Avinor

Reporting for Part 1 and Part 2 of the Norwegian Environment Agency's orders: "Overall assessment of PFAS contamination at Avinor's airports"

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Summary

Avinor has been directed by the Norwegian Environment Agency to conduct an overall assessment of PFAS contamination at 39 of its airports. A total of 59 sites have been examined for PFAS at these airports. The order is comprised of three parts;

- Part 1 comprises a report from surveys conducted at the airports
- Part 2 comprises an assessment of possible remedial action for PFAS-contaminated soil, as well as a calculation of the cost of implementation and prioritisation of contaminated sites based on cost/effect
- Part 3 is a separate assessment of the risk of local impacts due to the contamination

Part 1 and Part 2 are reported here, and Part 3 is covered in Norconsult's report «Reporting for Part 3 of the Norwegian Environment Agency's orders: "Overall assessment of PFAS contamination at Avinor's airports"

The surveys at the airports consist mainly of the results from the first surveys of PFAS conducted on the fire training sites (BØF), in connection with Avinor's Environmental Project in the period 2010-2015 (sub-project 2, DP2). In the DP2 surveys, PFOS was detected at almost all of the fire training sites. At 18 of the airports, an extended risk assessment of local conditions was carried out. Sixteen of these eighteen airports are affected by the order.

In Part 1 of the order, reports have been prepared from surveys carried out at the 59 sites examined. A total of 32 sites have acalculated volume of ≥ 0.5 kg and are considered to have been well enough surveyed for the assessment of remedial action, cost calculation and prioritisation of measures in Part 2. A total of 10 sites are assessed to have such low concentrations and/or volume in soil (< 0.5 kg) that they will not be included in cost/effect assessments and prioritisation in Part 2. Seventeen of the sites are too poorly surveyed for them to be included in Part 2.

For the 32 sites that are considered to have been well enough surveyed, and have a calculated volume of PFOS (kg) in the ground ≥ 0.5 kg, calculated volume ranges from 0.5 to 81 kg per site. The total calculated volume of PFOS for these 32 sites is approximately 314 kg, but as many sites are not delimitated downwards to concentrations < 3 µg/kg in area and depth, uncertainty for this estimate is that the volume can vary from half (approximately 130 kg) to more than twice as large (approx. 800 kg).

In Part 2 of the order, a literature review has been carried out for the comparison and assessment of the suitability of various methods of action. On the basis of the literature review, *in situ* and *ex situ* methods of action for saturated and unsaturated zones respectively (above/below groundwater level) have been compared, and the suitability of methods assessed based on the level of development (lab, pilot and in use) and documented long-term efficacy. The methods of development "in use" deemed suitable for measures in contaminated masses are coverage/shielding, incineration and external landfill disposal, and for groundwater "pump and treat". Incineration is currently the most expensive method per volume of contaminated masses compared to covering or excavation and landfill disposal, and no cost has been calculated for remedial action using this method.

For all the sites in Part 2 (n=32), the suitability of the sites for the implementation of measures using the three methods has been assessed. The assessments are based on the site-specific information that has emerged from the surveys of the localities, such as mass type, whether the pollution is in contact with groundwater, proximity to the sea, proven concentrations of PFOS/ΣPFAS in groundwater, etc. A total of three sites are considered to be potentially suitable for carrying out "pump and treat", four sites are

considered as suitable for covering/shielding (two of these in combination with "pump and treat"), and all localities are considered suitable for excavation and external disposal.

In view of the order's wording regarding "removal of PFAS from circulation", and for the most comparable cost/effect assessment between the different sites and scope of action, the priority order of remedial action methods is based on excavation and external disposal at approved landfill for PFAS contaminated masses, as well as coverage. Water purification has been included in the construction phase for all localities where the measures include excavation below groundwater levels

Furthermore, site-specific action limits have been set for each location. The limit of remedial action is set to the concentration limit where the volume of PFOS/ΣPFAS removed is significantly reduced, and/or the cost per kg removed increases significantly. Finally, the sites are ranked by cost per kg of PFOS/ΣPFAS removed with the proposed site-specific action limit.

The site with the lowest cost per kg of PFOS/ΣPFAS removed, and the highest priority for measures, is Rørvik BØF 2, followed by Kristiansund BØF B and Tromsø BØF 2. Total cost of measures at Rørvik BØF 2 and Kristiansund BØF B are calculated at 7.5 and 7.3 MNOK repectively, with a cost per kg ΣPFAS removed of NOK 357,000 and NOK 482,000 respectively. Tromsø BØF 2 is the site with the largest volume of PFOS/ΣPFAS removed (96 kg) of all, and due to a relatively large volume of masses (22,000 m^3) the total cost of remedial action will also be relatively high (51 MNOK). The cost per kg Σof PFAS removed at Tromsø BØF 2 is calculated at NOK 533,000.

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1 Introduction

On 2 August 2018, Avinor was directed by the Norwegian Environment Agency to conduct an overall assessment of PFAS contamination at its airports. [1] The order covers all of Avinor's airports, with the exception of Oslo Airport (Gardermoen), Kristiansand Airport (Kjevik), Harstad-Narvik Airport (Evenes) and Longyearbyen Airport on Svalbard, where action plans and/or measures are already required to be prepared based on the risk of local and regional impacts. A total of 39 airports are covered by the order.

The order is divided into three parts;

- Part 1 comprises a report from surveys conducted at the airports
- Part 2 comprises an assessment of possible remedial action for PFAS-contaminated soil, as well as a calculation of the cost of implementation and prioritisation of contaminated sites based on cost/effect
- Part 3 is a separate assessment of the risk of local impacts due to the contamination

Part 1 and Part 2 are reported here, and Part 3 is covered in Norconsult's report «Reporting for Part 3 of the Norwegian Environment Agency's orders: "Overall assessment of PFAS contamination at Avinor's airports" [2].

The reporting in Part 1 forms the basis for the further work on Parts 2 and 3.

1.1 Basis

The basis for reporting in Part 1 is in the order given as the surveys carried out at Norwegian airports until 2017. The surveys at the airports consist mainly of the results from the first surveys of PFAS conducted on the fire training sites, in connection with Avinor's Environmental Project in the period 2010-2015. Contaminated ground was included in Sub-Project 2 (DP2), and in the period 2011-2012, Sweco Norway AS and Cowi AS carried out a survey and risk assessment (based on the Norwegian Environment Agency's Guide 99:01 [3]) of all old and active fire training sites at the airports (DP2 reports). On the basis that PFOS was detected in almost all fire training sites, a classification of probable environmental risk and vulnerability was carried out at the airports with regard to the impact on the local environment and local recipients. The classification resulted in 18 airports being assessed with an uncertain level of risk, or apparent unacceptable risk [4]. In the period 2012-2014, Sweco and Norconsult AS took samples of biota at these 18 airports, and in some places supplementary samples of soil and water. Based on the results of all the surveys, Sweco and Norconsult conducted an extended risk assessment of local conditions for the 18 airports in 2015-2016. The following 16 of these 18 airports are affected by the order:

- Alta
- Bergen
- Fagernes
- Florø
- Haugesund
- Kristiansund
- Lakselv
- Leknes
- Molde
- Røros
- Røst
- Sogndal
- Stavanger
- Tromsø
- Trondheim
- Ålesund

At some of the airports (Fagernes, Narvik (Framnes) and Sogndal) recent biota surveys have been conducted [5], [6], [7] and at Narvik also recent soil surveys [8], [9], [10]. This information has been available during reporting in connection with Part 1 of the order. Other available information for the reporting has been Avinor's vulnerability card for most of the airports, Avinor's environmental monitoring reports from 2017-2018 for some of the airports with active fire training sites (Ålesund, Tromsø, Molde, Kirkenes, Florø, Haugesund and Alta), annual reports (from 2016 or 2017) for oil separators on fire training sites for Stavanger,

Kristiansund and Lakselv, as well as documents (action plans, applications to the County Governor of Troms and Finnmark and permits) related to intermediate storage of PFAS contaminated masses at Hammerfest , Vadsø and Kirkenes airports. The vulnerability cards are Avinor's assessment of vulnerability for recipients at the airports. The environmental monitoring reports are results from annual environmental monitoring at the various airports, which have been sent to the County Governor of the relevant county where the airport is located.

For the first surveys carried out in conjunction with DP2, analyses were mainly carried out for the compounds PFOS and PFOA in soil and water. Some samples were analysed for an extended analysis package with a total of 11 or 12 PFAS compounds, but the number of samples with an extended analysis varies from location to location. In the tables in the DP2 reports, the PFOS, PFOA and 6:2 FTS compounds are shown for soil samples with analysis of multiple PFAS compounds. Analysis of other compounds can be seen in the analysis attachment from the laboratory (in cases where these attachments are complete). The risk assessment reports prepared in 2015-2016 were based on the analysis results of the DP2 surveys, as well as analysis of some soil samples still stored in the laboratory, together with new data from analysis of samples of biota and water samples from 2012 to 2014. During the period that the surveys were conducted, the reporting limit for PFAS compounds in soil changed from approximately <2 µg/kg to <0.1 µg/kg.

2 Part 1

Part 1 of the order is as follows (excerpt from the order):

> *"Create a summary of surveys at Norwegian airports that have been conducted in the years leading up to 2017. Avinor shall report the surveyed volumes and the prevalence of PFOS in the soil at all airports, with the exception of the four airports for which action plans have already been drawn up. The Norwegian Environment Agency has prepared a proposal for a reporting form to be completed for each airport. In cases where the total volume of PFAS is more than 20% higher than the volume of PFOS, we also want total volumes of PFAS to be stated"* **[1]**.

2.1 Methodology for Part 1

2.1.1 Reporting per airport (Appendix A - Reporting forms for Part 1)

2.1.1.1 Drawings

For each airport, there are the following map illustrations:

- Overview map for the airport with sites examined for PFOS/PFAS. Overview maps from the 2015/2016 risk assessment reports have been used for those airports that have such and DP2 reports for the remainder. A new overview map has only been created for Narvik.
- For sites for which volumes have been calculated, two different map figures have been prepared. One map illustration shows the concentration intervals in the top soil (0-1 meters) based on interpolation using average concentration in samples from this depth in each sample point. The highest detected concentration has also been shown in the sampling point regardless of sampling depth. The second map illustration shows the concentration intervals in the total of the surveyed volume based on interpolation using average concentration in samples from all depths in each sample point. The highest detected concentration has also been shown in the sample point. The difference in the concentration intervals in the interpolated area of the two map illustrations will show where the highest concentrations have been detected (top soil or deeper masses).
- For sites that are not well enough surveyed for volumes to be calculated, only the location of sampling points and the highest detected concentration have been shown in each sampling point.

2.1.1.2 Volume of PFOS/PFAS used at the site

There have been changes to the types of foam that have been used at Avinor's airports. It is stated in the risk assessment reports that extinguishing foam with PFOS as the main PFAS component was used until 2001, and between 2001 and 2012 a foam with other PFAS compounds was used as the main component. The volume of PFOS should then have been within the requirements of the Product Regulations (up to 0.001 weight percentage or 10 mg/l). The use of foam with PFAS at Avinor's airports was phased out in 2012.

Information on volumes that have been used is mainly only indicated for airports with risk assessment. In the risk assessment reports, an estimate of the volume of PFOS and/or PFAS used at the sites has been carried out based on the period that the fire training site has been used. Information on these calculations is provided in Chapter 5 of the risk assessment reports.

Reference is made in the reports to information from Solberg Scandinavian AS (which was a manufacturer of AFFF) that the percentage of PFAS in foam used before 2001 was 4%, but it is uncertain how much of this was PFOS. Supplier Egenes Brannteknikk AS and manufacturer Dr. Sthamer report that foam used from 2001 to 2011/2012 had a 1.6% PFAS content.

For sites used before 2001, the calculation of the volume of PFOS used is based on 4% PFOS content in the foam. For sites used after 2001 and up to 2011/2012, the calculation of the volume of PFAS used is based on a 1.6% content of PFAS in the foam.

These calculations have uncertainties that have not been quantified. Among other things, prescriptions for different types of extinguishing foam will have varying percentages of PFOS and PFAS. It is not known whether several different types of extinguishing foam have been usedfor all the sites, the time period and frequency of use.

2.1.1.3 Soil sampling and volume calculation

In the reporting form's section on soil sampling (Chapter 1.3 in the forms), the total number of soil samples, the number of soil samples in the range 0-1 meters deep, and the number of soil samples in masses deeper than 1 meter are given. Many samples are taken at intervals that go both over 0-1 meters and deeper than 1 meter. It is therefore commented on how many samples there will be in total when "splitting up the samples" that go over both intervals. I.e. a sample that is, for example, from 0.5-1.5 metres will be entered as two samples in the comment. This will reflect the number of soil samples used in calculating depth uncertainty in the volume calculations (Chapter 2.1.3.3).

Furthermore, the highest concentrations of PFOS and of ΣPFAS in soil are stated. For ΣPFAS in the reporting form, the highest total concentration has been selected. This means that if the highest concentration is in a sample analysed only for PFOS and PFOA, then ΣPFAS is the sum of PFOS and PFOA. In cases where PFOA has not been detected, it will then be the highest concentration of PFOS which is also stated as the highest concentration of ΣPFAS.

Calculated volumes of PFOS/ΣPFAS, and uncertainty intervals above the different concentration limits, have been reported in sub-chapter. 4 in the forms. Interpolated concentration, area and volume of soil used in the calculation are shown for each concentration limit. Comments have been made as to the volumes that have previously been calculated in the risk assessment reports, and for some of the sites volumes are also calculated in the DP2 reports.

It has been assessed whether the contaminated area has been delimitated in horizontal and vertical distribution. To determine whether a PFAS contaminated area is sufficiently delimitated, the outermost sample points are used in the survey area. The criteria that are used are that there must be a minimum of four outer sample points in four different directions relative to the contaminated area, or a physical delimitation such as exposed bedrock. And that the outermost sample points in four different directions are below the reporting limit or less than 3 µg/kg for PFOS/ΣPFAS. In these cases, the contaminated area is considered to be delimitated. For sites where the area is not delimitated within the criteria, as described in Chapter 2.1.3.3, the assumed source area specified in the map illustrations is a discretionary assessment of the amount of area that is not delimitated.

The contaminated area may be delimitated in one or more directions (x,y,z). Lower concentrations in one or more directions (x,y,z) relative to the concentrations in the rest of the examined area may indicate a delimitation in the relevant direction.

In order for a site to be considered to be sufficiently delimitated in depth, one of two criteria must be achieved; either that measurements have been taken in the entire depth down to bedrock, or that concentrations in depth are below the reporting limit or less than 3 µg/kg for PFOS/ΣPFAS.

2.1.1.4 Water sampling and annual dispersion volume

Water samples have been taken as random checks. The concentration of PFOS/ΣPFAS in the water samples will be influenced by different variables such as flow conditions, precipitation, tide, distance from source, etc., thus representing a snapshot. There are extremely varying numbers of samples at each location, and some have only one water sample taken, for example, by a ditch or a small pond, while others have multiple sample points (for example, in streams, surface water and groundwater) and several samples from each point. Water samples were taken in connection with the DP2 project at some of the airports in 2011 and/or 2012, and it is mainly at the 18 airports that have been risk assessed that water samples have also been taken after 2012.

Most of the groundwater wells established in connection with the DP2 project were established in excavation shafts in 2011. Groundwater samples were taken at some airports in 2011, the same year as the establishment, and for some airports samples were taken in 2012. For some of the risk-assessed airports, sampling of these wells was continued. Samples of water have also been taken in excavation shafts in some places. Sampling of groundwater in newly established groundwater wells in excavation shafts is expected to have elevated concentrations of PFAS due to the mobilization of the compounds and suspension in the water, in the same way as when sampling water in excavation shafts.

For water sampling, it has been reported in the form where water samples have been taken, for example groundwater, stream, seawater, oil separator. As with soil samples, the highest concentrations of PFOS and of ΣPFAS in water (groundwater and surface water) are stated, and for ΣPFAS it is the highest overall concentration, regardless of how many compounds are analysed. Water samples from oil separators are not considered representative of surface water, and it is therefore only commented with regard to concentrations in oil separators for the sites where this is sampled.

The total annual dispersion volume of PFOS and ΣPFAS is stated for the total of 41 sites for which estimates are available. Estimates have only been carried out for some of the sites examined in the DP2 surveys, and for all the sites where a risk assessment has been carried out. The calculations carried out of annual dispersion volumes have uncertainties related to the concentrations used in the estimates. In addition, the calculations will have uncertainties related to the volumes of water that are used, and whether the water balance is affected, for example, by trenches and drainage that have not been mapped.

The calculations of annual dispersion volume from the source areas are mainly for PFOS, only a few sites (9) have calculations for ΣPFAS. For 12 sites, leaching is assumed from oil separators. For these, dispersion volumes are mainly calculated for both PFOS and ΣPFAS.

Based on the calculations, it is the discharge from the source areas that has the greatest impact on annual emissions, not emissions from oil separators. From the source areas, emissions of PFOS (including PFAS for the few sites where this is calculated) are calculated between 0.3-912 g/year (average 121 g/year). There are generally relatively high concentrations of ΣPFAS in water from oil separators, but the volumes released are in the risk assessment reports calculated to be between 1-50 g/year for PFOS (average about 9 g/year), and between 6-155 g/year for PFAS (average 53 g/year).

2.1.1.5 Biota sampling

It is stated for each site whether biota samples have been taken, the type of biota, the number of samples taken and the highest detected concentration of PFOS and ΣPFAS. For comparison with the highest detected concentrations on the site, the median concentration in a comparable population of the species in question is also stated at another site.

Samples of aquatic biota are mainly taken, and a few samples of terrestrial biota (such as vegetation, earthworms). For the sites where biota samples have been taken, there is a large variation in the number of samples, and in the species that have been sampled. Different species have different ways of life and ways of obtaining nourishment, and will thus show different effects of PFAS contamination. Samples of stationary species (such as annelid, seaweed, common limpet) taken in an area affected by the source can be expected to have higher concentrations than non-stationary species (such as cod and salmon).

Uncertainty is still associated with assessments of the impact and risk of PFAS in biota. This is reflected in the fact that EFSA, in a risk assessment dated 13 December 2018, established new temporary critical loads for PFOA and PFOS. However, for PFOS and for PFOA, the temporary critical load (given as TWI - tolerable weekly intake) is set to 13 and 6 ng/kg body weight per week respectively (converted to TDI PFOS (13/7 =) 1.86 ng/kg body weight /day PFOA (6/7 =) 0.86). The critical loads are temporary based on the fact that there are questions in the assessment that are unresolved, and that an assessment should be made of whether to impose total critical loads for several PFAS compounds [11], [12].

Biota and annual dispersion volumes are part of a local risk assessment in Part 3 of the order, described in Norconsult's report Reporting for Part 3 of the Norwegian Environment Agency's orders: "Overall assessment of PFAS contamination at Avinor's airports" [2].

2.1.1.6 Uncertainty and other factors

Does the estimate of the volume of PFOS in the soil correspond with the measured concentrations in water and biota?

For most airports, insufficient surveying has been carried out to provide a sure answer to this question. There is a large variation in the sample range in soil, water and biota. As a result, for some of the sites there will be great uncertainties in the estimated volumes of PFOS in soil, and too few samples in water or biota to assess whether the concentrations are representative. In many cases, however, the samples can give an indication of whether the volume in the soil is correct.

For all sites with both calculations of the volume of PFOS in the soil, water and/or biota samples, an assessment has been carried out of whether the estimation of the volume of PFOS in the soil is likely to correspond to measured concentrations in water and biota. For some sites, it is concluded that it is likely that there is a possibility that there is a contribution to the spread of PFAS from other sources at the airport.

The volume of PFOS in the soil will depend on conditions such as when there has been activity at the site, how much foam has been used, type of masses, and depth to groundwater. Measured concentrations in water will depend on conditions such as where the sample is taken in relation to the source area, dispersion direction and water volumes at the sampling point. Concentrations in the same sample point can vary significantly depending on the sampling time for the different samples. Measured concentrations in biota will depend on different factors such as the age and trophic level of the individual, where the sample is taken in relation to the direction of dispersion from the source, type of biota, the recipient's proximity to the source, size and water replacement. PFAS in biota samples will to a greater extent represent an effect over time compared to water samples that would represent a snapshot.

Has the site been sufficiently surveyed with a view to assessing the order of prioritisation?

This is assessed according to criteria for calculating volumes given in Chapter 2.1.3.1, thus leading to a division of the sites into three categories;

- Aggregate-calculated sites ranked in priority order
- Sites that have low concentrations and/or volumes of PFOS/ΣPFAS (<0.5 kg)

- Sites that are insufficiently surveyed

The criteria for calculating volumes of PFOS/ΣPFAS are set so that the priority order for sites with respect to remedial action shall be based on the most equal basis for all sites. The volume of PFOS/ΣPFAS is calculated for all sites that meet the criteria. For those sites that do not meet the criteria, there is either so little PFOS/ΣPFAS in soil that the sites cannot be prioritised for measures based on a cost/effect assessment, or they are considered to be poorly surveyed. Sites where the analysed soil sampleshave lower concentrations than what is given in criteria for calculating amounts in Chapter 2.1.3.1 and/or volumes of PFOS/ΣPFAS in the examined volume is less than 0.5 kgare considered to have too low a volume in soil to be prioritised based on a cost/effect assessment. In cases where sites are considered to be insufficiently surveyed there may be special conditions at the site, such as the fact that the runway has been extended and laid over old fire training sites, or that it is uncertain whether the area for BØF has actually been examined (some sites have no clear signs in the terrain of where fire training has taken place). For these sites, there may be indications that there is PFAS in the ground (for example, sites where concentration in water samples indicate that the amount of leakage may be high), but they cannot be prioritised based on the calculated volume of PFOS/ΣPFAS in soil and fall out of the priority list.

