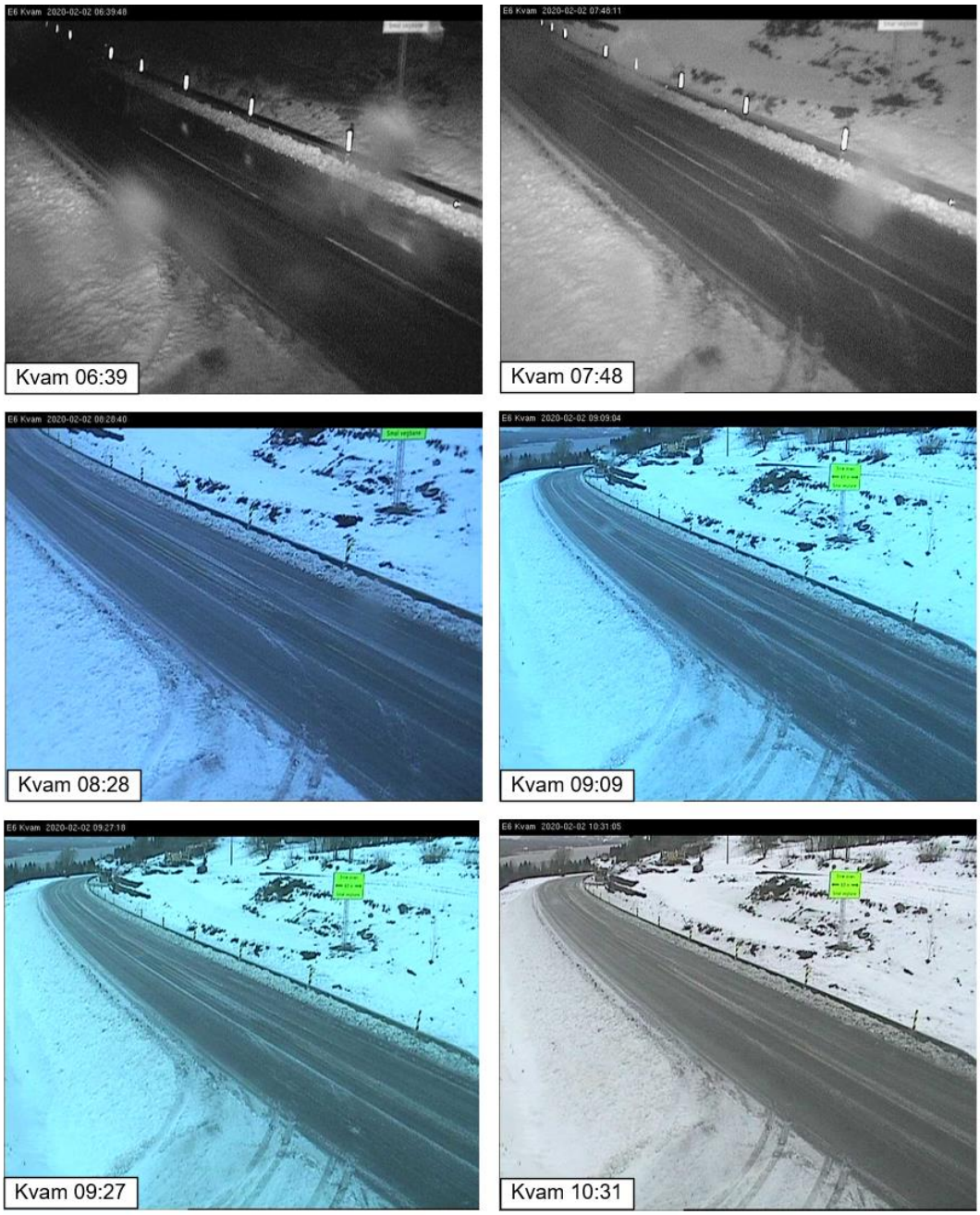

Figure 22: Web camera images from the weather station 'E6 Kvam' from the period between 06:39 and 10:31. Source: NPRA

The main contractor has not documented that the contractor responsible for road maintenance obtained web camera footage on 2 February, neither to provide a basis for decision-making nor to follow up maintenance measures.

1.9.5 Terrestrial radiation from the road surface

The accident happened in the morning, following a night of precipitation in the area. The web camera images from the 'E6 Snåsa' weather station camera show that the cloud cover cleared up from approx. 08:40 (see section 1.9.4.2).

When the sky clears, a situation will arise where the road surface temperature drops as a result of terrestrial radiation from the earth's surface (including the surface of the road). Solid substances, including the road surface, emit infrared radiation over a continuous range of wavelengths ('black body'), primarily towards the sky. In the opposite direction, the atmosphere emits radiation that is absorbed by the ground and reduces the heat loss. Cloud cover emits radiation across all wavelengths in the same way as the ground. Gases, particularly water vapour and carbon dioxide, only emit radiation on certain wavelengths.

When conditions are suitable, for example when the cloud cover clears, the ratio between incoming and outgoing radiation can become so high that the road surface cools down rapidly, and ice can form even at an air temperature above 0 °C.

The weather data recorded by the 'E6 Snåsa' weather station show that the road surface temperature decreased from 09:00 until approx. 11:00. The road surface temperature then levelled off at about -1 °C, while the air temperature was between 1 °C and 2 °C (see Figure 21). The clouds cleared up during the same period. The sun came out at about 12:00, while the road surface temperature started to rise and passed 0 °C at 13:30.

1.10 Use of salt in winter maintenance

1.10.1 General information

The use of salt is described in exhibit *D2-ID9300a Bruk av salt*[11] ('The salting instructions') to the operations contract in force for the section of road where the accident occurred (see section 1.13). The following is quoted from the introduction to this exhibit:

> *The overriding purpose of using salt in winter maintenance is to maintain or restore bare pavement road conditions. Snow, sleet and ice on the trafficked area shall primarily be removed using mechanical methods. Endeavours shall be made to limit salt consumption by using low salt dosages and ensuring that snow clearing and salting can be repeated frequently as necessary.*

1.10.2 Salt application methods

The following is stated in exhibit *D2-ID9300a Bruk av salt*[11] about salt application methods:

> *Four different application methods have been defined for salt:*
>
> - *Dry salt*

[11] Norwegian Public Roads Administration. (2014). D2 Tegninger og supplerende dokumenter: D2-ID9300a Bruk av salt.

- *Pre-wetted salt*[12]
  - *Normally 30 per cent pre-wetting liquid by weight, minimum 25 per cent by weight. If the proportion of pre-wetting liquid exceeds 30%, the liquid used must be brine.*
- *Pre-wetted fine-grained salt*
  - *Salt for use as fine-grained salt must be able to pass through a standard 4-mm sieve, and at least 50% of the salt must be able to pass through a standard 1-mm sieve. Otherwise, the same requirements shall apply as for pre-wetted salt.*
- *Brine*
  - *The brine should have the highest possible concentration of salt, at least 20 per cent salt by weight.*

The NPRA's training material[13] refers to the table below to determine which application methods are suitable for different purposes and for different road surface and weather conditions:

		Application method			
Purpose	**Road surface conditions/weather conditions**	**Dry salt**	**Pre-wetted salt**	**Pre-wetted fine-grained salt**	**Brine**
Anti-icing	Dry road	Shall not be used	Shall not be used	Can be used	Suitable
	Damp road surface	Shall not be used	Suitable	Suitable	Suitable
	Wet road	Shall not be used	Suitable	Suitable	Can be used
	Rain on cold road surface/freezing rain < 1 mm/h	Shall not be used	Suitable	Suitable	Can be used
	Rain on cold road surface/freezing rain > 1 mm/h	Shall not be used	Suitable	Suitable	Shall not be used
Anti-compaction	Before snowfall, dry or damp road	Shall not be used	Shall not be used	Can be used	Suitable
	Before snowfall, wet road	Shall not be used	Suitable	Suitable	Shall not be used
	During snowfall	Suitable	Suitable	Suitable	Shall not be used
	After snowfall	Suitable	Suitable	Suitable	Shall not be used

[12] Salt grains pre-wetted with brine or water.
[13] Norwegian Public Roads Administration. (2015). Opplæring i vinterdrift for operatører: Driftskontrakter med oppstart 2016. NPRA reports, No 369.

De-icing	Thin film of ice and hoar frost	Shall not be used	Suitable	Suitable	Suitable
	Roadway covered in thick snow and/or ice	Can be used	Suitable	Suitable	Shall not be used

Figure 23: Overview of suitable applications methods for different purposes. Source: NPRA

The figure is based on the recommendations and guidelines set out in the salt tables in the NPRA's exhibit *D2-ID9300a Bruk av salt.*[11]

The training material proceeds to state:

> *As shown in the table, there is no one application method suitable for all road surface and weather conditions. In most cases, it will therefore be an advantage to have maintenance arrangements where what is known as combination spreaders are available. Combination spreaders can be used to apply dry salt, pre-wetted salt or brine. To apply brine with sufficient dosage and range, these spreaders need brine tanks with good capacity.*

1.10.2.1 *Brine*

Brine is a pre-mixed solution of salt dissolved in water. The brine usually has a salt concentration of approx. 20% and is spread directly onto the road surface. This method ensure even and precise application, and is less reliant on traffic to redistribute the salt. Little salt is lost to the surrounding environment, and the method has a rapid effect on the road.

Brine is very well suited for anti-icing application to dry or slightly damp roads. The method can also to a certain extent be used for de-icing purposes on thin films of ice and hoar frost.

The brine, in which the salt has already been diluted, can lose its intended melting capacity and function when water is introduced, for example in case of precipitation, which makes this a vulnerable method. Brine application therefore requires close follow-up after use, particularly in connection with precipitation.

1.10.3 Purposes of using salt

The following is stated in exhibit *D2-ID9300a Bruk av salt*[11] about the different purposes of using salt:

> *Salt can be used in winter maintenance for the following purposes:*
>
> *1. Anti-icing*
>
> *2. Anti-compaction*
>
> *3. De-icing*

1.10.3.1 *Anti-icing*

The following is stated in exhibit *D2-ID9300a Bruk av salt*[11] about anti-icing:

Salting of trafficked areas free of snow or ice (dry, damp or wet) to prevent roads from becoming slippery due to freezing or hoar frost.

Typical weather and road surface conditions that trigger a need for salting as an anti-icing measure are:

- *Wet or damp road and temperatures dropping to below freezing*
- *Danger of hoar frost (dew deposited in sub-zero temperatures) on dry road surface*
- *Before freezing rain or rain on cold road surface (sub-zero)*
- *Water from melted snow and ice on cold road surface/build-up of ice*
- *Water from tunnel washing etc. on cold road surface*

When salt is used for the purpose of anti-icing, is must be used in the lowest possible dosage. This requires good maintenance arrangements with sufficient capacity. Salting must be carried out as close in time as possible to the weather event and repeated frequently if necessary.

When salting takes place on wet roads (spray from vehicles), a lot of salt will be lost from the road and the salting will lose effect sooner. This makes it particularly important to implement the measure close in time to the weather event and repeat frequently if necessary. Increasing the dosage will not be effective in such situations, as even large quantities of salt will be rapidly lost from the road.

1.11 The contractor's winter road maintenance

1.11.1 Use and interpretation of available weather data

The main contractor has informed the NSIA that weather forecasts from *Yr*, *Halo*, *Met* and *Vegvær* are used as a basis for making decisions about maintenance measures on the road network, but that the forecasts are not documented, neither by the main contractor nor by the contractor responsible for road maintenance. The main contractor has therefore been unable to produce documentation of the weather forecasts on which the maintenance measures carried out on the E6 road before the accident were based.

The main contractor has stated that weather data are considered in dialogue between several employees. The NSIA has been informed that the employee who carried out maintenance measures on the road network on the day of the accident had long experience of interpreting weather forecasts for the area in question. The NSIA has not been informed that the contractor responsible for road maintenance was aware that there was a possibility of precipitation on the road network after the final round of salting before the accident (see section 1.9.2–1.9.4).

The documentation submitted shows that the contractor responsible for road maintenance implements maintenance measures based on *'weather events on road'* or *'forecast weather events on road'*. Manual R610 – *Standard for drift og vedlikehold av riksveger*

('Standard for operation and maintenance of national roads')[14] (hereinafter referred to as Manual R610) gives the following definition of a *weather event*:

> *A weather event is a weather condition or change in weather conditions that affects and changes the road surface conditions in relation to the approved road surface conditions. Weather events are usually related to precipitation, moisture deposited from the air, wind or a change in temperature.*

The main contractor has referred to the NPRA's salt table for descriptions of measures to be implemented in connection with different weather events (see Figure 26). The main contractor has not drawn up its own procedures for implementing maintenance measures on the basis of different weather events.

The main contractor has stated that the contractor's personnel have found that the weather can change a lot within the relevant contract area. The NSIA has also been informed that the contractor responsible for road maintenance is aware of locations on the road network that can be particularly challenging in terms of winter maintenance, but that the accident site is not one of these locations/areas (see section High-risk sections of road – winter maintenance 1.13.5).

1.11.2 Choice and implementation of maintenance measures on the day of the accident

The NSIA has received the trip history report (fleet management data) for one of the salting vehicles engaged in maintenance measures on the E6 road before the accident (see Table 1). According to the numbering, maintenance measures were carried out in the northbound lane between 03:42 and 03:45, and in the southbound lane between 04:30 and 04:32. The heavy goods vehicle whose driver lost control was southbound when the accident occurred at 10:42.

The accident occurred on the E6 road, main section 36, km 7,853, and the report shows that the accident site had most recently been salted at 04:30 (see Table 1). *'N'* and *'S'* refer to the *northbound* and *southbound* direction of travel, respectively.

Table 1: Trip history data for the section of road where the accident occurred. Source: Main contractor

Location	Time	Equipment
5000-EV-6-36-6000 (N)	2 February 2020, 03:42:02	Plow, side blade, spreader
5000-EV-6-36-7000 (N)	2 February 2020, 03:43:40	Plow, side blade, spreader
5000-EV-6-36-8000 (N)	2 February 2020, 03:45:20	Plow, side blade, spreader
5000-EV-6-36-8000 (S)	2 February 2020, 04:30:00	Plow, side blade, spreader
5000-EV-6-36-7000 (S)	2 February 2020, 04:31:32	Spreader
5000-EV-6-36-6000 (S)	2 February 2020, 04:32:44	Spreader

[14] Norwegian Public Roads Administration. (2014). Manual R610 Standard for drift og vedlikehold av riksveger ('Standard for operation and maintenance of national roads').

The production data received show that, at 04:30, 9.88 litres of brine was applied over a section of 108 metres of road that included the accident site. This means that approx. 0.09 litres of brine per metre was applied to the stretch of road in question, which corresponds to about 25 g/m^2 of brine. The vehicle spreading salt at the accident site was travelling at a speed of 35–37 km/h. The salting is in accordance with the quantity of salt in brine (20–30 g/m^2) prescribed for anti-icing in the salt table for anti-icing under winter maintenance class DkC (see Figure 26):

- For damp or wet roads when there is a risk of freezing and the road surface temperature is higher than -3 °C, with a forecast of falling air temperature.

- For dry or damp roads when there is a risk of hoar frost or freezing and the road surface temperature is between -3 °C and -6 °C, and the weather forecast predicts a road surface temperature below the dew point and decreasing air temperature.

When there is a risk of hoar frost or freezing (in the form of rain/freezing rain), a significantly higher concentration of salt or a different salting method, such as pre-wetted salt or slurry,[15] must be used (cf. figure 26).

The main contractor has informed the NSIA that the salting carried out before the accident was done using same method *'as usual'*, and that the quantity of salt was in accordance with the applicable salt table for winter maintenance class DkC (see Figure 26).

The main contractor has informed the NSIA that brine is applied to the road network in winter, as this is the only salting method available to the contractor responsible for road maintenance under the operations contract in question. According to the main contractor, the operations contract is based on the use of brine for winter salting.

1.11.3 Documentation of maintenance measures

The main contractor has provided the NSIA with documentation of the contractor responsible for road maintenance's reporting regarding maintenance measures carried out during the period from 27 January to 2 February 2020 (until the time of the accident). A total of 17 maintenance measures were carried out on the road network in this contract area during the period in question. The most important findings relating to this documentation of the maintenance measures implemented are described below.

- The road segment (*Rode*) has not been specified for any of the 17 documented maintenance measures. Nor does the documentation show what part of the stated sections of road (European road, county road) maintenance measures have been carried out on.

- The intension behind the maintenance measure *(Intensjon for iverksatte driftstiltak*) has only been specified for 7 of the 17 documented maintenance measures. In all these cases, *'salting'* has been given as the intention.

- The winter maintenance class has been described as 'B, C, D and E' for 6 of the 17 documented maintenance measures. Different road friction requirements apply to each of the winter maintenance classes, but the documentation does not show which

[15] Pre-wetted salt that has been crushed.

maintenance measures have been carried out on which sections of road with pertaining winter maintenance classifications. For 6 of the 17 documented maintenance measures, no winter maintenance class has been specified for the road sections in question.

- The reason for maintenance measures implemented *(Årsak til iverksatte driftstiltak)* has been recorded as both 'weather event on road' *(værhendelse på veg)* and forecast of potential weather event on road *(prognose på mulig værhendelse på veg)* for 11 of the 17 documented maintenance measures. However, the assessments that formed the basis for the decision (the presumed 'weather event') have not been described. Neither the presumed 'weather events' nor the weather forecasts that formed the basis for the decision to implement the measures have been documented.

