REPORT

GEOSFAIR - Geohazard Survey from Air

CONSOLIDATION OF REQUIREMENTS - ANALYSIS OF QUESTIONNAIRE

DOC.NO. 20210309-02-R
REV.NO. 0 / 2022-11-08

NORWEGIAN GEOTECHNICAL INSTITUTE
NGI.NO

Project

Project title:	GEOSFAIR – Geohazard Survey from Air
Document title:	Consolidation of requirements - Analysis of questionnaire
Document no.:	20210309-02-R
Date:	2022-11-08
Revision no. /rev. date:	0 / 2022-11-08

Client

Client:	The Norwegian Research Council
Client contact person:	Mette Brest Jonassen
Contract reference:	321035/O80

for NGI

Project manager:	Regula Frauenfelder
Prepared by:	Elisabeth Hoffstad Reutz, Regula Frauenfelder, Sean Salazar
Reviewed by:	Edward McCormack (NPRA), Tore Humstad (NPRA), Sean Salazar

Summary

This report presents a synthesis of the results of a questionnaire distributed to personnel from the Norwegian Public Roads Administration (NPRA) and several county road administrations. The aim of the survey was to evaluate the current and potential use of uncrewed aircraft systems (UAS), or drones, for assessing roads exposed to landslide, rockfall, and avalanche hazards. Furthermore, the survey aimed to identify the challenges or barriers to uptake. The recipients of the survey were identified as key persons in their organisations working with avalanche danger in the road sector, either as responsible persons for avalanche danger assessments or as operators/managers of avalanche-prone roads. Results from a total of 36 respondents to the questionnaire are summarized and some recommendations are proposed.

Contents

Appendix

Review and reference page

1 Background

The research project *Geohazard Survey from Air – remote decision support with focus on avalanche applications (GEOSFAIR)* explores the use of instrumented drones to make faster and better assessments of roadside avalanche hazards. Natural hazard assessment and management requires investigation and data collection in often inaccessible terrain, and the risk of avalanches is often greatest in storms and dark times with poor visibility. Information about snow, boulders, soil and water masses may therefore be deficient. Drones can carry instruments such as cameras, radars and laser scanners that can provide crucial information to avalanche specialists that can be used in decision-making. GEOSFAIR is organized as an Innovation Project for the Public Sector (grant no. 321035) and receives funding from the Research Council of Norway. The project is owned by the Norwegian Public Roads Administration, while NGI and SINTEF are research partners in the project.

2 Introduction

As a part of the GEOSFAIR project, a questionnaire (cf. Appendix A) was developed and sent out by email to selected persons at the Norwegian Public Roads Administration (NPRA) and at other road owner/operator organisations (such as the county administrations) in Norway. The aim of the survey was to evaluate the current and potential use of uncrewed aircraft systems (UAS), or drones, for assessing roads exposed to landslide, rockfall, and avalanche hazards. Furthermore, the survey aimed to identify the challenges or barriers to uptake. The recipients of the survey were identified as key persons in their organisations working with avalanche danger in the road sector, either as responsible persons for avalanche danger assessments or as operators/managers of avalanche-prone roads.

The survey was sent to 65 persons in total, of which 26 people are engineers with varying professional geoscience backgrounds at the NPRA, 34 people are geoscience engineers working at 11 county municipalities (all counties represented, except Oslo) and five people working as main responsible persons at the NPRA for the day-to-day operation of the road network ("byggeherre-representanter"). A total of 36 people responded to the questionnaire.

In the survey, respondents were prompted to give examples of the use of drones for operation/management of roads prone to natural hazards ("drift/forvaltning av skredutsatt veg"). In this context, it is important to clarify that in Norwegian, and in the NPRA in particular, the term "skred" is used as a collective term for all types of rapid mass movements that can hit a road, such as snow avalanches, landslides, debris floods, rock fall, ice fall and even sudden road collapses. When answering the questionnaire, many respondents did not specify what type of rapid mass movements they referred to when using the word "skred"; in such cases the term "gravitational processes" is used in this report.

This report is divided into two main sections. Section 3 describes answers from all respondents of the survey, while Section 4 only describes the subset of answers from the participants working at the NPRA (hereafter also referred to as the road administration).

3 Results from the survey

3.1 The participants

Thirty-six (36) individuals responded to the questionnaire. Fifteen (15) of the respondents worked for NPRA and 21 for the county municipalities, resulting in good representation from both groups. There is also variation in the participants' backgrounds as displayed in Figure 3-1. The data from the survey is, therewith, not biased towards respondents with a specific professional background or respondents working at a specific organization.

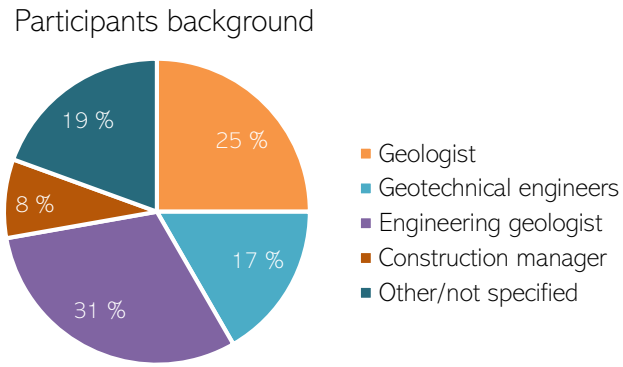

Figure 3-1. Professional/technical backgrounds of the survey participants (n = 36).

It is also worth noting that 10 out of 11 county municipalities in Norway are represented by at least one person. Vestland county has the most participants, while Oslo is the only county not represented. The latter is not prone to the natural hazards addressed in this survey, except for (rare events of) rock fall or ice fall.

3.2 The use of geodata and drones within the organisations

3.2.1 The current use of geodata

Ninety percent of the participants replied that they use geodata on a regular basis during their workday. The most commonly used geodata among the participants were different types of maps and online map portals. Terrain models were also a common survey answer, in addition to geotagged photos and databases and registers of confirmed events. This illustrates that most of the participants are familiar with the use of different types of geodata.

3.2.2 The current use of drones and drone data

When asked if they currently are using drones or data collected by drones 25 of the 36 participants answered “yes”, as displayed in Figure 3-2. The ones that currently do not use drones or drone-captured data had different backgrounds and worked both for the road administration and within different county municipalities. It is worth mentioning

that in one county municipality none of the employees that responded to the survey worked with drones or drone data.