Other factors of significance for any clean-up/ initiation of measures

In the last part of the reporting forms (Sub-Chapter 7) information from Naturbase (www.naturbase.no) is included about registered protected areas, species of national administration interest, nature types, intervention-free natural areas, or recreation areas. Avinor's airport vulnerability assessment has also been provided for some of the airports, as well as information on angling or drinking water sources. These are factors that are part of the local risk assessment in Part 3 of the order [2]. If other factors have been identified that may be of significance for cleanup, this has been commented on.

2.1.2 Sites where the total volume of ΣPFAS is more than 20% higher than the volume of PFOS

At active airports, or airports where fire training sites (BØF) have been closed later than 2001, foam with PFAS compounds other than PFOS may have been used as their main components. At these sites, concentrations and volumes of ΣPFAS can be expected to be significantly higher than concentrations and volumes of PFOS. This is also the case at some other sites, which is due to the fact that in foam with PFOS as the main component there will be a mix of different compounds in smaller concentrations. The Norwegian Environment Agency's order asks for an assessment of whether there are sites where the total volume of ΣPFAS is more than 20% higher than the volume of PFOS. This shall be used in assessing whether the site should be given a higher priority in Part 2 of the order, than if emphasis is only placed on PFOS [1].

An assessment has been made for each site as to whether there is an indication that the soil contamination has a significant contribution from other PFAS compounds in addition to PFOS. The following criteria are set to determine if there is such an indication:

- There must be a minimum of four soil samples analysed for more PFAS compounds than PFOS and PFOA
- At least two of the soil samples must have concentrations of ΣPFAS more than 20% higher than PFOS concentrations
- The average of ΣPFAS /PFOS for all soil samples analysed for multiple PFAS compounds at the site > 1.2

If the first criterion is not met, there is no data basis for assessing ΣPFAS at the site. If all the criteria are met, the site is considered to have an indication of significant contamination of other PFAS compounds in addition to PFOS.

2.1.3 Calculations of volumes of PFOS/ΣPFAS in the ground

The purpose for the calculations of volumes of PFOS/ΣPFAS is to have a basis for prioritising possible remedial action. The sampling basis for calculations of volumes of PFOS/ΣPFAS is generally not sufficient to calculate volumes with great precision, as evidenced by the uncertainty of the calculations (Chap. 2.1.3.3). The ground surveys carried out are considered as informative surveys, which can be used to get an overview of which sites have a high degree of pollution, and therefore should be given priority for further examination and measures. This is partly due to the fact that the surveys have been carried out at the same time that the problems associated with PFAS compounds in soil were increasingly actualised, and that for most sites no supplementary soil sampling has been carried out after the contamination was uncovered in the surveys from 2011-2012 (only analysed stored soil samples from 2011-2012). In the period after the surveys were carried out, the level of knowledge and focus on issues related to PFAS compounds has increased. The surveys reveal for most of the sites whether they are contaminated by fire fighting foam, and the probable degree of contamination, but do not provide a delimitation of contamination horizontally and in the depths (as defined in Chapter 2.1.1.3).

The volume calculated will reflect the examined volume of masses. The examined volume is defined by the outermost sampling points, and by the deepest sample. With the exception of the sites where the contamination is delimitated by bedrock, or there are very low concentrations/not detected PFOS/ΣPFAS in the deepest samples, a discretionary average depth has been used. In some sampling points, samples have only been taken in top soil, and in other sampling points there are samples only from deeper lying masses. If there are few sampling points, or few samples have been taken representing different depth levels, the uncertainty in relation to the examined volume will be greater. If there are high concentrations in the extremes or in the deepest samples, this will be reflected in the uncertainty of the calculation that there may be a greater volume than what has been uncovered. The variation in the basis for the different sites also results in a large variation in uncertainty at the sites.

The purpose of the methodology, both for calculating volumes and for uncertainty indication, is for the calculations to be carried out in a uniform manner. The calculations are carried out based on the data basis available, and only for sites that meet the criteria for calculating volumes.

2.1.3.1 Criteria for calculating volumes

The priority order for sites with respect to remedial action will be greatly affected by the volume of PFOS/ΣPFAS in the soil, and costs of removing all or part of it. In order to calculate the volume in soil, the following criteria have been established:

- There must be a minimum of four sampling points
- There must be a minimum of six samples of PFOS/ΣPFAS concentrations > 3 µg/kg
- There must be a minimum of two samples of PFOS/ΣPFAS concentrations > 20 µg/kg

Sites with fewer than four sampling points are considered to have been inadequately examined. Sites that do not meet the last two criteria are considered either to be inadequately examined, or to represent such low volumes in soil that the site will not be included in the prioritisation in Part 2.

The current norm value for concentrations of PFOS in soil is 100 µg/kg. This is being updated and is expected to be significantly lower. The Norwegian Environment Agency has not set condition classes for

PFOS in soil, not general acceptance criteria for concentrations in soil. The action limits for each site will then be set based on cost/effect assessments. The order states that priorities in Part 2 shall be based on cost/effect assessments. It is considered that sites that do not meet the last two requirements for calculating volumes, and otherwise are considered to have been adequately examined, will not be given first priority. This is due to an expectation that in order to remove the equal volume of contamination at low concentrations in soil, measures must be taken for a far greater volume of masses than for remedial action with higher concentrations in soil. Lower concentrations than 20 µg/kg are expected to constitute too low amounts per volume of masses to be appropriate based on a cost/effect assessment, understood as NOK per kg PFOS removed from circulation.

2.1.3.2 Volume calculation

Thevolume of PFOS/ΣPFAS is calculated for the entire examined volume, and for masses at 0-1 metre's depth (Chap. 0). This is done so that in assessing methods,it can be easily assessed whether measures are most effective for top soil (0-1 metres) or for deeper masses (> 1 metre). This in turn relates to the costs of remedial action. Calculated amounts for the entire examined volume are stated in the sub-chapter of the reporting forms. 4 i Appendix A - Reporting forms for Part 1. In the figures in the same chapter of the appendix, both calculated volumes at 0-1 metre depth, and for the entire examined volume are shown.

In each sampling point, an average concentration based on measured PFOS/ΣPFASconcentrations is calculated vertically in the soil profile at the point. The average concentration is calculated in each survey point where there are multiple samples, and for points with only one sample, the detected concentration in the sample is used. Measurements of PFOS/ΣPFAS below the reporting limit are considered as zero in the average calculations. Based on the average PFOSΣ/PFASconcentration in the points, the concentration distribution for the entire survey area (µg/kg) is interpolated using the "natural neighbour" method in the Surfer software.

To perform the calculation of average concentration in top soil, only measurements from the uppermost metre are used. If there are multiple measurements at the same point within the depth interval of 0-1 metre, the average of these is used. Maps are then created for measurements from the uppermost metre in the same way as for the average for the entire survey depth. The average concentration (µg/kg) in each sampling point with samples at 0-1 metre deep is used to interpolate the concentration distribution over the examined area using the "natural neighbour" method in the Surfer software.

The maps have contours according to the seven concentration classes (µg/kg) given in the order <3, 3-30, 30-150, 150-500, 50-1000, 1000-3000 and >3000 µg/kg. The area surveyed is defined by the outermost survey points. For each concentration interval, average concentrations and area will be extracted from each map.

Calculation of the volume of PFOS/ΣPFAS is arrived at as follows for both calculations for the whole of the examined volume, and for the uppermost metre:

1) Calculate volume (m^3) of the masses by multiplying the examined area (m^2) by the thickness of the contaminated masses (m).
2) Calculate the weight (kg) of the masses by multiplying the volume of the masses (m^3) by the density of the masses (kg/m^3). The density of the masses is based on the descriptions in DP2 and the risk assessment reports, and is a discretionary assessment.
3) Calculate weight (kg) PFOS by multiplying weight (kg) of contaminated masses by the proportion of fine material and the average interpolated PFOS/ΣPFASconcentration in the masses (µg/kg). The proportion of fine material (<20 mm) in the masses is established based on the descriptions in DP2 and the risk assessment reports, and is a discretionary assessment.

For each site, the cumulative volume of PFOSΣPFAS (i.e. including all concentrations above) is calculated for the concentration limits stated in the order. That means, the volume of PFOS/ΣPFAS is calculated for concentrations (µg/kg) >3, >30, >150, >500, >1000 and >3000. Applied methodology provides the calculated amount for the examined volume. Insufficient delimitation in the data basis results in uncertainty in the calculations.

2.1.3.3 Uncertainty in the calculations

The uncertainty shall quantify the volumes not revealed through the surveys and volumes that may be over/underestimated based on the survey. The probability of unrevealed volumes will be presented through a discretionary assessment of the size of the area and depth that is not delimitated by the survey. This assessment is related to local variations and depends on how well DP2 or risk assessment reports describe these conditions (such as groundwater level, mass type, depth to bedrock, etc.).

There are a number of factors that influence the uncertainty of each calculation, some of which are quantifiable and some not. Examples of factors that are not possible to quantify, for example, are whether any hotspots have been hit, or how good applied assumptions are in relation to the reality at each site. Uncertainty associated with the survey basis depends on the following:

- Number of sampling points
- Number of samples
- How the sampling points are distributed by area
- How the samples are distributed in depth
- How well the samples seem to find the contamination

It has been chosen to specify an uncertainty interval for each volume calculation based on quantification of uncertainty for the factors of area, depth, volume, density of the masses, weight and proportion of fine material. The amount of uncertainty associated with each factor depends on the basis of the survey, as well as discretionary assessments based on descriptions of the respective sites.

Area

Area uncertainty is calculated based on the minimum number of sampling points. Uncertainty factor within the examined area is established by the formula:

(4/number of sampling points) x area surveyed

In this way, the uncertainty within the area surveyed relates to the number of sampling points that are at each site. With a low number of sampling points per area, parts of the surveyed area are more likely to not be contaminated or more contaminated thus increasing the uncertainty in the volume calculated based on average concentrations at each sampling point.

Uncertainty about the area surveyed is also based on how much larger an area is assumed to be necessary to detect the lowest concentration class or a physical delimitation at the outer edges of the area. This is a discretionary assessment of contaminated area beyond the survey area, assumed source area, which is shown in the map illustrations (Appendix A - Reporting forms for Part 1) for each site.

The uncertainty of the area in each concentration interval is related to the surveyed area and uncertainty factors within (given by the above formula) and outside of the area examined (assumed source area).

Depth

To deal with depth uncertainty in the same way for all calculations, this is also related to the minimum number of sampling points. This is expressed as 4 sample points in relation to the number of samples taken in each depth layer (0-1 metre and deeper). The number of samples used in the calculation is the sum of samples in the depth intervals 0-1 metre and deeper than one metre.

At one metre's depth, the uncertainty is equal to 4/number of samples taken in that layer. For the average of the entire survey volume, the uncertainty is equal to 4/number of samples in the layers, as well as an addition with a discretionary assessment of how much extra depth is assumed to be necessary to obtain a demarcation in depth. The assessment relates to any information about the dispersion potential of the masses/mass type, depth of groundwater and depth to bedrock where information is available, or if samples in depth show that there is no PFOS/ΣPFAS further down than a given depth.

Average concentrations

Uncertainty in calculating the average concentration for each concentration limit of PFOS/ΣPFAS, based on average concentration in single points, is indicated as area and depth uncertainty with PFOS/ΣPFAS, as this is related to the number of sampling points and the number of samples per volume.

A consistent pattern for the sites is that with few exceptions there is a relatively low number of soil samples. There is also often a relatively large difference in measured concentrations, especially at the places where a so-called hotspot is detected. As a result, the median and average concentrations will often be very different. Averages will therefore often provide higher concentrations than the median, and for the high concentrations to be part of the calculation, the average concentration is considered to be most representative.

Volume, density and weight of the masses

Uncertainty related to the volume of the masses comes from uncertainty related to area and depth. I.e. uncertainty about the volume of the masses comes from the examined area in relation to the assumed source area, and the examined extension in depth of the contamination.

Uncertainty regarding the density of the masses and the proportion of fine material in the masses is established after assessment of the type of masses based on the description given of the masses for each site. The degree of detail of the information on mass type given in the descriptions in the reports varies. Uncertainty is generally set at 25%. If the descriptions are good, there is a lower uncertainty.

Uncertainty for the weight of the masses will stem from uncertainty related to volume and density.

Uncertainty related to volume of PFOS/ΣPFAS

Since all the uncertainty factors for the calculated volume of PFOS/ΣPFAS are interrelated, there will be a reproductive uncertainty in the calculation. Reproductive uncertainty is calculated according to:

$$\frac{\Delta z}{z} = \sqrt{\left(\frac{\Delta x}{x}\right)^2 + \left(\frac{\Delta y}{y}\right)^2 + \cdots}$$

x and y are factors in the total z.

The uncertainty of the volume of PFOS/ΣPFAS within the surveyed volume is related to the amount of sample coverage of the area, and the uncertainty of the volume of PFOS/ΣPFAS outside the surveyed area is related to how well the survey apparently finds the contamination, and the local conditions such as

thickness of uncompacted material. At the sites where the results of the survey indicate that the contamination is only partially uncovered, i.e. slightly delimitated in area and/or depth, less uncertainty is assumed within the surveyed area than outside of it.

2.1.3.4 Other uncertainties

- Soil sampling on the fire training sites was mainly carried out in 2011-2012, that is 7-8 years ago, and for sites with a high degree of leakage, the contamination situation may look different today.
- Internal movement/intermediate storage of PFOS/PFAS masses to/from fire training sites after the surveys were carried out.

2.1.3.5 Differences between calculations performed in 2015-2016 and new calculations

For the sites where an extended risk assessment has been carried out in 2015-2016, calculations of the volume of PFOS in soil have also been carried out. Since in 2015-2016, volumes were not calculated for all surveyed sites, as well as the new concentration divisions stated in the order, new volume calculations were needed for the sites. The new methodology, with the intention of prioritising the sites based on the most possible similar basis, is slightly different from previous procedures. The various methods cause the volume estimates to be different.

Differences in methods are:

- The concentration divisions are different, and the area of the contamination will therefore be greater when concentrations down to 3 µg/kg should be included, compared to the use of 100 µg/kg (applicable norm value).
- For the risk assessments, the calculations are carried out more conservatively. Therefore, the proportion of fine material/stone/blocks in the masses has not been taken into account. For calculating the remaining volumes with respect to remedial action, the estimated proportion of stone/blocks from filler is deducted from the volume for the calculation as these will not contain PFOS/PFAS. This will reduce the calculated volume of PFOS/ΣPFAS.
- The risk assessments are based on a discretionary assessment of the estimated extent in area and depth of the contamination, and given a standard deviation of uncertainty for area and depth. The new calculations are based on the area and depth of the survey, and the uncertainty reflects how well the site has been examined (correlation with the number of sample points and soil samples), and a discretionary assessment of the delimitation of contamination based on how well the samples in the examined volume appear to find the contamination.

2.2 Results from Part 1

2.2.1 Reporting per airport

Summary of surveys with calculated volumes of PFOS/ΣPFAS for each airport are given alphabetically in Appendix A - Reporting forms for Part 1 for the 39 of Avinor's airports covered by the order. A total of 59 sites were surveyed at these airports. The sites are shown in Table 1.

2.2.2 Sites where the total volume of /PFAS is more than 20% higher than the volume of PFOS

Table 1 shows how many of the soil samples analysed at the 59 sites were analysed for compounds other than PFOS and PFOA, in how many of the samples concentrations of ,PFAS are more than 20% higher than concentrations of PFOS, as well as whether there are sites indicating significantly higher concentrations of other PFAS compounds than PFOS. The criteria for the assessment are stated in Chapter2.1.2.

The table shows that for many sites there are no or few samples that have been analysed for more compounds than PFOS and PFOA. For some sites, there may be significant volumes of other PFAS compounds in soil that have not been examined. This applies in particular to the active fields Alta, Kirkenes active, Kristiansund active, Stavanger active, Trondheim active and Ålesund active.

A total of 11 sites are considered to have an indication of significantly higher concentrations of PFAS compounds other than PFOS. Eight of these sites are part of Part 2 (Chapter 2.2.3.1), and will have a higher priority than if only PFOS is being emphasised.

Although several of the samples analysed at these sites have concentrations of ΣPFAS more than 20% higher than concentrations of PFOS, there is not a good enough basis to assess how much higher these concentrations are. For that, more samples need to be analysed for multiple PFAS compounds.

Therefore, no amounts of -PFAS are calculated or reported -in the reporting forms Appendix A - Reporting forms for Part 1, except for Molde Airport. The information is only used in the prioritisation in Part 2.

At Molde Airport there is an active and an old BØF in the same place, and since in several of the samples on the new part of BØF PfOS is not detected, but high concentrations of /PFAS, /PFAS have been used in the calculations for this site. Since it is only for Molde that concentrations of /PFAS are included in the calculations, further on in Part 1 of the report, as a simplification, volumes of PFOS will be mentioned in the tables and figures.

Table 1: Overview of the number of samples of the total scope of samples analysed for other PFAS compounds than PFOS and PFOA, how many of the samples with a concentration of /PFAS more than 20% higher than the PFOS concentration, and whether it is indicative of a significant contribution from other PFAS compounds.

Airports and sites	Samples analysed for other PFAS than PFOS and PFOA	PFAS more than 20% higher than PFOS	Indication of significant contribution from other PFAS compounds
Alta Airport - BØF1 (active)	2 of 18	0	Too few samples analysed
Bergen Airport Flesland - BØF 1 (youngest, not active)	6 of 17	4	Yes
Bergen Airport Flesland - BØF 2 (old)	2 of 22	1	Too few samples analysed
Berlevåg Airport - BØF 1 (old)	5 of 18	1	No
Brønnøysund Airport Brønnøy - BØF 1 (not active)	-	-	-
Båtsfjord Airport - BØF 1 (old)	-	-	-
Båtsfjord Airport - BØF 2 (younger, not active)	7 of 7	2	Yes
Fagernes Airport Leirin - BØF A (not active)	-	-	-
Florø Airport - BØF1 (active)	4 of 12	4	Yes
Florø Airport - BØF2 (old)	-	-	-
Førde Airport Bringeland - BØF 1 (old)	1 of 7	1	Too few samples analysed
Hammerfest Airport - BØF 1 (old)	-	-	-
Hammerfest Airport - BØF 2 (not active)	5 of 5	0	No
Hasvik Airport - BØF 1 (old)	-	-	-
Haugesund Airport Karmøy - BØF A (active)	10 of 10	8	Yes
Haugesund Airport Karmøy - BØF B (old)	-	-	-
Honningsvåg Airport Valan - BØF 1 (old)	-	-	-
Kirkenes Airport Høybuktmoen - BØF 1 (old)	-	-	-
Kirkenes Airport Høybuktmoen - BØF 3 (active)	3 of 3	2	Too few samples analysed
Kirkenes Airport Høybuktmoen - Operating area	1 of 12	1	Too few samples analysed
Kristiansund Airport Kvernberget - BØF B (old)	12 of 20	5	Yes
Kristiansund Airport Kvernberget - BØF A (active)	2 of 8	2	Too few samples analysed
Lakselv Airport Banak - BØF 3 (active)	9 of 25	3	No
Leknes Airport - BØF 1 (not active)	3 of 23	0	Too few samples analysed
Mehamn Airport - BØF 1 and 2 (not active)	-	-	-
Mo i Rana Airport Røssvoll - BØF 1 (old)	3 of 21	1	Too few samples analysed
Molde Airport Årø - BØF 1 (active and old)	11 of 38	10	Yes
Mosjøen Airport Kjærstad - BØF 1 (old)	2 of 11	1	Too few samples analysed
Namsos Airport – BØF 1 (old)	-	-	-
Narvik Airport Framnes - BØF North (not active) and filling	28 of 28	5*	Yes
Narvik Airport Framnes - BØF South (old)	-	-	-
Narvik Airport Framnes - Operating area/hangar	19 of 19	1	No
Narvik Airport Framnes - At diesel tank/snow depot	10 of 10	2	No
Røros Airport - BØF 1 (not active)	8 of 23	4	Yes
Rørvik Airport Ryum - BØF 1 (old)	-	-	-
Rørvik Airport Ryum - BØF 2 (younger, but not active)	4 of 11	1	No
Røst Airport - BØF1 (not active)	6 of 14	0	No
Røst Airport - BØF2 (old)	-	-	-
Sandane Airport Anda - BØF 1 (old, not active)	-	-	-
Sandnessjøen Airport Stokka - BØF 1 (old)	-	-	-
Sogndal Airport Haukåsen - BØF1 (not active)	8 of 21	0	No
Stavanger Airport Sola - BØF 1 (active)	-	-	-
Stavanger Airport Sola - BØF 2 (old)	12 of 20	3	No
Stokmarknes - BØF 1	-	-	-
Svolvær Airport Helle - BØF A (Not active)	-	-	-

Airports and sites	Samples analysed for other PFAS than PFOS and PFOA	ΣPFAS more than 20% higher than PFOS	Indication of significant contribution from other PFAS compounds
Svolvær Airport Helle - BØF B (Not active)	-	-	-
Sørkjosen Airport - BØF 1 (old)	-	-	-
Sørkjosen Airport - BØF 2 (not active)	9 of 22	3	Yes
Tromsø Airport Langnes - BØF 1 (active)	6 of 15	5	Yes
Tromsø Airport Langnes - BØF 2 (old)	7 of 15	3	Yes
Trondheim Airport Værnes - BØF 2 (active)	3 of 19	Not detected PFOS or PFAS.	Too few samples analysed
Vadsø Airport - BØF 1 (not active)	4 of 12	0	No
Vardø BØF 2 (oldest)	-	-	-
Vardø Airport Svartnes - BØF 1 (old)	3 of 13	Uncertain, as the analysis reports do not attach DP2 report.	-
Værøy old Airport - BØF 1 (not active)	-	-	-
Værøy Heliport - At the terminal area	-	-	-
Ørsta-Volda Airport Hovden - BØF 1 (old)	3 of 13	2	Too few samples analysed
Ålesund Airport Vigra - BØF 1 (active)	2 of 26	2	Too few samples analysed
Ålesund Airport Vigra - BØF 2 (old)	6 of 32	1	No

Cells marked with - means no samples analysed for anything other than PFOS and PFOA. For Narvik: *Total PFAS is only stated including LOQ in the analysis reports, but the summation of analysed compounds gives an indication of high PFAS concentrations

2.2.3 Calculations of volumes of PFOS/ΣPFAS in the ground

2.2.3.1 Division of sites according to the basis of the survey and calculated volumes

The total of 59 sites surveyed at Avinor airports are divided into three different categories according to how well they are surveyed and the volumes that have been calculated. The criteria for calculating volumes are given in Chapter 2.1.3.1,and categorization of sites given in 2.1.1.6

Table 2 shows the 32 sites that are considered adequately surveyed to be included in the prioritisation in Part 2, with calculated volumes of PFOS (kg) in the ground (≥ 0.5 kg) and with specified uncertainties. In Table 3, the 10 sites are shown that are deemed to have been adequately surveyed but have such low concentrations and/or volumes of PFOS in soil (<0.5 kg) that they will not be included in the prioritisation in Part 2. In Table 4, the 17 sites are shown that are deemed to have been too poorly surveyed to be included in the prioritisation in Part 2.