- For 3 of the 17 documented maintenance measures, anti-icing, de-icing and anti-compaction (*'anti-ising', 'de-ising'* and *'anti-kompaktering')* were all recorded as the purpose of the measures implemented (*Hensikt med iverksatte driftstiltak*). In seven cases, both anti-icing and de-icing were stated as the purpose of the measures, while anti-icing was given as the purpose of the remaining seven measures. The assessments that formed the basis for the decision (assumed 'purpose'), on the other hand, have not been described. The purposes of anti-icing, de-icing and anti-compaction are, in that order, to prevent freezing or formation of hoar frost on the road surface, to melt thin layers of ice and to prevent a layer of snow/ice from forming on the road.

- The method used for the maintenance measures implemented (*Benyttet metode for iverksatte driftstiltak'* has been described for 12 of the 17 documented maintenance measures. In all these cases, brine has been given as the salting method. For the remaining five cases, it was not specified whether dry salt, pre-wetted salt or brine was used.

- Whether the method used was in accordance with the salt table *(iht. salttabell)* has been described for 10 of the 17 documented maintenance measures. In all these cases, it was stated that the salting method was in accordance with the salt table. There is no documentation of whether this was the case in the remaining seven cases.

- The result of the measure (*Resultatet av tiltaket)* has not been assessed for any of the 17 documented maintenance measures. In all of these cases, the contractor has signed in the reporting field instead of describing the effect of the maintenance measures implemented.

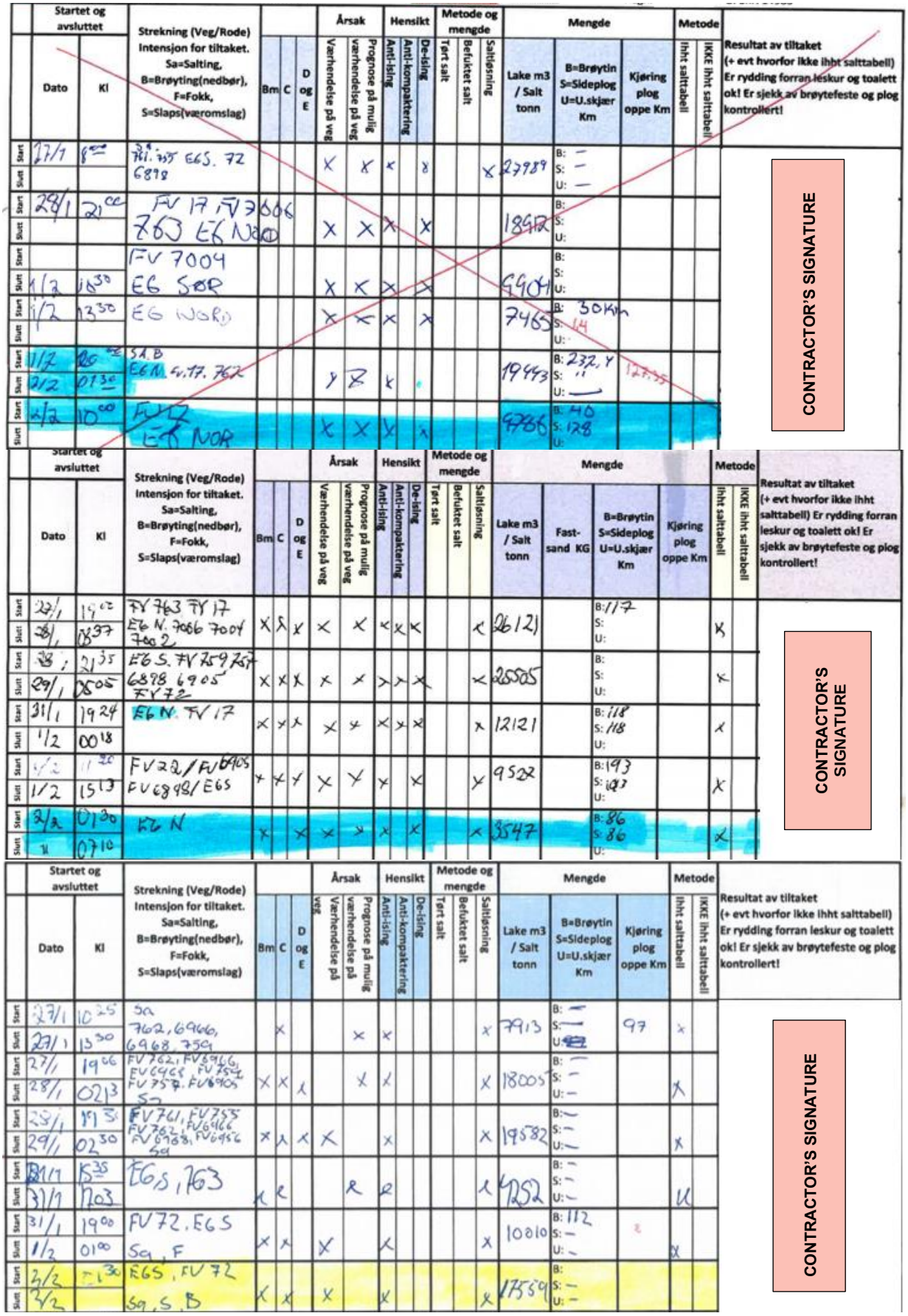

Figure 24: Documentation of maintenance measures implemented during the period from 27 January to 2 February 2020 (until the time of the accident). The signatures in the results field have been edited out. Source: Main contractor

1.11.4 Follow-up of maintenance measures

The NSIA has received records of the main contractor's reporting of driving conditions on the E6 road for the section Stamphusmyra–Vegset, which includes the accident site. The reporting shows that the observations described were made at 06:02 on 2 February 2020 – about four hours before the accident occurred. Conditions on the stretch of road with a total length of approx. 87 km were described as 'bare and wet, slush'. It was also stated that salting and snow clearing measures had been implemented and were in progress at the time. It was not specified where on the E6 road maintenance measures were implemented. The NSIA has been informed that no salting or friction measurements were carried out at the accident site in connection with this.

The main contractor's plan for systematic control and inspection of the road network stipulates that the E6 is to be inspected weekly (see Table 2). There is no mention of the inspection frequency varying according to the season, for example more frequent inspections during the 'winter preparedness period' (see section 1.13.4).

The plan also states that additional inspections of the road network shall be carried out when the weather conditions are challenging or in case of suspected nonconformities in the maintenance work. The main contractor has informed the NSIA that, generally speaking, no such additional inspections are carried out if meteograms or local conditions indicate a need. The main contractor has also stated that assessments are made on a continuous basis 'if extreme weather conditions or similar are forecast' (see Table 2).

The documentation received shows that the last general inspection made of the E6 road before the accident took place on 27 January 2020. The inspection report states that there were areas of both bare and wet road on the section Steinkjer–Snåsa. The inspection found no nonconformities in the winter maintenance.

1.12 The Norwegian Public Roads Administration's follow-up of winter road maintenance

1.12.1 General information

The NPRA is the road owner and client in relation to the contracting company Veidekke Industri AS, which had operating and maintenance responsibility for the section of road where the accident occurred. The following sections deal with the NPRA's follow-up of the winter road maintenance.

1.12.2 The client's control of maintenance measures

The NPRA uses a system known as SOPP (an abbreviation of its Norwegian name *System for oppfølging av driftskontrakter* - 'system for follow-up of operations contracts') to follow up and report on the contractors' performance under operations contracts. According to SOPP, road surface conditions are primarily to be followed up by means of spot checks (planned inspections).

The NPRA has informed the NSIA that an annual plan for planned spot checks is drawn up at the turn of each year. The number of spot checks scheduled per month for the road network covered by the operations contract in question is registered in connection with this work. Winter road maintenance is checked through the maintenance processes snow clearance, snow removal and sanding/salting. Any nonconformities in the road conditions (in relation to the requirements set out in the operations contract) will be registered by the

NPRA in ELRAPP,[16] and the contractor will be given a deadline to provide feedback on the nonconformity identified.

The NPRA has provided documentation showing that about 600 spot checks are planned on the road network covered by the operations contract every year, and that the majority of them are scheduled to take place in the winter season.

Documentation received shows that the NPRA has carried out a total of 538 spot checks on the national road network (including the E6) during the four-year contract period (1 September 2016–30 November 2020). Winter maintenance (process '95 snow clearance, snow removal, sanding/salting etc.') was checked in connection with 59 of these spot checks. No nonconformities relating to winter maintenance were registered in connection with the spot checks.

The documentation shows that for January 2020, 64 spot checks were scheduled on the road network in the contract area, 8 of which concerned the national road network (including the E6). The NPRA carried out 12 spot checks on the E6 road during the period from 1 January to 2 February 2020 (the day of the accident). The winter maintenance status was checked in connection with two of these spot checks, and no nonconformities were registered.

The submitted documentation does not specify whether the NPRA measured friction on the E6 road in connection with the two winter maintenance spot checks. The NSIA has been informed that the NPRA carried out about 160 friction measurements on the E6 road during the period 1 September 2016–14 December 2020. The NPRA carried out two friction measurements on the E6 road during the period from 1 January to 2 February 2020 (the day of the accident). No nonconformities relating to winter maintenance were registered in connection with these measurements.

1.12.3 The client's follow-up of contractors

The NPRA has stated that there are to be two construction meetings per month with the main contractor during the contract period. Other than construction meetings, spot checks and friction measurements, the NPRA had not established other systematic activities for documenting, following up or quality assuring winter road maintenance.

1.13 Operations contract *1707 Steinkjer 2016–2021*

1.13.1 General information

The NPRA is the road owner and client in relation to the contracting company Veidekke Industri AS, which had operating and maintenance responsibility for the section of road where the accident occurred. Veidekke Industri AS has functioned as the main contractor in connection with the relevant operations contract, as the company has used a subcontractor (contractor responsible for road maintenance) to carry out winter road maintenance on the road network covered by the operations contract.

[16] ELRAPP – A web-based system for follow-up of tasks in the NPRA's contracts.

The section of road where the accident occurred is covered by the operations contract *1707 Steinkjer 2016–2021*. The contract was entered into by the NPRA and Veidekke Industri AS, and is valid for the period 1 September 2016–31 August 2021.

The contract covers both summer and winter maintenance of county and national roads, including shared-use paths for cyclists and pedestrians, in the municipalities of Verdal, Inderøy, Steinkjer, Snåsa and Leksvik. The total length of the road network covered by this contract is 1,023.13 km. This includes 36.5 km of the E6 road. The traffic volumes on different parts of the road network in the contract area vary from an annual average daily traffic (AADT) of about 50 vehicles per day up to 16,550 vehicles per day. The E6 through Snåsa falls within the scope of this contract (see Figure 25).

The operations contract is an extensive contract that deals with all aspects of the operation and maintenance of the road network described. The contract also covers other tasks that form part of the contractor's work, such as inspection and registration, winter maintenance preparedness and reporting to the NPRA.

Among other things, the operations contract stipulates requirements for winter maintenance classes, the winter preparedness period, high-risk sections of road and contractual requirements concerning winter maintenance (see sections 1.13.2–1.13.6).

The contract points out that the contractor has functional responsibility[17] for carrying out winter maintenance. This means that it is up to the contractor to plan, identify needs and implement maintenance measures on its own initiative. The contractor is also responsible for documenting and reporting on maintenance measures, and for documenting and reporting on the road condition and function achieved after maintenance measures have been carried out. The operations contract also describes that it is up to the contractor to choose the methods, measures and resources applied, within the limits of the contractual requirements.

[17] *'Overall responsibility for decision-making, planning, engineering, execution, quality assurance, follow-up, documentation and reporting of measures necessary to fulfil contractual requirements, and documentation of and reporting on the resulting condition and function.'* Source: Operations contract *1707 Steinkjer 2016–2021*.

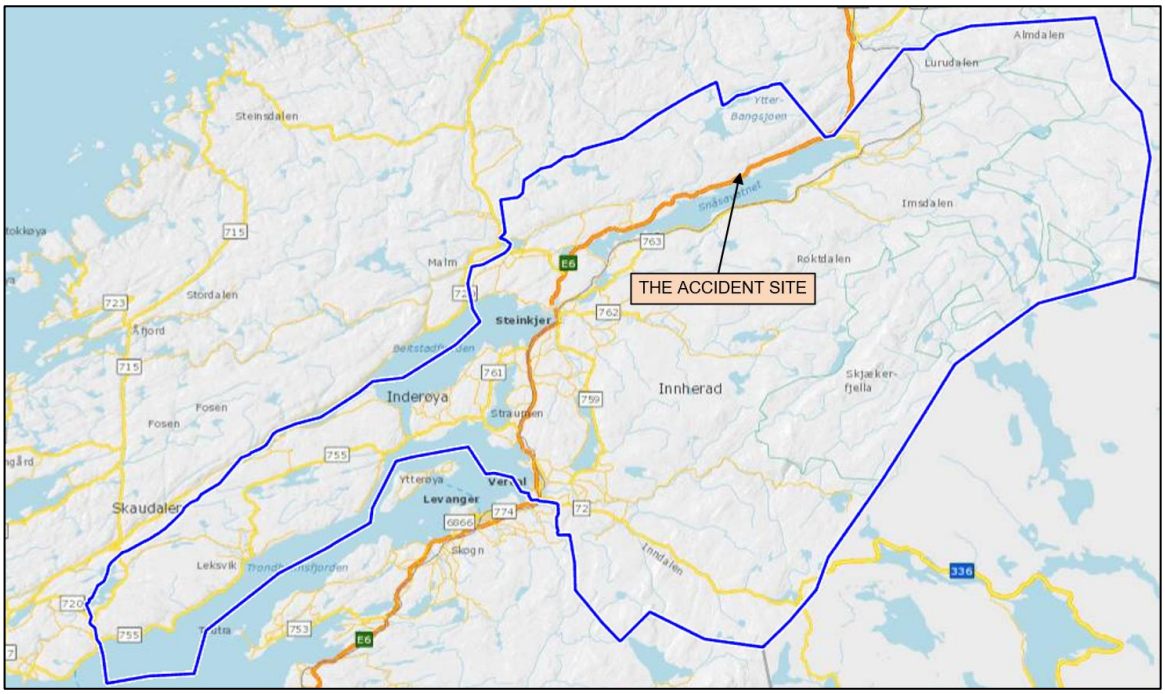

Figure 25: Area covered by operations contract '1707 Steinkjer 2016–2021' (outlined in blue on the map). As shown, the E6 road along Snåsavatnet lake is part of this area. Illustration: NPRA

1.13.2 Maintenance class

The winter maintenance regime for the section of road where the accident occurred is classified as winter maintenance class DkC. This is the middle of five winter maintenance classes in Norway, and is applied to roads with traffic volumes of 0–3,000 vehicles per day. This winter maintenance class requires the road to be bare (wet/dry) during periods of little precipitation/freezing or temperatures of around 0 °C. Approved road conditions are bare road (dry or wet) during periods of mild weather, and hard snow/ice during cold periods.

1.13.3 Maintenance measures

According to winter maintenance class DkC, salt is to be used during mild periods, while sand is to be used during cold periods when the road is covered in snow and ice. Salt is to be used preventatively to keep the road from becoming slippery with a thin layer of snow/ice or hoar frost, as well as to keep the road bare during periods without precipitation (snow). As long as snow and/or ice covers parts of the roadway, salt must only be used at road surface temperatures above -3 °C. Otherwise, sand is to be used.

Salt is to be used on bare roads (dry, damp or wet) to prevent slippery roads due to freezing or hoar frost, and for anti-icing purposes at temperatures above -6 °C. Salt can also be used to melt thin layers of ice and frost, and is to be used for de-icing at temperatures above -6 °C or if parts of the roadway are covered in snow and/or ice at temperatures above -3 °C (see Figure 26).

Risk of	Hoar frost	Freezing	Freezing	Freezing	Freezing
Weather forecast	Road surface temperature below dew point temperature	Dropping temperature	Dropping temperature	Rain/ freezing rain (<1 mm/h) (small amounts)	Rain/ freezing rain (>1 mm/h)
Road surface condition	Dry road	Damp road surface (no spray from vehicles)	Wet road surface (spray from vehicles)	Frozen roadway	Frozen roadway
Brine – quantity of salt g/m²					
Higher than -3 °C	15	20	30	40	(60)
-3 °C – -6 °C	20	30	(40)	40	(60)
Pre-wetted salt/slurry g/m²					
Higher than -3 °C			10	30	40
-3 °C – -6 °C			(15)	30	40

SALT TABLE FOR ANTI-ICING – WINTER MAINTENANCE CLASS DKC

Figure 26: Anti-icing salt table for winter maintenance class DkC. Source: NPRA

The maximum length of a sanding/salting cycle is three hours, and sand/salt must be applied when friction is expected to fall below the requirements defined for approved road surface conditions. Preventive sanding/salting must be started sufficiently early for the work to be completed and have an effect in relation to the expected weather event. It is a requirement that approved road surface conditions be restored within three hours.