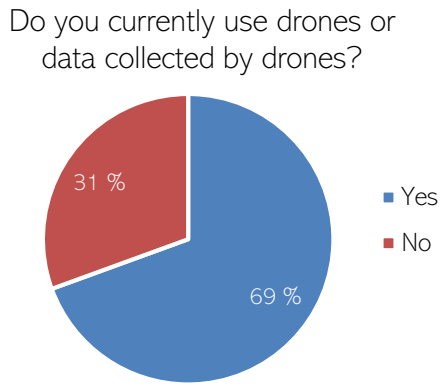

Figure 3-2. Current use of drones or drone data within the participant group (n = 36).

When asked to rank their knowledge on the use of drones within their organisation from 1 = "I know we have drones, but not much more" to 5 = "This is something I work with often", the ones that do not use drones or drone data ranked their knowledge the lowest, as depicted in Figure 3-3. The majority ranked their knowledge at a 3 (out of 5), indicating some knowledge, but also that they don't use drones on a regular basis. Only a few ranked their knowledge at a 5.

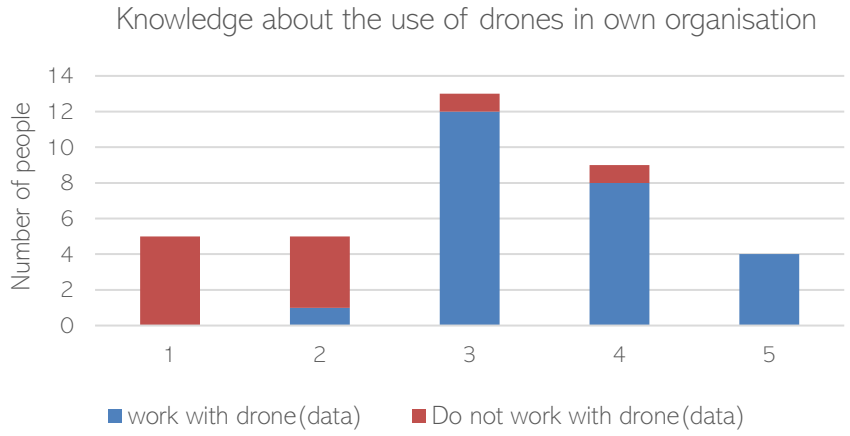

Figure 3-3. The participants' rating of their knowledge on the use of drones within their organisation. From 1 = "I know we have drones, but not much more" to 5 = "This is something I work with often" (n = 36).

When prompted to describe a task where one would typically use a drone or data collected by a drone, respondents generally answered that drones are used for aerial surveillance, typically to assess an area that is difficult to access, for instance to inspect a road cut. Several of the participants also used drones to assess an area before

conducting field work. Drones and drone-derived data are also used to map landslides, rock fall, avalanches and hazards connected to them. The stability and safety of an area is also assessed with the help of drones.

When asked to mention specific tasks where data collected by drones is used, the majority mentioned that they collected photos for documentation and to add to reports. Data from drones (mainly photos and videos) are also used for hazard assessments of gravitational processes, and to evaluate slope stability and inspect rupture zones. A few mentioned the use of photogrammetry from the drone-collected data to create 3D-orthomosaics (photography) and terrain models.

When prompted about the opportunities/possibilities that the use of drones provided for the organisation, respondents answered that the use of drones contributes positively to the organisation. Many of the participants highlighted that using a drone provides the opportunity to more easily and more efficiently inspect and obtain an overview of an area, especially if that area is difficult to access. It is also possible to get information from areas one otherwise would not access. Some also mentioned that in many cases the use of drones can replace the use of a helicopter, which is seen as a positive, given that using a drone is much cheaper than renting a helicopter, and for some, it is also easier to get access to a drone than to a helicopter (provided that they have access to their own drone and can fly it). For those that have access to a drone and a drone pilot, it is also easier to get information fast, which is useful during emergency assessments. A few also mentioned the opportunity of using drones for creating terrain models.

When asked about whom in their respective group or organisation could benefit most from using data collected by drones, the overall response was related to geologists, geotechnical engineers, persons collecting geodata or quality control engineers needing to gain an overview or to map an area. More specifically, it was mentioned that people working with natural hazards would find it useful, but it could also be handy, for instance during, construction work.

It was clear that the availability of qualified pilots is one of the key elements when deciding on whether to use a drone in a specific project or task, as displayed in Figure 3-4. The need (or absence of such a need) for daily situation assessments also plays a role whether a drone is used or not. The presence of a drone enthusiast within the organisation also seems to increase the chance of using drones. Overarching strategic decisions, on the other hand, do not seem to be as important.

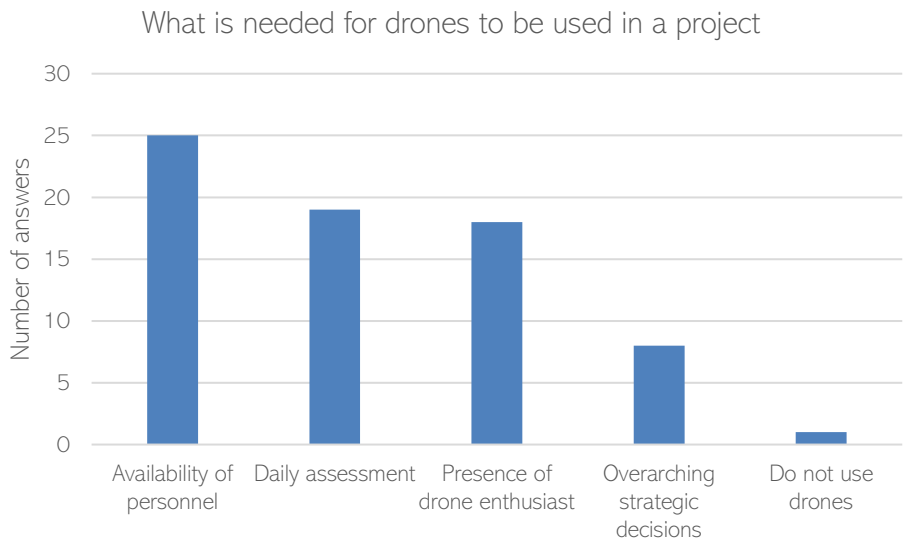

Figure 3-4. The participants' view on what it takes for a drone to be used in a project. Multiple answers were possible (n = 36).

When asked if respondents could list concrete examples of drone data from their organisation having been used in decisions regarding the management of hazard-prone roads, 22 out of 36 respondents gave examples, of which some are mentioned here: Several mentioned the use of drones when evaluating if a road was safe to open after the occurrence of rock falls or avalanches. Several also used the drone data to evaluate slope or snow pack stability and to investigate the area of a rupture, to evaluate the likelihood of a hazardous event occurring. Some also noted the use of drone data to get an overview of the deposits on a roadway right after an event. Some also used the data to create terrain models and to document the event.

