

NATURAL HAZARD PREPAREDNESS IN THE NORWEGIAN PUBLIC ROADS ADMINISTRATION (NPRA)

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ABSTRACT: The Norwegian Public Roads Administration (NPRA) is responsible for maintaining approximately 10,000 kilometers of public roads in Norway, which is roughly ¼ of the total amount of national and county roads. In 2020, NPRA was given the responsibility for natural hazard preparedness across the entire public road network in Norway. The primary task was to establish a 24/7 preparedness system to provide expert support during acute events. Additionally, a daily assessment of natural hazards risk on the roads is generated and disseminated to road owners who subscribe to the service. Over the years of its existence, the preparedness system has handled over 1100 inquiries. In 2023, 25% of these inquiries pertained to snow avalanches and slush avalanches. Consequently, natural hazard contingency plans have been a critical area of focus, aiding in identifying vulnerable road sections. These plans are essential tools for road owners and maintenance contractors, as well as for professionals providing expert advice during acute events. A purpose-built mapping tool called RESPONS is developed to assess and distribute the daily diligence-level for natural hazards affecting roads. Further development of the service will focus on online map-based contingency plans across digital devices for both contractors and professionals, more accurate forecasting, and increased safety for road users.

KEYWORDS: Contingency plans, Natural hazard preparedness, Norwegian Public Roads Administration

1. INTRODUCTION

Norway has the world's second-longest coastline, and its population was traditionally located in scattered settlements along the coast. The main livelihood was fishing, and boats were the most common means of transportation. Connecting the country with road infrastructure has resulted in many road sections being in avalanche-prone terrain. Today, the resources in the sea are still an important industry for the population along the coast, and fish export is the most important source of income, except for the oil and gas industry (Statistics Norway, 2024). Although traffic volumes may be small, expectations for accessibility and accepted risk are rapidly changing. Traditional physical avalanche protection of our road network is not socio-economically sustainable, thus new methods for handling avalanches and avalanche danger have been developed.

Avalanche protection with active measures such as monitoring and forecasting as well as avalanche control, requires closer follow-up by professionals, even after the avalanche protection has been deployed. Therefore, the need for avalanche

expertise is greater when using active measures than with physical measures such as tunnels and avalanche galleries. The Norwegian Public Roads Administration (NPRA) is responsible for 10,000 km of public roads in Norway. In addition, the counties and other road owners have operational responsibility for an additional 45,000 km of county roads and national roads. In 2020, the NPRA was given the responsibility for avalanche and flood preparedness for all national and county roads. The service was added to the geoscience section of Operation and Maintenance.

2. DESCRIPTION OF THE AVALANCHE AND FLOOD PREPAREDNESS DUTY

The most important task of the avalanche and flood preparedness duty is to provide an around the clock expert support during acute events for all road owners. There are two professionals on duty for a week at a time, who divide Norway into a Northern and Southern part. On average, each person has four duty periods per year.

The road owners need for professional assistance will vary but may include avalanche risk assessments in conjunction with the reopening of avalanche-closed roads. The safety of the contractor on-site and waiting traffic is prioritized before reopening time. Known neighboring avalanche paths that could threaten the road are

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mapped in natural hazard contingency plans. These plans are of great value to both the contractors and the professionals when handling acute events (Kosberg and Humstad, 2011; Kristensen et al., 2014).

Gathering information using drones has become more and more common (Solbakken et al., 2024). Drone-based data collection by the contractor on-site allows for better and quicker decision-making by avalanche experts at the office.

Field inspections are still necessary in many acute events. The person on duty is responsible to organize the call-out from a professional with the applicable expertise. A list of professionals from various road owners and private companies throughout Norway is available for this purpose. If there are no other professionals available the person on duty must perform the field inspection, even though it might involve long travel.

To prepare the road owners for possible events, assessment of the daily diligence-level for natural hazards is done by the duty officers. We have divided the country into 7 regions and categorize the hazard on a 4-level scale, see Figure 1. The assessment is conducted using a purpose-built mapping tool called RESPON, which is available internally in the NPRA, see Figure 2. External users can apply for access. Users can also subscribe to the service for selected areas and levels of diligence and receive the assessment by email. The assessment is made for large regions and will not replace local knowledge for each individual avalanche paths and weather conditions. Instead, we are trying to highlight which natural hazards may occur and which warning signs must be taken seriously. The assessment also helps road owners to know when they must prepare for events and step up their preparedness, such as having more people at work.

Green – Normal operation.
Yellow - Prepare, some small events possible.
Orange - Road closures expected.
Red - Restriction and severe damages on the road network.

Figure 1: Scale for diligence-level forecasted for the road network.