The following is quoted from footnote 1 of the anti-icing salt table for winter maintenance class DkC:[18]

> *Be aware of high loss of salt from the road when the road surface is wet. It is important to implement measures close in time to the weather event and repeat frequently if necessary.*
>
> *(…)*
>
> *Freezing rain or rain on a frozen roadway are rare weather events for which forecasts will be uncertain, but they nevertheless have the potential to make driving conditions very difficult. This indicates that the quantities spread should be high, and it is not expedient to set in place further distinctions by temperature of the roadway.*

[18] Norwegian Public Roads Administration. (2015). Opplæring i vinterdrift for operatører: Driftskontrakter med oppstart 2016. NPRA reports, No 369.

1.13.4 Winter preparedness period

Manual R610 provides the following definition of 'winter preparedness period':

> *Period of the year for which winter preparedness shall be in place with duty and, if relevant, shift rotas, and all resources (plant/machinery, materials, equipment and personnel) shall be readied, prepared and available for immediate implementation of measures as indicated by weather forecasts and needs. The winter preparedness period is to be defined on the basis of local conditions in terms of road standard, traffic, climate and weather conditions that are likely to occur.*

According to Manual R610, winter maintenance requirements apply during the winter preparedness period, which the operations contract defines as the period from 1 October to 30 April. This means that the accident occurred during the winter preparedness period.

1.13.5 High-risk sections of road – winter maintenance

Exhibit *D2-S29 Vinterdrift*[19] to the operations contract states that the NPRA has pointed out two sections of the E6 road that are known to be slippery and require extra attention. The sections in question are Hp 19 Kne–Langhammer and Hp 20 Hammer–Heimsjøen. The accident site is on the Hammer–Heimsjøen section.

During a meeting with the main contractor and the contractor responsible for road maintenance in February 2020, the NSIA was informed that the accident site was not considered to be a challenging location in terms of winter maintenance. When the operations contract was submitted, however, the NSIA was made aware that the accident site was part of a section of road described as a priority road section as regards winter maintenance. The NSIA received the following response from the main contractor regarding how this part of operations contract had been followed up:

> *We are particularly aware of the locations described by the NPRA. This is based on experience we have gained during past contracts of the sections of road/conditions in different weather situations. In the initial phase, concrete checks were carried out to correlate this with the actual conditions based on temperature, precipitation and how the road conditions change based on the prevailing climatic situations. This is still done occasionally, but we have now accumulated a greater store of experience of how different types of weather and weather situations affect the road surface. We are also in dialogue with many road users who also form part of our organisation, even if they are not doing the actual snow clearing on the section of road in question.*

Neither the main contractor nor the contractor responsible for road maintenance has submitted documentation of a procedure being developed to follow up road surface conditions on the section Hammer–Heimsjøen.

The NPRA has informed the NSIA that Hammer–Heimsjøen has been explicitly mentioned in the operations contract for winter maintenance due to the road geometry on the section (challenging curves and ascents).

[19] Norwegian Public Roads Administration. (2015). D2 Tegninger og supplerende dokumenter: D2-S29 Vinterdrift.

1.13.6 Contractual requirements

The following is quoted from the operations contract's chapter on goals for the contract and its performance under the heading *'Social responsibility'*:

> *By entering into the present contract, the contractor has accepted a social responsibility for maintaining traffic safety, passability, the environment and service in relation to the road users, people living along the road and the rest of society, within the limits of the area of responsibility and requirements set out in the contract.*

The following is quoted from the operations contract's chapter on requirements for operations and maintenance performance:

> *The contractor shall ensure that the road network is accessible to all road users throughout the year (with the exception of roads that are closed in winter) in accordance with the contractual standard for the road network, while maintaining traffic safety, the environment, universal design and service in relation to the road users and people living along the road.*
>
> *The contractor shall perform the work under the contract in a professional and careful manner, emphasising safety so as to avoid personal injury and damage to property. Particular care must be taken in relation to traffic safety, traffic flow, the working environment and the natural environment.*

The operations contract describes requirements of the contractor in connection with winter road maintenance. Table 2 shows a compilation of investigation findings relating to follow-up of contractual requirements concerning winter maintenance, as well as the performance and follow-up of winter road maintenance. The topics include systematic control of the road network, documentation of work performed and of the winter friction level, as well as the contents of the contractors' 'winter plan' and 'record of special incidents on the road network'.

Table 2: Compilation of investigation findings relating to follow-up of contractual requirements concerning winter maintenance, as well as the performance and follow-up of winter road maintenance.

1. Systematic control of the road network
Requirements stipulated in the operations contract
➢ The contractor shall establish and maintain a plan for systematic control of the road network. The road type/traffic volume and season, as well as the purpose of the control, are all factors in the assessment of the need for control of the road network. ➢ In addition to frequency-based inspections, the contractor shall conduct supplementary inspections when conditions (e.g. weather forecasts, traffic control centres) indicate a need.
Main findings in the documentation
• The main contractor's plan for systematic control and inspection of the road network states that the E6 road should be inspected weekly. The plan does not state whether the road type, traffic volume and/or season (winter/summer) have been considered when assessing the need for inspection of the road network in accordance with the requirements set out in the operations contract (see section 1.11.4). • The plan does not describe the purpose of inspections to be carried out of the road network. • The plan describes how climate stations are to be used to obtain information about weather and road surface conditions before preventive measures are implemented. The main contractor has been unable to document that the contractor responsible for road maintenance obtained information about weather and road surface conditions from climate station as a basis for deciding whether to implement maintenance measures on 2 February (see section 1.11.1). • The plan describes how, in addition to the ordinary routine inspections, additional inspections of the road network shall be carried out in the event of challenging conditions or suspected nonconformities in the maintenance work. The main contractor has stated that, generally speaking, no additional inspections are carried out of the road network if the meteogram or local conditions indicate a need. The main contractor has stated that assessments are made on a continuous basis 'if extreme weather conditions or similar are forecast' (see section 1.11.4). The main contractor has not provided any information about whether the road network is inspected in case of challenging weather conditions or suspected nonconformities in the maintenance work as stipulated in the operations contract. • The plan describes that the main contractor shall carry out internal control of the subcontractor (contractor responsible for road maintenance) by checking the quality of winter road maintenance through spot checks of road friction. The plan does not specify or give grounds for the frequency of such spot checks. The main contractor has informed the NSIA that no requirements are specified regarding the frequency of spot checks of road friction. The main contractor has not forwarded documentation to the NSIA to show that spot checks of road friction on the E6 road were carried out in the winter season 2019/2020 for the purpose of internal control of winter road maintenance carried out by the contractor responsible for road maintenance. In this context, the main contractor has stated that road surface conditions on the E6 road are observed through general inspections and simple braking tests.

2. Documentation of work performed

Requirements stipulated in the operations contract

- *The contractor shall keep a salt record that documents assessments and decisions for all winter maintenance salting. Separate records must be kept for each winter maintenance class.*
- *The record for each salting measure shall include information about the date/time the need for salting was assessed, the section of road the assessment applies to, a description and assessment of weather/road surface conditions (as a minimum the purpose, risk, weather forecast, road surface conditions, method and temperature interval), and the salting measure chosen (purpose, method and dosage).*
- *The contractor shall have a documented system in place for following up and evaluating results of salting as a basis for fulfilling the contractual requirements.*
- *The results of the evaluation must be presented at construction meetings twice per winter season.*

Main findings in the documentation

- The salt record for the period 27 January–2 February 2020 contains inadequate information about maintenance measures implemented and the result of the measures (see section 1.11.3).
- The salt record for the period 27 January–2 February 2020 shows that the contractors have not kept separate records for each winter maintenance class as required by the operations contract (see section 1.11.3).
- The NPRA and the main contractor have not presented documentation showing that the contractors had a system in place for following up and evaluating the result of maintenance measures implemented as required by the operations contract.
- The NPRA and the main contractor have not presented documentation showing that the contractors have presented an evaluation of the salting implemented twice per winter season 2019/2020 as required by the operations contract.

Comment from the main contractor

The main contractor has stated that the enterprise has systems in place for evaluating the effect of salting implemented by means of the salt record. The main contractor has also stated that:

'We also have systems in place to identify any errors in spreader quantities and let us know if they are significant. In addition, annual winter meetings and road segment inspections with pertaining safe job analyses take place before the start of each winter season. Veidekke can also confirm that winter maintenance, including salting, is discussed at construction meetings throughout the winter. Calibration forms and salt records are submitted on a continuous basis, and winter data are transferred every ten minutes.'

3. Documentation of winter friction level

Requirements stipulated in the operations contract

- *The contractor shall measure friction during the winter season in order to monitor road surface conditions and make active use of measurements as decision support in connection with winter maintenance.*
- *The contractor shall establish, as part of its quality system, a plan for measuring friction that ensures that the road friction requirements are met.*
- *Friction measurements must be reported to the client every two weeks.*

Main findings in the documentation

- The main contractor has not measured friction on the E6 road in order to monitor road surface conditions and make active use of measurements as decision support in connection with winter maintenance during the winter season 2019/2020 as required by the operations contract.
- The NPRA and the main contractor have not presented documentation showing that the contractors had established a plan for measuring road friction on the E6 road during the winter season 2019/2020 as required by the operations contract.

  The NPRA has stated that the main contractor's friction measuring device was out of operation for an extended period of time. According to the NPRA, the main contractor should have provided a back-up measuring device in this case, but this did not happen. The main contractor has stated the following to the NSIA:

  'The section of road in question is assigned to winter maintenance class DkC. That means that the section is to be maintained as a bare pavement road by means of salt when the road is free of snow/ice and/or the temperature is above -3 °C. If the road surface is colder than this and/or the roadway is covered in snow and/or ice, the road is to be maintained as a winter road by means of sanding. This assessment is not made on the basis of a single temperature fluctuation, but on 24-hour trends. In this case, the road conditions were such that it was maintained as bare pavement road, meaning that salt was used to improve friction. Generally speaking, more DkC-class roads are now increasingly maintained as bare pavement roads due to the mild climate we often enjoy. The winter 2019/2020 was relatively mild, and the road was largely maintained as a bare pavement road.'
- The main contractor has not reported friction measurements from the E6 road every two weeks during the winter season 2019/2020 as required by the operations contract.

Comment from the main contractor

The main contractor has stated the following:

'We do not measure whether the road is bare or not. This is observed through general inspections and simple braking tests. Such observations and tests have taken place at least once a week in accordance with the contract (...). Technically, a bare pavement road is defined as a road with a wet or dry bare surface, which will have a friction of between 0.4 and 1. Normally, the road friction will be +/- 0.8 after salting. Friction measurements are not normally carried out for decision support purposes, since new measures are to be implemented when we expect the road to freeze again. (…) As mentioned above, friction measurements are not used to monitor road surface conditions on bare pavement roads. This is linked to the fact that it is not required or expedient. Friction measurements for decision support purposes are mostly used on winter roads whose surface is covered in ice and/or snow, and where it is difficult to assess the difference between approved and not approved friction. (…) Friction measurement will not be expedient for a bare pavement road. The definition of bare pavement is very broadly defined by a friction interval of 0.4–1. A bare pavement road is either dry or wet, with a noticeable and good response to simple braking tests. A salted road will in most cases have a friction well above the minimum level of the defined friction interval, and a friction measurement will therefore not provide supplementary information.'

4. Winter plan

Requirements stipulated in the operations contract

- *Before every winter season, the contractor shall document that employees who are to carry out winter road maintenance have received the necessary introduction to and information about the winter plan. Among other things, the plan must provide a description and presentation of:*
  - *priority road sections and special circumstances*
  - *procedures and responsibility for mobilising crew and equipment*

Main findings in the documentation

- The plan contains two chapters entitled *Prioriterte strekninger i overgangsperioder* ('Priority road sections in transition periods') and *Prioritert liste av veier etter ÅDT og samfunnsmessig viktighet ved avvik* ('Priority lists of roads by AADT and societal importance in relation to nonconformities'). The section Hammer–Heimsjøen is listed in both these chapters, and is described as a section that is known to be slippery and require extra attention. The chapters do not describe any procedures relating to follow-up of the road surface conditions on this section in winter (see section 1.11.4).

  The NPRA has stated that the operations contract requires contractors to draw up procedures for following up road surface conditions on priority sections of road. In connection with this, the NPRA refers to requirements stipulated in the operations contract for a quality system to be developed:

  'The quality system with pertaining plans shall have been introduced in the organisation by the time the contractual work is initiated. The system shall cover all work and products for which the contractor is responsible. The contractor's quality plan must cover all operations and, as a minimum, contain such plans and elements as the contract requires.'

  The NPRA has also stated the following:

  'In an operation and maintenance contract that also requires ISO-9001 certification, the contractor is responsible for basing the planning, execution and follow-up of the contractual performance on relevant information. This includes risk assessments. The responsibility is heightened when the contractor has been explicitly informed that a section of road is known from experience known to be slippery and require extra attention to winter maintenance.'

- The plan contains no descriptions of special circumstances. The plan contains descriptions of a total of 31 road segments, and all the segment descriptions contain a section headed *Spesielle forhold* ('Special circumstances'). This section contains no information in any of the 31 road segment descriptions. This is also true for the description of road segment 1, which includes the accident site and parts of the priority road section Hammer–Heimsjøen.

- The plan does not contain a chapter entitled *Utkalling av mannskap og utstyr* ('Mobilisation of personnel and equipment'). The plan does contain a chapter entitled *Vinterberedskap* ('winter preparedness'), in which the following is written:

  'The person on duty shall keep up to date on meteograms, notifications received from traffic control centres or the general public, and information from the climate stations in the area. On the basis of the above, personnel are to be informed about conditions that may require mobilisation.'

  During the period 27 January–2 February 2020 (until the time of the accident), the Traffic Control Centre (VTS) received nine reports from road users of slippery roads on the road network in the same contract area as the accident site. Three of these notifications were received on 2 February, in the hours leading up to the accident. They were not forwarded to the NPRA, the main contractor or the contractor responsible for road maintenance.

5. Special incidents on the road network

Requirements stipulated in the operations contract

- *The contractor shall keep a record of special incidents[20] on the road network. The contractor shall draw up the record itself.*

  The record shall also cover communications from the general public and the NPRA, specifying the time and date when they were received, the place, what they concerned, who the communication was received from, and which action was taken.

Main findings in the documentation

- The main contractor has submitted documentation showing that the contractors kept a record of special incidents on the road network as required by the operations contract. This record contains a very limited amount of information about measures implemented in connection with special incidents that have occurred on the road network. The contractors have recorded the following information about the accident that occurred on the E6 road on 2 February 2020, in which two people died:

02.02.2020 10:53	E6	Hammer	VTS (Traffic Control Centre)	Yes	Collision between two heavy goods vehicles	02.02.2020 10:52	For information

  The minutes of the construction meeting between the NPRA and the main contractor on 6 February 2020 contains a section entitled *Rapportering av spesielle hendelser* ('reporting of special incidents'). The NPRA has referred to this section as documentation that the contractor keeps a record of special incidents on the road network. The section only says 'VTS log reviewed'. The NPRA has not been aware that the contractors have kept a separate record of special incidents on the road network.

  Neither the main contractor's record of special incidents on the road network nor the VTS log states that the NPRA, the main contractor or the contractor responsible for road maintenance has reviewed and evaluated the result of road maintenance measures implemented before the accident.

- The minutes of the construction meeting between the NPRA and the main contractor on 6 February 2020 contain a section entitled *Hendelser på veg* ('incidents on road'). This section contains no reference to the road traffic accident on the E6 road only four days earlier, in which two people died.

- The minutes of the construction meeting between the NPRA and the main contractor on 6 February 2020 contain a section entitled *HMS* ('HSE'). It is stated in this section that information received from the police that the accident site was slippery is perceived as unreasonable.

- The following is quoted from the VTS log for the period 27 January–2 February 2020:

  'VTS becomes aware that the media are writing that the road was slippery when the accident occurred. VTS would like to make clear that we did not receive a single call about slippery conditions on the E6 in this area, neither in the hours leading up to nor after the accident. Nor have the emergency services that attended the accident site reported poor road surface conditions.'

  VTS received three notifications from road users concerning slippery driving conditions on 2 February before the accident occurred at 10:42. All three notifications concerned slippery driving conditions on sections of road in the same winter maintenance contract area as the accident site.

[20] Incidents that are not recorded in other documentation or reporting, but that have consequences for the state of the road network, result in measures being implemented that differ from ordinary measures implemented in the course of the contractual work, or that there is reason to believe may give rise to subsequent follow-up questions.

1.14 Technical registration systems

1.14.1 Tachograph data control

The tachographs from both the Polish and the Norwegian heavy goods vehicles were sent to Germany for the data to be downloaded. However, both tachographs were so damaged that it was impossible to retrieve the data.

1.14.2 Driver data control

Fartsskriver AS downloaded data from driver tachograph card of the Polish driver at the request of the NSIA. The downloaded data[21] showed a breach of the working hours regulations on 2 February in that the limit for night work was exceeded. The daily working hours started at 12:12 on 1 February and ended at 01:00 on 2 February. The breach was registered at 00:58 on 2 February, and the total working hours for the day were 10.02 hours.

1.14.3 Vehicle data control

At the request of the NSIA, representatives of Volvo and BPW Hofstad downloaded data from the tractor unit and semi-trailer, respectively, of the Polish heavy goods vehicle. The downloaded data showed that no technical data about the heavy goods vehicle were recorded from its final journey before the accident.