There are a total of 32 sites that are considered to have been adequately surveyed, and that have calculated volumes of PFOS (kg) in the ground. For these sites, estimated volumes range from 0.5 to 81 kg. The total calculated volume of PFOS for these is approximately 314 kg of PFOS, but as many sites are not delimitated downwards to concentrations of < 130µg/kg in area and depth, uncertainty for this estimate is that the volume can vary from half (approximately 130 kg) to more than twice as much (approx. 800 kg).

For comparison purposes, the estimated consumption of PFOS and PFAS is also stated in the table. For the 17 risk-assessed airports affected by the order, the volume of PFOS used up to 2001 at a total of 19 sites has been estimated. It is estimated that a total of 18,900 kg has been used in these 19 sites alone (volumes range between 5 and 7,000 kg of PFOS). Uncertainty in respect of estimated consumption has not been quantified.

The largest volumes of PFOS in the ground are calculated for Tromsø Airport Langnes BØF 2, which is an old fire training site used during the period 1985-2001. Approximately 80 kg of PFOS has been calculated within the surveyed area at this site, but the uncertainty for the calculation is high, as the contaminated area is not very delimitated. For this site the highest consumption of PFOS is also estimated, with a total of 7,000 kg. The second largest volume of PFOS in the ground is calculated for Ålesund Airport Vigra BØF 2 (old), which was used in the period approx. 1978-1997. Approximately 50 kg of PFOS is estimated in the ground, but also here the uncertainty is high due to low delimitation in the contaminated area. Estimated consumption of PFOS is the third highest for this site, with 1,750 kg. Stavanger BØF 2 (old) has the second highest consumption with 1,790, but a much lower volume of PFOS is calculated in the examined volume for this site, with 5.4 kg.

The reason for the high leakage at Stavanger BØF 2 may be related to several different factors, including mass type. For Stavanger, the masses are described as sand, soil, crushed stone and gravel, while at the old fire training sites in Tromsø and Ålesund there are elements of marsh in the descriptions of the materials.

Table 2: Overview of the sites for which the volume of PFOS (kg) is calculated in the ground, with uncertainty (± kg). For the sites where PFOS/PFAS consumption is calculated, the volume (kg) is shown for comparison. The volume of PFOS at each site is expected to be within the stated uncertainty interval.

Sites for which volumes are calculated	PFOS (kg)	Uncertainty interval (± kg)	Estimated consumption PFOS (kg)	Estimated consumption PFAS (kg)	Comments
Tromsø Airport Langnes - BØF 2 (old)	81	35 - 186	7,000		The volume in soil is expected to be in the range of 35-186 kg PFOS.
Ålesund Airport Vigra - BØF 2 (old)	51	21 - 131	1,750		
Alta Airport - BØF1 (active)	24	15 - 36	900		
Rørvik Airport Ryum - BØF 2 (younger, but not active)	22	7 - 55			
Kirkenes Airport Høybuktmoen - BØF 1 (old)	21	10 - 68			
Kristiansund Airport Kvernberget - BØF B (old)	14	6 - 74	800	25	
Lakselv Airport Banak - BØF 3 (active)	13	6 - 26	810	140	
Berlevåg Airport - BØF 1 (old)	9.4	3.5 - 27			
Molde Airport Årø - BØF 1 (active and old)	9.3	4.7 - 20	1,480	250	Volumes in soil are calculated using concentrations of PFAS.
Tromsø Airport Langnes - BØF 1 (active)	8.4	3.3 - 22		1,900	
Bergen Airport Flesland - BØF 1 (youngest, not active)	7.9	2.1 - 31	580	430	
Haugesund Airport Karmøy - BØF B (old)	6.1	2.6 - 15		30	
Stavanger Airport Sola - BØF 2 (old)	5.4	2.4 - 13	1,790		
Bergen Airport Flesland - BØF 2 (old)	4.5	2.3 - 8.2	1,450		
Mo i Rana Airport Røssvoll - BØF 1 (old)	3.8	1.5 - 8.4			
Røros Airport - BØF 1 (not active)	3.8	0.9 - 7.2	480	90	
Mosjøen Airport Kjærstad - BØF 1 (old)	3.4	1.7 - 5.4			
Hammerfest Airport - BØF 1 (old)	3.2	1.1 - 12			
Sandnessjøen Airport Stokka - BØF 1 (old)	3.1	1.0 - 6.4			
Leknes Airport - BØF 1 (not active)	3.0	1.4 - 6.5	18	4	
Sørkjosen Airport - BØF 1 (old)	2.8	0.5 - 6.9			
Narvik Airport Framnes - BØF North (not active) and filling	2.6	0.9 - 12			
Ålesund Airport Vigra - BØF 1 (active)	2.5	1.1 - 4.0	370	405	
Fagernes Airport Leirin - BØF A (not active)	2.1	0.9 - 5.2	76	24	
Sogndal Airport Haukåsen - BØF1 (not active)	1.1	0.5 - 2.9	230	15	
Røst Airport - BØF1 (not active)	1.0	0.3 - 4.6	5	5	
Kirkenes Airport Høybuktmoen - Operating area	1.0	0.2 - 2.8			
Florø Airport - BØF1 (active)	1.0	0.3 - 1.9		70	
Ørsta-Volda Airport Hovden - BØF 1 (old)	0.8	0.4 - 1.8			
Kristiansund Airport Kvernberget - BØF A (active)	0.7	0.2 - 1.4		105	
Vardø Airport Svartnes - BØF 1 (old)	0.6	0.2 - 1.5			

Svolvær Airport Helle - BØF B (Not active)	0.5	0.1 - 1.1			
Total	**314**	**134 - 804**	**18,904**	**3,493**	

Table 3: Overview of sites that have too low concentrations and/or volumes (<0.5 kg) in soil for action to be appropriate.

Sites with low concentrations and/or amounts in soil	PFOS (kg)	Uncertainty interval (± kg)	Comments
Narvik Airport Framnes - Operating area/hangar	0.2	0.1-0.3	Low concentrations (19 samples)
Honningsvåg Airport Valan - BØF 1 (old)	0.1	0.06-0.2	Thin cover of unconsolidated material, small amount (26 samples)
Haugesund Airport Karmøy - BØF A (active)	0.05		Amount taken from DP2 report. Low concentrations of PFOS and PFAS (10 samples)
Værøy old Airport - BØF 1 (not active)	0.05		Amount taken from DP2 report. Low concentrations (8 samples), site used only 4 years
Røst Airport - BØF2 (old)	0.02	0-0.22	6 samples, thin layer of loose masses and naturally delimitated by terrain
Narvik Airport Framnes - At diesel tank/snow depot	0.01	0.001-0.06	Low concentrations (10 samples)
Hasvik Airport - BØF 1 (old)	0.01	0.005-16	Thin cover of loose masses, low concentrations (12 samples), small quantity
Båtsfjord Airport - BØF 2 (younger, not active)			Not estimated, low concentrations of PFOS and PFAS (7 samples)
Værøy Heliport - At the terminal area			Not calculated, low concentrations (5 samples)
Hammerfest Airport - BØF 2 (not active)			Not calculated, low concentrations (5 samples), BØF established in 2011/2012

Table 4: Overview of sites deemed inadequately surveyed.

Sites that are inadequately surveyed	PFOS (kg)	Comments
Brønnøysund Airport Brønnøy - BØF 1 (not active)	14.7	Amount taken from DP2 report. BØF is under runway.
Førde Airport Bringeland - BØF 1 (old)	1.4	Amount taken from DP2 report. BØF is under runway (7 samples).
Trondheim Airport Værnes - BØF 2 (active)	1	Amount taken from DP2 report. Low PFOS concentrations (19 samples), but active field has not been examined for PFAS.
Stavanger Airport Sola - BØF 1 (active)	0.2	Amount taken from DP2 report. Low PFOS concentrations (10 samples), but active field has not been examined for PFAS.
Båtsfjord Airport - BØF 1 (old)	0.07	Amount taken from DP2 report. Not sure the samples hit the centre of BØF (5 samples).
Mehamn Airport - BØF 1 and 2 (not active)	0.09	Amount taken from DP2 report. BØF is under runway (12 samples).
Vadsø Airport - BØF 1 (not active)		Only one sample from deeper layers, and due to errors in the tables in the DP2 report, it is uncertain whether it is the sample with the highest concentration.
Sandane Airport Anda - BØF 1 (old, not active)		Probably not examined in the area for BØF.
Sørkjosen Airport - BØF 2 (not active)		The contaminated area is not very delimitated, and training may have taken place south/southwest of the surveyed area.
Namsos Airport – BØF 1 (old)		Uncertainty related to sampling, the relatively small area examined and not very delimitated.
Rørvik Airport Ryum - BØF 1 (old)		Not calculated, not sure the samples hit the centre of BØF (7 samples).
Florø Airport - BØF2 (old)		Not calculated, samples not taken in the centre of BØF (4 samples).
Kirkenes Airport Høybuktmoen - BØF 3 (active)		Not calculated, too few sample points (3 samples), active field has not been examined for other PFAS compounds.
Narvik Airport Framnes - BØF South (old)		Not calculated, samples not taken of BØF itself (7 samples).
Stokmarknes - BØF 1		Not calculated, too few sample points (3 samples).
Vardø BØF 2 (oldest)		Not calculated, too few sample points (3 samples).
Svolvær Airport Helle - BØF A (Not active)		Not calculated, uncertain whether the samples are of BØF itself (7 samples).

2.2.3.2 Volume of PFOS and volume of masses

Calculated volumes of PFOS (≥ 0.5 kg) within surveyed sites at Avinor airports are shown in Figure 1, Figure 2 and in the overview map in Appendix B. Calculated volumes of PFOS and volume of masses within the surveyed area at each site are shown in Figure 3.

It is the sites with high concentrations of PFOS in soil that will have the highest amounts per volume. This is useful information for assessment of measures, as the cost of measures in most cases is expected to be linked to the volume of contaminated masses. For those sites where the amount of PFOS per volume is low, the volume for which measures are to be implemented will be large, and it is therefore expected that remedial action at such sites will be far more expensive per kg of PFOS than remedial action where the amounts are more concentrated in a smaller volume. Figure 4 shows the calculated amount of PFOS per examined volume of masses (g/m^3) at the various sites.

In Figure 5shows the average amount of PFOS per examined volume (g/m^3) above the stated concentration limits and the amount of PFOS (kg) within the examined area at each of the sites. In Table 5, sites are ranked according to the average amount of PFOS per volume (g/m^3) above the given concentration limits, from the highest to the lowest. If there is a high figure for the average amount per volume, this shows that the site has a significant volume of concentrations above the high concentration limits. It is stated in this ranking that, for example, Rørvik BØF 2 and Tromsø BØF 2 have high estimated amounts of PFOS (kg), and also the largest proportions of the amounts above the high concentration limits. For Kirkenes BØF 1 and Lakselv BØF 3 there are also relatively high estimated amounts of PFOS, but of these amounts the largest proportions are not above the high concentration limits. This can also be seen in Figure6 and Figure9 showing calculated amounts and volume of masses in separate figures for Rørvik BØF 2, Tromsø BØF 2, Kirkenes BØF 1 and Lakselv BØF 3. Figure7, Figure8, Figure 10 and Figure 11 shows map figures for the same sites with interpolation of concentrations in the different class divisions based on soil samples at 0-1 metre's depth, and based on soil samples throughout the examined depth.

Figure6 and Figure7 also shows that for Tromsø BØF 2, the highest detected concentrations in masses are deeper than 1 metre. For Rørvik BØF 2 the survey has only been carried out to a depth of 1.1 metres, and it is described in the DP2 report that the centre of the field is located on a small hill where it is shallow to the bedrock on top of this, and more loose masses to the southeast. Therefore, there is almost no difference in calculated amounts at 0-1 metres and throughout the examined volume.

For Kirkenes BØF 1 and Lakselv BØF 3 there are slightly lower concentrations in soil than at Rørvik BØF 2 and Tromsø BØF 2, but concentrations are more evenly distributed throughout the examined depth interval, so that almost half the amount is estimated to lie at 0-1 metre's depth.

For Tromsø BØF 2, the concentration in the outermost point to the northeast (section 2) is very high and is not delimitated, which results in a high degree of uncertainty in the calculation. Rørvik BØF 2 and Kirkenes BØF 1 also have inadequate delimitation in contaminated areas, and relatively high uncertainty. Lakselv apparently has a better delimitation of the highest concentrations. In Figure 12 are shown examples of delimitation of contamination at Ålesund BØF 2 and Alta BØF 1. At Ålesund BØF 2, high concentrations have been shown in the centre of the training site, but high concentrations have also been detected at one extreme point to the west, which results in a considerable uncertainty in the calculation. For Alta BØF 1, the highest concentrations are more delimitated, in addition to the fact that the area has a natural delimitation to the surrounding sea.

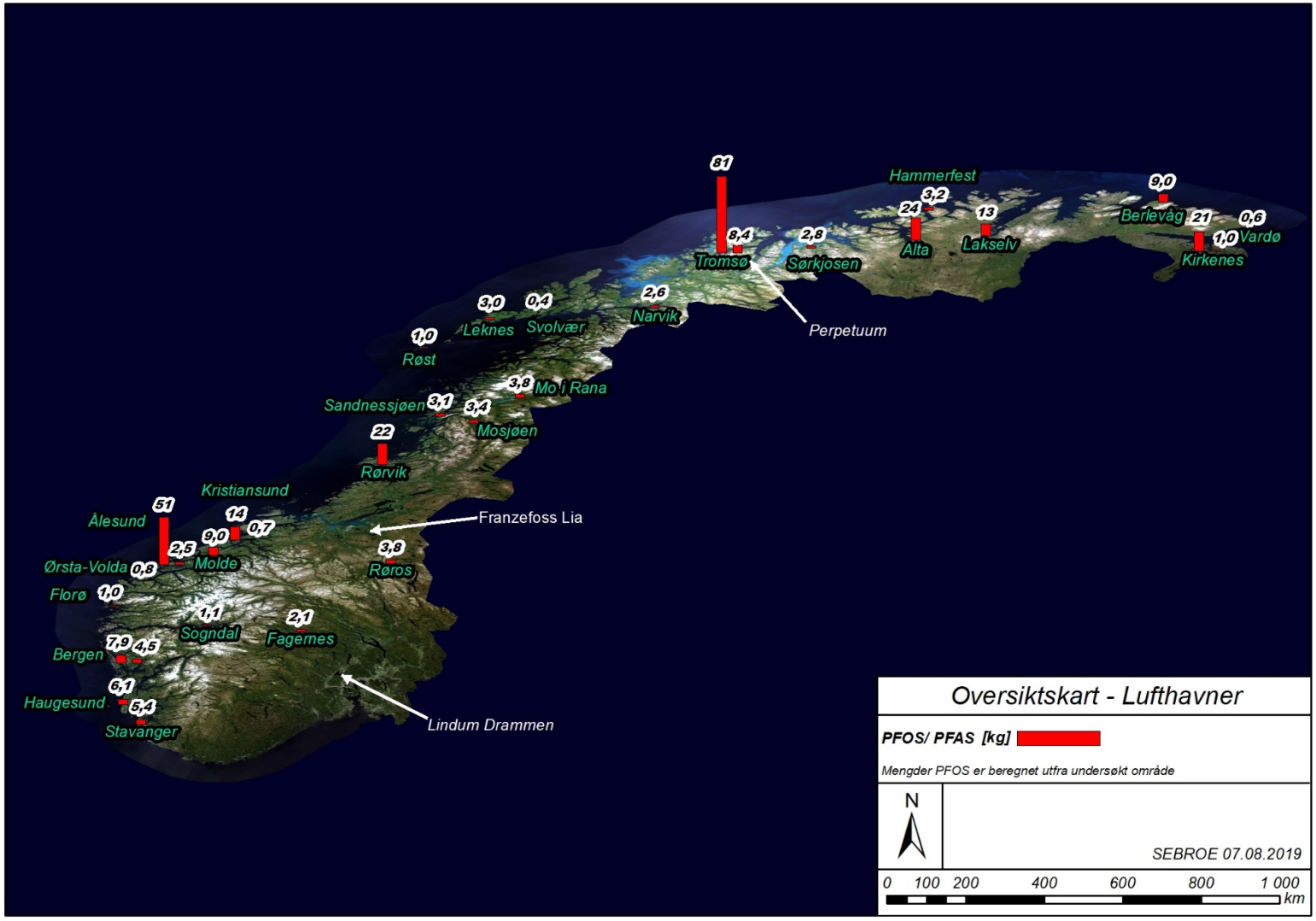


Figure 1: Localization of the sites with calculated amounts of PFOS within the surveyed area, and the localization of landfills with permission to deposit PFAS contaminated masses (see Chapter 0).

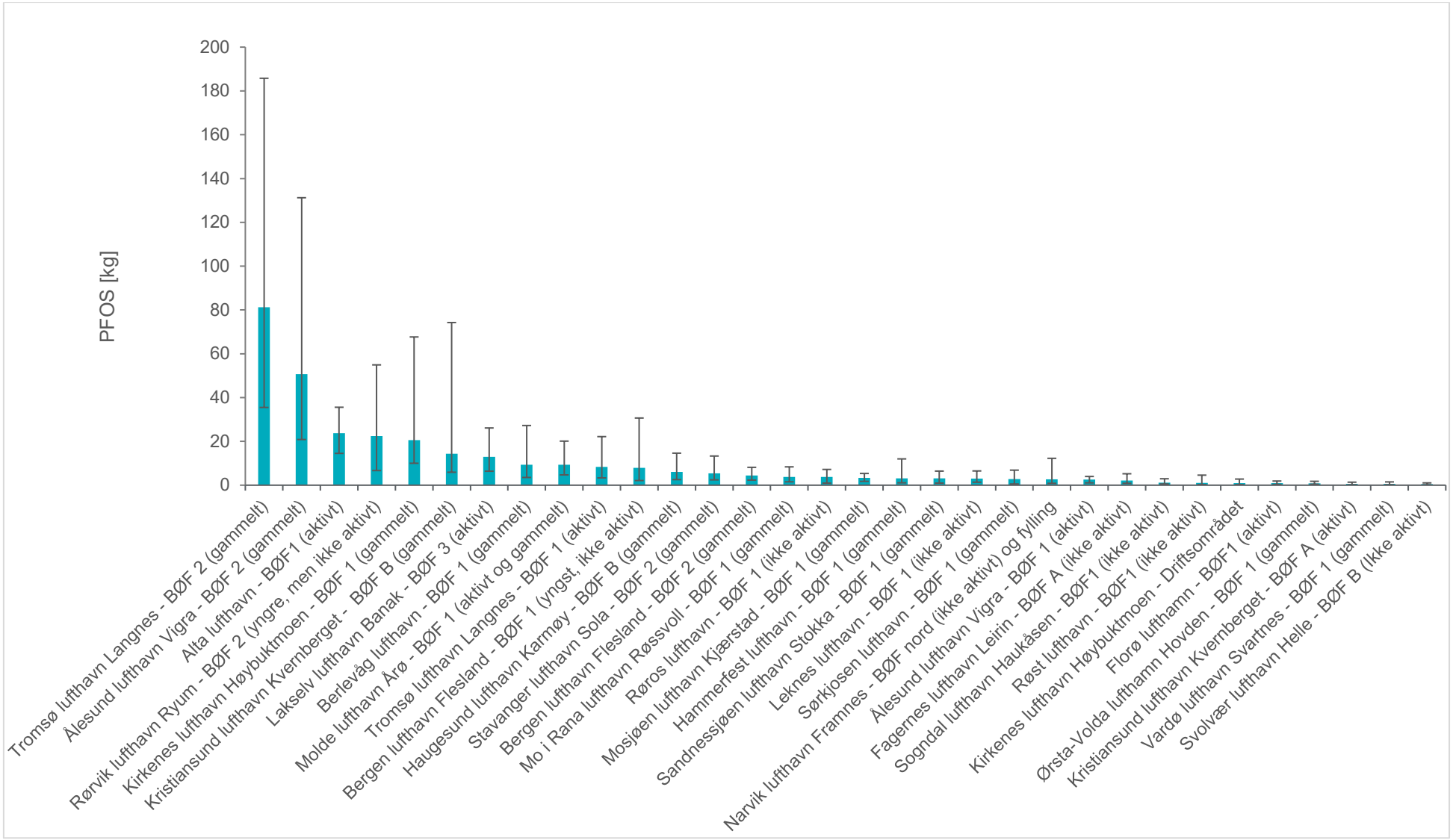


Figure 2: Calculated amounts of PFOS (kg) in surveyed sites at Avinor's airports, with uncertainty.