Most of the participants do not know whether their organisation outsources drone surveys to external vendors (Figure 3-5). Among the nine respondents that do know, the types of surveys vary: some surveys were for bridge inspections, to get an overview after the occurrence of a landslide, to evaluate the chance of rock fall, laser scanning of the terrain to evaluate the amount of snow in an avalanche assessment, and to create terrain models and 3D-scanning of constructions. The main reason for the outsourcing was the lack of necessary equipment (i.e. a drone), software, or personnel able to handle the drone, and in one case the survey was considered as too extensive to be carried out by in-house staff.

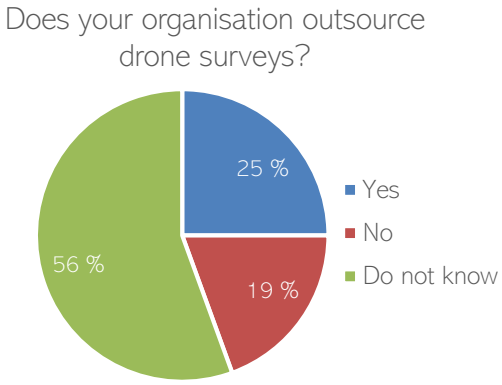

Figure 3-5. Outsourcing of drone surveys to external vendors (n = 36).

3.2.3 Challenges when using drones

With the aim of gaining an overview of the different challenges connected to the use of drones in projects, the participants were asked questions about the different stages connected to drone usage. Several challenges were mentioned connected to the planning of a potential drone survey. The weather is mentioned as a challenge and the lack of daylight also posed a limitation when using drones. Several respondents also mentioned different factors that made operating a drone in the survey area challenging, such as the proximity to large roads, power lines, houses, and areas with air traffic. In addition, it was mentioned that operating drones was time-consuming, for example needing to check flight regulations, to get approval for using a drone in particular areas. The availability of a drone and a drone pilot was also mentioned as a challenge by some. In that context, it is worth mentioning that several respondents found the certification process to be time consuming, which prevented them from getting their certification. Furthermore, short battery life on the drone was mentioned as a challenge when planning where to conduct the survey, but this would depend on the specific drone used. It should be mentioned that some did not note any challenges when planning a survey.

Similar challenges as the ones mentioned above were listed, when asked about challenges connected to mobilizing personnel and equipment for on-site drone surveys. Several mentioned the lack of personnel who could operate the drone. Again, the weather was also mentioned. There were also some complaints about the quality of the cameras carried by the drone, but this would depend on the specific drone used. Here, as in the section above, there were also respondents that did not mention any challenges.

There are also some challenges connected to the use of data collected by drones. The consensus being that the respondents do not feel competent with the processing programs. Some mention that, within their organisation, there is a lack of software to process the data, as well as knowledge on how to use the software. Most of the participants in the survey found it quite time consuming and difficult to use the different programs needed to process the data. An overwhelming amount of data was also mentioned as a problem. Some also found it difficult to collect data to create a proper

terrain model. Others mentioned the challenge by receiving orthophotos that are not properly georeferenced. But here, again, there were also a few participants that did not face any problems.

3.2.4 Regulations of drone usage

From the questionnaire, one can see that the majority do take HSE[1] considerations into account when planning a drone survey (Figure 3-6). Some of the mentioned considerations are not to fly the drone above roads, people, buildings or close to airports. The weather is considered before flying, as are the regulations connected to operating a drone.

Most of the organisations have a (required) operations manual, which is followed as part of the current regulation of drone usage within the organisation. Some also mentioned that they are in the process of creating procedures and checklists according to the new regulations. In several of the organisations, there is a designated person or group that is responsible for the drones, ensuring that the use of drones is in accordance with the regulations.

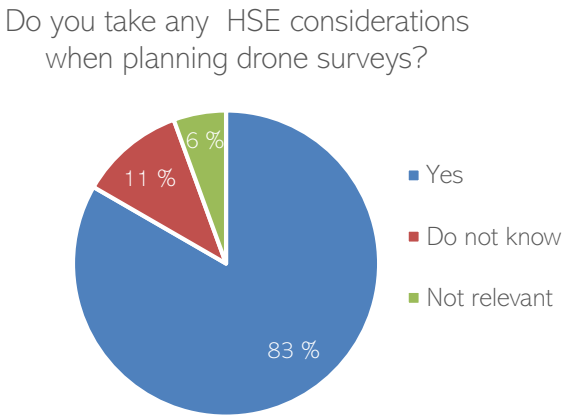

Figure 3-6. On whether HSE considerations are taken into account when planning a drone survey (n = 36).

3.3 The potential, or increased use of drones within own organisation

In general, the participants in the survey had a positive attitude towards increasing the use of drones and data collected by drones, as presented in Figure 3-7. The overview of what kind of data respondents would like to use in their projects, Figure 3-8, illustrates that the majority wanted data that is optical camera based (photos, video, digital elevation models, 3D-products, or orthophotos). From the same figure, it can also be seen that data obtained by laser scanning was also of interest for quite a few respondents.

[1] HSE = Health, Safety, and Environment policy (https://www.arbeidstilsynet.no/hms/)

Regarding data from thermal images, airborne radar and electromagnetic measurements, the desire was not that large.

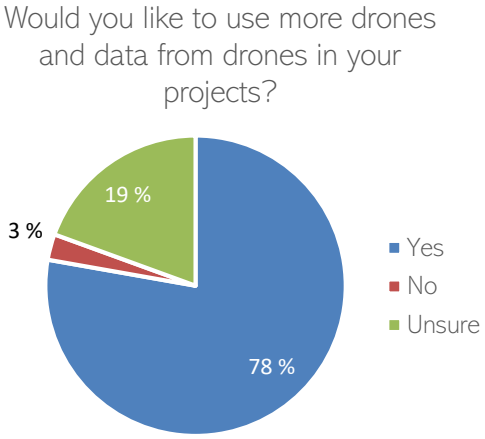

Figure 3-7. Interest for using drones and data collected by drones in their projects (n = 36).