1.15 Laws and regulations

1.15.1 General legal framework

The framework conditions for use, operation, inspection and control in the road sector are mostly regulated by Act No 4 of 18 June 1965 relating to road traffic (the Road Traffic Act) and Act No 23 of 21 June 1963 relating to roads (the Road Act) with pertaining regulations.

1.15.2 Requirements for road operation and conditions

1.15.2.1 *General information*

The NPRA's Manual R610 sets out guidelines for the operation and maintenance of national roads. The standard for operation and maintenance of national roads stipulates requirements for the function and condition of objects as well as for the performance of operations and maintenance work. The manual has the status of directions.

1.15.2.2 *Ensuring traffic safety*

The following is quoted from section 1.1 *Generelle krav* (‘General requirements’) of Manual R610 under *Mål for drift og vedlikehold* (‘Goals for operations and maintenance’), sub-section *Trafikksikkerhet* (‘Traffic safety’):

Limit the number of injuries and fatalities as well as material damage

[21] The report (‘Sjåførbrudd skiftrapport’) was analysed under EU Regulation 561/2006 and Directive 2009/5, using European working hours.

Particular to the performance of operational/maintenance tasks: Operations and maintenance shall be carried out in such a way that their performance do not cause road traffic accidents.

Under the chapter *Vinterdrift* ('Winter maintenance'), the following is written under *Generelt* ('general information'):

Winter maintenance is intended to ensure:

- *Predictable and good accessibility with good regularity and safe traffic flow under winter conditions for all road users in a manner that takes into account environmental considerations*
- *Visibility, readability and other functions for objects, particularly with regard to traffic management, traffic safety and traffic flow*
- *Visibility for all road users*
- *Access to road equipment for personnel engaged in operations and maintenance work*

1.15.2.3 *Documentation of maintenance measures*

The following is quoted from section 1.1 *Generelle krav* ('General requirements') of Manual R610 under *Dokumentasjon* ('Documentation'):

Documentation of operational and maintenance tasks performed, including assessments that form the basis for operations and maintenance decisions and changes to the object resulting from operations and maintenance, as well as filing of documentation, shall be carried out in accordance with the quality system and other governing documentation for the individual objects and activities, as well as in accordance with official laws and regulations.

1.15.3 Requirement for certified systems

A requirement for contractors to establish, introduce, maintain and keep up-to-date a quality system compliant with standard NS-EN ISO 9001:2008 *Quality management systems* was introduced in the NPRA's operations contracts with start dates falling on or after 1 September 2008.

The NPRA later updated the quality system requirement, and the current operations contract requires a quality management system (previously called 'quality system') that is compliant with standard NS-EN ISO 9001:2015 *Quality management systems*. The ISO standard for quality management stipulates requirements for what elements a quality management system should contain and presents the basic level of quality in an enterprise. Contracting companies are required to have a quality management system certified in accordance with the ISO standard. This standard applies to contracting companies that are not ISO certified.

Quality can also be documented by an independent third party through accreditation.[22] The NPRA does not require contracting companies engaged to carry out maintenance work on the Norwegian road network to be accredited (see section 1.18.2.1).

1.16 Special investigations

1.16.1 Simulation of vehicle speed

On assignment for the NSIA, Rekon DA has evaluated the background material available for a simulation of the speed of the two heavy goods vehicles involved in the accident, but concluded that there is not sufficient data available for a simulation to yield reliable results.

1.17 Authorities, organisations and leadership

1.17.1 NPRA

The Norwegian Public Roads Administration (NPRA) is an administrative agency under the authority of the Ministry of Transport, with sector responsibility for roads and road traffic within the bounds defined by the superior authorities.

The NPRA consists of six divisions plus the Directorate of Public Roads. The divisions are Operations and Maintenance (Tromsø), Construction (Bergen), Transport and Society (Trondheim), Road Users and Vehicles (Arendal), IT (Drammen) and Shared Services (Moss).

The NPRA is the road owner for the section of road where the accident occurred.

1.17.1.1 *Traffic control centres*

The traffic control centres (VTS) are the operational NPRA units that deal with traffic control and information on the European, national and county road network.

The traffic control centres are tasked with monitoring and controlling road traffic on national and county roads and providing notification of incidents on the road network and information about the status of the road network. These tasks cover normal situations, nonconformities and undesirable incidents, as well as planned situations and emergencies.

The centres carry out this work on behalf of road owners/road managers in the NPRA, county authorities, the state-owned construction company Nye Veier and public-private partnerships.

1.17.2 Veidekke Industri AS

Veidekke ASA is a Scandinavian contracting and property development company established in 1936. The company is engaged in building and construction work and road maintenance, and it produces asphalt, crushed stone and gravel. Veidekke ASA comprises two business areas, Construction and Infrastructure, and its head office is in Oslo. The company has approximately 8,600 employees in Scandinavia.

[22] Accreditation is an official recognition by an internationally recognised accreditation body of an organisation's expertise and ability to perform certain activities in accordance with specified requirements.

Veidekke ASA mostly has operations contracts with the NPRA as a direct client. The operations contract *1707 Steinkjer (2016–2021)* (see section 1.13) is an ongoing contract between Veidekke ASA and the NPRA, and the contract area includes the section of road where the accident occurred.

Veidekke Industri AS is a subsidiary of Veidekke ASA.

1.17.3 Trans Speed

Trans Speed is a Polish freight forwarding and transport company established in 2006. The company's office is in Lebork in Poland, and it has 14 vehicles.

The Polish driver was an employee of the company.

1.17.4 Kristensen Transport AS

Kristensen Transport AS is a Norwegian freight forwarding and transport company established in 1928. The company's office is in Nord-Statland, and it has 40 vehicles and 65 employees.

The Norwegian driver was an employee of the company.

1.18 Additional information

1.18.1 Operation and maintenance of porous asphalt pavement

The Directorate of Public Roads, represented by the Technology Department, published a report[23] on the operation and maintenance of porous asphalt pavements in 2009. The report was written by the company ViaNova Plan og Trafikk, and formed part of the NPRA's agency project on environmentally friendly road pavements (2004–2008). The report deals with issues relating to the operation and maintenance of porous asphalt pavements, as well as maintenance procedures adapted for these types of asphalt.

The report states, among other things:

> *The surface temperature of porous pavements during snowfall with air temperatures above freezing will be somewhat lower for porous than for dense pavements.*
>
> *(...)*
>
> *It is necessary (..) to be aware that, under certain weather conditions, the thermotechnical properties of porous road pavements may differ from those of ordinary types of road pavement.*
>
> *(...)*
>
> *One argument in favour of porous pavements is that they provide good drainage, thus reducing spray from vehicles. (...) However, it will also mean that salt water will to a greater extent be drained from roadways with a porous pavement, which means that it is difficult to judge what effect this will have compared with salt transport from a dense pavement.*

[23] Norwegian Public Roads Administration. (2009). Miljøvennlige vegdekker: Drift og vedlikehald av porøse asfaltdekker. Teknologirapport nr. 2545.

(…)

Further studies are needed of the risk of freezing/hoar frost on porous pavements.

1.18.2 Previous accidents investigated by the NSIA

1.18.2.1 *Multiple vehicle collision on the E16 road in Lærdalen valley in Lærdal on 6 April 2018*

In the early hours of Friday 6 April 2018, a multiple vehicle collision occurred on the E16 road in Lærdalen valley in Lærdal municipality (AIBN Report Road 2019/02[24]). Five vehicles were involved in the incident, and all sustained material damage. Two persons were injured in connection with the accident.

The contractor responsible for road maintenance chose to use 15 g/m^2 of brine as a preventive measure at the accident site in the afternoon of 5 April. The contractor did not follow up the effect of the measure or how the road surface conditions developed as the evening progressed and in the early hours of 6 April, however. The accident site was not salted during the nine hours leading up to the accident. At the time of the accident, the road friction at the accident site was very low as a result of insufficient residual salt on the road. The road friction was also particularly low at the accident site compared with adjacent road sections.

The investigation found the quality of the contractor's decisions relating to maintenance measures, the implementation of maintenance measures, documentation of road conditions and control measures to be inadequate. In addition, the investigation found that the NPRA had not done enough to follow up and quality-assure the winter maintenance work.

The AIBN submitted the following safety recommendation following the investigation:

> *The Accident Investigation Board Norway recommends that the Norwegian Public Roads Administration investigate the possibility of establishing third-party inspection as a measure to raise the quality of maintenance work.*

At the time of publication of the present report, the above-mentioned safety recommendation had not been closed by the NPRA, whose reply to the recommendation was as follows:

> *The recommendation for third-party inspection must be studied and will be considered in connection with work on the enterprise development project 'Vinterdrift' ('Winter maintenance') (2018–2019), as well as in the course of our work on a new contract strategy, which will take place in 2019 and 2020.*
>
> *A thorough assessment will require looking into how such third-party inspections can be implemented in practice, for example with regard to relevant companies/agencies, level, frequency etc. It would be relevant to find examples from other industries and determine to what extent these examples can be transferred to operations contracts.*
>
> *The recommendation will be considered in the course of our work on a new contract strategy for the maintenance of national roads. There is a need to*

[24] Accident Investigation Board Norway (2019). Report on multiple vehicle collision on the E16 road in Lærdalen valley in Lærdal on 6 April 2018. AIBN Report Road 2019/02.

evaluate the road maintenance contract strategy in light of the regional government reform and transition to contracts for national roads only. This work has already started and will continue into 2020. The AIBN's recommendation will be considered in the course of this work.

1.18.2.2 *Multiple vehicle collision on the E39 road near Åsane in Bergen on 22 February 2016*

On Monday 22 February 2016, a multiple vehicle collision occurred near Åsane on the E39 road in the City of Bergen (AIBN Report Road 2017/06[25]). About 60 vehicles were involved in the incident, and 45 of them sustained material damage to a greater or lesser extent. Ten people suffered minor injuries in connection with the accident.

The accident was caused by rapid ice formation on the road. The investigation found that a sudden change of weather, with the sky clearing followed by a drop in road surface temperature, caused liquid on the road surface to freeze very quickly. The change of weather had been predicted and was described in the weather forecast available on the evening before the accident. The contractor responsible for road maintenance monitored the situation throughout the night and took action by applying pre-wetted salt, which was last done 3.5 hours before the accident. However, the measure did not have the expected effect because the weather turned. The investigation has shown that there was too little salt left on the road surface when the weather changed, and the investigation authority concluded that this was the result of the maintenance frequency on the section of road in question being too low.

The investigation also found that the surface of the right lane on the section of road where the accident occurred consisted of stone mastic asphalt. Among other things, the investigation report referred to a report published by the Danish Road Directorate.[26] The examination showed that stone mastic asphalt is more demanding in terms of winter maintenance, particularly in relation to salting as a compensatory measure to maintain satisfactory friction. The investigation report continues:

Among other things, the investigation shows that wet road surfaces freeze faster on roads with porous asphalt types than on roads with dense types of asphalt, such as asphalt concrete. The investigation also showed that more salt needs to be applied to porous asphalt types than dense asphalts, and that a certain traffic volume is required to 'pump' the salt solution up from the pores in the porous asphalt pavement and keep the roadway free of ice.

The report also referred to a study conducted by the *The Federal Highway Administration*,[27] which looked into the advantages and disadvantages of porous asphalt pavements. It emerged, through experience from European countries, that porous asphalt pavements are at risk of frost formation. The report also referred to studies where porous pavement surfaces have been found to cool down more quickly than dense asphalt pavements.

[25] Accident Investigation Board Norway (2017). Report on multiple vehicle collision the E39 road near Åsane in Bergen on 22 February 2016. AIBN Report Road 2017/06.
[26] Danish Road Directorate. (2012). Winter service of porous asphalt. European experience. Technical note 123.
[27] The Federal Highway Administration. (2014). U.S. Department of Transportation. Office of International Programs. https://international.fhwa.dot.gov/pubs/quiet_pav/contents.cfm.

1.18.2.3 *Head-on collision on the RV 7 road near Veme in Ringerike on 10 February 2014*

On Monday 10 February 2014, a heavy goods vehicle skidded on the RV 7 road near Veme (AIBN Report Road 2015/01[28]). The vehicle ended up in the opposite lane and partly outside the roadway. A bus approaching in the opposite lane was unable to stop and collided with the heavy goods vehicle. Two other heavy goods vehicles approaching the accident site had difficulties stopping in time. Three persons on the bus died and several people were injured. The drivers of the heavy goods vehicles did not sustain any physical injuries in the accident.

The investigation showed low friction at the accident site compared with adjacent sections of road. The AIBN concluded that the condition of the road (road surface conditions) was a material contributing factor to the accident. The road network had last been inspected at approximately 21:00, and the accident occurred at 23:45 – almost three hours later.

The AIBN submitted the following safety recommendation following the investigation:

> *The Accident Investigation Board Norway recommends that the Norwegian Public Roads Administration, in collaboration with the contractor that maintains the road during winter, intensify its work to monitor and follow up stretches of road/areas of road that require extra winter maintenance under special weather conditions.*

The safety recommendation was closed by the NPRA on the basis of, among other things, increased focus on drawing up winter plans and following up operations contract.

1.19 Implemented measures

Neither the NPRA, the main contractor nor the contractor responsible for road maintenance has implemented measures after the accident for the purpose of improving the selection, performance and follow-up of maintenance measures implemented on the road network in the winter season.

[28] Accident Investigation Board Norway (2015). Head-on collision on the RV 7 road near Veme in Ringerike on 10 February 2014. AIBN Report Road 2015/01.

2. ANALYSIS

2.1 Introduction

2.1.1 Decision to initiate an investigation

The NSIA decided to initiate an investigation based on the severity of the accident and the scope of damage/injuries involved. It was also emphasised that the accident occurred on a main road that is one of the most important transport routes between Northern and Southern Norway. The NSIA found at an early stage of the investigation that the road surface conditions at the accident site had been challenging, and that the road friction at the accident site was poorer that on adjacent sections of road.

2.1.2 Investigation method

2.1.2.1 *Introduction*

The collision between the two heavy goods vehicles and the circumstances surrounding the accident have been investigated and analysed in line with the NSIA's framework and analysis process for systematic safety investigations (the NSIA method[29]). The sequence of events, from the last maintenance measure implemented on the section of road in question until emergency service responders arrived at the scene of the accident, has been mapped in the form of sequential presentation in a STEP[30] diagram.

The investigation then looked into connections between the sequence of events and contributing factors at different levels of the sociotechnical system. Contributing factors are factors that did not necessarily have a clear causal effect, but that are deemed to increase the risk of an accident. In connection with this work, an influence diagram was drawn up, showing all the factors that may have contributed to the accident.

2.1.2.2 *Local safety problems*

The STEP analysis is based on mapping of the sequence of events, and it forms the basis for identifying potential local safety problems that had a bearing on the sequence of events relating to the accident. Relevant safety problems could be factors relating to the driver, vehicle or road conditions. Local safety problems in a sequence of events can be identified by taking a nonconformity approach (where did the sequence of events deviate from safe or expected function), a hazard control approach (where did the sequence of events involve loss of control/weak control) or a barrier approach (where could the sequence of events have been changed or interrupted).

The STEP analysis identified the following four local safety problems in the sequence of events leading up to the accident and the circumstances surrounding it (in chronological order):

[29] Norwegian Safety Investigation Authority. (2018). The NSIA method: Framework and Analysis Process for Systematic Safety Investigations. ISBN 978-82-690725-3-2.
[30] Sequentially Timed Events Plotting.

- The working hours of the Polish HGV driver exceeded the requirements stipulated in the Regulations of 2 July 2007 No 877 relating to driving and rest periods for road transport in the EEA.
- The driver of the Polish heavy goods vehicle did not adjust his driving behaviour to match the change in road friction.
- The Polish heavy goods vehicle lost its road grip, and the driver lost control of the vehicle.
- The tractor unit of the Norwegian heavy goods vehicle caught fire after the collision.

The Polish driver's working hours exceeded the applicable limit in the early hours of 2 February (the day of the accident). However, the breach was registered based on the total working hours exceeding the legal limit of ten hours by only a couple of minutes, which means that it is not a material breach. A review of the downloaded driver data identified no other breaches in the driver's driving, rest and working hours in the days leading up to the accident.

The nonconformity in the Polish driver's working hours is not in itself deemed to have contributed to the accident. Based on the above, the NSIA chose not to analyse the safety problem *'The Polish HGV driver's working hours exceeded the requirements stipulated in the Regulations of 2 July 2007 No 877 relating to driving and rest periods for road transport in the EEA'* further in the present investigation.

The NSIA deems the safety problem *'The Polish heavy goods vehicle lost its road grip, and the driver lost control of the vehicle'* to have been the immediate cause of the collision between the two heavy goods vehicles. The safety problem *'The driver of the Polish heavy goods vehicle did not adjust his driving behaviour to match the change in road friction'* is considered to have been a contributing factor in this context. These issues are discussed in more detail in sections 2.2 and 2.3.

Both drivers were killed instantly in the crash between the vehicles. The fire in the Norwegian tractor unit thus had no bearing on the extent of personal injuries caused by the accident. Therefore, the NSIA chose not to analyse the safety problem *'The tractor unit of the Norwegian heavy goods vehicle caught fire after the collision'* further in the present investigation.