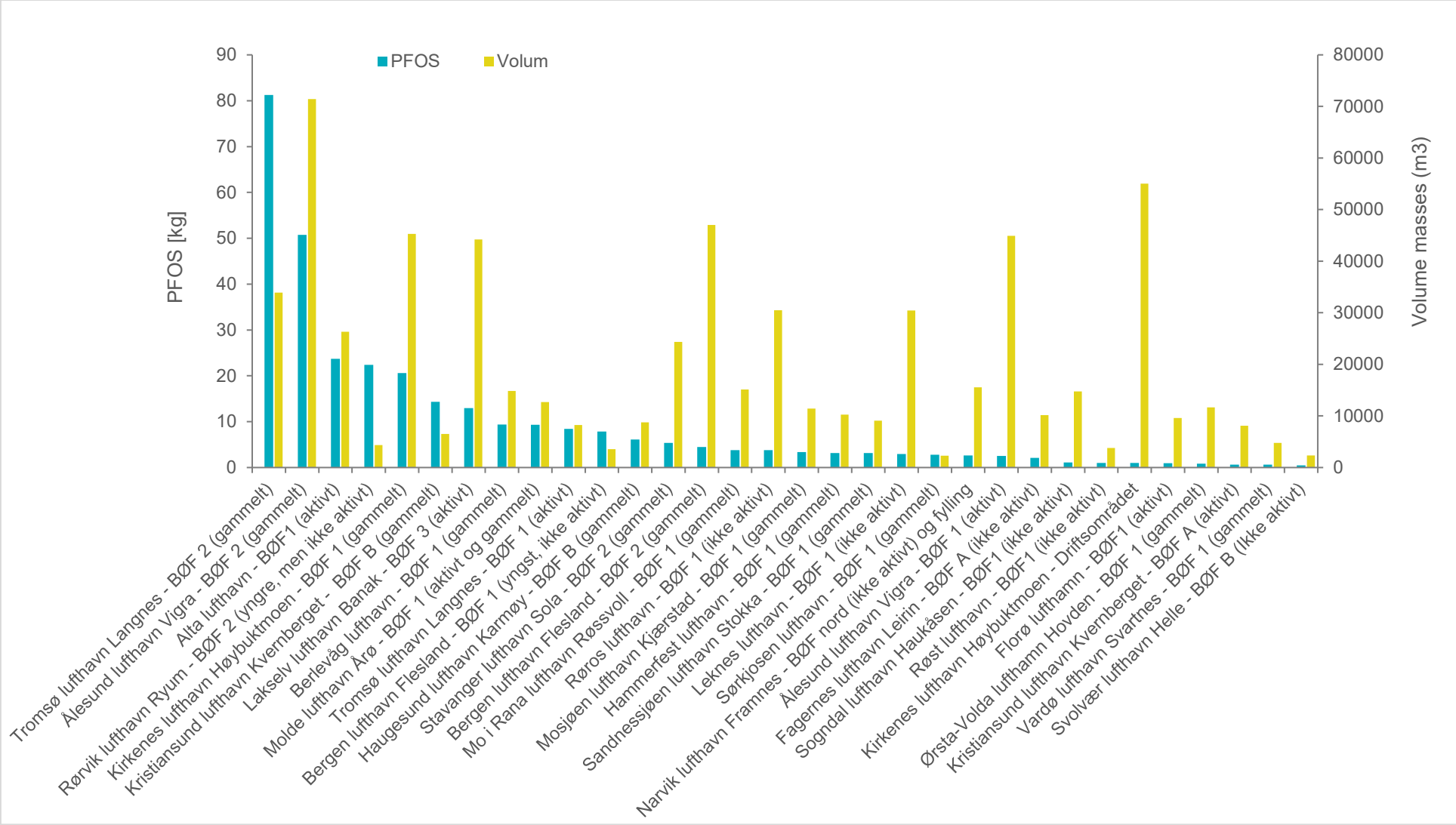


Figure 3: Calculated amounts of PFOS (kg) and volume of masses (m^3) within the surveyed area at each site.

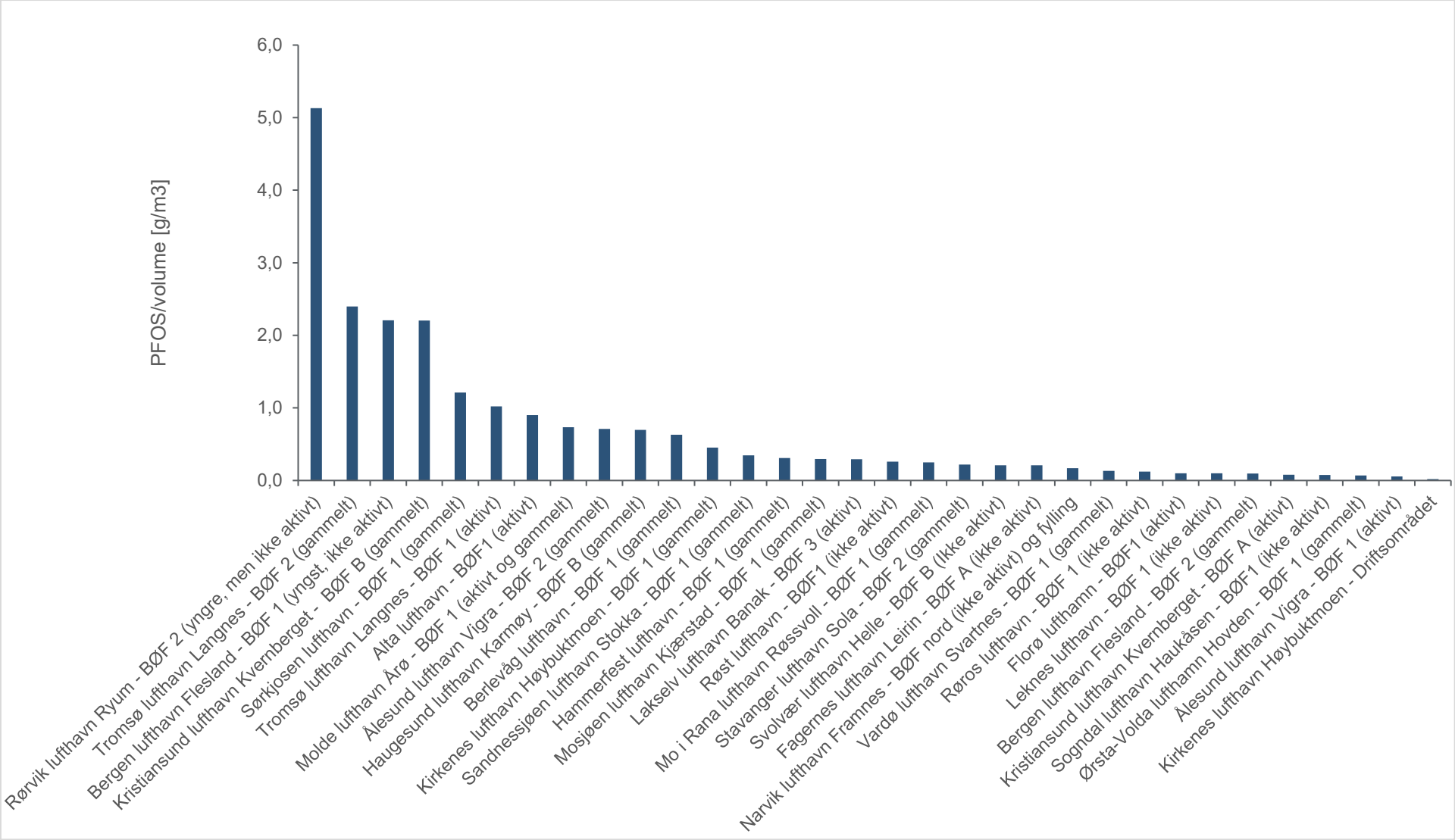


Figure 4: Amount of PFOS per examined volume (g/m^3) (> 3 µg/kg in Table 5) for the sites with calculated amounts at Avinor's airports.

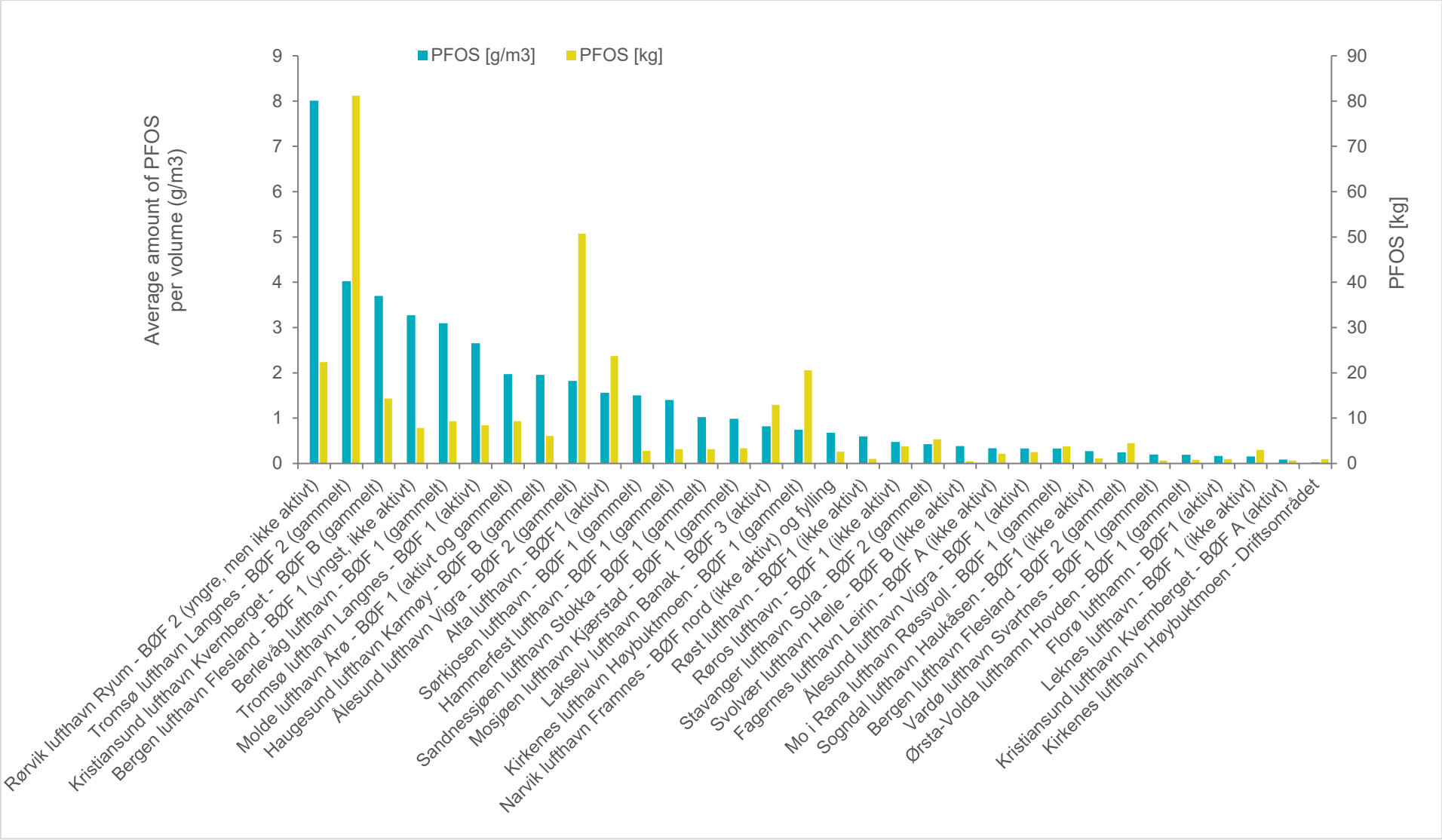


Figure 5: Average amount of PFOS per examined volume (g/m^3) (AVG in Table 5) and calculated amounts of PFOS (kg) within the surveyed area.

Table 5: Overview of the amount of PFOS (kg) within the surveyed area, and the cumulative amount of PFOS per examined volume (g/m^3) above each concentration limit (µg/kg), as well as average amount/volume across all limits and maximum amount/volume. The sites are ranked from highest to lowest average (AVG) amount of PFOS (g/m)^3.

Airports and sites	**PFOS [kg]**	**PFOS [g/m^3]**	**PFOS [g/m^3]**	**PFOS [g/m^3]**	**PFOS [g/m^3]**	**PFOS [g/m^3]**	**PFOS [g/m^3]**	**PFOS [g/m^3]**	**PFOS [g/m^3]**
		>3,000	**>1,000**	**>500**	**>150**	**>30**	**>3**	**AVG**	**Max**
Rørvik Airport Ryum - BØF 2 (younger, but not active)	22	12.2	12.2	7.2	6.0	5.1	5.1	8.0	12.2
Tromsø Airport Langnes - BØF 2 (old)	81	6.53	4.67	4.18	3.66	2.72	2.40	4.0	6.5
Kristiansund Airport Kvernberget - BØF B (old)	14	6.9	4.6	4.1	2.2	2.2	2.2	3.7	6.9
Bergen Airport Flesland - BØF 1 (youngest, not active)	7.9	6.8	3.5	2.7	2.3	2.2	2.2	3.3	6.8
Berlevåg Airport - BØF 1 (old)	9.4	7.8	4.4	3.1	2.0	0.7	0.6	3.1	7.8
Tromsø Airport Langnes - BØF 1 (active)	8.4	5.39	3.29	2.67	2.13	1.41	1.02	2.7	5.4
Molde Airport Årø - BØF 1 (active and old)	9.3	4.9	2.7	1.6	1.0	0.8	0.7	2.0	4.9
Haugesund Airport Karmøy - BØF B (old)	6.1	4.7	2.7	1.8	1.1	0.8	0.7	2.0	4.7
Ålesund Airport Vigra - BØF 2 (old)	51	4.6	2.1	1.5	1.2	0.8	0.7	1.8	4.6
Alta Airport - BØF1 (active)	24	-	2.7	2.0	1.3	1.0	0.9	1.6	2.7
Sørkjosen Airport - BØF 1 (old)	2.8	-	2.1	1.7	1.3	1.2	1.2	1.5	2.1
Hammerfest Airport - BØF 1 (old)	3.2	3.3	2.0	1.4	0.9	0.5	0.3	1.4	3.3
Sandnessjøen Airport Stokka - BØF 1 (old)	3.1	-	2.0	1.5	0.9	0.4	0.35	1.0	2.0
Mosjøen Airport Kjærstad - BØF 1 (old)	3.4	-	1.9	1.3	0.9	0.5	0.3	1.0	1.9
Lakselv Airport Banak - BØF 3 (active)	13	-	1.7	1.1	0.6	0.4	0.3	0.8	1.7
Kirkenes Airport Høybuktmoen - BØF 1 (old)	21	-	1.4	0.8	0.6	0.5	0.5	0.7	1.4
Narvik Airport Framnes - BØF North (not active) and filling	2.6	-	1.3	1.0	0.6	0.3	0.2	0.7	1.3
Røst Airport - BØF1 (not active)	1.0	-	1.1	0.9	0.5	0.3	0.3	0.6	1.1
Røros Airport - BØF 1 (not active)	3.8	-	-	1.0	0.5	0.2	0.1	0.5	1.0
Stavanger Airport Sola - BØF 2 (old)	5.4	-	-	0.8	0.5	0.3	0.2	0.4	0.8
Svolvær Airport Helle - BØF B (Not active)	0.5	-	-	0.7	0.4	0.2	0.2	0.4	0.7
Fagernes Airport Leirin - BØF A (not active)	2.1	-	-	0.6	0.3	0.3	0.2	0.3	0.6
Ålesund Airport Vigra - BØF 1 (active)	2.5	-	-	0.8	0.4	0.1	0.1	0.3	0.8

Airports and sites	**PFOS [kg]**	**PFOS [g/m^3]**	**PFOS [g/m^3]**	**PFOS [g/m^3]**	**PFOS [g/m^3]**	**PFOS [g/m^3]**	**PFOS [g/m^3]**	**PFOS [g/m^3]**	**PFOS [g/m^3]**
Mo i Rana Airport Røssvoll - BØF 1 (old)	3.8	-	-	-	0.5	0.3	0.2	0.3	0.5
Sogndal Airport Haukåsen - BØF1 (not active)	1.1	-	-	0.6	0.3	0.1	0.08	0.3	0.6
Bergen Airport Flesland - BØF 2 (old)	4.5	-	-	0.5	0.2	0.1	0.1	0.2	0.5
Vardø Airport Svartnes - BØF 1 (old)	0.6	-	-	-	0.3	0.2	0.1	0.2	0.3
Ørsta-Volda Airport Hovden - BØF 1 (old)	0.8	-	-	-	0.4	0.1	0.1	0.2	0.4
Florø Airport - BØF1 (active)	1.0	-	-	-	0.3	0.1	0.1	0.2	0.3
Leknes Airport - BØF 1 (not active)	3.0	-	-	-	0.2	0.1	0.1	0.2	0.2
Kristiansund Airport Kvernberget - BØF A (active)	0.7	-	-	-	-	0.1	0.1	0.1	0.1
Kirkenes Airport Høybuktmoen - Operating area	1.0	-	-	-	-	0.0	0.02	0.0	0.0

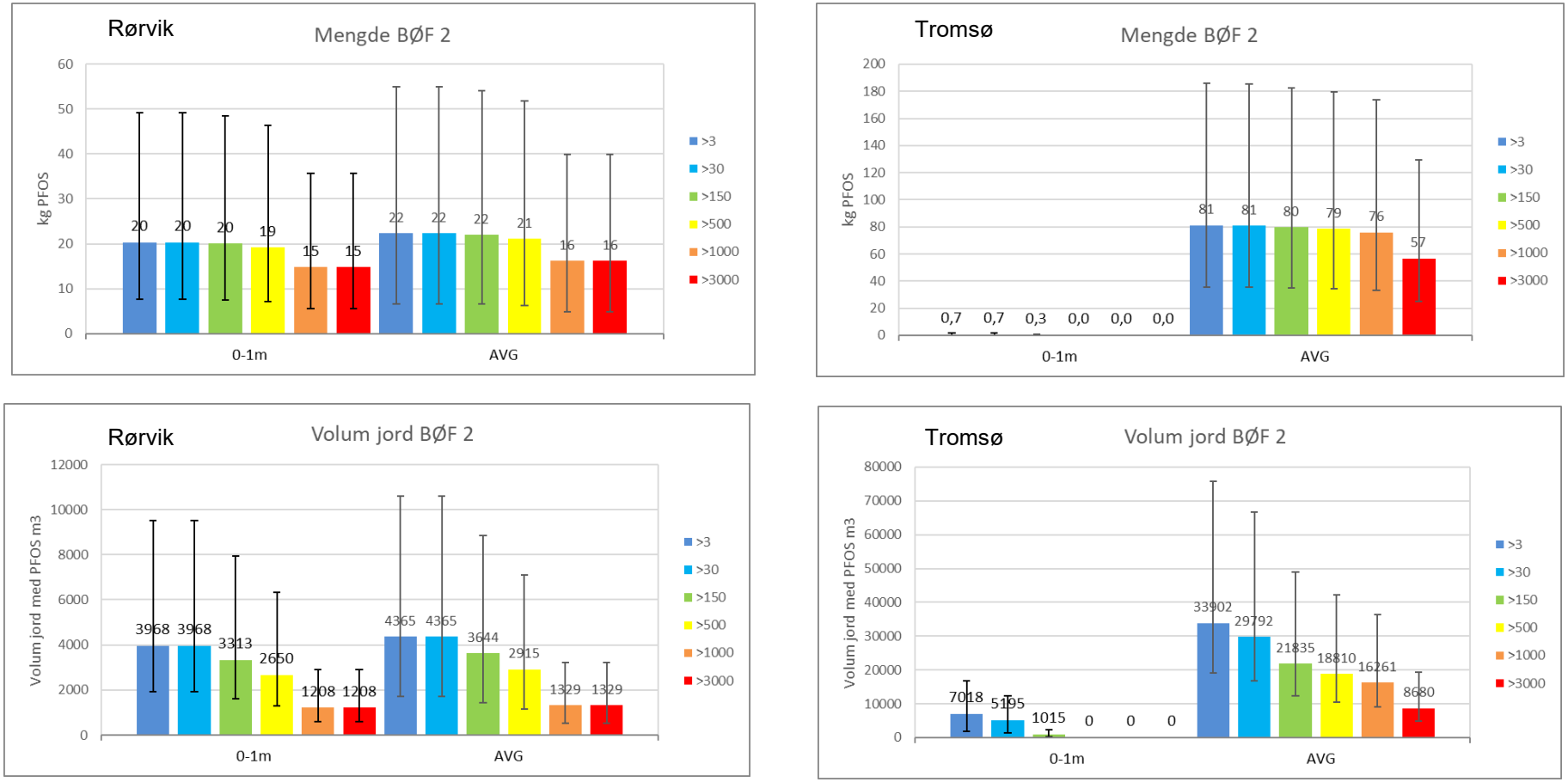


Figure6: Cumulative amount of PFOS (kg) and volume of masses (m^3) within each class at the Rørvik BØF 2 (old) and Tromsø BØF 2 (old) sites.