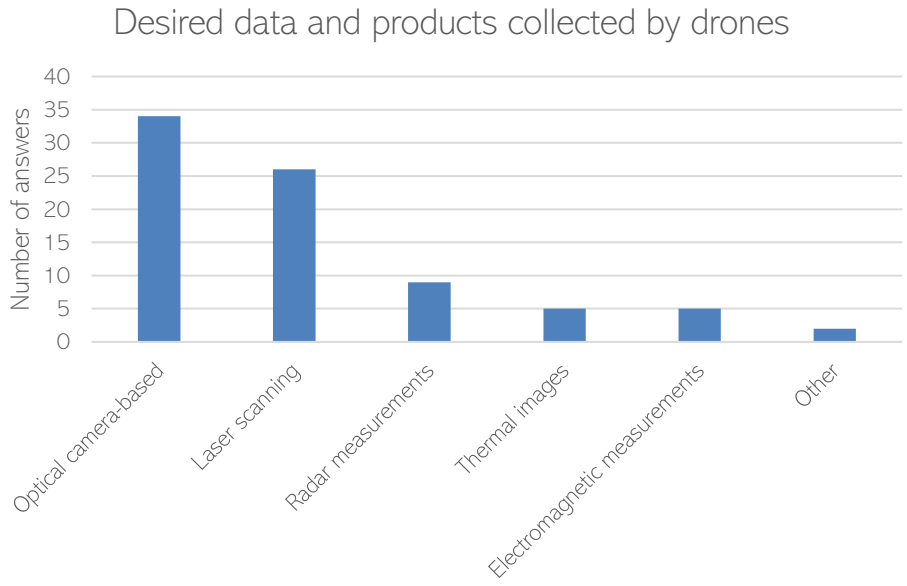

Figure 3-8. Overview of what kind of data and product collected by drones that is desired among the questionnaire participants. Multiple answers were possible (n = 36).

3.3.1 The biggest obstacles for using drones more

The answers from this survey indicate that many respondents use geodata and drones, but that there exist a number of thresholds and obstacles that need to be overcome in order to increase the use of drones within their organisations. What seems to be the main obstacle, based on the answers, is the lack of knowledge in several "stages" of the workflow (between using a drone, to having a final, usable product, such as an orthophoto or elevation model). Another factor mentioned were the rules for using

drones, which are viewed as strict. There is also a wish for more organisational support and for a tighter assemblage of existing drone competence.

Some mention that the use of drones is not prioritized by the management within their organisations, hence other tasks are prioritized. It was mentioned that a 2-day crash course, or similar, would be nice as this would enable staff to dedicate a couple of days to concentrated learning, instead of always prioritizing other tasks when trying to learn about drones on their own. The procurement of more and better drones, as well as of better sensors, in order to get better data and have more drones available, would also make it easier to increase the use. Several mentioned that it is time consuming to become a certified[2] drone operator, which means that there is a lack of available personnel who can use drones. It seems like the regulations regarding the certification and use of drones for some feels too comprehensive and is an obstacle in and of itself.

There is also a lack of knowledge on how to handle and process the drone data or to create terrain models using the data. The lack of knowledge about the different software packages that are used when processing data and creating models was also viewed as a challenge. It was mentioned that easier-to-use software, where both the data could be processed and analysed, would be desirable.

3.3.2 Important factors to increase drone usage

When asked about the most important factors to increase the use of drones within their organisation, it is clear that there is a need for available people with knowledge, and the training of more people to operate drones, as presented in Figure 3-9. Organisational requirements with good procedures and available resources are also of importance. The use of drones also needs to yield an added-value to a survey work e.g., increased staff safety. A need for field work may also increase the use of drones.

Other factors that might increase the use of drones within an organisation were mentioned. Several mentioned that if the requirements for getting certified and using the drones was less extensive, and that the administrative work connected to the use of drones was reduced, it would be easier to use drones more frequently. There seems to be a struggle to find the time to keep up to date on new rules and regulations, in order to use the drone. An easier way of processing and analysing the collected data was requested. To get the equipment and time to make drone surveys possible, it is also important that the management in general is positive to drone usage.

[2] Certified with the Civil Aviation Authority of Norway (Luftfartstilsynet)

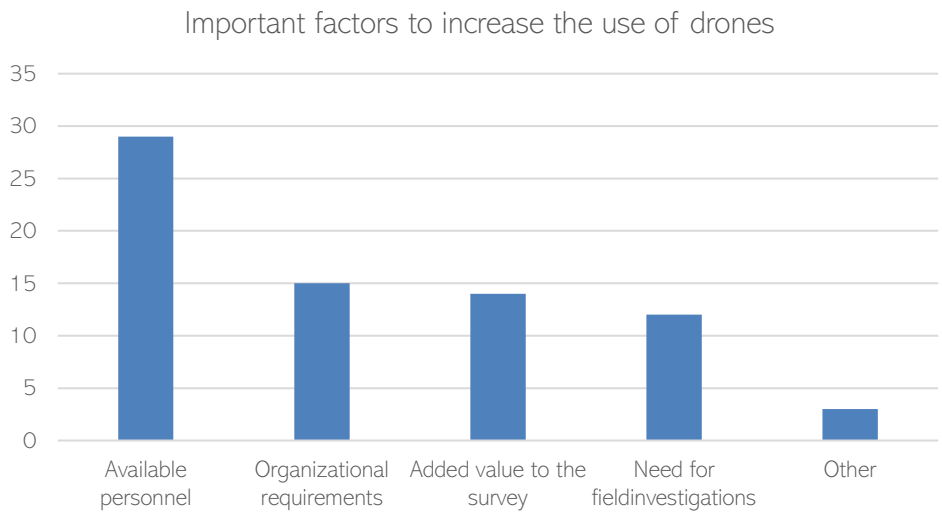

Figure 3-9. Factors that would contribute to an increased use of drone(data) within their own organisation according to the individual questionnaire participants. Multiple answers were possible (n = 36).

4 Results from NPRA respondents

As the GEOSFAIR project is led by the NPRA, this section will focus on the answers received from the 15 employees working there. This section is therefore structured similar to the general overview from the survey presented in Section 3.

4.1 The participants

Fifteen (15) of the respondents to the survey work at NPRA. As seen from Figure 4-1, these respondents have different professional/technical backgrounds, so the answers are not expected to be skewed towards participants with a specific background. Thirteen (13) of the 15 participants use geodata on a regular basis during their workday. The most commonly used geodata type among the participants are maps and online map portals, while several also use terrain models. Some use geotagged photos and registers of confirmed events. The responses illustrate that most of the participants are familiar with the use of different types of geodata.

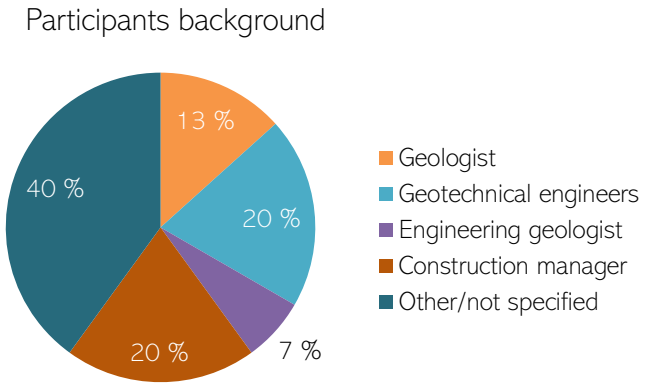

Figure 4-1. Different backgrounds of the participants, within the group working at the NPRA (n = 15).