2.1.2.3 *Systemic safety problems*

Local safety problems can be considered possible symptoms of underlying systemic safety problems. By examining how the local safety problems identified in the sequence of events were (or were not) identified and dealt with by the organisations and authorities involved, it is possible to form an impression of their safety management and risk management.

Systemic safety problems usually refer to organisational and management factors, as well as weaknesses in framework conditions that impact on the effectiveness of risk management. A systemic safety problem constitutes a risk factor (regardless of whether or not it contributed to the accident in question) that the organisation or authorities have

some degree of control over and responsibility for, and that will increase the risk of accidents in future unless it is dealt with.[31]

In the present case, the NSIA has identified several systemic safety problems related to winter maintenance operations. These issues will be discussed in sections 2.4 and 2.5.

2.1.3 Structure of the analysis

An assessment of the sequence of events is provided in section 2.2. This includes an assessment of the triggering event and the collision, as well as survival aspects.

In section 2.3, the NSIA assess the interaction between the different elements of the traffic system (road user, vehicle and road), seen in light of the road traffic accident in question. Driving behaviour, tyre equipment, handling characteristics, meteorology, road surface condition, road geometry and road surface will all be assessed.

Section 2.4 contains an assessment of the involved contractor's planning, implementation, documentation and follow-up of maintenance measures. The NRPA's follow-up and quality assurance of winter road maintenance are assessed in section 2.5. The NSIA has chosen to present detailed assessments of systemic safety problems related to these factors.

Finally, an evaluation of and lessons learned from the winter road maintenance are discussed in section 2.6.

2.2 Assessment of the sequence of events

2.2.1 Triggering event and collision

The accident was triggered by the southbound heavy goods vehicle losing its grip on the road and entering the opposite lane. The southbound heavy goods vehicle then collided head-on with the northbound one. The vehicle lost its road grip in a right-hand curve at the bottom of a long slope (see section 2.3.4). The passenger in the northbound vehicle has stated that the southbound vehicle continued ‘straight ahead’ in the curve before the point of the collision, which indicates that the vehicle's front wheels lost road grip first. Traces (rubber and scratch marks left on the asphalt) at the accident site also support that the point of impact between the vehicles was in the northbound lane.

2.2.2 Survival aspects

Damage to the two tractor units indicates that the heavy goods vehicles collided with an overlap of approx. 50–55% at the driver's positions, and that both drivers died instantly in the collision. The points of impact between the vehicles, in combination with the amount of energy involved in the collision (based on the weight and speed of the two vehicles, see section 2.3.2), meant that it was impossible for the two drivers to survive the situation. However, there was survival space for the passenger in the northbound vehicle. The passenger managed to evacuate the tractor unit after the collision, and sustained some physical injuries in the accident. By that time, a fire had broken out in the vehicle.

[31] Norwegian Safety Investigation Authority. (2018). The NSIA method: Framework and Analysis Process for Systematic Safety Investigations. ISBN 978-82-690725-3-2.

2.3 Assessment of interaction in the traffic system

2.3.1 The HGV driver's behaviour

Both tachographs were so damaged in the collision that it has been impossible to retrieve data from them. Consequently, the NSIA has not had any tachograph data available as a basis for documenting the speed of the two vehicles before and at the time of the accident. Nor did the vehicles leave marks on the roadway before the point of the collision that could be used to calculate their speed.

The NSIA downloaded other technical data from both the tractor unit and the semi-trailer of the southbound heavy goods vehicle for the purpose of collecting information about the vehicle's speed before and at the time of the accident, and then use this to form an impression of the driving behaviour. However, the downloaded data did not include speed data from 2 February (the day of the accident) – probably because the power supply was interrupted at the moment of impact.

Downloaded data included speed data for the semi-trailer for the days before the accident, but no GPS coordinates linked to the registered speeds. It has therefore been impossible to compare the chosen speed with the speed limit on the roads the heavy goods vehicle had driven. It has thus not been possible for the NSIA to use the speed data as a basis for assessing the driver's driving behaviour. However, the NSIA has noted that the semi-trailer has on several occasions registered a maximum speed in excess of the maximum permitted speed for road transport in Norway.[32]

The sequence of events shows that the driver of the triggering (southbound) heavy goods vehicle failed to sufficiently adjust the speed of the vehicle to match the road surface conditions before the accident occurred. However, the NSIA has not found any information to indicate that the southbound vehicle was travelling at high speed before the accident. The investigation has shown that there was very low road friction at the accident site, however, and the NSIA is of the opinion that the road surface conditions on the section of road in question were the immediate cause of the heavy goods vehicle losing its road grip there (see section 2.3.3).

Local ice formation on the road network is very challenging for all road users. It can be difficult to detect changes in road friction and areas of ‘clear ice’ in time. This requires particular attention to speed, and the risk of losing control and having an accident is high under such conditions.

2.3.2 Tyre equipment and handling characteristics

Both heavy goods vehicles were fitted with winter tyres at the time of the accident, and all tyres complied with the applicable regulations. The tyres of the southbound vehicle were all marked *M+S*, which is the minimum requirement for approved winter tyres in Norway. The tyres on the tractor unit were also marked with the Alpine symbol *3PMSF*,

[32] Section 13 fourth paragraph of the Regulations No 747 of 21 March 1986 relating to pedestrian and vehicle traffic (the Traffic Rules) reads as follows: *‘On stretches of road with a specified speed limit higher than 80 km/h, motor vehicles with a maximum authorised mass exceeding 3,500 kg or motor vehicles with a trailer must not be driven at speeds greater than 80 km/h.’*

which means that their pattern, material and structure have been developed especially for use under winter conditions.

None of the tyres on the southbound vehicle had studs or visible siping,[33] which is used to improve the tyres' properties in winter conditions. Siping has been proven to have a positive effect on the retardation and passability properties of winter tyres.[34] In the NSIA's view, the friction properties of the southbound vehicle's tyres were somewhat reduced due to the absence of siping. However, it is the NSIA's assessment that there is no basis for concluding that winter tyres with intact winter siping would have been sufficient to prevent the vehicle from losing its road grip on the extremely slippery road. Nor is siping of winter tyres a regulatory requirement.

Tyre equipment is of great importance to traffic safety and passability in winter road conditions. Using approved winter tyres will not always prove sufficient for the road surface conditions that may occur on the Norwegian road network during winter, however, even when the driver adjusts the speed to match the prevailing road surface conditions.

Technical examination of the southbound heavy goods vehicle found dry greaseless areas on approx. 30% of the coupling surface of the tractor unit's turntable (see section 1.7.2.2). Similar dry, greaseless areas were found on the upper coupler plate around the semi-trailer's king pin (see section 1.7.2.3).

Insufficient grease on both the turntable and the king pin may create resistance against changes in the angle between the tractor unit and the semi-trailer, which may have negatively affected the heavy goods vehicle's ability to turn when entering the curve before the point of the collision under the prevailing friction conditions (see section 2.3.3). However, it is impossible to ascertain to what extent this has affected the vehicle's manoeuvrability before the collision or how important it has been to the sequence of events in connection with this accident.

Nevertheless, it is the NSIA's opinion that technical aspects of the southbound vehicle (tyre equipment and the state of the turntable and king pin) contributed to lowering safety margins before the time of the accident.

2.3.3 Meteorology and road surface conditions

No friction measurements were carried out at the accident site, as the road friction changed from the time of the accident until the NPRA arrived. However, statements from several witnesses who were at the accident site before, during and after the accident indicate that the road friction at the accident site was very low. Witnesses described the roadway as *'extremely slippery'*, *'slippery as soap'* and *'hopeless to walk on'*.

The weather data and web camera images obtained from the weather station 'E6 Snåsa' show that precipitation in the area ceased between 08:00 and 09:00, and that the cloud cover cleared. At the same time, the road surface temperature fell below 0 °C, while the

[33] Cutting thin slits across the tread of tyres for the purpose of improving traction during steering and braking on slippery roads. The outer part of the tyre becomes softer and more flexible, and the contact surface increases.
[34] Directorate of Public Roads. (2019). Dekktester for tunge kjøretøy: Har seiping av dekk en effekt? NPRA reports, No 553.

air temperature remained above freezing and increased slightly as the morning progressed.

Although the weather data were obtained from a weather station some distance away from the accident site and must be interpreted with caution, the NSIA believes that the observations provide indications that conditions were favourable for cooling of the roadway caused by terrestrial radiation from the road surface. The NSIA believes that this cooling process explains the formation of ice by water freezing on the roadway, and thus also the low road friction at the accident site when the accident occurred.

The process of roadway cooling followed by ice formation, as described in section 1.9.5, can be rapid and local. There are several factors that influence this process, such as topography (road cuttings, vegetation, wind, water seepage etc.), type of asphalt pavement (microstructure), drainage conditions and traffic volume. In the NSIA's assessment, this could explain why witnesses driving behind the southbound heavy goods vehicle did not perceive the road as slippery before the accident site.

The contractor's salting, in the form of application of approx. 25 g/m^2 brine, took place at 04:30 at the accident site, and was intended as an anti-icing measure. However, footage from the weather station 'E6 Kvam' shows that slush formed on the roadway as the morning progressed, and that the salting therefore did not have the desirable preventive effect. The NSIA believes that precipitation may have diluted the brine so much that it had insufficient melting capacity to keep the road free of snow and ice in the hours leading up to the accident. The maintenance measure will be discussed in more detail in section 2.4.

2.3.4 Road geometry and road surface

The investigation has shown that the horizontal curve radius at the accident site varies through the right-hand curve and towards the point of the collision. There is also a relatively significant change in the horizontal curve radius at the beginning of the curve. The cross slope in the right-hand curve is also below the required minimum limit[35] over a distance of approx. 100 meters up to the point of the collision.

The investigation has also shown that the greatest non-conformity in the cross slope is found approx. 90 metres before the point where the collision occurred. Moreover, the investigation has shown that the longitudinal slope of the road varies between approx. -5% and -7% on the section up to the point of the collision. The resultant slope varies between approx. 6% and 9% on the section in question, well above the minimum requirement of 2% to ensure drainage.

It is the NSIA's view that the nonconformity in the cross slope of the road, in combination with a varying horizontal curve radius in the right-hand curve, is unfortunate. The combination of the curvature, cross slope and longitudinal slope of the section of road immediately before the point of the collision may have contributed to increasing the amount of friction needed to manoeuvre a vehicle safely through the curve.

[35] The minimum limit for cross slope is arrived at through calculations based on the cross slope requirements stipulated in Manual R610 – Standard for drift og vedlikehold av riksveger ('Standard for operation and maintenance of national roads') (pages 30–31). The calculations of the minimum and maximum cross slope limits take the horizontal curve radius values measured as their point of departure.

The NSIA cannot rule out the possibility that the resultant slope of the road may have contributed to draining salty liquid away from the roadway at the accident site in the time between the last salting and the time of the accident (see section 2.3.3).

The combination of nonconformity in the cross slope of the road and varying horizontal curve radius is fairly common on the Norwegian road network, but the NSIA is of the opinion that it is particularly important to take these conditions into consideration when assessing what maintenance measures are necessary in winter (see section 2.4).

The investigation has also shown that the accident site is on a section of road that is to be given priority in connection with winter maintenance, and that this priority is based on, among other things, the road geometry on the section of road in question (see section 1.13.5). The NSIA would therefore have expected the main contractor or contractor responsible for road maintenance to follow up the road surface conditions better after 06:00 and until the accident occurred at 10:42 – about five hours later. Follow-up of priority road sections of road is assessed in section 2.5.2.

The structure of the road determines the road's ability to store and conduct heat, and good heat storage will moderate the effect of heating and cooling of the road surface. Witness statements indicate that road friction at the accident site differed from that of adjacent sections of road. The NSIA believes that the local deviation in road friction can also be linked to the pavement on the section in question, as the main road at the accident site is paved with stone mastic asphalt, while the adjacent sections are paved with asphalt concrete.

Stone mastic asphalt has a surface that drains liquid off the roadway. International research[36] has shown that freezing of wet road sections happens sooner on porous pavements than on dense asphalt pavements (such as asphalt concrete). Moreover, compared with dense asphalt types, more salt must be applied on porous types of asphalt to maintain a given friction value.[23] However, the NSIA's view is that the asphalt types used on the road network are primarily chosen based on consideration for traffic load and wear, and that the link between the properties of different asphalt pavements and road friction in winter is not given weight in this context (see section 1.18.1).

All things considered, the NSIA finds that aspects of the road conditions at the accident site (horizontal curve radius, cross slope and longitudinal slope) contributed to lowering the safety margins before the accident occurred.

2.3.5 Summary

It is the NSIA’s assessment that low road friction at the accident site was the immediate cause of the southbound heavy goods vehicle losing its road grip and entering the opposite lane. However, the investigation has shown that the accident was a result of interaction between several elements of the traffic system (see Figure 27).

The NSIA believes developments in the weather and road surface conditions in the area, as well as the road geometry and asphalt surfacing at the accident site, contributed to the accident occurring where it did. The tyres on and the handling characteristics of the

[36] Danish Road Directorate (2012). Winter service of porous asphalt. European experience. Technical note 123.

southbound vehicle, combined with the driver’s choice of speed, also had a bearing on the sequence of events.

The identified contributory causes of the accident are illustrated in Figure 27.[37] The figure must not be considered exhaustive, but refers to the factors that the NSIA, in the course of its investigation, has found to have had a negative impact on the sequence of events.

[37] The investigation has not identified circumstances relating to the Polish HGV driver's driving, rest and working hours that the NSIA believes may have contributed to the accident (dotted line in Figure 27).

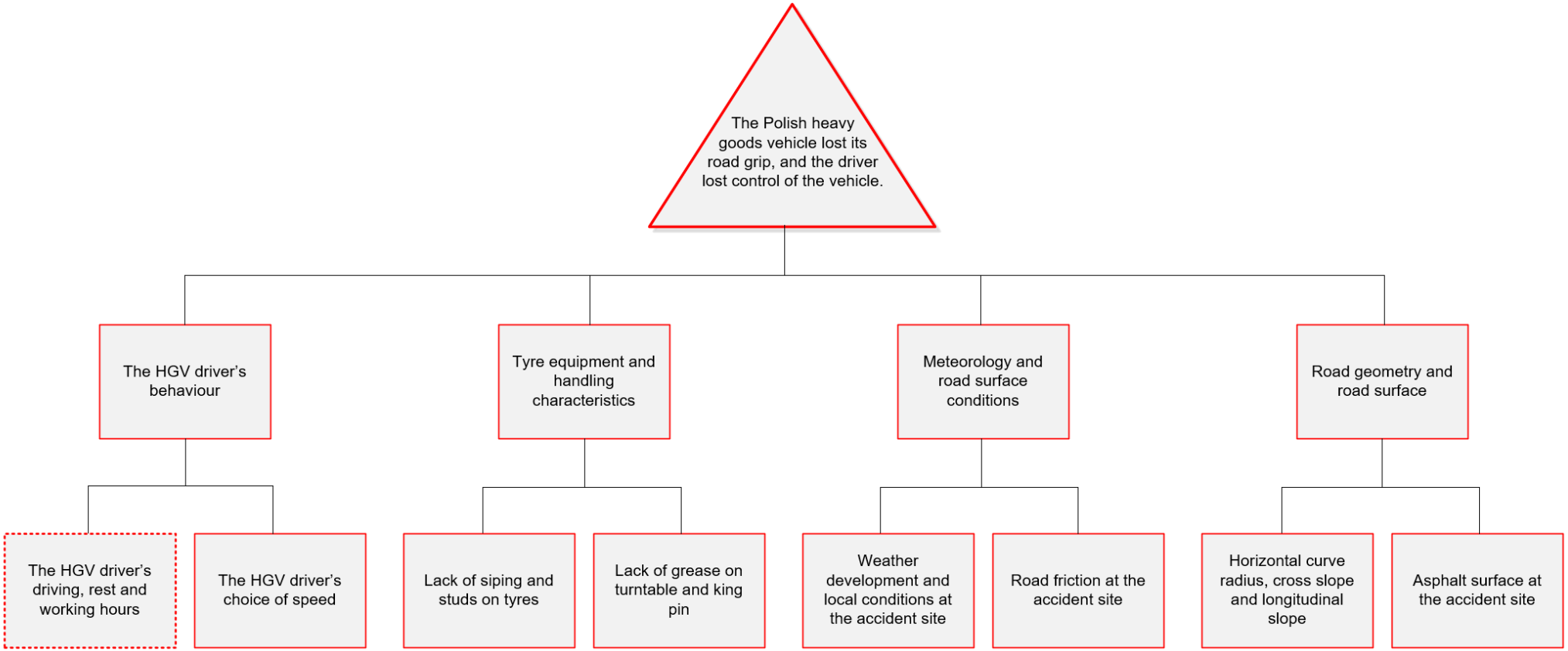

Figure 27: The safety problem that was the immediate cause of the collision between the heavy goods vehicles, and contributory factors to the accident. Illustration: NSIA

2.4 Assessment of the contractors' winter road maintenance

2.4.1 Introduction

The investigation has shown that road friction at the accident site was very low and differed from that of adjacent sections of road. In the NSIA's assessment, this was the immediate cause of the southbound heavy goods vehicle losing its grip on the road and entering the opposite lane (see section 2.3.5).