We collaborate with other public agencies, and daily weather briefings from the Norwegian Meteorological Institute (MET) are the main source of information. The Norwegian Water Resources and Energy Directorate (NVE) contributes to the same meeting with their assessment of avalanche and flood hazards. Unlike the hazard warnings from NVE and MET, which create forecasts for all users, our assessments of diligence-level focus only on the hazards that can affect the roads.

The Road Traffic Control Center conveys road messages to the public and coordinates involved resources when an acute event is reported. An increasing number of avalanche monitoring systems, that automatically close roads when there is an event, requires that the professional on duty understands how the different systems detect avalanches and what potential sources of error there might be. The person on duty will play a crucial role in either confirming or cancelling out the alert to avoid unnecessary closures.

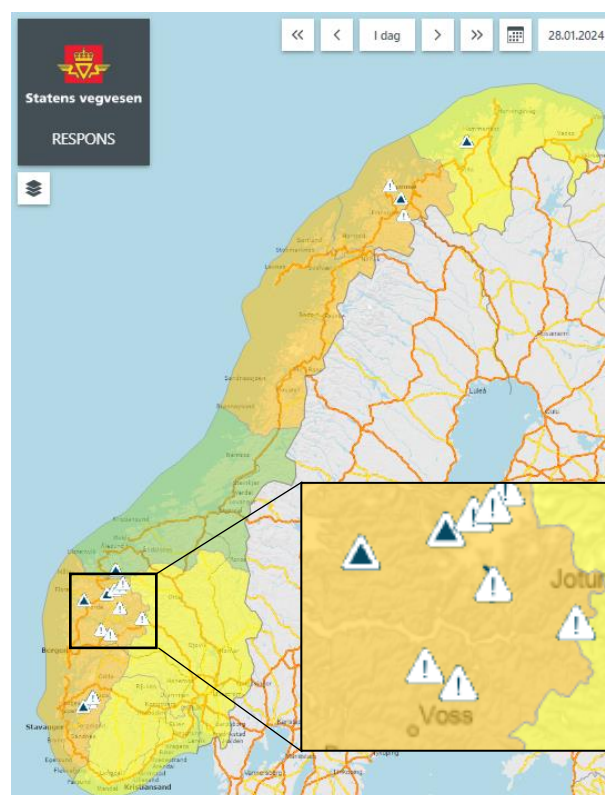


Figure 2: Screenshot from mapping tool RESPON during a snow avalanche cycle in January 2024. Map shows forecasted diligence-level and road closures due to snow avalanches.

3. RESULTS

From 2020, the inquiries to the avalanche and flood preparedness duty are registered in a local database. Data from the daily assessments are stored in another database from 2022.

3.1 *Handling of inquiries*

The avalanche and flood preparedness has handled more than 1100 inquiries since its inception in 2020. Snow avalanches account for 35%. Approximately 65% of the inquiries relate to national roads, while the remaining 35% concern county roads.

70% of the inquiries involve professional assistance after events. This can be a simple assessment in the office together with road owners based on photos. Events that require field inspections are carried out by foot or by helicopter. In recent years, drones have largely taken over for helicopters, allowing contractors on the road to provide sufficient background material for office-based professionals to make assessments without the need to travel. Other inquiries mostly concern a need to assess the hazards in advance of expected events, either for road owners or emergency organizations, see Figure 3.

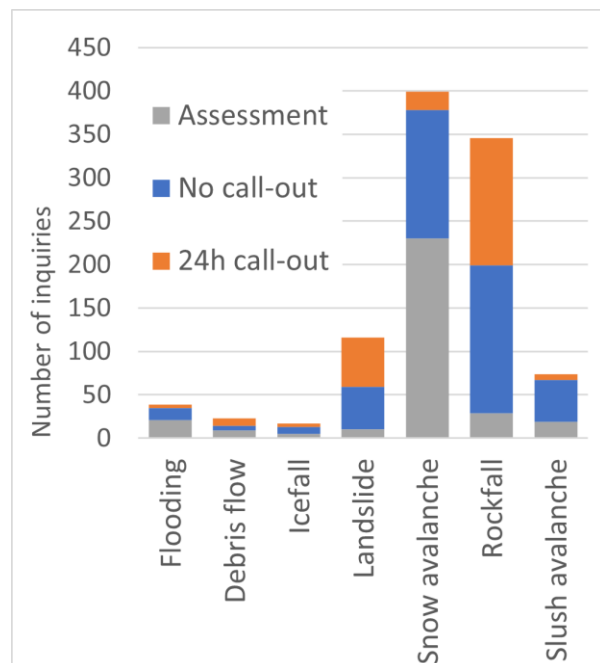


Figure 3: Distribution of inquiries since start-up in 2020. The bars show the distribution of assessment in advance compared to whether the incident resulted in a call-out in 24 hours or handling at the office.