4.2 The use of drones within the NPRA

4.2.1 The current use of drones and drone data

Eight (8) out of the 15 participants currently use drones or data collected by drones, as displayed in Figure 4-2. The ones that currently do not use drones or drone data had different backgrounds and nothing (as revealed by the survey) in common. The participants were asked to rank their knowledge on the use of drones within their organisation between 1; “I know we have drones, but not much more” and 5; “This is something I work with often”, Figure 4-3. The majority ranked their knowledge at a 3, indicating some knowledge, but also that they don't use drones on a regular basis. Only a few ranked their knowledge at a 5. Those who do not currently work with drones or drone data had the least knowledge about their use.

Within the road administration, a task where one would typically use a drone or data collected by a drone is to get an overview of an area. Several mentioned the use of drones to map gravitational processes and hazard-prone terrain. Drone videos and photos are also used to evaluate the stability of an area. One respondent also mentioned the use of drone data to create terrain models which were then used to plan safety measures. Several mentioned the use of drones to obtain an aerial overview for evaluating hazards connected to gravitational processes, when asked about specific tasks where data collected by drones are used. Drone data is also used as a tool to evaluate rupture zones or slope stability in specific areas. Collected photos are used to document and illustrate incidents that have been mapped. Data collected by drones is also used as a tool in the planning and design phase for projects.

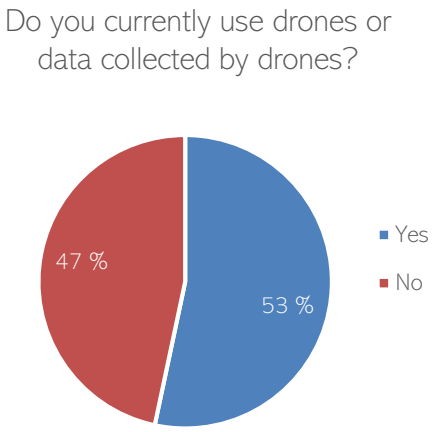

Figure 4-2. Current use of drones or drone data within the participant group working at the NPRA (n = 15).

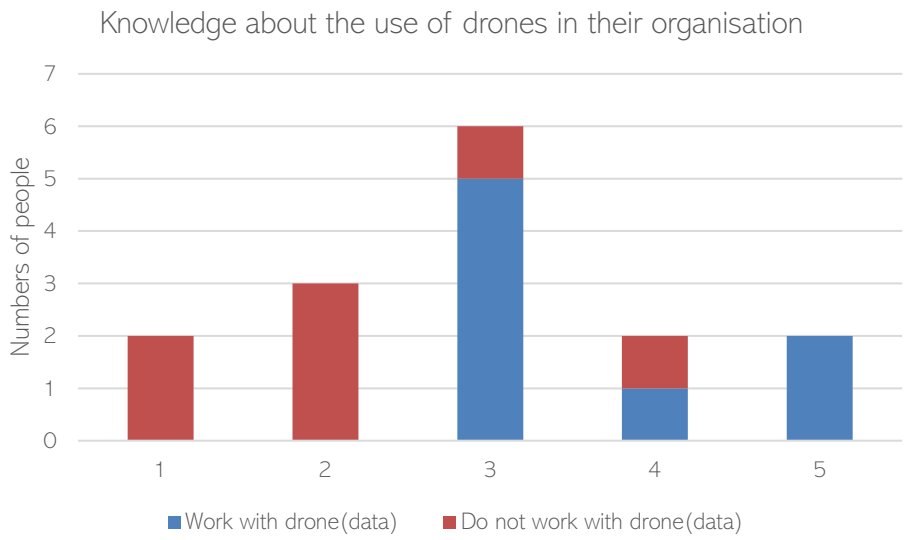

Figure 4-3. NPRA participants' ratings of their own knowledge about the use of drones within their organisation. From 1 = "I know we have drones, but not much more" to 5 = "This is something I work with often" (n = 15).

When asked about what opportunities/possibilities the use of drones provides for the road administration, the majority of respondents highlighted that the use of drones enables multiple opportunities. Several of the participants mentioned that drones provide an easier way to gain an overview of a gravitational process incident. By using a drone, it is also possible to access areas that are difficult to reach, and hence make it possible to obtain more information. This contributes to making the workday easier and safer, as one is less likely to put oneself at risk trying to collect data. It was mentioned that it is useful both for ordinary mapping and during emergency assessments to more quickly obtain better information for decision-making. In some cases, it was pointed out that one could substitute the use of a helicopter with a drone.

When asked about whom in their respective group or organisation could benefit the most from using data collected by drones, it was mentioned that people working with natural hazards would find it useful, but it could also be handy for instance during construction work. The overall response was related to needing to gain an overview of a site or needing to map an area.

The presence of available (qualified) persons, or a drone enthusiast within the organisation, seems to be a key element on whether a drone is used in a specific project, see Figure 4-4. Daily assessments and overarching strategic decisions do not seem to be as important.

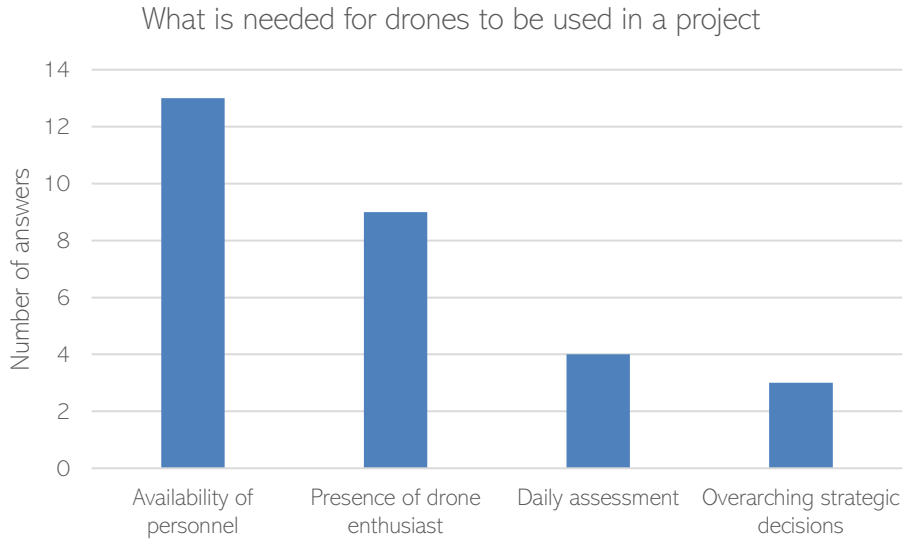

Figure 4-4. The participants' views on what is required for a drone to be used in a project at the NPRA. Multiple answers were possible (n = 15).