On this basis, the NSIA obtained further information and documentation from the contractors involved about maintenance measures carried out at the accident site before the accident. An initial review of the information compiled indicated shortcomings relating to the planning, execution and follow-up of the measures implemented before the accident.

The NSIA then requested further information from the contractors regarding systems and procedures established by the enterprises for winter maintenance operations. The NSIA then compared the information obtained with contractual requirements concerning winter maintenance.

The investigation identified several shortcomings relating to winter road maintenance. The relevant findings have been thematically considered, and the categories are presented in Figure 28.

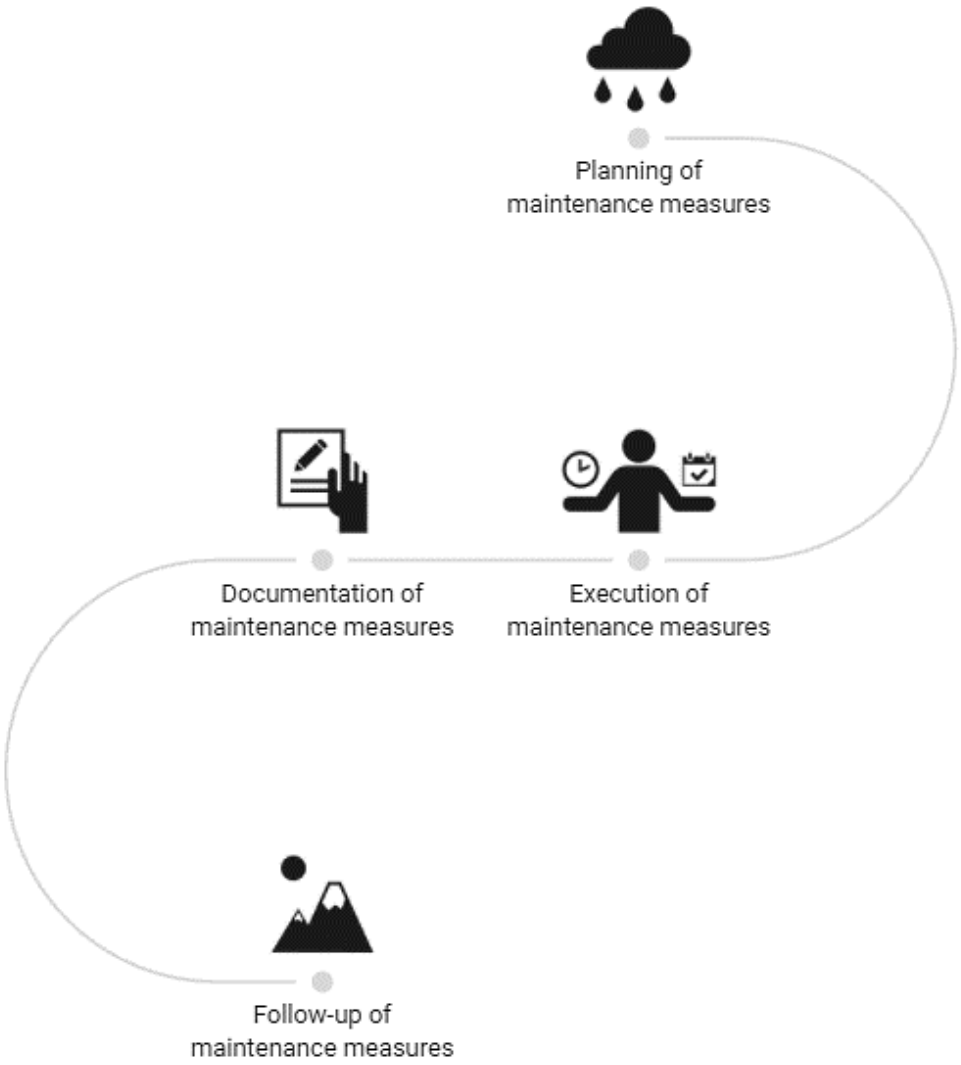

Figure 28: Thematic categorisation of investigation findings relating the contractor's winter road maintenance. Illustration: NSIA

The NSIA's detailed assessment of investigation findings relating to shortcomings in the winter road maintenance is presented below (see sections 2.4.2–2.4.5).

2.4.2 Planning of maintenance measures

2.4.2.1 *Obtaining and documenting weather data*

The main contractor has stated that weather forecasts were obtained from several different sources as a basis for making decisions about maintenance measures on the E6 road on 2 February 2020. Neither the contractor responsible for road maintenance nor the main contractor has been able to document the weather data obtained or the staff's assessment of the relevant weather forecasts, however. Consequently, the NSIA has been unable to verify that relevant weather data were obtained as a basis for making decisions about maintenance measures carried out before the accident occurred.

The NSIA is also of the opinion that the failure to document the weather data obtained makes it more difficult for the NPRA and the main contractor to quality-assure the winter maintenance. This also gives rise to challenges for the assessment of winter road maintenance performed (see section 2.6.1).

2.4.2.2 *Interpretation of weather forecasts*

The main contractor has not confirmed to the NSIA that the contractor responsible for road maintenance was aware that there was a possibility of precipitation on the road network after the final round of salting of the E6 road before the accident occurred. In this context, the NSIA questions the contractors' emphasis on expertise in monitoring and interpretation of weather forecasts.

In the NSIA's opinion, the accident shows that local ice formation on the road network makes for a challenging situation for the road users involved, but potentially also for contractors involved in winter maintenance when it comes to interpreting weather data correctly and choosing suitable salting measures for the prevailing conditions. However, the NSIA is of the opinion that the investigation findings show that, in this case, the contractor responsible for road maintenance did not take sufficient account of the available weather forecasts when choosing the measures (see section 2.4.3). In light of the above, the NSIA questions whether the theoretical training provided has given the contractor responsible for road maintenance a sufficient basis for interpreting weather data and choosing suitable salting measures.

2.4.2.3 *Summary*

The NPRA's Manual R610 describes how assessments underlying decisions regarding maintenance measures shall be carried out in accordance with the applicable quality system and other governing documentation for activities carried out on the road network, including winter maintenance (see section 1.15.2.3). In light of this, the NSIA finds that the contractors should have drawn up a procedure for documenting weather data that form part of the basis for making decisions about maintenance measures on the road network.

The NPRA has informed the NSIA that the contractors are certified to ISO 9001 (quality management systems standard) (see section 1.15.3), and that the enterprises should therefore have satisfactory quality management systems in place. The NSIA notes that the certification has nonetheless not contributed to important information such as weather data obtained, and employees' interpretation of weather forecasts being documented. In the NSIA's opinion, this important sub-process should be included in the quality management of enterprises that provide winter maintenance services.

2.4.3 Execution of maintenance measures

2.4.3.1 *Choice of salting measure*

The contractor responsible for road maintenance spread approx. 25 g/m^2 of brine on the E6 road on the morning of 2 February 2020, and the NSIA has been informed that the quantity of salt was in accordance with the value stated in the salt table that the contractors consult when choosing salting measures (see Figure 26). The quantity of brine corresponds to about 4 grams of pure salt per square metre. At the same time, the recorded weather development showed precipitation of as much as 4 mm/hour in the areas near Snåsa and Kvam during the period from the accident site was last salted until the time of the accident (see section 1.9.4). The NSIA is of the opinion that the contractor responsible for road maintenance chose the wrong salting measure on the day of the accident, seen in light of the weather forecast for the area.

The investigation has found that precipitation was forecast through the night and on the morning of 2 February. The weather stations at Kvam and Snåsa also registered precipitation during the period when the salting was taking place. In this context, the NSIA questions the choices made by the contractor responsible for road maintenance in terms of both method and dosage. According to the salting instructions, the measure chosen, 25 g/m^2 of brine, should not be used when precipitation (rain) is forecast, because of the risk that the brine may be diluted (see section 1.10). When there is a risk of freezing and precipitation, brine with a significantly higher salt content or another salting method shall be used.

The NSIA believes that the salting method and dosage chosen were not sufficient to prevent ice from forming at the accident site. The NSIA's assessment is that, based on the weather forecasts available, a salting method that is less vulnerable to precipitation and consequent dilution of the salt concentration should have been chosen, for example pre-wetted salt. The relevant salt table also refers to this salting method (see Figure 26).

In the NSIA's opinion, the contractor responsible for road maintenance chose to use brine based on what was considered standard practice (see section 1.11.2), not on the weather forecasts available. This is substantiated by information provided by the main contractor that the salting was done using the same method *'as usual'*.

The main contractor has informed the NSIA that the contractor responsible for road maintenance may only use brine for salting under the relevant operations contract. No further grounds have been given by the main contractor. However, the investigation has found no indications that the contractor responsible for road maintenance did not have the opportunity to use other methods than brine for salting.

2.4.3.2 *Choice of time for initiating salting*

It is crucial for optimal winter maintenance that salting takes place at the right time.[38] The investigation has shown that the accident site was last salted at 04:30 – more or less in the middle of a forecast period of precipitation. The investigation has also shown that the weather stations located closest to the accident site recorded a period of precipitation at 04:30, at the same time as brine was applied to the accident site. Any precipitation after the salting may therefore have reduced the amount of residual salt on the roadway.

In light of the above, the NSIA questions the basis for the contractor responsible for road maintenance's timing of the salting. Neither the main contractor nor the contractor responsible for road maintenance has been able to give grounds for why salting was initiated at that time.

2.4.3.3 *Summary*

Moisture on the roadway will have a bearing on the loss of salt, and brine is a salting method that is particularly susceptible to dilution by precipitation. The NSIA is of the opinion that the contractor responsible for road maintenance failed to take sufficient account of the precipitation forecast for the area in question. Both the choice of salting measure and the time at which the measure was initiated support this. Contractors engaged in winter maintenance must have good knowledge of salting in order to be able

[38] Norwegian Public Roads Administration. (2012). Opplæring i drift og vedlikehold for operatører: Vinterdrift. NPRA reports, No 131.

to choose the correct method and dosage for the relevant weather forecasts and prevailing weather conditions. In this context, too, the NSIA questions the contractor's expertise when it comes to interpreting the available weather data and considering suitable salting measures (see section 2.4.2).

The NSIA would also like to point out that it is important to follow up the effect of road salting in order to achieve effective winter maintenance and make road surface conditions as predictable as possible. Shortcomings relating to the contractor's follow-up of maintenance measures will be evaluated in section 2.4.5.

2.4.4 Documentation of maintenance measures

The investigation has identified a number of shortcomings in the contractors' documentation of implemented maintenance measures (see Figure 24). The relevant investigation findings are summarised below (see section 1.11.3):

- The contractor responsible for winter maintenance has on several occasions failed to describe the intention behind the maintenance measures implemented (for example *'salting'*). The NSIA is of the opinion that the applicable documentation should, as a minimum, specify the intention behind the salting, as the absence of such information can complicate quality assurance of the winter road maintenance.

- The contractor responsible for road maintenance has on several occasions referred to both *'weather event on road'* and *'forecast of potential weather event on road'* as a reason for implementing maintenance measures. However, no further description of the assumed weather events[39] or weather forecasts in question has been provided in the documentation. The NSIA is of the opinion that neither the main contractor nor the NPRA can quality-assure winter road maintenance in an adequate manner if weather forecasts and weather events that have been deemed to trigger a need for maintenance measures are not documented.

- The contractor responsible for road maintenance has in some cases specified both *'anti-icing'*, *'de-icing'* and '*anti-compaction'* as the purpose of maintenance measures implemented. At the same time, several different sections of road in different winter maintenance classes have been documented with the same salting measure. The NSIA also considers this problematic in terms of quality assurance of winter road maintenance. For example, salt is not to be used for the purpose of anti-compaction on sections of road assigned to winter maintenance class DkC (this includes the E6 road).[40]

- The contractor responsible for road maintenance has in a number of cases failed to describe which method has been used for salting. The NSIA considers the absence of this information an indication that the contractor does not have an adequate understanding of the importance of interpreting weather data in connection with the assessment of suitable salting measures (see sections 2.4.2 and 2.4.3). The NSIA sees no other explanation for why the contractor responsible for road maintenance has repeatedly failed to document which salting method was chosen.

[39] See section 1.11.1 for the definition of *'weather event'*.
[40] Norwegian Public Roads Administration. (2015). Opplæring i vinterdrift for operatører: Driftskontrakter med oppstart 2016. NPRA reports, No 369.

- The NSIA considers the absence of descriptions of the effect of salting to be the most serious shortcoming in the contractor responsible for road maintenance's documentation of maintenance measures implemented. The effect of salting may have been observed, but the investigation has shown that it has not been the contractor responsible for road maintenance's standard practice to document the result (effect) of salting, despite the main contractor's guidelines stating that this information should be recorded in the salt record (see Figure 24). The contractor's personnel have chosen to only sign the salt record, without stating the result of salting. This will be considered further in section 2.4.5.

- The operations contract stipulates a requirement for a salt record to be kept for each winter maintenance class. Figure 24 shows that this requirement has not been complied with.

Overall, the investigation shows that the contractors' documentation of winter road maintenance work (the salt record) is inadequate both in terms of descriptions of maintenance measures and descriptions of the result of the measures (see Figure 24).

The documentation of maintenance measures links the basis for the decision-making with the choice of measure and the result of the measure. In light of this, the NSIA considers that shortcomings in the contractors' documentation of winter road maintenance work also indicate shortcomings in the planning, implementation and follow-up of winter maintenance. It is the NSIA's opinion that several investigation findings support this assessment (see sections 2.4.2–2.4.5).

2.4.5 Follow-up of maintenance measures

2.4.5.1 *Follow-up of maintenance measures implemented before the accident*

The investigation has shown that conditions were favourable for freezing on the roadway before the time of the accident, with local precipitation followed by the cloud cover clearing and the road surface temperature falling due to terrestrial radiation.

However, the investigation has shown that the contractor responsible for road maintenance did not follow up the effect of the salting carried out at the accident site at 04:30, six hours before the accident. The main contractor observed the road surface conditions on the E6 road on the section Stamphusmyra–Vegset, which includes the accident site, at approx. 06:00 on the day of the accident (see section 1.11.4). The conditions on the section of road, which is about 90 km long in total, were reported as *'bare'*, *'wet'* and '*slush'*.

However, the NSIA considers that the main contractor's reporting says very little about the effect of the salting carried out. The reports also describe salting and snow clearance being initiated on the road network. The inspection report does not specify where on the E6 road maintenance measures were carried out, however. The investigation has shown that no further maintenance measures (snow clearance and/or sanding/salting) took place at the accident site around 06:00 on 2 February. The investigation has also shown that no spot checks or friction measurements were carried out on the roadway in the area in question before the time of the accident.

Web cameras are an important tool for contractors in their winter road maintenance, and active use of images from the road network can make significant contributions to

improving the decision-making basis for winter maintenance measures. The investigation has shown that the contractors did not use images from the road network to follow weather developments in the area in question and observe whether the salting had the intended preventive effect. Web camera images from Kvam and Snåsa showed slush in the roadway after salting and the cloud cover breaking up, respectively.

The use of brine as an anti-icing measure is vulnerable to precipitation because the melting capacity of the solution is reduced when the salt concentration is diluted.

The NSIA considers that, based on the weather development recorded, the contractors' follow-up was not sufficient to identify that the salting had not had the intended preventive effect, and that there was a risk of the roadway freezing.

2.4.5.2 *Systematic follow-up of winter maintenance*

In the NSIA's opinion, systematic monitoring and follow-up of maintenance measures implemented to ensure that the desired effect is achieved is crucial to achieving satisfactory road surface conditions and passability for road users. The NSIA is of the opinion that the salting implemented at the accident site on the morning of the day of the accident was not sufficiently followed up by the contractors, considering that there was precipitation in the form of rain in the contract area in question.

It is also the NSIA's opinion that the inadequate follow-up of the measure can be explained by shortcomings in the main contractor's systems for follow-up and quality assurance of winter road maintenance performed by the contractor responsible for road maintenance. In this context, the investigation has identified shortcomings relating to the contractors' systematic follow-up of winter maintenance. Relevant investigation findings are summarised below (see Table 2):

- The operations contract describes how the road type, traffic volume and season shall form part of the basis for assessing the need for control of the road network. The main contractor's inspection plan stipulates weekly inspections of the E6 road, but the inspection frequency does not vary depending on the season. The NSIA has also noted that the purpose of inspections of the road network is not described (e.g. ‘quality assurance of winter maintenance’).

- The main contractor's inspection plan states that internal control of the subcontractor (contractor responsible for road maintenance) shall be carried out by checking the quality of the winter road maintenance through spot checks of road friction. The main contractor has not forwarded documentation to show that road friction spot checks were carried out on the E6 road in the winter season 2019/2020 for the purpose of internal control of the contractor responsible for road maintenance's winter road maintenance. The main contractor has stated that road surface conditions on the E6 road are assessed through visual observation and simple braking tests. The NSIA questions whether this constitutes a sufficient basis for systematic follow-up and quality assurance of the contractor responsible for road maintenance's winter road maintenance.

- The inspection plan does not state how often spot checks of road friction are to take place. In this context, the main contractor has stated that there are no requirements in place concerning the frequency of spot checks. In the NSIA's opinion, the main

contractor misses out on important data by not utilising the value frequent road friction spot checks can add to winter maintenance.