Inquiries received by phone vary somewhat throughout the year and are normally most frequent in winter. Two events have caused especially many inquiries, the extreme weather Gyda in January 2022 (Sundvor, 2022) and Hans in August 2024 (Granerød et al. 2023; Lunde and Tharaldsen 2024). Both extreme weather events affected large parts of South Norway and resulted in approximately 50 inquiries each to the person on duty, see Figure 4.

During major regional extreme weather events that affect large parts of the society and infrastructure, the duty officer's main tasks have been to provide professional assistance to contractors out on the road. Inspections, damage assessments and reopening are prioritized when the extreme weather is over, and we have an overview of the situation.

During the extreme weather Gyda, the duty officer participated in a total of 24 meetings with the emergency response organization in NPRA. The tasks were mainly to present weather forecasts and hazard assessments that were relevant to the road network. More than 100 roads were affected, mainly because of flooding and landslides. The event was well forecasted and the consequences less than expected. Several weather stations recorded more than 120 mm of precipitation in 24 hours. In addition, snowmelt resulted in increased flood levels and high water-saturation in the ground.

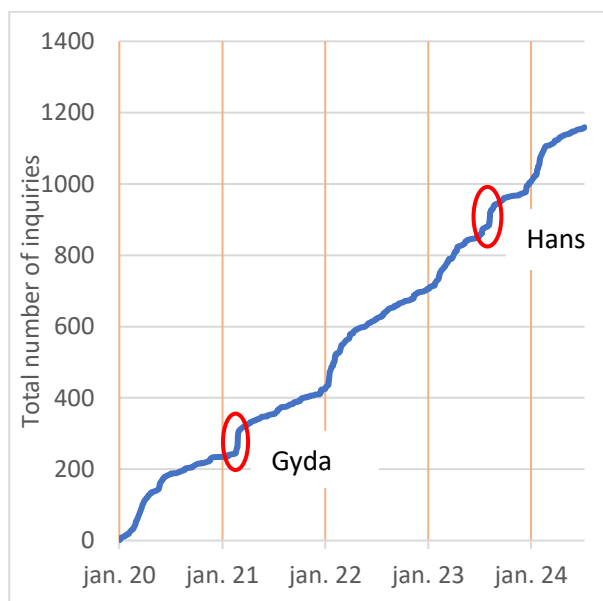


Figure 4: Accumulation of inquiries since the start in 2020. Extreme weather events Gyda and Hans in red circles.

3.2 Assessment of the daily diligence-level

We have been conducting assessments of the daily diligence-level since the start of the service in 2020, but the statistics in Figure 5 are from 2022 until July 2024. The assessments are carried out Monday, Wednesday and Friday, and more often if needed, and include an assessment for the present day and the two upcoming days. About 80% of the days had a green level, and there has been a total of 14 days with a red caution level since 2022. There was a marked increase in the number of days with a yellow hazard level or higher from 2022 to 2023.

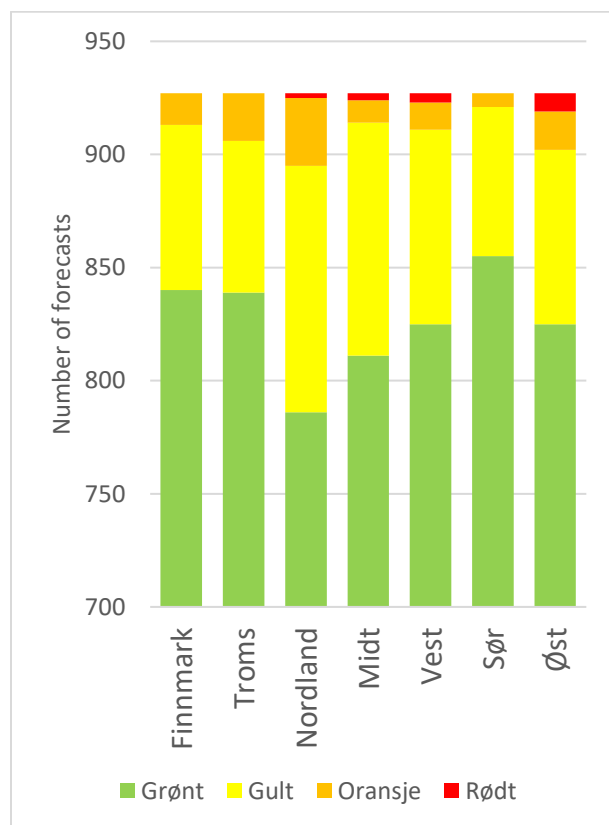


Figure 5 Distribution of the daily published diligence level since 1.1. 2022

4. DISCUSSION AND CONCLUSION

Avalanche and flood preparedness has now been operational for just over 4 years. In total, we have handled over 1100 inquiries. We are not contacted for all incidents; however, we see that more people are aware of the service today than in the early stages. Some of the counties, with many avalanche-prone roads, have their own preparedness duty that handles events on county roads either all year round, or part of the year.