When asked if respondents had any concrete examples of when drone data had been used in a decision regarding the management of roads prone to gravitational processes, 12 out of 15 respondents reported examples. Several respondents mentioned the use of drones to evaluate whether to open a road after a gravitational process incident. Additionally, drones had been used to evaluate stability and safety when deciding whether to close a road or to keep it open. Drones have also been used to get an overview

of the deposits, and to make sure they do not pose a threat, for instance by blocking a river. The creation of terrain models and the use of drones to document incidents was also mentioned.

Most of the participants from the road administration did not know whether drone surveys are outsourced to external vendors, as presented in Figure 4-5. But among the four respondents that did know, the type of the surveys varied. The surveys have dealt with bridge inspections, and in some cases after occurrence of a gravitational process. The main reason for the outsourcing was due to the lack of available personnel that could operate the drone, and the lack of knowledge on how to perform the survey.

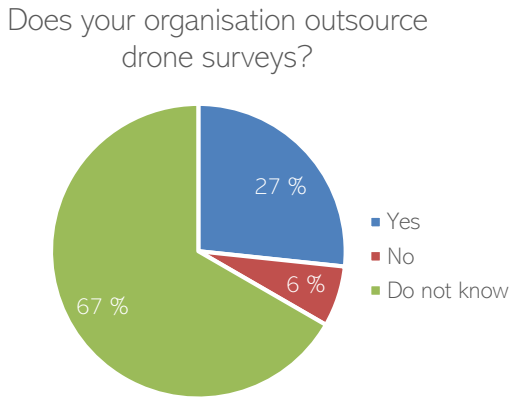

Figure 4-5. Outsourcing of drone surveys to external vendors, answers from the participants working at the NPRA (n = 15).

4.2.2 Challenges when using drones

With the aim of gaining an overview of the different challenges connected to the use of drones in projects, the participants were asked questions about the different stages connected to drone usage. Several challenges were mentioned connected to the planning of a potential drone survey. Some respondents mentioned that the weather and the lack of daylight could be a problem. The main challenge, however, seems to be access to available personnel who can operate the drone. Some also mentioned that getting certified with the Civil Aviation Authority of Norway (Luftfartstilsynet) and the requirements when using the drone was a challenge. The approval of using a drone in a specific project was also time consuming. One respondent also mentioned that flight planning for autonomous flying is quite challenging and time consuming. Similar challenges were outlined when asked about challenges connected to mobilizing personnel and equipment for drone surveys on site. Again, access to available personnel who are certified to operate the drone is a problem. In addition, the weather was also mentioned.

There are also challenges connected to the use of data collected by drones. The main challenge seems to be the large amount of data that need to be handled, which is time

consuming. It is also mentioned that one might not be able to take full advantage of the collected data, due to lack in competence. Respondents also mentioned that the process from collecting data to creating a terrain model takes time, and not many have the knowledge to do it. It should be noted that some did not face any challenges at this stage.

4.2.3 Regulation of drone usage

From the questionnaire, one can see that the majority do take HSE[3] considerations into account when planning a drone survey, as presented in Figure 4-6. There are operational manuals that are followed as part of the current regulation of drone usage within the road administration. In addition, respondents explicitly mentioned that they consider where they stand, when the drone is above, and take weather conditions into account. Some also mentioned that there are designated persons that are responsible for the drones.

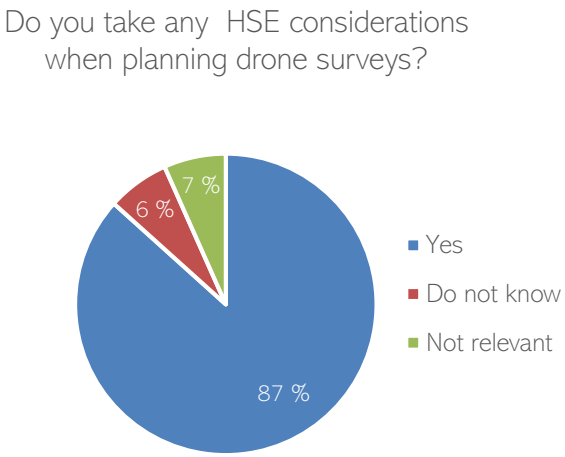

Figure 4-6. Are HSE considerations taken into account when planning a drone survey, answers from the participants working at the NPRA (n = 15).

4.3 The potential, or increased use of drones within the road administration

Most of the participants would like to increase the use of drones and data collected by drones, as displayed in Figure 4-7. The respondents not currently using drones were either positive towards or were unsure about increasing drone use. The majority of respondents would like to collect data that is optical camera based (photos, video, digital elevation models, 3D-products, or orthophotos), as seen in Figure 4-8. It can also be seen that data obtained with laser scanning methods would be of interest. Only a few respondents would like data from thermal images, airborne radar, and electromagnetic measurements.

[3] HSE = Health, Safety, and Environment policy (https://www.arbeidstilsynet.no/hms/)

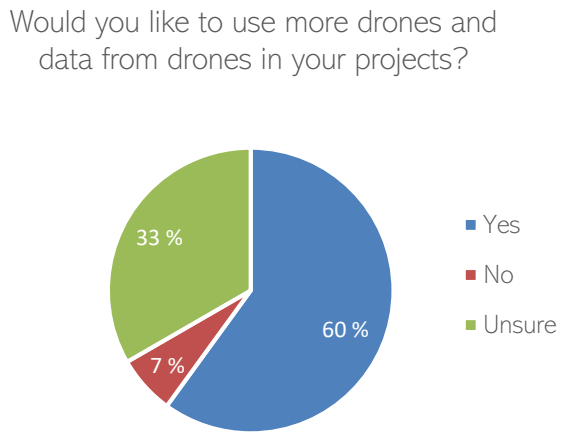

Figure 4-7. Interest in using drones and data collected by drones in their organisation, answers from the participants working at the NPRA (n=15).