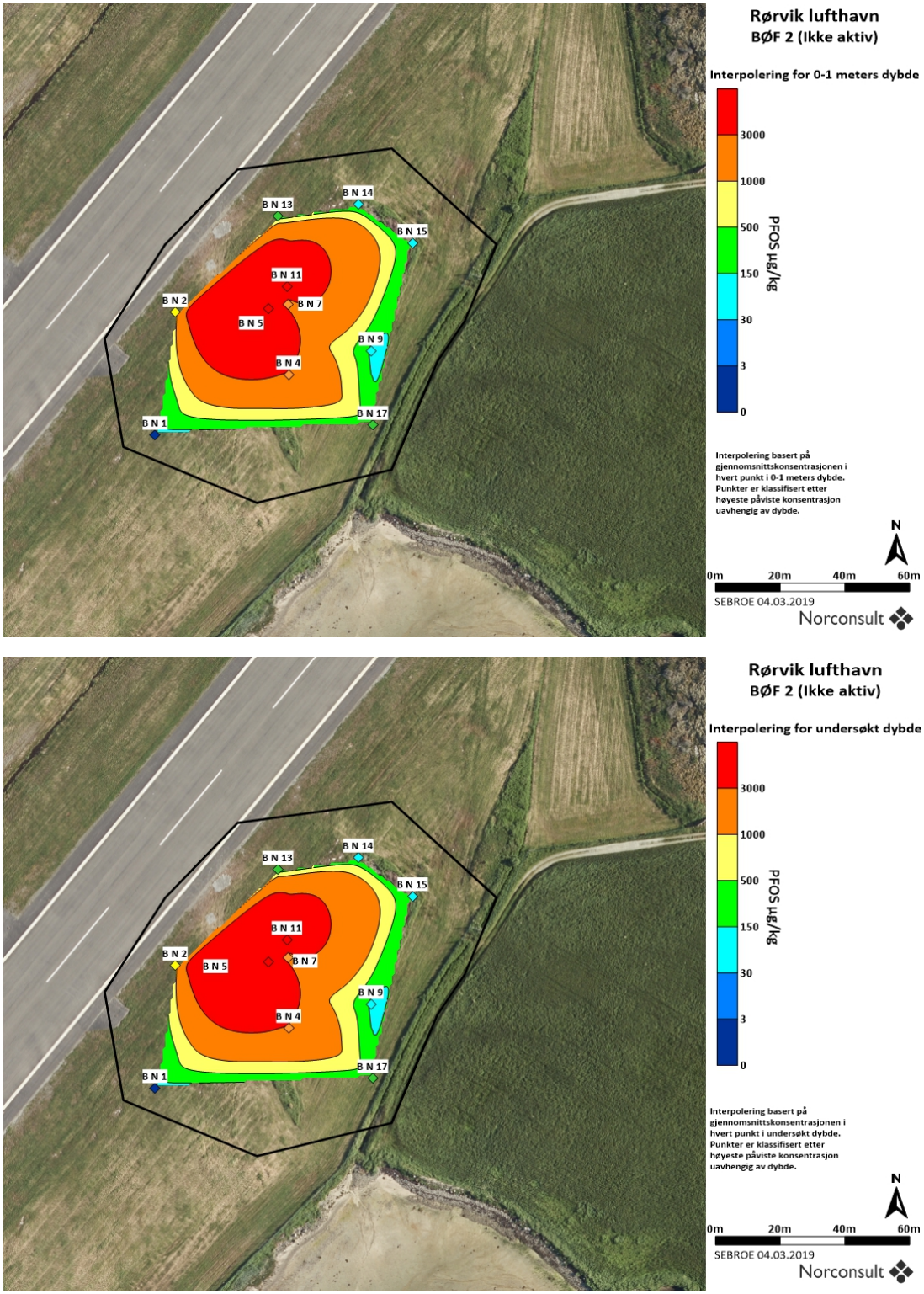


Figure7: Map figures with interpolation for depth of 0-1 metre and for examined depth at Rørvik BØF 2. The colour of the point shows the highest detected concentration in the point regardless of depth (sampling points with samples only in deeper layers are not shown in figures with interpolation for 0-1 metre).

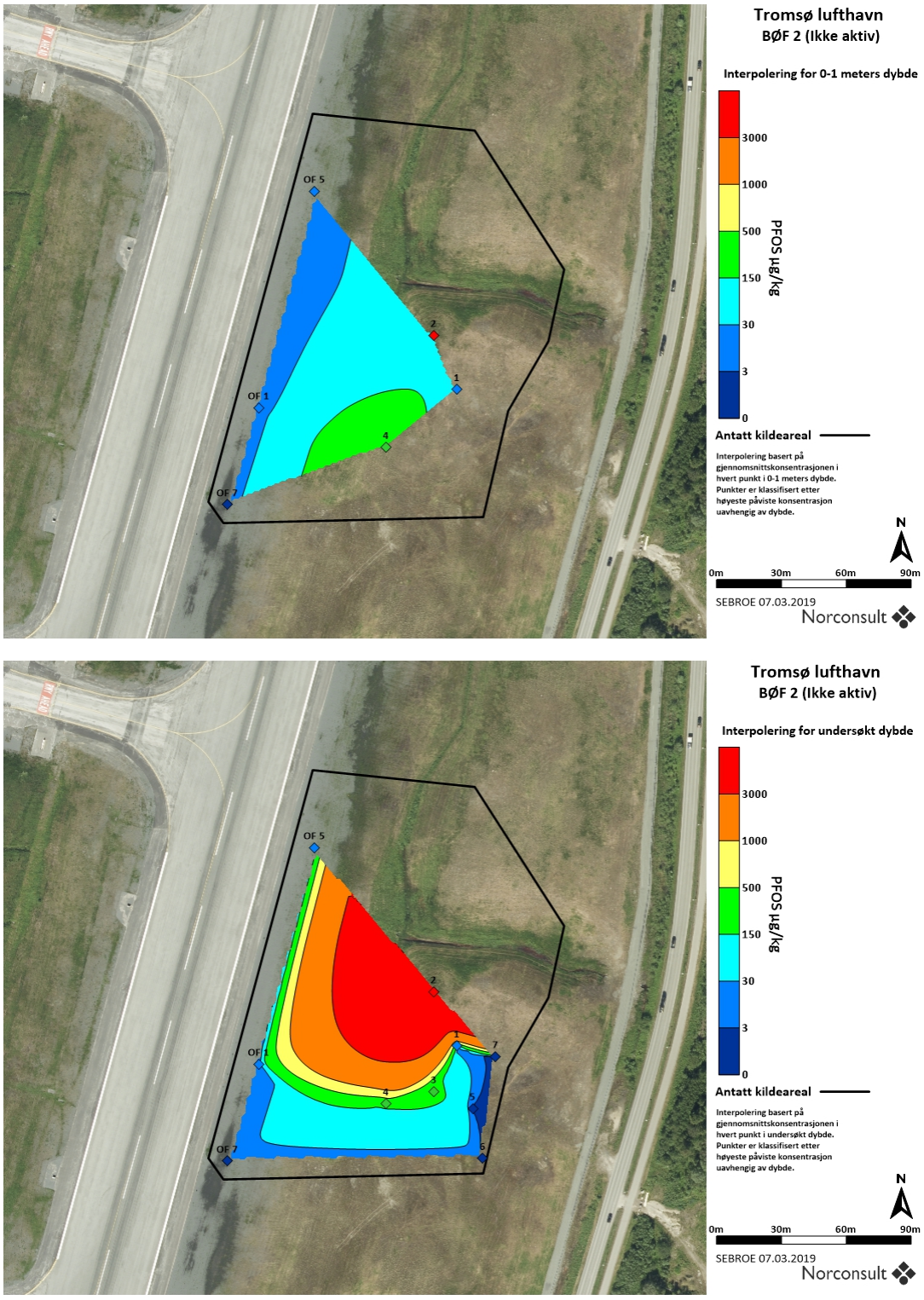
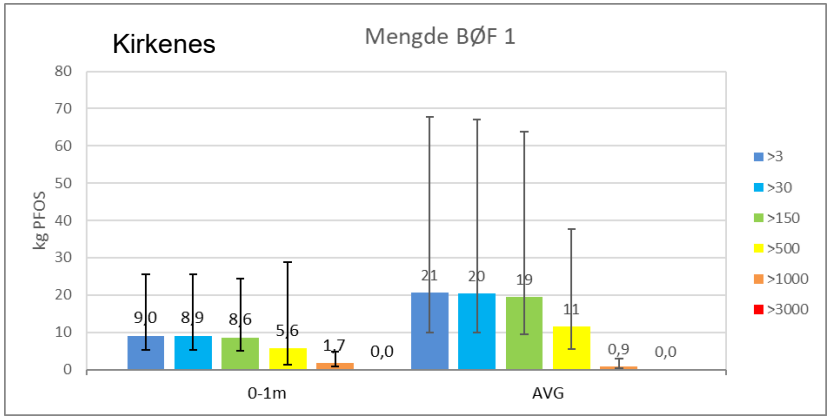
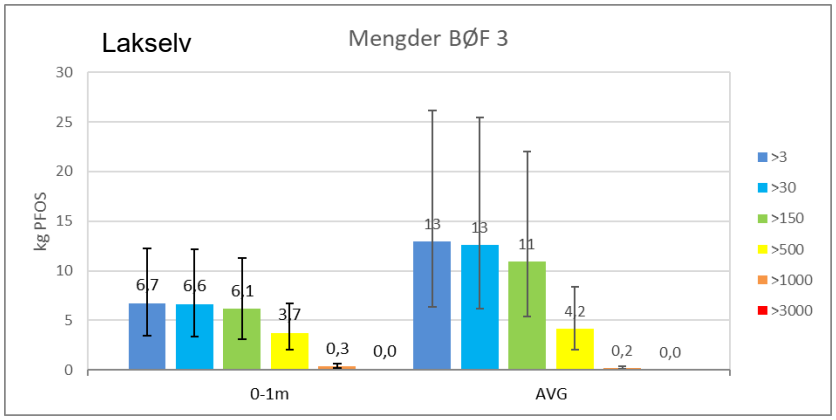
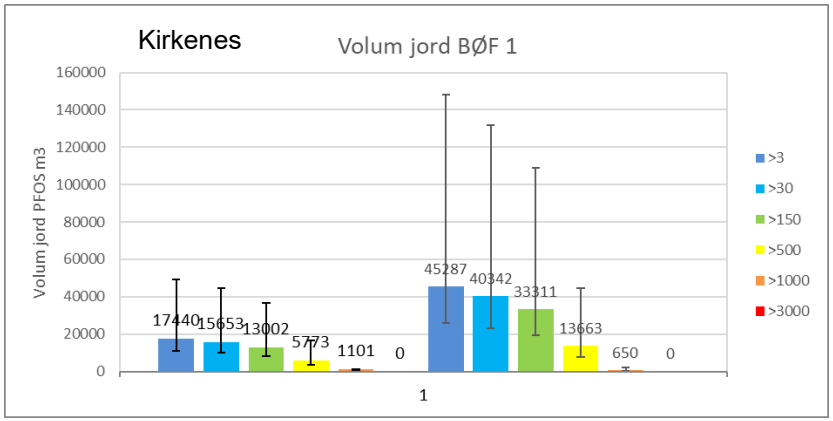


Figure8: Map figures with interpolation for depth of 0-1 metre and for examined depth at Tromsø BØF 2. The colour of the point shows the highest detected concentration in the point regardless of depth (sampling points with samples only in deeper layers are not shown in figures with interpolation for 0-1 metre).







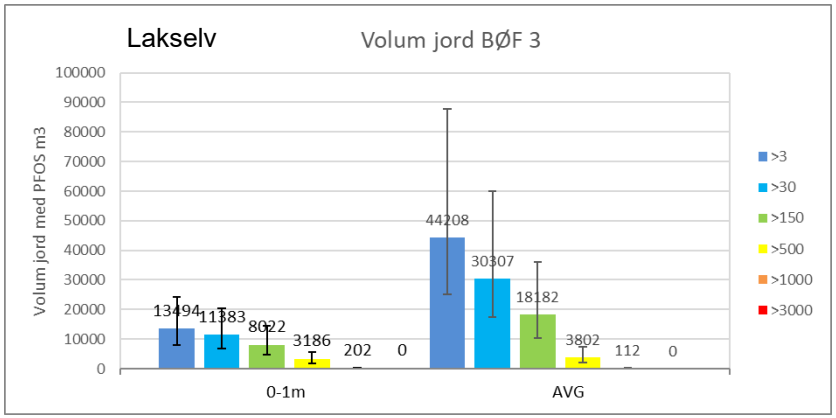


Figure9: Cumulative amount of PFOS (kg) and volume of masses (m^3) within each class at the Kirkenes BØF 1 (old) and Lakselv BØF 3 (active) sites.

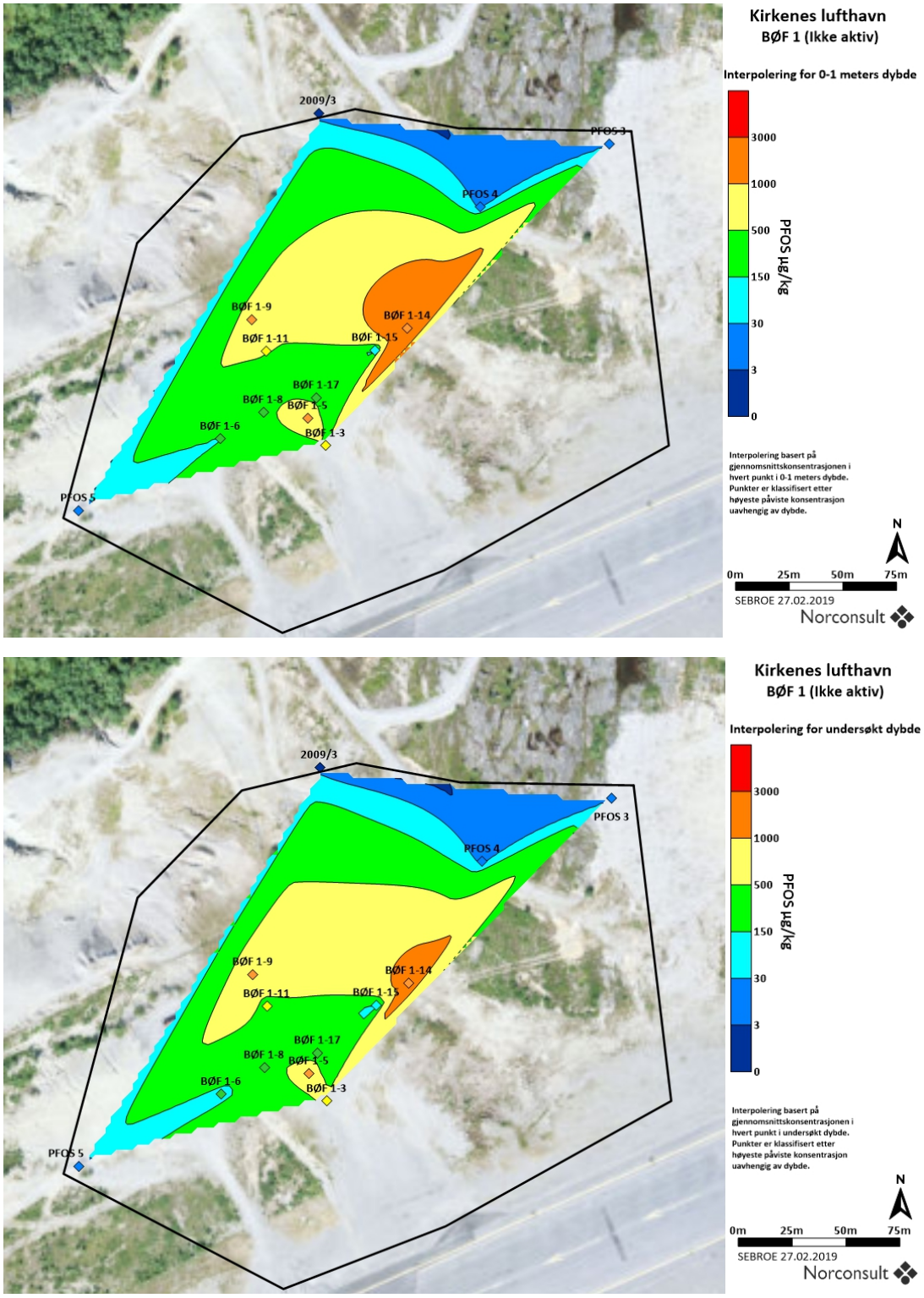


Figure 10: Map figures with interpolation for depth of 0-1 metre and for examined depth at Kirkenes BØF 1. The colour of the point shows the highest detected concentration in the point regardless of depth (sampling points with samples only in deeper layers are not shown in figures with interpolation for 0-1 metre).