- The operations contract sets out requirements for additional inspections of the road network in case of challenging weather conditions or suspected nonconformities in the maintenance work. The main contractor has stated that, generally speaking, no additional inspections are carried out of the road network outside of routine inspections, but that assessments are made on a continuous basis *'if extreme weather conditions or similar are forecast'* (see section 1.11.4). The NSIA considers this a sign that the contractors have chosen to put only a minimum of effort into their follow-up of winter maintenance.

- No documentation has been presented to the NSIA to show that the contractors had established a system before the accident for following up and evaluating the results of maintenance measures as required by the operations contract. The main contractor has made reference to the salt record in this context, but the investigation has shown a consistent failure to document the results of salting in the records (see section 2.4.4). The main contractor has also referred to the fact that the enterprise has systems in place to identify any errors in spreader quantities and that safe job analyses are carried out before the start of each winter season. The NSIA would like to emphasise that this does not constitute systems for following up and evaluating the results (effect) of salting.

- The NSIA has not been presented with documentation showing that the contractors have presented evaluations of the results of salting at construction meetings during the winter season 2019/2020 as required by the operations contract. In this context, the main contractor has stated that the salt records are submitted to the NPRA and that salting is discussed at construction meetings. The NSIA would like to emphasise that this does not demonstrate that the contractors have actively evaluated and presented the results (effect) of salting.

- The main contractor has not measured friction on the E6 road in order to monitor road surface conditions and make active use of measurements for decision support in connection with winter maintenance during the winter season 2019/2020 as required by the operations contract. Nor has the main contractor reported friction measurements from the E6 road every two weeks during the winter season 2019/2020 as required by the operations contract.

  In this context, the main contractor has stated that friction measurements are not performed on the E6 road in order to monitor road surface conditions during winter, as this is neither required nor considered expedient on bare roads. The NSIA emphasises that the operations contract requires the contractor to measure friction during the winter season precisely in order to monitor road surface conditions and make active use of the measurements for decision support in connection with winter maintenance.

  The NSIA believes that friction measurements at the accident site could have revealed that the salting had not had the desired preventive effect. The NSIA also points out that witnesses to the accident have stated that, at the time of the accident, the roadway at the accident site appeared bare, but was in fact covered in ice.

- The NSIA has not been presented with documentation showing that the contractors had established a plan for measuring road friction on the E6 road during the winter season 2019/2020 as required by the operations contract.

  The main contractor has stated that the E6 road is maintained as a bare pavement road by means of salt when the road is free of snow/ice and/or the road surface temperature is above over -3 °C. If the road surface temperature is below -3 °C and/or the roadway is covered in snow and/or ice, the road is maintained as a winter road by means of sanding. The main contractor has also stated that several sections of road assigned to winter maintenance class 'DkC' are largely maintained as bare pavement roads due to the mild climate.

  This approach to winter maintenance is vulnerable because it can be difficult for road users to visually identify any nonconformities in road friction. The NSIA is of the opinion that this gives rise to a greater need for friction measurements.

2.4.5.3 *Summary*

The NSIA is of the opinion that the inspection frequency on the E6 road should be increased during the 'winter preparedness period' (see section 1.13.4) on grounds of both road type, traffic volume and season. However, the main contractor's inspection plan does not show whether these factors have formed part of the assessment basis when the inspection frequency for the E6 road was decided. The E6 road is the longest road in Norway, and it is a heavy traffic route of varying standard. The NSIA therefore considers it natural that this road should be inspected more frequently during the winter season.

In the NSIA's opinion, active follow-up and evaluation of the result (effect) of salting are crucial to ensure good winter maintenance and make the road surface conditions as predictable as possible. Moreover, systematic evaluation of the result of salting will encourage learning and improvement of the winter road maintenance. Contractors should therefore make active use of friction measurements and road friction spot checks, in addition to other general inspections of the road network, in their winter road maintenance. This will help to provide a basis for winter maintenance that provides a road system with high levels of safety and regularity for road users.

The NSIA finds that the investigation findings show that the contractors' follow-up of winter maintenance has not been targeted, systematic or in line with the principles of learning and continuous improvement. The findings also show that the contractors have failed to fulfil several of the contractual requirements relating to winter maintenance. In light of this, the NSIA considers that the NPRA's follow-up of the winter road maintenance has also been inadequate (see section 2.5).

2.5 Assessment of the Norwegian Public Roads Administration's follow-up of winter road maintenance

2.5.1 Introduction

The investigation has identified shortcomings relating to the winter road maintenance carried out before the accident as well as to the contractors' general planning, implementation, documentation and follow-up of maintenance measures. In this context, the investigation has also identified shortcomings relating to the NPRA's follow-up of the winter road maintenance.

The following sections present the NSIA's assessments of the investigation's findings relating to follow-up of priority sections of road and special incidents on the road network (see sections 2.5.2 and 2.5.3). The NSIA has chosen to emphasise these two topics in this analysis, as it is considered that the accident in question and findings made in the course of the investigation show that they are factors in the operations contract that the NPRA should give particular priority to in its follow-up of the winter road maintenance. In this context, findings also indicate shortcomings in the contractors' compliance with contractual requirements.

Based on findings made in the course of the investigation, the NSIA has also chosen to present assessments relating to the NPRA's quality assurance of winter road maintenance and the cooperation between the NPRA, the traffic control centres (VTS) and the contractors (see sections 2.5.4 and 2.5.5).

Investigation findings relating to the NPRA's follow-up of the winter road maintenance have also been thematically considered, and the categories are presented in Figure 29.

The NSIA believes that the investigation findings can also offer lessons on winter maintenance that are of relevance beyond the accident in question, and the analysis must be read in light of this view.

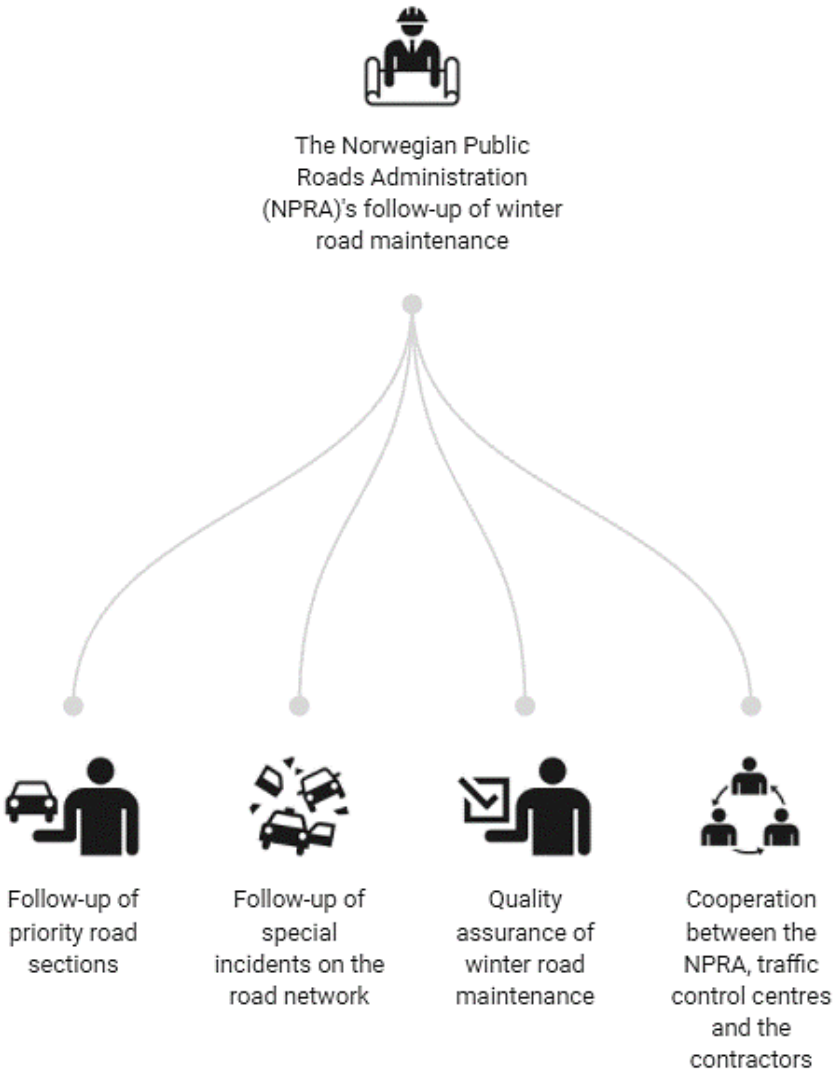

Figure 29: Thematic categorisation of investigation findings relating the NPRA's follow-up of the winter road maintenance. Illustration: NSIA

Accreditation[41] of contractors is discussed in the final part of section 2.5.6.

2.5.2 Follow-up of priority road sections

According to the main contractor, the section of road where the accident occurred is not considered a high-risk location in terms of winter maintenance (see section 1.11.1). The NSIA questions the contractor's assessment in this context, particularly in light of the fact that the accident site is located on a section of road described in the operations contract as a section that is known to be slippery and require extra attention in connection with winter maintenance.

The investigation found that the accident occurred on a section of road described in the operations contract as a 'priority road section' as regards winter maintenance. However, neither of the contractors involved had drawn up any procedures for following up road surface conditions on this section of road (see section 1.11.4).

[41] Accreditation is an official recognition by an internationally recognised accreditation body of an organisation's expertise and ability to perform certain activities in accordance with requirements specified.

In this context, the NPRA referred to the requirement stipulated in the operations contract for a quality system to be established, including that the contractors' quality plan must cover all maintenance operations. The NPRA also refers to ISO-9001 and the fact that the contractors are responsible for basing their planning, execution and follow-up of the contractual performance on relevant information. The NPRA also refers to the fact that this responsibility is heightened when the operations contract explicitly states that a section of road is known to be slippery and require extra attention in connection with winter maintenance.

In the NSIA's opinion, an expectation gap exists between the NPRA and the contractors when it comes to the requirements set out in the operations contract and the preparation of procedures for following up road surface conditions on priority road sections. In light of this, the NPRA finds that the contractors' preparation of procedures for following up road surface conditions on priority road sections has not been adequately followed up or quality assured by the NPRA.

The investigation has also shown that the section of road where the accident occurred has been deemed to be a winter maintenance priority due to its road geometry. The NSIA considers that investigation findings at the accident site also indicate a need for enhanced follow-up of road surface conditions on this section of road in winter.

The NSIA submits one safety recommendation on this point.

2.5.3 Follow-up of special incidents on the road network

2.5.3.1 *Record of special incidents on the road network*

The investigation has shown that the contractors have kept a record of special incidents[42] on the road network as required by the operations contract (see Table 2). However, the investigation has found the information recorded about measures implemented to be inadequate.

The operations contract stipulates that the contractors' record of special incidents on the road network shall contain information about measures implemented in connection with special incidents on the road network. In connection with this, the investigation has shown that the record kept by the contractors involved provide very limited information about the measures implemented. For example, the only information entered by the contractors regarding measures in connection with the road traffic accident that occurred on the E6 road on 2 February 2020, in which two people died, was *'for information purposes'*.

The NSIA considers the contractors' record of special incidents on the road network inadequate to fulfil the contractual requirement. The investigation has also shown that the NPRA has failed to follow up the contractors' record-keeping of special incidents on the road network in a satisfactory manner. The NPRA has also referred to the VTS log as documentation of the contractors' record of special incidents on the road network. The

[42] Incidents that have consequences for the state of the road network, result in measures being implemented that differ from ordinary measures implemented in the course of the contractual work or that there is reason to believe may give rise to subsequent follow-up questions.

NSIA is of the opinion that this shows that the NPRA's follow-up of contractual requirement has been inadequate (see section 2.5.4).

The NSIA submits one safety recommendation on this point.

2.5.3.2 *Systematic follow-up and evaluation of special incidents on the road network*

The operations contract also requires the contractors' record of special incidents on the road network to include communications from both the NPRA and road users. In this context, the NSIA is of the opinion that any reports of difficult driving conditions on the road network that have been forwarded to the traffic control centres by road users should also be recorded (see section 2.5.5). Any maintenance measures implemented on the road network prior to a special incident, including road traffic accidents, or, alternatively, grounds for why the contractors did not implement maintenance measures, should also be recorded.

In the NSIA's opinion, these factors should form the basis for a systematic assessment of the winter road maintenance carried out prior to road traffic accidents that occurred in winter. In this context, the NSIA questions the purpose of the contractors' record-keeping of special incidents on the road network. The record does not show that whether the NPRA or the contractors have reviewed and evaluated the result of maintenance measures implemented on the road network prior to road traffic accidents. Nor has the investigation found any indications that the contractors have used the record as a basis for systematic follow-up and evaluation of special incidents, including road traffic accidents, that occur during the winter months.

The NSIA is of the opinion that neither the NPRA nor the contractors involved have attached sufficient importance to follow-up and evaluation of special incidents, including road traffic accidents, that occur on the road network during the winter months (see section 2.6.1).

An evaluation is a systematic assessment of whether the goals and requirements pertaining to an activity, for example winter road maintenance, have been met. Evaluations are conducted to contribute to learning and help to identify needs for improvement and organisational changes (see section 2.6.2). In this context, the NSIA expects the NPRA, which is both the client and the road owner, in addition to being an important party to the traffic safety work, to take the initiative to evaluate winter road maintenance in light of road traffic accidents that occur on the road network. This includes follow-up of contractual requirements relating to special incidents on the road network.

At the same time, the NSIA also expects the main contractor, which is one of the biggest contracting companies and winter maintenance service providers in Scandinavia, to take the initiative to carry out internal evaluations of winter road maintenance in light of road traffic accidents that occur on the road network in winter. In the NSIA's opinion, these evaluations should make up an important part of the main contractor's systematic safety work, particularly in light of the goal of winter maintenance on the road network as described in Manual R610 (see section 2.6.1).

The NSIA submits one safety recommendation on this point.

2.5.4 Quality assurance of winter road maintenance

The NPRA carried out two friction measurements on the E6 road in January 2020 (see section 1.12.2). In the NSIA's opinion, only two friction measurements per month in the defined winter preparedness period (see section 1.13.4) is not sufficient to provide a basis for a systematic assessment of whether the maintenance measures implemented have had the intended effect, depending on the weather and road surface conditions during the period in question. The NSIA is also of the opinion that the investigation shows that friction measurements and spot checks of the roadway are not sufficient to achieve systematic follow-up and quality assurance of winter road maintenance.

As road owner and client, the NPRA has defined the framework conditions for winter maintenance with pertaining financial and technical resources. The NSIA is of the opinion that the NPRA's quality assurance of the winter road maintenance should primarily take the form of systematic follow-up of contractual requirements relating to winter maintenance, in addition to friction measurements and spot checks on the road network.

What the investigation has shown, on the other hand, is that, other than construction meetings, spot checks and friction measurements, no other systematic activities have been established under the auspices of the NPRA to follow up contractual requirements relating to winter road maintenance (see section 1.12.3). In the NSIA's opinion, findings made in the course of the investigation show that these measures are not sufficient to address the NPRA's follow-up of contractual requirements relating to winter road maintenance.

In this context, the investigation has shown that the contractors involved have failed to fulfil contractual requirements relating to systematic control of the road network, documentation of work performed and documentation of winter friction level (see Table 2, sections 2.4.4 and 2.4.5). Contractual requirements relating to the content of the contractors ‘winter plan’ and ‘record of special incidents on the road network’ have also not been complied with (section 2.5.3).

The present investigation as well as previous investigations of road traffic accidents that have occurred in winter show that the NPRA's follow-up of contractual requirements relating to winter road maintenance has been inadequate and should be given higher priority. In light of the above, the NSIA considers that the NPRA should enhance its quality assurance procedures[43] by ensuring better communication, traceability and management in the process of following up contractual requirements relating to winter maintenance.

The NSIA submits one safety recommendation on this point.

2.5.5 Cooperation between the NPRA, traffic control centres and the contractors

The main contractor's winter plan contains a procedure for the mobilisation of personnel that states that the contractor responsible for road maintenance's duty personnel shall at

[43] A quality assurance procedure is a procedure that describes how an enterprise is to ensure that responsibilities, duties and tasks are attended to and regulations complied with in connection with an activity (for example ‘winter maintenance’).

all times keep up to date on reports of road surface conditions via the traffic control centres or the general public (see Table 2).

It is specified in the VTS log that the Traffic Control Centre (VTS) did not receive any reports of slippery road conditions on the E6 road in the area where the accident occurred, neither in the hours leading up to nor after the accident. However, the investigation has shown that VTS received five reports of slippery road conditions on sections of road in the same winter maintenance contract area as the accident site on 2 February 2020. Three of these reports were received before the time of the accident. VTS did not forward any of them to the NPRA, the main contractor or the contractor responsible for road maintenance.

The investigation has shown that none of the reports concerned road surface conditions on the section of road where the accident occurred, but they did concern sections in the same winter maintenance contract area as the accident site. VTS has stated that the reports did not concern the accident site, but has given no further grounds for not forwarding them. In this context, the NSIA questions the centre's judgement in deciding not to forward the reports of slippery conditions on the road network, particularly in light of the main contractor's procedure stipulating that the contractor responsible for road maintenance shall at all times be up to date on reports on road surface conditions received by VTS.