4.1 Managing incidents

Inquiries related to snow avalanches on the road, rarely result in call-outs for an avalanche professional. The main reason is probably that snow avalanche paths close to the roads are well mapped and we have a good historical database. Contractors participate in avalanche courses and have mobile applications integrated in systems that are used daily for documentation. All data are stored in national databases. For most snow avalanche events, the task for the professional on duty will be to make a local assessment together with the road owner and contractor about when it is safe to start the cleanup.

Rockfall and landslides often occur in new locations and have therefore a limited historical database. In such events, there is a greater need for professional assistance in the field.

To reduce closure time, controlled traffic management and partial opening are often practiced. However, we have seen that this creates challenging working conditions for the contractors to re-establish accessibility. The assessment of neighboring avalanche paths will be very important in such traffic management, because lined up vehicles can be in avalanche-prone terrain for a long time.

There are many factors that decide how an incident can be solved in the best possible way. Available detour routes provide better time for safe and efficient cleanup. On high-traffic roads, detour routes rarely have the capacity to handle a prolonged closure, and such events therefore place greater demands on those involved having good plans for reopening. All road closures on national roads that last more than four hours are evaluated so that we better can handle future closures.

4.2 Responsibilities and roles

It is the person on duty, in consultation with the contractor and road owner, who agrees on whether there is a need for a professional inspection or not. For most inquiries the assessment is carried out from the office, based on photos and other available information. The people on-site often contribute with pictures and videos, which can provide as good a basis for decision-making and faster reopening than if a professional spends many hours travelling to the location.

It is the road owner's responsibility to open and close the road in the event of a natural hazard.

However, we see that professional advice is generally followed. It is therefore important that both the duty officer and the professional out in the field have sufficient competence to provide good professional advice. When people are involved in incidents on the road, it is the police who are in charge during the rescue. Dialogue with the police has at times been challenging, but conducting courses and joint exercises has led to a better understanding of each other's roles.

Since 2023, The Road Traffic Control Center in the Norwegian Public Roads Administration has been more closely linked to the avalanche and flood preparedness. When the diligence level is assessed as orange or higher, it is considered whether to establish regular contingency meetings between different professional communities within the NPRA to maintain a safe and predictable operation of the road network. If the situation escalates with road closures and events over a larger area, other road owners and external stakeholders such as the police, health services, and municipalities are also involved. A common meeting place provides better situational understanding and better interaction when the road network and other infrastructure do not function as expected. We are also continuing to create more clear guidelines for when and how contingency meetings should be conducted.

4.3 Criteria for assessing the diligence levels

We observe an increase in published hazard assessments with yellow and orange diligence levels from 2022 to 2023. Some of the increase can be attributed to more proactive warnings of the consequences following heavy rainfall. It is challenging to establish clear criteria for how heavy rainfall should affect the hazard assessment. Anticipated events can range from local floods to large debris flows destroying the roads. We need several years of data to evaluate how heavy rainfall should impact the hazard assessment. Improved weather models for precipitation patterns will enhance the accuracy of our assessments.

Since the start of the preparedness system in 2020, a red level of caution has not been considered in the Troms and Finnmark county. Often, the consequences of events in this area can be less than in southern Norway because of lower traffic volume. Snow avalanches as the main problem traditionally cause less damage to the road than other types of natural hazards, and the closure time can be shorter. The community has also traditionally accepted road closures to a

greater extent than in the southern part of Norway. However, evaluations of several of these incidents show that the assessments were at a too low level. Therefore, we must create better criterias and threshold values in the northern part of Norway to improve the quality of the assessments.

4.4 Further work

In challenging situations where several external actors are involved and various natural hazards are to be managed, we see the importance of being able to share data and have access to the same background information about the vulnerable road network. Our mapping tool RESPONS has been developed to move contingency plans from paper into a digital mapping solution. It is challenging to keep the data updated and to present it in a clear way. Although external partners can access RESPONS, we see that it is difficult to achieve a solution that all road owners actively use. Therefore, we must continue to work on making relevant data available in a more open solution while improving the quality of the background data.

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