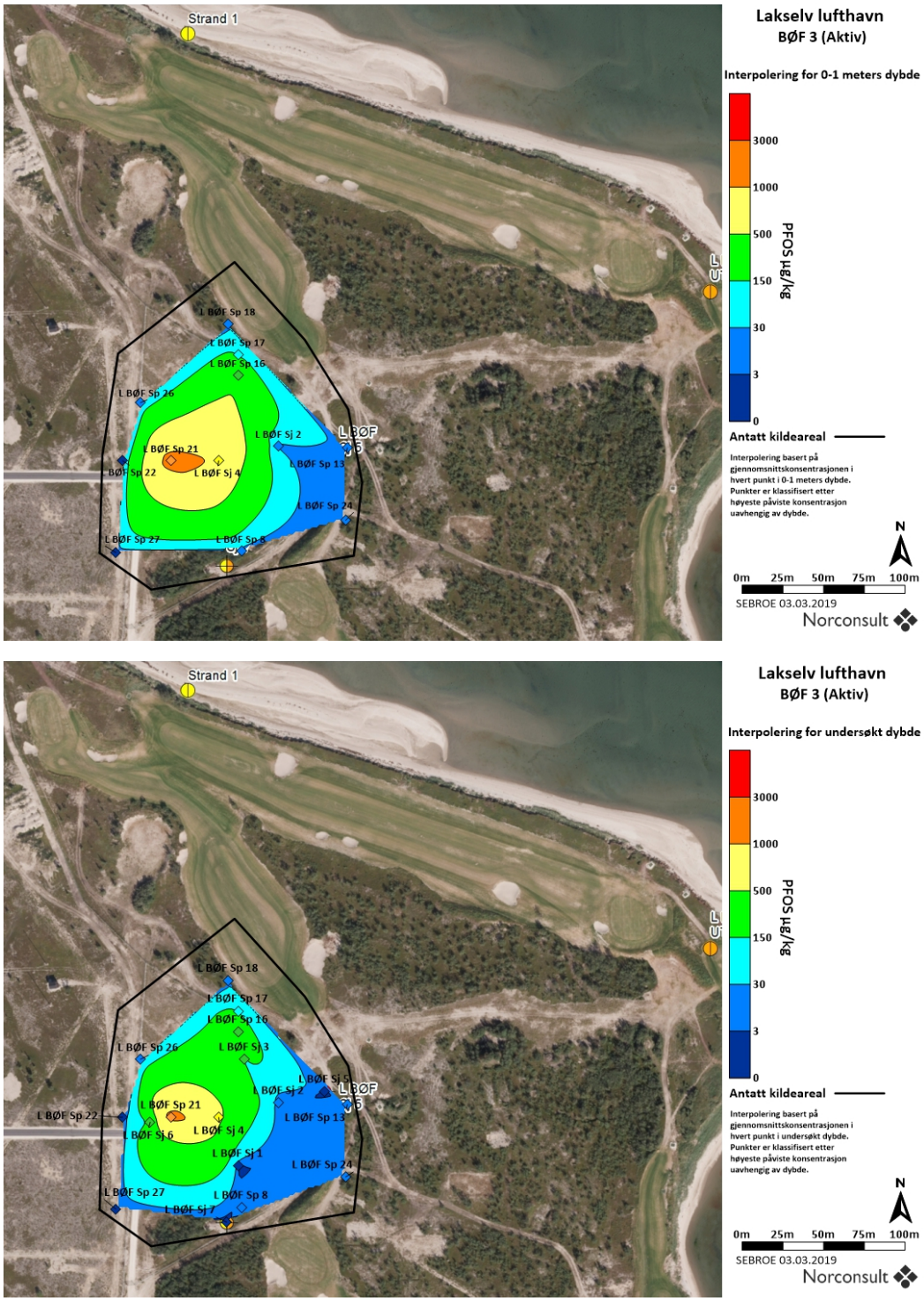
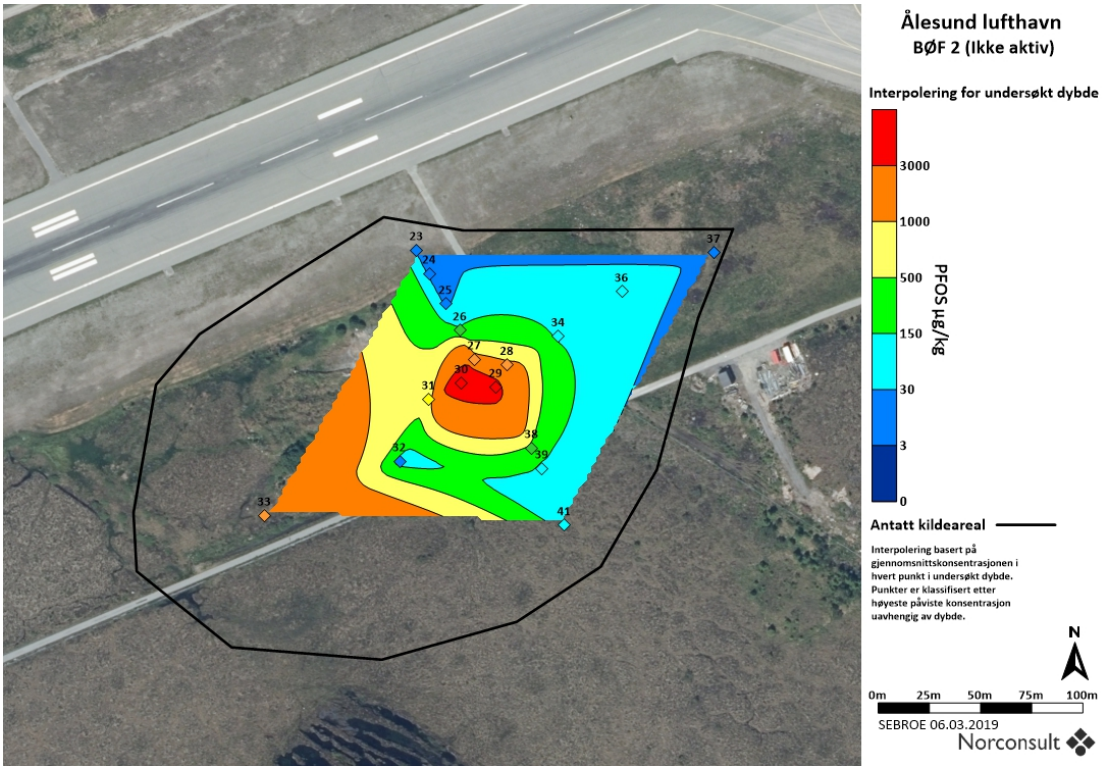


Figure 11: Map figures with interpolation for depth of 0-1 metre and for examined depth at Lakselv BØF 3. The colour of the point shows the highest detected concentration in the point regardless of depth (sampling points with samples only in deeper layers are not shown in figures with interpolation for 0-1 metre).



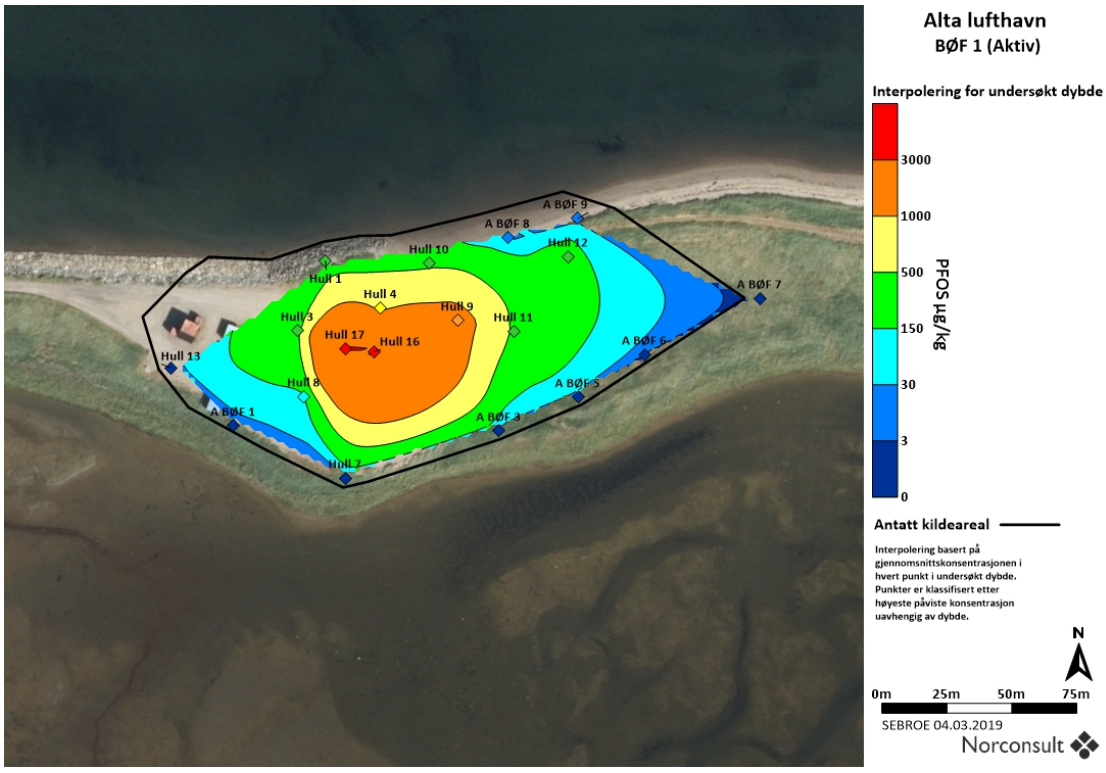


Figure 12: Map figures with interpolation for examined depth at Ålesund BØF 2 (not active) and Alta BØF 1 (active). Colour of the point shows the highest detected concentration in the point.

In Table 6, the proportion of the total amount of PFOS within the examined volume above increasing concentration limits (µg/kg) has been shown at the sites for which calculations have been carried out. The sites are ranked in the same order as in Table 5 (from highest to lowest average amount of PFOS per volume (g/m^3)).

Sites with a large proportion of the total amount of PFOS above the high concentration limits are the same as those with a high average amount of PFOS per volume. For these, a limit of action set to one of the higher concentration limits is expected to provide high action efficiency, in the form of a large proportion removed from the total. The proportions in the table do not provide information about uncertainty in the calculations. If the surveys have only revealed the strongest contamination at a site, a so-called "hotspot", the proportion of the total amount of PFOS above the high concentration limits will be higher than in reality. These sites will nevertheless have amounts of PFOS in the examined volume that are more concentrated in a smaller volume, and will thus be more effective for remedial action than sites that do not have amounts above the high concentration limits.

Table 6: Percentage of total amount within the examined volume for increasing concentration limits (µg/kg). The sites are ranked in the same order as in Table 5 (from highest to lowest average amount of PFOS per volume (g/m^3)).

		Percentage PFOS (%) of the total amount					
Airports and sites	**PFOS [kg]**	**>3,000**	**>1,000**	**>500**	**>150**	**>30**	**>3**
Rørvik Airport Ryum - BØF 2 (younger, but not active)	22	73%	73%	94%	98%	100%	100%
Tromsø Airport Langnes - BØF 2 (old)	81	70%	94%	97%	98%	100%	100%
Kristiansund Airport Kvernberget - BØF B (old)	14	61%	87%	88%	99%	100%	100%
Bergen Airport Flesland - BØF 1 (youngest, not active)	7.9	37%	81%	94%	100%	100%	100%
Berlevåg Airport - BØF 1 (old)	9.4	50%	73%	82%	90%	99%	100%
Tromsø Airport Langnes - BØF 1 (active)	8.4	34%	80%	90%	96%	99%	100%
Molde Airport Årø - BØF 1 (active and old)	9.3	15%	50%	74%	95%	98%	100%
Haugesund Airport Karmøy - BØF B (old)	6.1	30%	62%	82%	95%	99%	100%
Ålesund Airport Vigra - BØF 2 (old)	51	10%	59%	82%	94%	99%	100%
Alta Airport - BØF1 (active)	24	-	56%	78%	96%	100%	100%
Sørkjosen Airport - BØF 1 (old)	2.8	-	62%	86%	99%	100%	100%
Hammerfest Airport - BØF 1 (old)	3.2	19%	59%	75%	88%	97%	100%
Sandnessjøen Airport Stokka - BØF 1 (old)	3.1	-	27%	57%	82%	98%	100%
Mosjøen Airport Kjærstad - BØF 1 (old)	3.4	-	14%	53%	81%	90%	100%
Lakselv Airport Banak - BØF 3 (active)	13	-	1%	32%	84%	97%	100%
Kirkenes Airport Høybuktmoen - BØF 1 (old)	21	-	4%	56%	94%	99%	100%
Narvik Airport Framnes - BØF North (not active) and filling	2.6	-	23%	47%	67%	92%	100%
Røst Airport - BØF1 (not active)	1.0	-	23%	50%	82%	100%	100%
Røros Airport - BØF 1 (not active)	3.8	-	-	9%	56%	89%	100%
Stavanger Airport Sola - BØF 2 (old)	5.4	-	-	21%	77%	98%	100%
Svolvær Airport Helle - BØF B (Not active)	0.5	-	-	16%	67%	99%	100%
Fagernes Airport Leirin - BØF A (not active)	2.1	-	-	33%	88%	99%	100%
Ålesund Airport Vigra - BØF 1 (active)	2.5	-	-	5%	40%	82%	100%
Mo i Rana Airport Røssvoll - BØF 1 (old)	3.8	-	-	-	70%	98%	100%
Sogndal Airport Haukåsen - BØF1 (not active)	1.1	-	-	0%	53%	87%	100%
Bergen Airport Flesland - BØF 2 (old)	4.5	-	-	11%	53%	95%	100%
Vardø Airport Svartnes - BØF 1 (old)	0.6	-	-	-	49%	94%	100%
Ørsta-Volda Airport Hovden - BØF 1 (old)	0.8	-	-	-	23%	70%	100%
Florø Airport - BØF1 (active)	1.0	-	-	-	58%	95%	100%
Leknes Airport - BØF 1 (not active)	3.0	-	-	-	53%	94%	100%
Kristiansund Airport Kvernberget - BØF A (active)	0.7	-	-	-	-	96%	100%
Kirkenes Airport Høybuktmoen - Operating area	1.0	-	-	-	-	33%	100%

3 Part 2

Part 2 of the order is as follows (excerpt from the order):

> *"Assess possible remedial action at the different airports, how much PFOS (and other PFAS's, when they constitute a significant proportion of the total PFAS contamination) the individual measure might support, as well as the cost of such. Create an order of priority for various measures aimed at removing as much as possible of the contamination from circulation in the most cost-effective way possible.*
>
> *The cost assessments that Avinor makes will provide answers as to what is the most cost-effective way of implementing these measures. The order of priority should then be used to reveal how much PFOS has been removed from circulation at different cost levels, and if so where these measures should be implemented. This will give us a better overview of the extent of the overall PFOS contamination at Avinor's airports, how much of the contamination should be removed by implementing the various measures, and the order in which these should be implemented.".*

Result/Purpose: The maximum amount of ΣPFAS (kg) should be removed at the lowest possible cost.

Only sites for which the amount of PFOS has been calculated in Part 1 are included in the prioritisation in Part 2.

It is stated in the order that Part 2 shall be a cost/effect assessment, whereby the amounts of PFOS that are removed from circulation are assessed against the cost of removal measures.

3.1 Methodology for Part 2

It is specified in the order that measures should not be reported in detail, but that the possibility and cost shall be reported in a general manner. A number of prerequisites have been provided for measures and prices to keep cost calculations at an overall level. The suitability of the different sites for remedial action is assessed using a number of factors that can affect the price of such action. The threshold for each site is established when assessing the proportion of total PFOS/ΣPFAS removed, and cost per kg removed. The order of priority is stated as cost per kg PFOS/ΣPFAS removed.

3.1.1 Remedial action methods

The various available remedial action methods are assessed using a suitability form. In this form, the suitability of the methods is assessed based on available information about how tested and feasible the technology is (lab, pilot and in use), advantages and disadvantages and documented long-term effects.

Methods that have been tested/documented will not be included in the calculation of the cost of the relevant sites.

3.1.2 The suitability of the sites for the methods of action

For all the sites in Part 2 (n=32), the suitability of the sites for the implementation of remedial action using the methods that have development level "in use" assessed. The assessments are based on the site-specific information that has emerged from the surveys on the sites, such as mass type, whether the contamination is in contact with groundwater, proximity to the sea, etc. For the sites for which the cost of remedial action is to be calculated, the suitability for implementation of such action will depend on various factors:

- Groundwater level and estimated contamination depths
- Detected concentrations of PFOS/ΣPFAS in groundwater
- Active or old BØF – additional costs of remedial action on active BØF
- Uncertainty in the calculations
- Depth distribution of the amount of PFOS in the soil
- Mass type
- Sites where data suggests that otherPFAS compounds than PFOS make up a significant part of the soil contamination
- Distance from landfill
- Distance from runway
- Possible with combination of remedial actions

The various suitability factors listed are assessed for each site. Some of the factors are priced into the cost of remedial action, and will in this way affect the order of priority in the form of increased or reduced costs. This applies to water purification in the construction phase with excavation under groundwater level, excavation work on active fire training sites (demolition/re-establishment) and distance from the runway.

3.1.3 Prices and costs

3.1.3.1 Costs

The purpose of calculating costs of remedial action is to be able to assess the cost/effect at each site, compare costs at different sites with each other, and to obtain an overview of the total costs. Costs will be related to the location of the sites in the country and different conditions at each airport.

The costs calculated for remedial action are a basic calculation (Figure 13) as defined in the Norwegian Ministry of Finance's Guide No. 2 "Common system of concepts KS 2" [13]. The definition of the basic calculation in the guide is as follows (quote):

"The deterministic sum of the probable cost of all itemized specific cost estimations (cost items) at the time of analysis."

A more detailed description of the terms in Figure 13 is given in Chapter 3 of the guide [13].

No costs have been assessed for factors that are considered part of a detailed report for each site. This means that unspecified costs are not included in the calculations, as these include costs that are expected but have not been recorded due to a lack of itemizing. Examples of unspecified costs for remedial action at Avinor's PFAS contaminated sites are the following (the list is not exhaustive):

- Consideration has not been given as to whether construction and transport work must be carried out at night or if it can be carried out in daytime
- Any need for clearing and removing vegetation
- Any need for the establishment/demolition of temporary pioneer roads, interim storage areas, or alterations to internal roads
- For old fire training sites, no costs have been included for demolition and removal of any installations in the ground, concrete vessels/platforms, asphalt or other
- No costs have been included for environmental technical assistance during the construction phase, or any costs for geotechnical assistance in connection with stability assessments for the excavation of masses

- Any additional costs due to the type of masses, such as peat/marsh masses that may need to be excavated when frozen

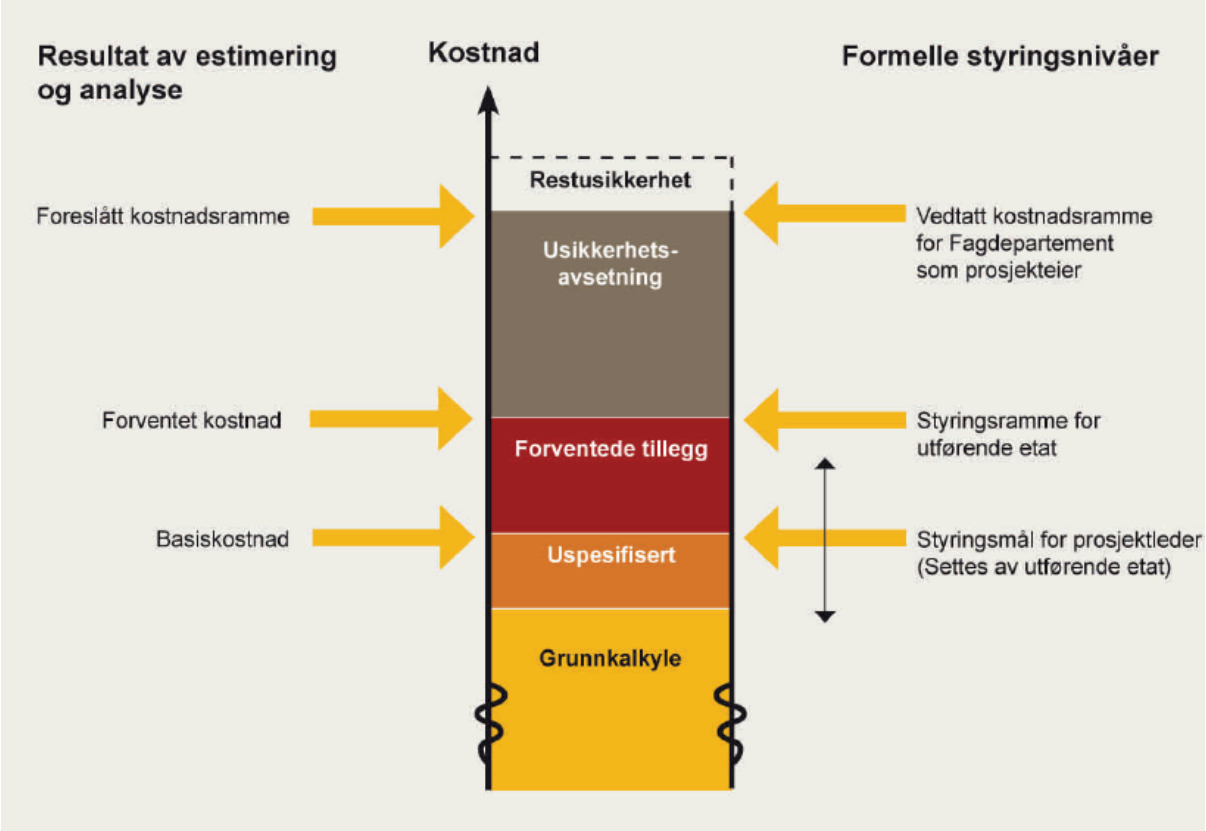


Figure 13: Key concepts for uncertainty management and the relationship between economic variables for a project (the figure is taken from the Norwegian Ministry of Finance's Guide No. 2 "Common system of concepts KS 2" [13].

3.1.3.2 Pricing

In order to estimate the most realistic costs of remedial action, prices have been obtained from excavation contractors, landfills and operators carrying out water purification. Experience figures from Avinor have also been used for measures related to the demolition and re-establishment of new fire training sites, and ongoing "pump and treat" measures at Gardermoen. Based on information from different operators, prices are set that are assumed to be realistic for each site and that can be used in an overall assessment of costs. Prices will reflect the market as it is today. There is a high probability that there will be changes in the type of remedial action being offered, and in prices, over the coming years as a result of ongoing research and testing of various methods of remedial action for PFAS-contaminated soil.

Unit prices have been used for various stages of measures, e.g. for excavation and external landfill disposal:

- Excavation (NOK/m^3)
- Sorting (NOK/m^3)
- Loading up (NOK/m^3)
- Transport and landfill disposal fee (NOK/tonne)

- Transport of clean masses (NOK/tonne)
- Internal transport of clean masses, placement and compression (NOK/m^3)

Due to distance restrictions for construction works near the runways, the sites' distance to the runway will affect the cost. This applies in particular to the two measures related to excavation with external landfill disposal and coverage/shielding of the PFAS contamination. For the construction works, a factor has therefore been added that will increase costs depending on the site's distance from runway.

For some of the varying conditions at each airport that are not controlled to such a large extent by the volume of masses being excavated, an additional cost is added that is independent of the magnitude of the remedial action. This applies to active fire training sites (demolition and re-establishment) and water purification with excavation under groundwater level.

3.1.3.3 Assumptions

Since the prices will be used for cost calculations and then prioritisation of the sites, not concrete planning of remedial action, there will be a number of prerequisites and assumptions that form the basis of the prices.