The NSIA believes that these circumstances indicate that there is room for improvement in the cooperation between VTS and the parties involved in the planning, execution and follow-up of maintenance measures and road surface conditions on the road network.

The NSIA considers that the NPRA must ensure that more account is taken of reports from road users concerning road surface conditions on the road network during winter. Road users should also be able to expect the NPRA to systematically address reports concerning road surface conditions. The NSIA considers that the NPRA should establish guidelines to provide a better basis for effective cooperation between the NPRA, VTS and contractors involved in winter road maintenance. Such guidelines should also be suited to form an important basis for systematic follow-up of reports concerning road surface conditions.

The NSIA submits one safety recommendation on this point.

2.5.6 Accreditation of contractors

The NPRA does not require contracting companies engaged to carry out winter maintenance on the road network to be accredited (see section 1.15.3).

In connection with the investigation into a multiple vehicle collision on the E16 road in Lærdal in 2018 (AIBN Report Road 2019/02[44]), the investigation authority submitted a safety recommendation to the NPRA regarding the establishment of third-party inspections (accreditation) as a measure to raise the quality of winter road maintenance (see section 1.18.2.1). The NSIA considers technical expertise to be vital to winter road

[44] Accident Investigation Board Norway (2019). Report on multiple vehicle collision on the E16 road in Lærdalen valley in Lærdal on 6 April 2018. AIBN Report Road 2019/02.

maintenance and believes that accreditation of contractors could be a way of improving road safety.

At the time of publication of the present report, the above-mentioned safety recommendation had not been closed by the NPRA, whose reply was that the recommendation will be considered in the course of its work on a new contract strategy for maintenance of national roads. The NSIA also considers this safety recommendation to be of relevance to the present road traffic accident investigation.

2.6 Improvement of winter road maintenance

2.6.1 Evaluation of winter road maintenance

Manual R610 describes the goal of winter operation and maintenance of the road network as being to limit the number of injuries and fatalities as well as material damage. Operation and maintenance should ensure safe traffic management under winter conditions for all road users and be carried out in a way that does not cause road traffic accidents (see section 1.15.2.2).

However, the investigation findings indicate a need to improve the quality of the contractors' and the NPRA's winter road maintenance. Road traffic accidents are often caused by a number of factors that interact with each other, but the NSIA has in several investigations pointed out that low road friction has contributed to drivers losing control of their vehicles, even when travelling at moderate speeds and complying with legal tyre requirements.

The VTS log and statements show that, after the accident, the NPRA believed that the road at the accident site was not slippery. However, witness statements from the road users involved, as well as from witnesses and emergency service responders who were present at the accident site, substantiate that the roadway on the E6 road was covered in ice and very slippery at the time of the accident. Based on information obtained in the course of the investigation, the NSIA sees no reason to doubt that road friction at the accident site was low at the time of the accident.

The NPRA has informed the NSIA that its assessment of the road surface conditions at the accident site was based on information received from the contractors involved. The NSIA attaches less importance to this information, as neither the contractor responsible for road maintenance nor the main contractor was present at the accident site shortly before or after the accident. The NSIA is of the opinion that the NPRA should have endeavoured to obtain reliable information about the road surface conditions at the accident site as soon as possible after the accident for the purpose of evaluating and learning from the winter road maintenance work carried out before the accident (see section 2.6.2).

The NSIA deems the low road friction at the accident site to have been the immediate cause of the collision between the two heavy goods vehicles, and the NSIA therefore finds that the NPRA's assessment and communication of the friction conditions at the accident site after the accident was incorrect. In the NSIA's opinion, it is important that the NPRA do more to obtain factual information about road surface conditions in light of road traffic accidents that occur in winter as a basis for improvement and evaluation of winter road maintenance.

In light of the above, the NSIA considers that the NPRA, as the agency with overall responsibility for winter maintenance, should prepare guidelines for an overall evaluation of winter road maintenance (see section 2.6.2).

2.6.2 Learning from winter road maintenance

The NSIA considers winter maintenance of the road network an essential contribution to traffic safety work. However, as the NSIA has pointed out, both in the present and previous investigations into road traffic accidents that have occurred in winter, that the quality of the contractors' planning, execution, documentation and follow-up of maintenance measures has been inadequate.[45] The NSIA has also found that the NPRA has not done enough to follow up and quality-assure the contractors' winter road maintenance.[46]

The NPRA and the contractors that perform winter road maintenance services seem to have a potential for improvement when it comes to cooperating and sharing experience across regions, and establishing systems that can improve winter road maintenance both at the regional and national level.

In the NSIA's opinion, the NPRA should prioritise increasing its contribution to traffic safety by establishing or further developing a management system[47] that can facilitate organisational safety learning both at the regional and national level through the preparation and follow-up of contractual requirements relating to winter maintenance. The NSIA considers this particularly relevant in light of the regional government reform, whereby responsibility for the administration of county roads was transferred from the NPRA to the county authorities.

In this context, the NSIA would like to see national guidelines for evaluating winter road maintenance in light of serious incidents and road traffic accidents that occur on the road network (see section 2.6.1). In the NSIA's view, such guidelines can form the basis for a systematic review of serious incidents and road traffic accidents that occur in winter, as well as make a positive contribution to necessary organisational learning.

The NSIA submits one safety recommendation on this point.

[45] AIBN Report Road 2019/02, AIBN Report Road 2017/06 and AIBN Report Road 2015/01.
[46] Accident Investigation Board Norway (2019). Report on multiple vehicle collision on the E16 road in Lærdalen valley in Lærdal on 6 April 2018. Report Road 2019/02.
[47] A management system covers the activities, systems and processes used to plan, execute, evaluate and correct operations so that they comply with stipulated requirements.

3. CONCLUSION

3.1 Main conclusion

The accident occurred when the driver of a Polish heavy goods vehicle heading south on the E6 road lost control of the vehicle, which then entered the opposite lane. The vehicle collided head-on with a Norwegian heavy goods vehicle travelling north. Both drivers were killed instantly in the collision.

The road friction at the accident site was very low, even in comparison with adjacent road sections. Developments in the weather and road surface conditions in the area, as well as the road geometry and asphalt pavement at the accident site, contributed to the accident occurring where it did. The tyres on and the handling characteristics of the southbound vehicle, combined with the driver's choice of speed, also had a bearing on the sequence of events.

The investigation has uncovered several shortcomings in the contractor's winter road maintenance, as well as in the NPRA's follow-up and quality assurance of the winter road maintenance.

3.2 Investigation findings

3.2.1 Sequence of events and survival aspects

a) The driver of the southbound vehicle lost control and the vehicle entered the opposite lane, where it collided with the northbound vehicle.

b) Both drivers were killed instantly in the collision.

c) A passenger in the northbound heavy goods vehicle managed to evacuate the vehicle after the collision.

d) The fire that broke out in the Norwegian tractor unit had no bearing on the extent of personal injury caused by the accident.

e) The driver of the southbound heavy goods vehicle failed to sufficiently adjust his speed to match the road surface conditions before the accident occurred.

3.2.2 Vehicles

a) Both tachographs were so damaged in the collision that it was impossible to download speed data from the vehicles involved.

b) The southbound vehicle was fitted with studless winter tyres, and there was no visible siping on the tires.

c) The northbound vehicle was fitted with both studded and studless winter tyres, and the tyres on the semi-trailer had visible siping.

d) Both the turntable and the king pin of the southbound heavy goods vehicle had dry areas without grease.

3.2.3 Weather and road surface conditions

a) The road was very slippery at the accident site when the accident occurred. The road friction at the accident site was very low, even in comparison with adjacent road sections.

b) Precipitation had been forecast for the early hours and morning of 2 February.

c) The contractor responsible for road maintenance chose to apply approx. 25 g/m^2 of brine as a preventive measure at the accident site in the morning of 2 February.

d) The measure was carried out at the accident site at 04:30 – more or less in the middle of a forecast period of precipitation.

e) The contractor responsible for road maintenance did not follow up the result (effect) of the salting at the accident site during the six hours leading up to the accident.

f) The main contractor's last general inspection of the road network before the accident occurred took place at approx. 06:00 on 2 February. No salting, spot checks or friction measurements of the road surface were carried out at the accident site.

g) Web camera images from the weather station 'E6 Snåsa' show that the cloud cover cleared up from approx. 08:40 on 2 February.

h) Web camera images from the weather station 'E6 Kvam' show small amounts of ice and/or snow in the roadway from approx. 07:30 in the morning of 2 February.

i) The quantity of salt remaining on the roadway was not enough to prevent freezing or ice formation at the accident site in the morning of 2 February.

3.2.4 Road conditions

a) Viewed in the southbound vehicle's direction of travel, the horizontal curvature at the accident site forms an approx. 230-metre-long right-hand curve. The accident occurred just under 30 metres past the middle of this curve.

b) The measurement data registered show that the horizontal curve radius varies through the right-hand curve and towards the site of the collision, and that the cross slope of the curve is consistently below the minimum requirement.

c) The resultant slope varies between approx. 6% and 9% on the section in question, and exceeds the minimum requirement of 2% to ensure drainage throughout the right-hand curve.

d) The road at the accident site is paved with stone mastic asphalt.

3.3 Winter road maintenance

3.3.1 Systematic control of the road network

a) The main contractor's inspection plan does state that the road type, traffic volume and/or season have been part of the basis for decision-making when assessing the inspection frequency on the road network as required by the operations contract.

b) It has not been standard practice for the main contractor to conduct additional inspections of the road network in cases of challenging weather conditions or suspected nonconformities in the maintenance work as required by the operations contract.

c) The main contractor's inspection plan states that internal control of the contractor responsible for road maintenance shall take place in the form of spot checks of road friction. The main contractor has not forwarded documentation to the NSIA to show that such spot checks were carried out on the E6 road in the winter season 2019/2020 for the purpose of internal control of the contractor responsible for road maintenance's winter road maintenance.

3.3.2 Documentation of work performed

a) The contractors have failed to keep salt records that satisfy the minimum requirements stipulated in the operations contract when it comes to documenting the assessments and decisions that formed the basis for salting.

b) The contractors have not kept separate salt records for each winter maintenance class as required by the operations contract.

c) The NPRA and the main contractor have not documented that the contractors have had a documented system in place for following up and evaluating the result of maintenance measures as required by the operations contract.

d) The NPRA and the main contractor have not documented that the contractors have presented an evaluation of salting implemented in the winter season 2019/2020 as required by the operations contract.

3.3.3 Documentation of winter friction level

a) The main contractor has not measured friction on the E6 road in order to monitor road surface conditions and make active use of measurements for decision support in connection with winter maintenance during the winter season 2019/2020 as required by the operations contract.

b) The NPRA and the main contractor have not presented documentation showing that the contractors had established a plan for measuring road friction on the E6 road during the winter season 2019/2020 as required by the operations contract.

c) The main contractor has not reported friction measurements from the E6 road every two weeks during the winter season 2019/2020 as required by the operations contract.

3.3.4 Winter plan

a) The accident site is located on a section of road described in the operations contract as known to be slippery and require extra attention. The main contractor's winter plan does not describe any procedures relating to follow-up of road surface conditions on priority road sections in winter.

b) The main contractor's winter plan contains no descriptions of special circumstances.

c) The main contractor's winter plan contains a procedure that states that the contractor responsible for road maintenance shall at all times be up to date on reports of road surface conditions received via VTS. Three reports of challenging road surface conditions on sections of road in the same winter maintenance contract area as the accident site were received prior to the accident. VTS did not forward them to the NPRA, the main contractor or the contractor responsible for road maintenance.

3.3.5 Special incidents on the road network

a) The contractors have kept a record of special incidents on the road network as required by the operations contract. The operations contract requires the contractors' record to include information about measures implemented in connection with special incidents on the road network. In connection with the accident in question, the main contractor has only noted *'for information purposes'* under measures in the record.

b) Neither the NPRA nor the contractors have performed a systematic assessment and evaluation of the winter road maintenance work carried out on the E6 road prior to the accident.

4. SAFETY RECOMMENDATIONS

The investigation of this accident has identified several areas in which the NSIA deems it necessary to submit safety recommendations for the purpose of improving road safety.[48]

Safety recommendation ROAD No 2021/02T

The investigation of the head-on collision on the E6 road by Hammer in Snåsa on 2 February 2020 has found that the accident occurred on a section of road described in the operations contract as a 'priority road section' for winter road maintenance. The contractors had nonetheless not documented any procedures for following up the road surface conditions on the section. The investigation has shown that the contractors' preparation of procedures for following up road surface conditions on priority sections has not been followed up or quality assured by the Norwegian Public Roads Administration.

The Norwegian Safety Investigation Authority recommends that the Norwegian Public Roads Administration, through operations contracts, ensure that contractors follow up road surface conditions on priority road sections in winter, and establish internal procedures for ensuring followup of this contractual requirement.

Safety recommendation ROAD No 2021/03T

The investigation of the head-on collision on the E6 road by Hammer in Snåsa on 2 February 2020 has shown that the contractors have kept a record of special incidents on the road network in accordance with requirements in the operations contract. The investigation has shown that the records contain insufficient information about what measures have been implemented in connection with the incidents. In connection with the accident, the main contractor has only noted 'FYI' as a measure in the records. The Norwegian Safety Investigation Authority considers that the contractors' record of special incidents on the road network constitutes insufficient documentation under the contractual requirement.

The Norwegian Safety Investigation Authority recommends that the Norwegian Public Roads Administration establish internal procedures for ensuring follow-up of contractual requirements relating to records of special incidents on the road network, and for ensuring that special incidents on the road network constitute a special follow-up point in connection with winter road maintenance.

[48] The investigation report is submitted to the Ministry of Transport, which will take necessary measures to ensure that due consideration is given to the safety recommendations, cf. the Regulations of 30 June 2005 on Public Investigation and Notification of Traffic Accidents etc. Section 14.

Safety recommendation ROAD No 2021/04T

The investigation of the head-on collision on the E6 road by Hammer in Snåsa on 2 February 2020 has shown that the contractors have kept a record of special incidents on the road network in accordance with requirements in the operations contract. The investigation has shown that the records contain insufficient information about what measures have been implemented in connection with the incidents. In connection with the accident, the main contractor has only noted *'FYI'* as a measure in the records. The Norwegian Safety Investigation Authority considers that the main contractor should carry out internal evaluations of winter road maintenance in light of road traffic accidents that occur on the road network during winter.

The Norwegian Safety Investigation Authority recommends that Veidekke Industri AS carry out measures in its own organisation that ensure evaluation and learning from winter road maintenance in light of serious incidents and road traffic accidents that occur during winter in the area covered by the contract.

Safety recommendation ROAD No 2021/05T

The investigation of the head-on collision on the E6 road near Hammer in Snåsa on 2 February 2020 has revealed that the contractors have not fulfilled contractual requirements relating to systematic control of the road network, documentation of work performed and of the winter friction level, as well as the contents of the contractors' 'winter plan' and 'record of special incidents on the road network'. The investigation has shown that, over and above construction meetings, and possible spot checks and friction measurements, the Norwegian Public Roads Administration has not established any other systematic activities for the purpose of following up contractual winter maintenance requirements.

The Norwegian Safety Investigation Authority recommends that the Norwegian Public Roads Administration review and enhance internal quality assurance procedures to ensure adequate follow-up of contractual winter maintenance requirements.

Safety recommendation ROAD No 2021/06T

The investigation of the head-on collision on the E6 road near Hammer in Snåsa on 2 February 2020 has revealed that, prior to the accident, multiple road users notified the Traffic Control Centre (VTS) of challenging road surface conditions on the road network covered by the same contract area for winter road maintenance as the accident site. VTS did not forward these reports, however. The Norwegian Safety Investigation Authority considers that the Norwegian Public Roads Administration must ensure that road user reports concerning road surface conditions on the road network during winter are effectively addressed. Furthermore, road users should also be able to expect the Norwegian Public Roads Administration, as construction client and road owner, to systematically safeguard the interests of road users.

The Norwegian Safety Investigation Authority recommends that the Norwegian Public Roads Administration improve its internal procedures for cooperation with VTS and the contractors involved in winter road maintenance, as the basis for systematic follow-up of reports concerning road surface conditions.

Safety recommendation ROAD No 2021/07T

The investigation of the head-on collision on the E6 road near Hammer in Snåsa on 2 February 2020 has identified shortcomings in the contractors' planning, implementation, documentation and follow-up of operational measures, and in the Norwegian Public Roads Administration's follow-up of winter road maintenance. The Norwegian Safety Investigation Authority has identified similar shortcomings in winter road maintenance in several previous investigations. The Norwegian Public Roads Administration and the contractors that perform winter road maintenance services seem to have a potential for improvement when it comes to cooperating and sharing experience across regions, and establishing systems that can improve winter road maintenance both regionally and nationally. In this context, the Norwegian Safety Investigation Authority believes that the Norwegian Public Roads Administration should increasingly facilitate national learning from winter road maintenance.

The Norwegian Safety Investigation Authority recommends that the Norwegian Public Roads Administration draw up guidelines for the evaluation of winter road maintenance as a basis for a systematic assessment of serious incidents and road traffic accidents that occur on the road network during winter.

The Norwegian Safety Investigation Authority

Lillestrøm, 7 June 2021

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