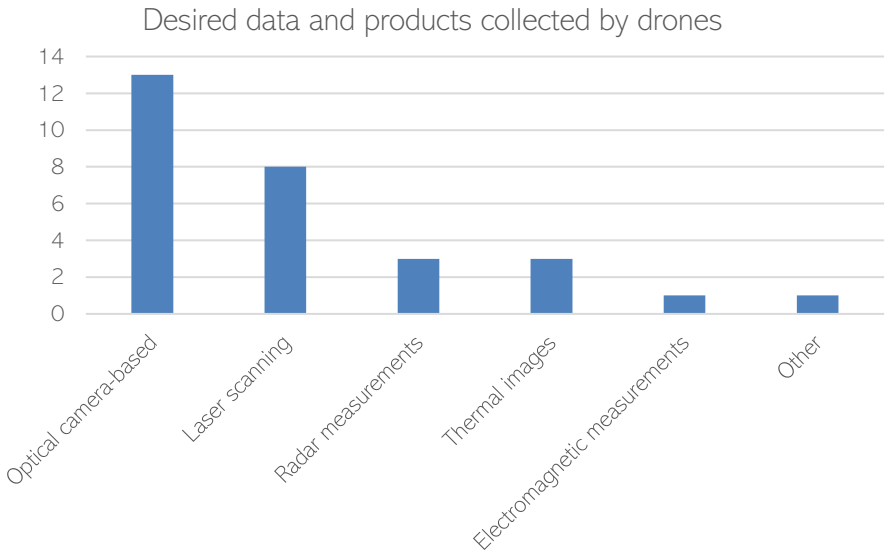

Figure 4-8. Overview of what kind of data and product collected by drones that is desired among the participants working at the NPRA. Multiple answers were possible (n = 15).

4.3.1 The biggest obstacles for using drones more

When asked about the largest obstacles for increasing the use of drones in the organisation, several mentioned that there is a need for more personnel to get certified. However, this is a time-consuming task which seems to be hard to prioritise. Both the certification process and the requirements when using the drone are perceived to be a bit too comprehensive. Several also mentioned that the regulations do not differentiate between the use of a small and a large drone. Additionally, one respondent mentioned that the threshold for using drones to do anything other than take pictures and look at these is very high due to the lack of a common system for both the handling and analysing of drone data.

4.3.2 Important factors to increase drone usage

When asked about the most important factors to increase the use of drones within their organisation, it is quite clear that there is a need for available personnel with knowledge, and the training of more personnel, see Figure 4-9. Organisational requirements with good procedures and available resources are also of importance. The use of drones also needs to add value to the survey (e.g., increased safety) to increase their use.

Another factor that might increase the use of drones is available software that makes handling the data easier. It was also mentioned that if the regulations differentiated on the size of the drone, it might be easier to get the certification and use the drone. Having immediate access to a drone (e.g. in the car), to be used if needed without any extra planning, might also contribute to increased use.

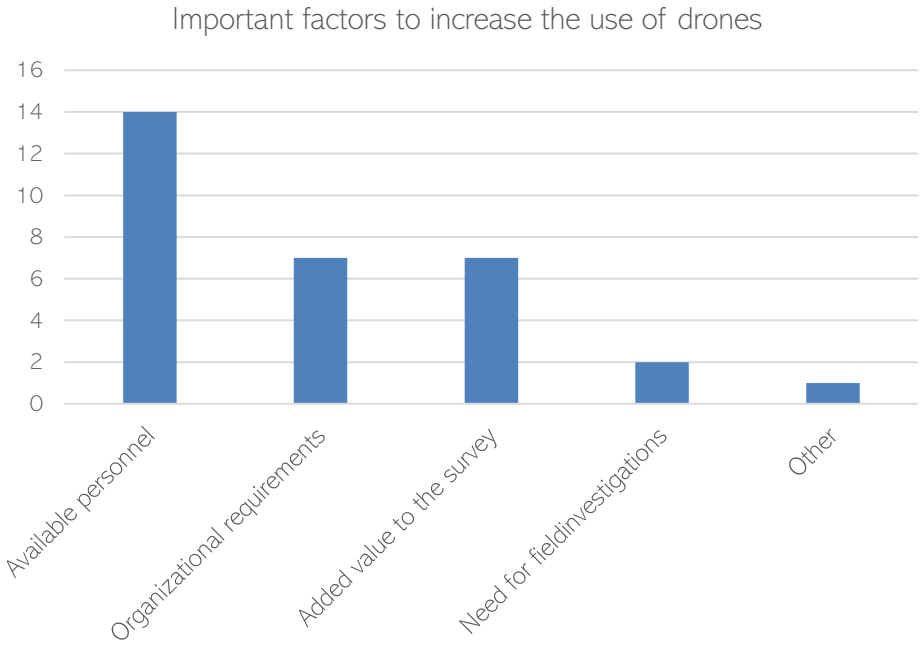

Figure 4-9. Factors that would contribute to an increased use of drone(data) within NPRA. Multiple answers were possible (n = 15).

5 Summary

The survey provided insights on the use of drones in the road sector to assess roadways exposed to risk due to gravitational process hazards. The survey focussed on the current use of drones within the road owner/operator organisations, as well as drone use going forward. The survey results indicated that the respondents considered drones to be a good tool to provide a quicker, easier, and safer way to assess areas that would otherwise be difficult to reach. Overall, the survey participants were supportive about increasing the use drones and drone data. However, to increase drone usage, there were obstacles noted that need to be addressed.

Key takeaways from the survey include:

- Drones provide an easier and more efficient method to obtain an overview of an area, or an incident that deposited material (snow, rocks, mud) on a roadway than conventional site visits. Drones are, among other things, used to support decisions regarding opening or closing of roads, and also to evaluate the safety and risk connected to fallen material in an area.
- The biggest obstacle to increase the use of drones within the organisations surveyed is the lack of personnel certified to use drones. Staff find it difficult to prioritize drone competence building during a busy workday. The certification process is perceived as time-consuming and there is also some dissatisfaction with the fact that the regulations do vary depending on the size of the drone. It was mentioned in the survey that if the certification process and the administrative work was a bit less extensive, drone use would likely increase.
- A second obstacle to increased drone usage is the large amount of data collected by drone and the handling of that data. Most of the drone data are from optical cameras, since the majority of the survey respondents use photos and video sensors on the drone. Only a few respondents reported using terrain models. It is mentioned that lack of knowledge might prevent drone users from taking full advantage of the collected data.
- The participants take HSE considerations into account when operating a drone, and most of the organisations have developed, or are in the process of developing, operational manuals and procedures.
- The majority of the respondents would like to increase the use of drones and drone data within their organisation. The majority requested optical data while several wanted data from laser scanning.