The following prerequisites are assumed:

- It is assumed that excavated PFAS contaminated masses can be temporarily stored over a short period of time under dense cover near the fire training site, pending further transport to boat and then to landfill
- Wet masses must be temporarily stored in leakproof containers or another system of water collection. No additional cost has been calculated for this
- It is assumed that the shortest possible excavation time for sites with excavation under groundwater level is sought so as to minimize the need for drainage and purification of water from excavation pits.
- It is assumed that clean masses that are used for refilling can be temporarily stored at/near the airport until it is ready for refilling in the excavation pit
- It is assumed that excavation, uploading and transport are coordinated thus allowing the excavation contractor and transporters to work relatively smoothly without much waiting time
- For active fire training sites, an additional charge for clean-up is calculated due to the fact that the collection platform must be demolished and re-established, and fire training must be temporarily carried out elsewhere
- It is assumed that it is possible to obtain clean gravel masses locally, which can be refilled in excavation pits after remedial action has been taken
- Costs are included for sorting masses with a sorting bucket on an excavator for the sites where this is considered to be suitable. It has not been considered whether a screening machine can be placed for sorting contaminated masses at any of the sites, as screening machines are space-intensive, and there are requirements for the height of machines that are to be located inside the airport and near the runway.

3.1.4 Site-specific action limits

Increased volume of masses results in increased cost for most methods of remedial action (with the exception of, for example, active barriers). For remedial action that includes excavation of masses, whether for sorting, washing or landfill disposal, choosing sites with a high level of PFOS/ΣPFAS per volume will be most cost-effective. The amount of PFOS in the soil, amount of PFOS per volume, and amount per volume above the different concentration limits are shown in Figure 2, Figure 3, Figure 4 and Table 5. In addition, the cost of remedial action will be affected by the suitability factors listed in Chapter3.1.2.

The limit of remedial action for each site is set to the concentration limit where the amount of PFOS/ΣPFAS removed is significantly reduced, and/or the cost per kg removed increases significantly. The limit of remedial action will vary from site to site.

3.1.5 Order of priority

The sites are ranked by cost per kg of PFOS/ΣPFAS removed at the proposed site-specific remedial action limit. It is considered as cost-effective to implement remedial action on sites with the lowest prices per kg PFOS/ΣPFAS removed. Sites with a high price per kg PFOS/ΣPFAS removed will be placed at the bottom of the priority list.

3.2 Results from Part 2

3.2.1 Remedial action methods

A literature review has been carried out for the comparison and assessment of the suitability of various remedial action methods. On the basis of the literature review, *in situ* and *ex situ* methods of remedial action for saturated and unsaturated zones respectively (above/below groundwater level) have been compared, and the suitability of methods assessed based on the level of development (lab, pilot and in use) and documented long-term effect (Appendix C).

Documented long-term effect is considered to be an important assessment criterion in light of the order's wording of "removing PFAS from circulation." The content of the wording was elaborated by the Norwegian Environment Agency at a meeting on 8 April 2019 when a 100-year perspective was deemed a minimum to be included in the wording "remove from circulation." By far the majority of the methods described in the reviewed literature have either not been carried out at full scale and/or they have no documented effect for such a time perspective. Several of the methods assessed have only been tested as a pilot, where the effect is only documented for a significantly shorter time frame (perhaps only a couple of years). "Pump and treat" for groundwater, incineration of contamination in masses, coverage/shielding of materials and external landfill disposal are methods that are in use and that have a documented long-term effect. Assessment of the suitability of the sites for "pump and treat" and covering/shielding is in Chapters 3.2.2 and Appendix D. Assessment of the suitability of the sites for excavation measures is in Chapter3.2.2. There are available facilities in Norway for the incineration of contaminated masses, for example Renor incinerates hazardous waste at 2,000oC in its facilities, but the method is energy intensive and is expected to have a high cost (rough estimate between 5,000-8,000 NOK/tonne) (pers. with. Øystein Bjerke, Renor). Incineration is therefore not considered an appropriate method for assessing cost/effect, and no assessment of the suitability of the sites has been carried out for this method.

Water purification has been included in the construction phase for all sites where remedial action includes excavation below groundwater level (Chapter 0). A corresponding literature review and comparison of water purification methods has been carried out as for methods of remedial action in soil (Appendix C). In the cost estimates, cleansing with activated charcoal is general assumed, as this is the method that is currently considered to be the most tested and documented. However, other methods of water purification may be applicable depending on water type (organic content, particle content, other contaminants), PFAS concentration level and type of PFAS compounds (short chain vs. long chain), but this must be assessed in more detail when specifying remedial action for each airport/site.

Reviewed literature for remedial action in soil:

Banzhaf, S., M. Filipvic, J. Lewis, C.J. Sparrenbom & R. Barthel (2017). A review of contamination of surface, ground, and drinking water in Sweden by perfluoroalkyl and polyfluoroalkyl substances (PFASs). Ambio 46: 335-346. DOI 10.1007/s13280-016-0848-8.

Yao, Y., T.U. Sack, K. Volchek & C.E. Brown (2015). PFC-Contaminated Soil and Its Remediation Strategies: A review. Proceedings of the Thirty-Eighth AMOP Technical Seminar, Environment Canada, Ottawa, ON, pp. 314-339.

Yao, Y., C.E. Brown, J. Vogan, J. Burdick, I. Ross, T. Pancras, C. Ptacek, N. Thomson, L. Groza, J. Ma & J.R. Baldwin (2016). Degradation of Perfluoroctanesulfonic Acid (PFOS) and Perfluoroctanoic Acic (PFOA) in Aqueous Film Forming Foam (AFFF)-Impacted Groundwater and Soils by Oxidation Methods. Proceedings of the Thirty-ninth AMOP Technical Seminar, Environment Climate Change Canada, Ottawa, ON, pp. 383-407.

NGI v/ H. Knutsen, Å. Høisæter & G. Aasen and OSL Avinor v/ J.S. Krokstad & K.G. Moe (2018). In-situ jordvasking som tiltaksmetode for PFAS-forurenset jord. Presentasjon på Miljøringens temamøte 15. mars 2018.

Ross, I., J. McDonough & J. Miles (2018). A review of emerging technologies for remediation of PFASs. Remediation 28:101–126. DOI: 10.1002/rem.21553.

Reviewed literature water purification:

McCleaf P., S. Englund, A, Östlund, K. Lindegren, K. Wiberg & L. Ahrens (2017). Removal efficiency of multiple poly- and perfluoroalkyl substances (PFASs) in drinking water using granulate activated carbon (GAC) and anion exchange (AE) column tests. Water Research 120: 77-87. DOI: 10.1016/j.watres.2017.04.057.

Ross, I., J. McDonough & J. Miles (2018). A review of emerging technologies for remediation of PFASs. Remediation. 2018; 28:101–126. DOI: 10.1002/rem.21553.

Yong, Q. (2007). Study of treatment technologies for perfluorochemicals in wastewater. PhD Thesis. Kyoto University. https://doi.org/10.14989/doctor.k13340.

Zaggia, A., L. Conte, L. Falletti, M. Fant & A. Chiorboli (2016). Use of strong anion exchange resins for the removal of perfluoroalkylated substances from contaminated drinking water in batch and continuous pilot plants. Water Research 91: 137-146. DOI: 10.1016/j.watres.2015.12.039.

3.2.2 The suitability of the sites for the methods of remedial action

3.2.2.1 "Pump and treat"

Based on the survey information available, an assessment of the suitability of the sites has been carried out for the "pump and treat" method, whereby groundwater is pumped up and cleansed of PFAS compounds through granulated activated charcoal before refiltration. If most of the contamination is located in the unsaturated zone, not in groundwater or masses in the saturated zone, such a measure will primarily reduce the dispersion of groundwater caused by leaching from the unsaturated zone. If most of the contamination is in the saturated zone and groundwater, "pump and treat" will be a cleaning up measure. The effectiveness of remedial action depends on the total amount of PFAS contamination in the saturated zone, where it is concentrated, diffusion, and site-specific conditions such as the permeability and organic content of the masses. Although tests show good effect in terms of reduction in concentrations in the water treated, it may take a long time to remove significant amounts if the permeability of the masses is low.

It is assumed that suitable sites for “pump and treat” are those that have relatively high average concentrations (> 5000 ng/l) of PFAS in samples of groundwater, and suitable mass type. Suitable masses are relatively permeable, and with low content of organic matter (for example, not marsh). High content of organic material in the masses results in high humus content in the groundwater that quickly clogs the carbon filter and requires a greater degree of pretreatment.

No groundwater samples have been taken at all the sites for which amounts have been calculated in soil, and only a few sites have samples from more than one well over time. The detailing of the description of the mass type at the sites varies greatly, and no size distribution analyses have been performed. Information is generally not provided from reports from the surveys as to whether soil samples are taken above or below groundwater level in the given depth intervals at which the samples are taken, only at how deep groundwater level they may have been observed. In general, many of the soil samples are taken at intervals which means that there can be no distinction between samples taken above or below groundwater level. Therefore, separate calculations have not been made of PFOS in masses in unsaturated and saturated zones.

The suitability assessments for the sites are shown inAppendix D. Only the three sites Lakselv BØF 3, Stavanger BØF 2 and Røros BØF 1 are assessed to be "presumably suitable". Insufficient information is available for 9 of the 32 sites for these to be assessed. To assess whether the method should be carried out at the three sites that are believed to be suitable, supplementary surveys of groundwater and hydrogeological conditions will be needed. For example, more environmental wells must be established, supplementary sampling and analysis of groundwater, measurements of groundwater levels and surveys of size distribution in the masses.

For calculations of the amount of ,PFAS in the groundwater at these sites, a discretionary assessment has been carried out of the area that may be contaminated (shown in Figure 14, Figure15 and Figure 16). The assessments are based on the description of the mass type, the assumed flow direction of the groundwater, gradient, etc. drainage trenches and concentrations of PFOS/ΣPFAS in analyses of groundwater and soil in the saturated zone. This information has been used as a basis for estimating the transport speed of PFAS contamination, which affects the diffusion of the contamination in groundwater. The transport speed of the PFAS compounds depends on the hydraulic conductivity (K) and the distribution coefficient (K_d) for the compounds in the masses in the saturated zone. The K value depends on the size distribution of the masses, and since no size distribution analyses have been done on masses at the fire training sites, there is a level of uncertainty in calculated groundwater speeds and transport speed of the contamination.

Most groundwater analyses include 12 PFAS compounds, and the calculations of the amounts in groundwater are therefore based on concentrations of PFAS. Each of the compounds has variations in water solubility, speed of leaching from unsaturated zone to groundwater, distribution between soil and water, as well as transport speed. This has not been taken into account in order to simplify calculations of amounts in groundwater.

On the basis that the substances are surfactant, the highest concentrations are expected to be near the water surface with a gradual reduction at depths. No measurements have been carried out that can provide this gradient at the sites, and it is therefore assumed that the depth of contamination for -PFAS in groundwater is approximately 1.5 metres. It is further calculated with an average concentration in the samples from the groundwater wells for the entire potentially contaminated area and depth. The wells are mainly located on the fire training sites, with the exception of at Røros Airport where there are also wells in the terminal area. PFAS concentrations in groundwater can be expected to be highest near the fire training sites, with a gradual reduction with increasing distance due to dilution. It is therefore probable that the method of calculating the amounts in groundwater results in an overestimate. Calculated amounts of ΣPFAS in groundwater at the three sites are shown in Table 7. The assessments and calculations that form the basis of the calculation of amounts of ∑PFAS in groundwater for each of the three sites are shown in the sub-chapters below.

Table 7: Calculated amounts of ΣPFAS in groundwater at sites deemed suitable for "pump and treat".

Airports and sites	**Unit**	**Lakselv Airport Banak - BØF 3 (active)**	**Stavanger Airport - BØF 2 (old)**	**Røros Airport**
Area of contaminated groundwater	m^2	140,000	70,000	415,000
Contamination depth	m	1.5	1.5	1.5
Contaminated volume	m^3	210,000	105,000	622,500
Pore volume 30%	m^3	63,000	31,500	186,750
Volume of contaminated water	l	63,000,000	31,500,000	186,750,000
Average cons. of PFAS (ng/l) measured in wells	ng/l	17,118	45,400	6,217
Amount of PFAS in groundwater	**kg**	**1.1**	**1.4**	**1.2**

Proportion of PFAS in groundwater of total amount in soil and groundwater	%	8	21	23

Lakselv BØF 3

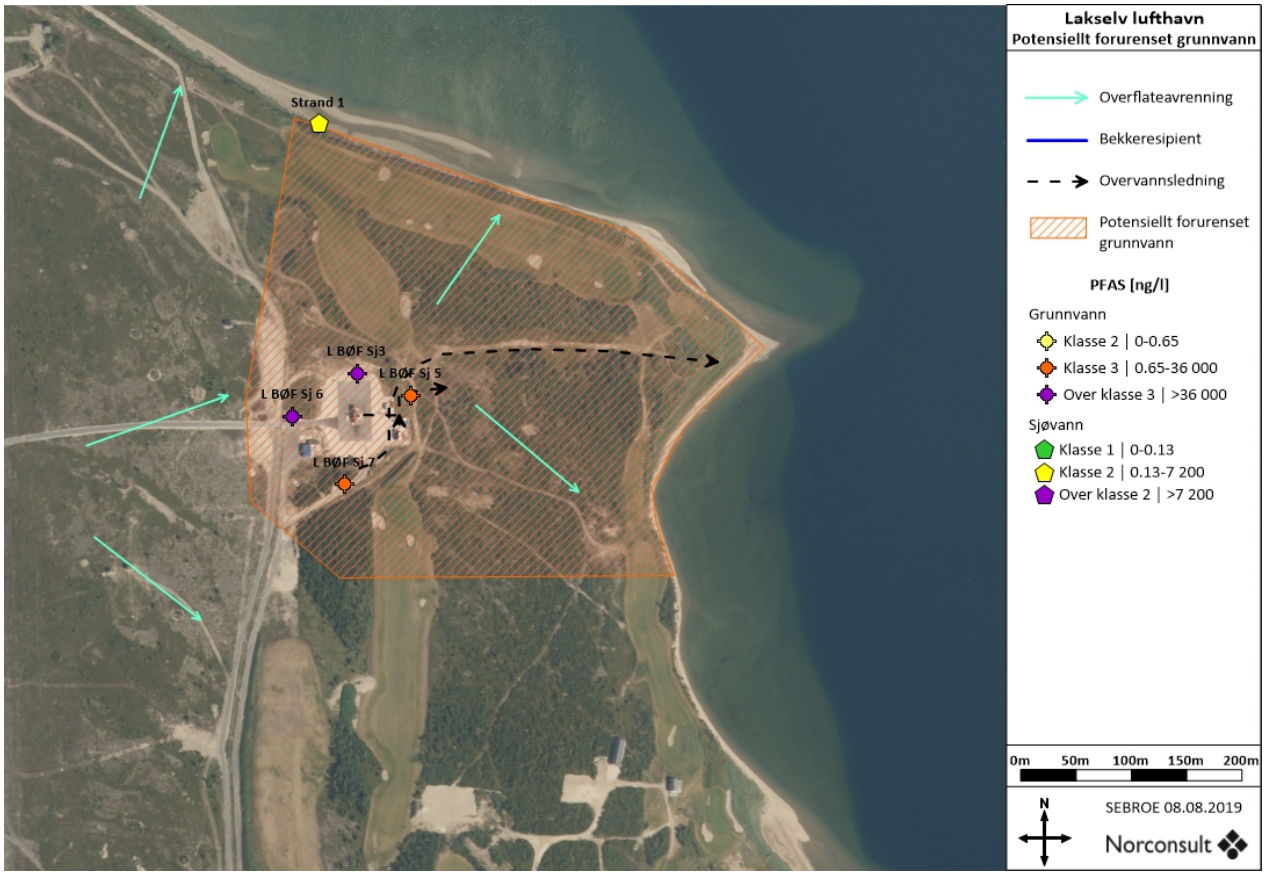


Figure 14: Potentially contaminated groundwater at Lakselv BØF 3. The sampling points L BØF Sj5, 6 and 7 are groundwater wells, and L BØF Sj3 is a water sample from a shaft. Sampling point Strand 1 is a water sample taken from a shaft excavated on the beach.

During the survey in 2011 at Lakselv BØF 3 (active) a water sample was taken in a shaft (L BØF Sj3), and a total of three wells were established in excavation shafts (L BØF Sj5, 6 and 7). The water sample in shaft 3 was analysed only for PFOS, and had 58, 900 ng/l PFOS. On 31 May 2012, a water sample was taken from each well, and the same on 5 June and 4 September 2013. The measured concentrations of PFAS in the nine groundwater samples were between 640-67500 ng/l, the lowest concentrations were in L BØF Sj7 (640-986 ng/l) and the highest in L BØF Sj6 (30,000-67,000 ng/l). The average concentration of PFAS in groundwater samples from the three wells is approximately 17,000 ng/l. A water sample taken in a shaft excavated on the beach north of BØF (Strand 1 sampled 1 June 2012) showed PFAS of 95.4 ng/l, suggesting diffusion via groundwater to the north.

There is no indication of a significant contribution from PFAS compounds other than PFOS in soil samples at this site (Chapter 2.2.2), but there are for some of the groundwater samples far higher concentrations of PFAS than PFOS (between 1.2-14 times higher), particularly in the samples from well LF BØF Sj5 (12-14

times higher in all samples). In masses in the saturated zone there are 6 samples with concentrations of PFOS from i.p. to <5.2 µg/kg and two samples of 139 and 209 µg/kg. By using the average of the measured PFOS concentrations in soil below groundwater levels (8 soil samples) and the average concentration of PFAS in groundwater, the distribution coefficient (K_d) for PFOS in the masses in the saturated zone will be 3 l/kg. This results in a retardation for PFOS of 15.

In general, the examined masses are described as rough, medium, fine sand and silt, and in the shafts where wells are established they are described as medium and coarse sand in levels between 1-3.1 meters deep. BØF is located at approx. 5 m above sea level, and groundwater level is about 2.5 metres below terrain. This results in a gradient from the training platform to the sea of 0.008.

By assuming a hydraulic conductivity (K) of 5 x 10^{-4} m/s (medium, and coarse sand), the estimated groundwater speed will be 1.7 x 10^{-5} m/s, and due to retardation it will take about 8 years for the PFAS contamination to be transported 300 metres. There is a distance of between 250-300 metres to the sea from the training platform, and the site has been used for fire training since 1978, that is for more than 40 years. Although there are no samples of groundwater downstream from well L BØF Sj5, it is expected that there has been, and is still ongoing, dispersion with groundwater to sea. It is estimated that 810 kg of PFOS and 140 kg ΣPFAS are used at the site, and there is estimated to be approximately 13 kg of PFOS in the examined volume of masses (Chapter 2.2.3).

The relatively low concentrations of PFOS in masses in the saturated zone indicate that there are also low amounts of PFOS in these masses, and that a "pump and treat" measure will mainly cover contamination already in the groundwater and leaching from the unsaturated zone. It is estimated in the risk assessment report that approximately 0.5 kg of PFOS annually leaks from BØF 3, and that it will take 15-40 years before the estimated approximately 13 kg of PFOS in soil has leaked out. There will therefore be a need for groundwater pumping for many years to come, alternatively "pump and treat" may be suitable in combination with other measures to remove contamination in the unsaturated zone.

As shown in the estimate in Table 7 the proportion of PFAS contamination in groundwater at Lakselv BØF 3 is approximately 8% of the calculated total amount (in examined soil (13 kg) and in groundwater (1.1 kg)).

Stavanger BØF 2

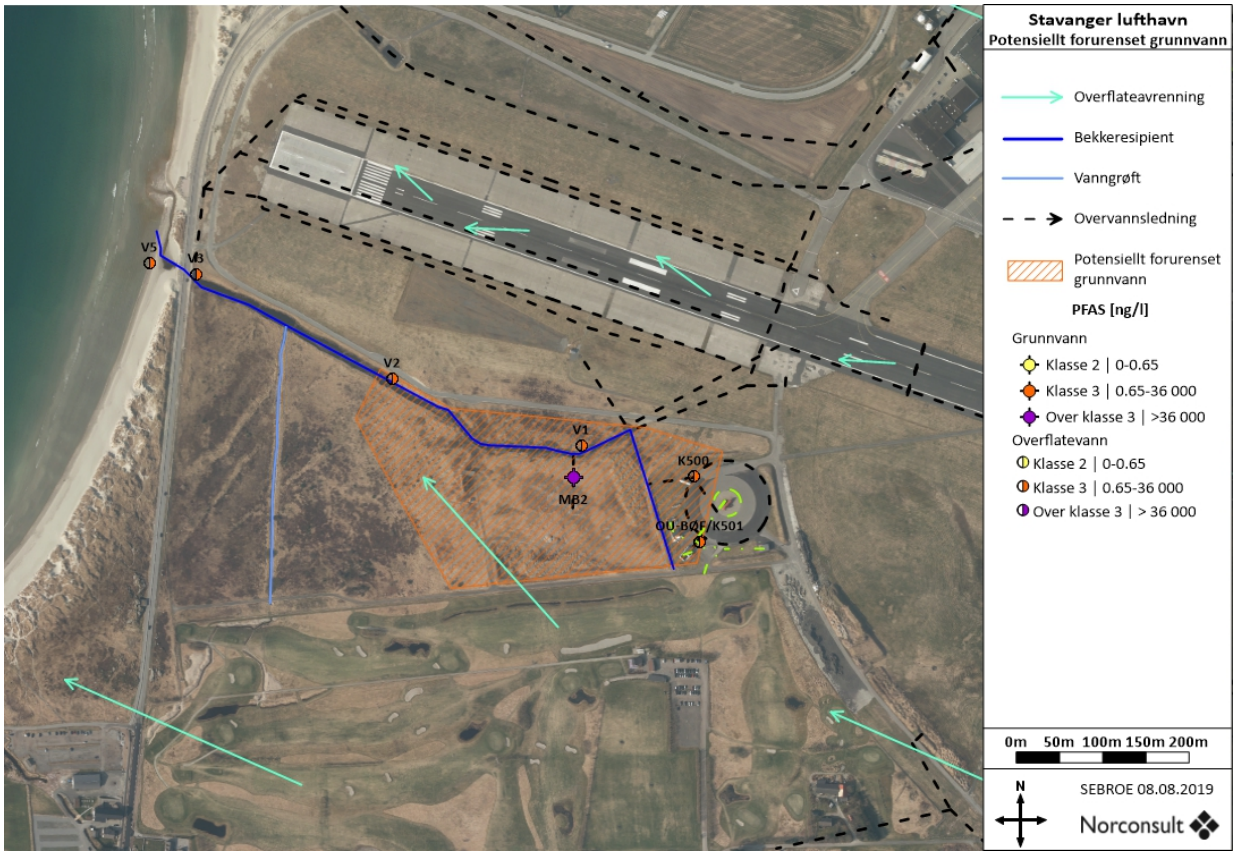


Figure15: Potentially contaminated groundwater at Stavanger BØF 2. Sampling point MB2 is a groundwater well, and V1-V3 and V5 are sampling points for surface water samples in Regebekken.