6 Recommendations

Based on the analysis of the survey results, the following recommendations are made to support increased use of drones within the NPRA:

- When the participants were asked to rank their knowledge about the use of drones within the organisation between 1; “I know we have drones, but not much more” to 5; “This is something I work with often”, the majority ranked their knowledge at a 3, or below. This suggests that many NPRA employees have somewhat limited knowledge concerning drone usage. As a first step to increase the use of drones, it is recommended that increasing the overall level of information about how drones are used, or can be used, within the organisation, is needed. This could be achieved through workshops, participation in field tests and demonstrations (such as conducted as part of GEOSFAIR), and in-house presentations of use cases where drones have been effectively used to address NPRA needs.
- Based on the respondents' answers, when planning a potential drone survey, or mobilising people and equipment for a job, a main challenge is access to available personnel who can operate the drone. The survey indicated that an important element of whether a drone is used for a specific project or not is simply the timely presence of available staff with the correct expertise. Based on this, it is recommended an effort to certify more staff in drone operations. To make NPRA staff supportive of drone training, the organization should clearly communicate the advantages of using drones and facilitate access to certification for any staff who are interested.
- The certification process is perceived by the survey respondents to be time-consuming and difficult to prioritise as part of their daily work activities. Based on this, and as mentioned in the recommendation above, it is recommended that employees are encouraged to complete drone certification by facilitating time and resources to do so while at work. One way of achieving this might be to arrange day-courses or give the employees a certain number of hours to complete the certification, so that the time is clearly allocated for certification. This might include, for example, the NPRA sponsoring periodic certification sessions.
- Another barrier to the use of drones is that requirements and regulations for operating a drone are perceived as extensive and overly complicated. It is recommended to focus on training and making personnel more familiar with the requirements, so that following them ends up as a routine or habitual task, rather than having to re-learn the requirements before each drone operation. The NPRA should also make sure that procedures are well documented and logical, to minimize the burden of administrative work when a drone is used.
- As drones are used by NPRA staff during both routine or planned operations surveys and during acute and emergency situations, it is important that available personnel have access to drones on short notice. It recommended that the NPRA have enough drones to quickly respond to acute situations, but this number will be

limited by the number of NPRA staff certified for operating drones at a given location or office.

- Some respondents reported that obtaining internal NPRA approval for using drones in projects was time consuming. It is recommended that NPRA creates an easy and standard procedure both for the applicant, and for management granting permission, to use drones.
- Handling the large amount data that can be collected by a drone was mentioned as a challenge. It was mentioned by survey respondents that they may not be able to fully utilize the collected data, due to lack of knowledge on how to handle or process this data. To address this barrier, it is recommended that the NPRA arrange courses on the tools and software used to handle data generated from drones. This will help ensure that those who are operating drones are familiar with how to handle data, and the various options available for effective use of the data. The NPRA should also demonstrate the software and processing steps for drone generated data and create easy-to-follow data handling procedures and perhaps, processing frameworks.
- Most NPRA drone operations use optical camera-based data with most of the output being photos and videos. However, as supported by the GEOSFAIR goals, drones provide the opportunity to collect data using a range of sensors such as lidar or radar. Simple use of optical data from a drone might miss opportunities to collect better or complementary information. Increasing knowledge about the different types of data that can be collected by drones, and the application of this data, will support the increased utilisation of drones by NPRA staff. The use of other forms of drone-derived data can be supported by field tests and demonstrations (for example as completed by GEOSFAIR) and by developing associated software procedures for routine handling of data.

Kontroll- og referanseside/ Review and reference page

Dokumentinformasjon/*Document information*		
Dokumenttittel/*Document title* Consolidation of requirements - Analysis of questionnaire		**Dokumentnr./*Document no.*** 20210309-02-R
Dokumenttype/*Type of document* Rapport / Report	**Oppdragsgiver/*Client*** The Norwegian Research Council	**Dato/*Date*** 2022-11-08
Rettigheter til dokumentet iht kontrakt/ *Proprietary rights to the document according to contract* Oppdragsgiver / Client		**Rev.nr.&dato/*Rev.no.&date*** 0 / 2022-11-08
Distribusjon/*Distribution* ÅPEN: Skal tilgjengeliggjøres i åpent arkiv (BRAGE) / OPEN: To be published in open archives (BRAGE)		
Emneord/*Keywords* GEOSFAIR, UAV, RPAS, drone, usage of drones, NPRA		

Stedfesting/*Geographical information*	
Land, fylke/*Country*	**Havområde/*Offshore area***
Kommune/*Municipality*	**Feltnavn/*Field name***
Sted/*Location*	**Sted/*Location***
Kartblad/*Map*	**Felt, blokknr./*Field, Block No.***
UTM-koordinater/*UTM-coordinates* **Zone: East: North:**	**Koordinater/*Coordinates*** **Projection, datum: East: North:**

Dokumentkontroll/*Document control*
Kvalitetssikring i henhold til/*Quality assurance according to NS-EN ISO9001*

Rev/ *Rev.*	**Revisjonsgrunnlag/*Reason for revision***	**Egenkontroll av/ *Self review by:***	**Sidemanns-kontroll av/ *Colleague review by:***	**Uavhengig kontroll av/ *Independent review by*:**	**Tverrfaglig kontroll av/ *Interdisciplinary review by:***
0	Original document	2022-08-19 Elisabeth Hoffstad Reutz / Regula Frauenfelder	2022-11-04 Sean Salazar		

Dokument godkjent for utsendelse/ *Document approved for release*	**Dato/*Date***	**Prosjektleder/*Project Manager***
	8 November 2022	Regula Frauenfelder

NGI (Norwegian Geotechnical Institute) is a leading international centre for research and consulting within the geosciences. NGI develops optimum solutions for society and offers expertise on the behaviour of soil, rock and snow and their interaction with the natural and built environment.

NGI works within the following sectors: Geotechnics and Environment – Offshore energy – Natural Hazards – GeoData and Technology

NGI is a private foundation with office and laboratories in Oslo, a branch office in Trondheim and daughter companies in Houston, Texas, USA and in Perth, Western Australia

www.ngi.no

NGI (Norges Geotekniske Institutt) er et internasjonalt ledende senter for forskning og rådgivning innen ingeniørrelaterte geofag. Vi tilbyr ekspertise om jord, berg og snø og deres påvirkning på miljøet, konstruksjoner og anlegg, og hvordan jord og berg kan benyttes som byggegrunn og byggemateriale.

Vi arbeider i følgende markeder: GeoMiljø – Offshore energi – Naturfare – GeoData og teknologi.

NGI er en privat næringsdrivende stiftelse med kontor og laboratorier i Oslo, avdelingskontor i Trondheim og datterselskaper i Houston, Texas, USA og i Perth, Western Australia.

www.ngi.no

OSLO
TRONDHEIM
HOUSTON
PERTH

NORWEGIAN GEOTECHNICAL INSTITUTE
NGI.NO

Main office
PO Box 3930 Ullevaal St.
NO-0806 Oslo
Norway

Trondheim office
PO Box 5687 Torgarden
NO-7485 Trondheim
Norway

T (+47)22 02 30 00
NGI@ngi.no

BIC NO. DNBANOKK
IBAN NO26 5096 0501 281
ORGANISATION NO.
958 254 318MVA

ISO 9001/14001
CERTIFIED BY BSI
FS 32989/EMS 612006