During the survey in 2011 at Stavanger BØF 2 (old) a well was established in an excavation shaft (MB2 in shaft 14). Water samples were taken in the well on 25th May, 2012, and three times in 2013 (20th March, 3rd and 26th June). The measured concentrations of PFAS in the four samples of groundwater were between 12,800-86,600 ng/l, and the average concentration of PFAS is approximately 45,000 ng/l. No samples of groundwater have been taken in the active area (BØF 1), and only PFOS has been analysed in soil samples. PFOS concentrations above 45 µg/kg have been detected, and the highest concentrations are to the north and northwest. The northwestern part of BØF 1 has been assessed as part of the potentially contaminated groundwater area as the areas are located right next to each other. Groundwater transport from the two fire training sites is expected to be to the west, northwest and towards Regebekken in the north. There is a ditch that flows into Regebekken west of the two fire training sites, some of the groundwater is expected to be cut off/drained by this. Water samples from Regebekken (V1-V3 and V5) show concentrations of PFAS between 226-660 ng/l. Stormwater from the active fire training site is also led to the channel, and the distribution of the contribution of PFAS from groundwater and stormwater is therefore not known. Samples have not been taken from the ditch to the west.

There is no indication of a significant contribution from PFAS compounds other than PFOS in the soil samples at Stavanger BØF 2 (Chapter 2.2.2), and there are relatively low contributions from PFAS compounds other than PFOS in the groundwater samples. In masses in the saturated zone there are 7 samples with concentrations of PFOS from i.p. to 40 µg/kg, one sample of 136 µg/kg, and six samples

between 300 and 1160 µg/kg. By using the average of the measured PFOS concentrations in soil below groundwater levels (14 soil samples) and the average concentration of PFAS in groundwater, the distribution coefficient (K_d) for PFOS in the masses in the saturated zone will be 6 l/kg.

In general, the examined masses are described as fine sand, but in four of the 14 described shafts there is crushed stone/gravel between 1.6-2.3 meters deep. In shaft 14 where the well is established, and below groundwater level in other examined shafts, there are masses of fine sand. BØF is located at approx. 4 m above sea level, and groundwater level is about 2.5 metres below ground. This gives a gradient from the eastern part of the assumed contaminated area to the sea of 0.003, and to Regebekken of 0.075.

By assuming a hydraulic conductivity (K) of 10^{-4} m/s (fine sand), the estimated groundwater speed to the sea will be 1.2 x 10^{-6} m/s, and to Regebekken 3 x 10^{-5} m/s. Due to retardation it will take about 270 years for the PFAS contamination to be transported 300 metres with groundwater. There is a distance of about 500 metres to sea from the MB2 well, and about 300 metres to the ditch in the west. It is therefore expected that PFAS contamination is not spread to sea directly via groundwater, but via groundwater that runs out to Regebekken. When using the same K value, it will take approximately 0.5-1 year for the contamination to be transported by groundwater from the MB2 well to Regebekken. BØF 2 was used for fire training for 16 years, in the period 1984-2000. That is now 35 years ago and much of the PFAS contamination used at this site (estimated at 1,790 kg PFOS) is expected to reach sea via Regebekken.

The calculated amount of PFOS in the examined soil volume at BØF 2 is 5.4 kg (Chapter 2.2.3). Estimated distribution of contaminated groundwater is shown in Figure15. With a contamination depth of 1.5 metres, and an average concentration of ΣPFAS of 45,400 ng/l, the estimated amount in groundwater will be 1.4 kg. As shown in the estimate in Table 7 this amounts to a proportion PFAS in groundwater of 21% of the total estimated amount of (in examined soil (5.4 kg) and in groundwater (1.4 kg)) at the site. There are no separate calculated amounts in masses in unsaturated and saturated zones, but the relatively high concentrations of PFOS in masses in saturated zones indicate that a significant proportion of the amount of PFOS is in these masses. By assuming that approximately 30% of the estimated amount in soil is in the saturated zone, the total amount of ΣPFAS in soil in the saturated zone and groundwater will be 3 kg (which amounts to approximately 56% of the total estimated amount at the site).

A "pump and treat" measure will include both contamination already in groundwater, masses in the saturated zone and leaching from the unsaturated zone. In the risk assessment report, the leaching from soil is estimated at 0.22 kg per year from BØF 1 and 2. There will therefore be a need for groundwater pumping for many years to come, alternatively "pump and treat" may be suitable in combination with other remedial action to remove contamination in the unsaturated zone.

Røros BØF 1

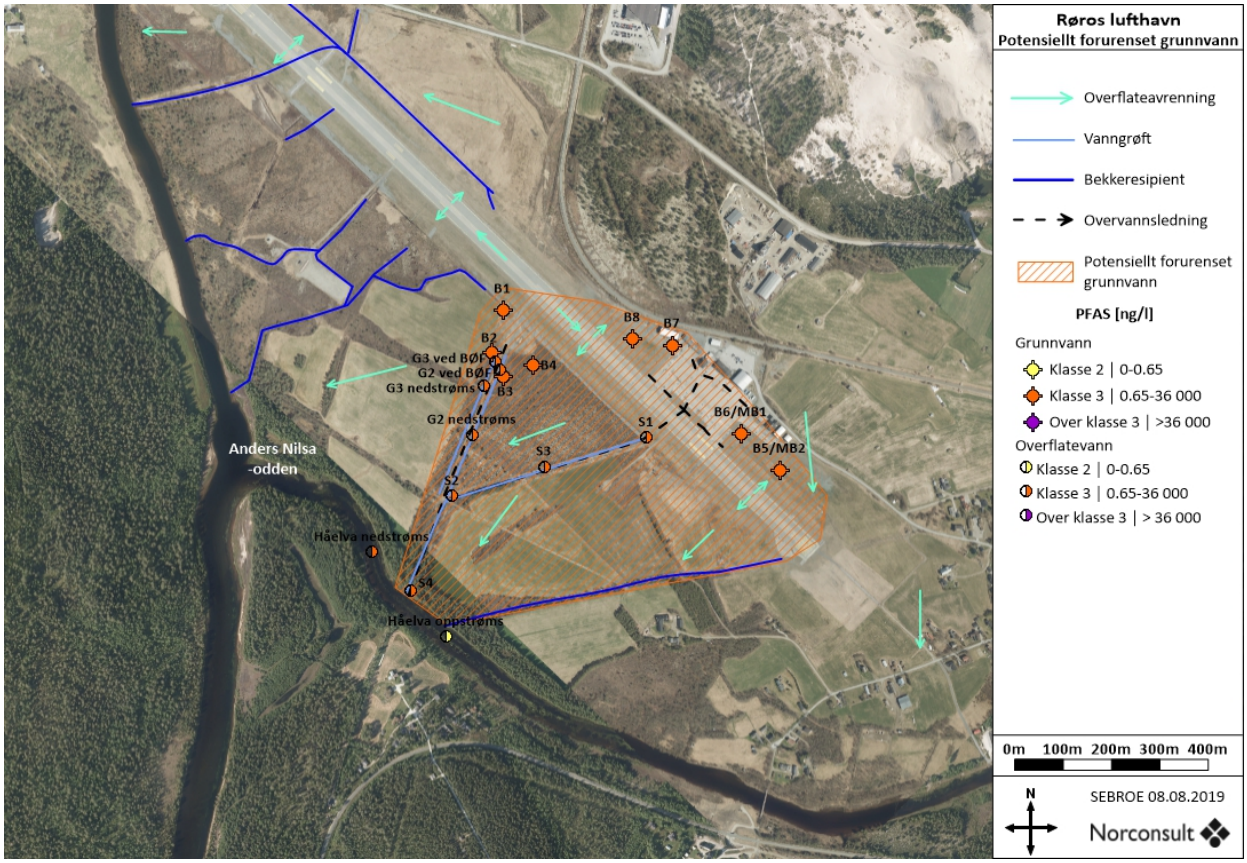


Figure 16: Potentially contaminated groundwater at Røros Airport.

During the survey in 2011 at Røros BØF 1 (not active) four wells were established in excavation shafts (B1-B4). On May 16, 2012, water samples were taken in the wells. In well B3, samples were also taken on 21st May and 10th September, 2013. The measured concentrations of PFAS in the six samples of groundwater were between 624.4-33,200 ng/l. A total of seven samples of groundwater have been taken from two wells southeast of the terminal area (B5 and B6), and two wells northwest of the terminal area (B7 and B8). These have concentrations of PFAS between 808-13,300 ng/l. The contamination at the terminal area and BØF is expected to be transported west and southwest with groundwater and in ditches (G1, G2 and G3) that flow towards Håelva. Varying concentrations of PFOS and PFAS have been detected in the trenches, in G2 and G3 flowing from BØF towards Håelva, PFOS has only been analysed and detected between 7-1,520 ng/l, and in G1 flowing from the terminal area to Håelva, PFAS between 447-2,710 ng/l has been detected. In Håelva, PFAS between 30-60 ng/l has been detected downstream of the outlet of the ditches. There is a ditch that flows from the southern end of the runways to Håelva, and it is expected that contaminated groundwater south of the terminal area will drain towards this. Samples have not been taken from the ditch.

The area for potentially contaminated groundwater includes the terminal area, BØF and the area between the ditches at BØF and the ditch in the east. The average concentration of PFAS in wells B1-B8 is approximately 6,200 ng/l.

There is no indication of a significant contribution from PFAS compounds other than PFOS in the soil samples at Røros BØF 1 (Chapter 2.2.2), and there are also relatively high contributions from PFAS

compounds other than PFOS in the groundwater samples. In masses in the saturated zone there are 3 samples with concentrations of PFOS below the reporting limit, and one sample with 2.3 µg/kg PFOS and 11.6 µg/kg PFOA. By using the average of the measured PFOS and PFOA concentrations in soil below groundwater levels (4 soil samples) and the average concentration of PFAS in groundwater, the distribution coefficient (K_d) for PFOS in the masses in the saturated zone will be 1 l/kg. The fire training site is established in an area with peat. In general, the examined masses are described as sand and gravel as the top bearing layer at BØF. Masses down to about one metre deep are described as sand, gravel, soil and peat, and at/below groundwater level there is sandy silt. The calculated $K_d$value is low for silty sand, and as only three soil samples have been analysed below groundwater level, the $K_d$value is very uncertain. However, there are concentrations of PFOS > 100 ug/kg in masses above groundwater level in three of the shafts sampled below groundwater level, which may indicate that the compounds are largely held back in the upper soil masses (0-1 metre) which partly contain peat.

BØF, the runway and the terminal area lie at about 625 metres above sea level, and about 4 metres above Håelva. Groundwater level is approximately 1.35 metres below ground, which gives a gradient from the terminal area to Håelva of 0.0038. Assuming a hydraulic conductivity (K) of 10^{-5} m/s (silty sand), the estimated groundwater speed will be 1.5×10^{-7} m/s, and due to the low gradient, the fine-grained masses and the PFAS compounds' retardation it will take about 250 years for the contamination to be transported 300 metres. It is about 550 metres from BØF 1 to Håelva, and about 700 metres from the terminal area to Håelva. A significant portion of the groundwater at BØF is expected to flow to Håelva via the G2 and G3 ditches just south of BØF, and some of the groundwater at the terminal area to ditch G1. The speed of the contamination transport to Håelva will therefore be faster.

BØF 1 was used for fire training with PFAS-containing foam in the period 1978-2016. It is estimated that 480 kg of PFOS and 90 kg ΣPFAS have been used at the site, and there is estimated to be approximately 3,8 kg of PFOS in the examined volume of masses (Chapter 2.2.3), and approximately 1.2 kgΣPFAS in the groundwater at BØF and the terminal area. It is now about 40 years since the use of the foam started, and it is expected that much of the PFAS contamination used at this site has been transported by the ditches to Håelva.

The low concentrations of PFOS in masses in the saturated zone indicate that there are also low amounts of PFOS in these masses, and that a "pump and treat" measure will mainly cover contamination already in the groundwater and leaching from the unsaturated zone. The leaching from the unsaturated zone is expected to be very low, as the risk assessment report (based on the measurements in groundwater and surface water at BØF) estimated that approximately 0.02 kg of PFOS is leaked in total from BØF per year. Groundwater pumping can be used as a measures in combination with other measures to remove contamination in the unsaturated zone.

Based on the estimate in Table 7 the maximum proportion of contamination that can be removed using "pump and treat" at Røros Airport is approximately 20% of the estimated total amount (in examined soil (3.8 kg) and in groundwater (1.2 kg)).

3.2.2.2 Coverage/Shielding

Coverage/shielding includes covering contamination in the unsaturated zone with a dense membrane to prevent leaching. A ditch is excavated around the entire area to be covered, and then the membrane is laid down to the depth the contamination is expected to have. The presumed suitable sites for coverage/shielding are those that do not have a significant part of the PFAS contamination in contact with groundwater at normal groundwater level or with tidal impact. Sites with the contamination in contact with groundwater may

be suitable for this type of remedial action in combination with those for groundwater. Coverage is expected to have restrictions on the use of the area, and will therefore not be suitable if, for example, the construction of an internal road at the airport or other use of the area is planned in the future.

Assessment of the suitability of the sites for coverage is in Appendix D. For coverage/shielding, the two sites at Narvik BØF north and filling and Røros BØF 1 are believed to be suitable. At Narvik BØF north and filling there is no described inflow of water in shafts, and there is bedrock at between 0.7-2 meters deep. At Røros BØF 1, contamination is in contact with groundwater, but there are low concentrations of PFOS (< 15 µg/kg) in soil samples of masses from the saturated zone as described in Chapter 3.2.2.1. Low amounts are also calculated of ΣPFAS in groundwater (1.2 kg) (Chapter 3.2.2.1).

At Lakselv BØF 3 and Stavanger BØF 2, coverage is believed to be suitable in combination with "pump and treat" measures. Lakselv BØF 3 also has relatively low concentrations of PFOS in the saturated zone as shown in chap. 3.2.2.1, but the site is located between 250-300 metres from the sea and is affected by the tides. The tidal difference at sea level is approx. 2-3 metres between high and low tide. At Stavanger BØF 2, relatively high concentrations of PFOS/ΣPFAS are detected in soil samples of masses from saturated zone (Chapter 3.2.2.1), and a significant proportion of the contamination is expected to be in the saturated zone.

The Berlevåg BØF 1, Bergen BØF 2 and Hammerfest BØF 1 sites may be suitable, but for Berlevåg BØF 1, the contaminated area must be delimited in depth and the depth to groundwater level must be examined, and the same applies for Bergen BØF 2. For Hammerfest BØF 1, it must be surveyed whether contaminated leakage water is due to water flowing through BØF from the ditch on the east side, and if necessary the flow of water must be prevented.

3.2.2.3 Excavation measures with external landfill disposal

All the sites where the calculated amounts of PFOS in soil (n=32) are considered to be suitable for the implementation of excavation measures with external landfill disposal of PFAS contaminating masses. An assessment has been made regarding site-specific factors such as the depth distribution of PFOS in the soil, whether the masses can be sorted and whether the distance from landfill will affect excavation measures with external landfill disposal.

Depth distribution of the contamination in the soil

As described in Chapter 2.1.3 the amounts of PFOS in masses from 0-1 metre and throughout the examined volume have been calculated. Both calculations for all sites are shown in Table 8, and compared to assess whether there are sites that have the largest proportion of PFAS contamination in masses from 0-1 metre. The assessment has been carried out to determine whether there are sites where it will be most cost-effective to limit measures to about one metre deep. For the sites Rørvik BØF 2, Berlevåg BØF 1, Røros BØF 1, Hammerfest BØF 1, Røst BØF 1 and Vardø BØF 1, the percentage of the amount is 0-1 metre high due to the fact that the surveyed depth or depth to bedrock is between 1 -1.2 metres. For Bergen, the estimated average depth to bedrock on the surveyed area is 40 cm. No sites have been revealed where the largest amounts are located in masses from 0-1 metre, and the calculated amount is significantly deeper than one metre. This is the reason why the amounts of PFOS//ΣPFAS in the whole of the surveyed volume are used further in the remedial action assessments.

For Stavanger BØF 2, however, there is information in the risk assessment report from 2016 that there are approximately 1.5 metres of surplus masses above the original terrain at BØF. These masses come from excavation works at various sites in the airport area. There is no description of where at the airport they come from or whether they may be contaminated. Samples have not been taken of the masses from 0-1.4

metres in the survey of the site, and they are not included in the calculations of the amounts of PFOS/ΣPFAS at BØF in this report. If excavation is to be carried out at BØF, these masses must be tested as they may be contaminated, but regardless of whether there is any contamination, they must be excavated in order to remove the amounts of PFOS/ΣPFAS calculated in the examined volume. It is assumed in the cost calculations that the surplus masses placed on BØF are clean, and therefore a cost has only been added for digging them up and putting them back after remedial action has been taken.

Table 8: Calculated amounts of PFOS (kg) in examined depths, and at 0-1 metre's depth, as well as proportion at 0-1 metre's depth.

Airports and sites	PFOS in examined depth (kg)	PFOS at 0-1 metre's depth (kg)	Proportion at 0-1 metre's depth	Comments
Tromsø Airport Langnes - BØF 2 (old)	81	0.7	1%	
Ålesund Airport Vigra - BØF 2 (old)	51	15	30%	
Alta Airport - BØF1 (active)	24	0.06	0%	
Rørvik Airport Ryum - BØF 2 (younger, but not active)	22	20	91%	Bedrock at 1.1 metre.
Kirkenes Airport Høybuktmoen - BØF 1 (old)	21	9.0	44%	Contamination not delimitated in depth.
Kristiansund Airport Kvernberget - BØF B (old)	14	1.1	8%	Contamination not delimitated in depth.
Lakselv Airport Banak - BØF 3 (active)	13	6.7	52%	
Berlevåg Airport - BØF 1 (old)	9.4	8.0	85%	Calculated contamination down to 1.2 metres, is not assumed to be deeper.
Molde Airport Årø - BØF 1 (active and old)	9.3	5.8	62%	Bedrock at 1.7 metres.
Tromsø Airport Langnes - BØF 1 (active)	8.4	3.9	47%	
Bergen Airport Flesland - BØF 1 (youngest, not active)	7.9	-	-	Estimated average depth to bedrock on the surveyed area is 40 cm.
Haugesund Airport Karmøy - BØF B (old)	6.1	3.3	55%	Contamination not delimitated in depth.
Stavanger Airport Sola - BØF 2 (old)	5.4	-	-	Added masses 0-1.5 metres.
Bergen Airport Flesland - BØF 2 (old)	4.5	1.8	40%	
Mo i Rana Airport Røssvoll - BØF 1 (old)	3.8	1.3	34%	Contamination not delimitated in depth.
Røros Airport - BØF 1 (not active)	3.8	-	-	Calculated contamination down to 1.1 metres, is not assumed to be deeper.
Mosjøen Airport Kjærstad - BØF 1 (old)	3.4	0.05	1%	Contamination not delimitated in depth.
Hammerfest Airport - BØF 1 (old)	3.2	2.6	81%	Average depth to bedrock of 1.2 metres.
Sandnessjøen Airport Stokka - BØF 1 (old)	3.1	1.5	48%	Contamination not delimitated in depth.
Leknes Airport - BØF 1 (not active)	3.0	1.8	59%	Contamination not delimitated in depth.
Sørkjosen Airport - BØF 1 (old)	2.8	1.3	47%	Contamination not delimitated in depth.
Narvik Airport Framnes - BØF North (not active) and filling	2.6	1.4	66%	
Ålesund Airport Vigra - BØF 1 (active)	2.5	0.9	36%	Contamination not delimitated in depth.
Fagernes Airport Leirin - BØF A (not active)	2.1	1.4	66%	
Sogndal Airport Haukåsen - BØF1 (not active)	1.1	0.2	15%	Contamination not delimitated in depth.
Røst Airport - BØF1 (not active)	1.0	0.8	83%	Examined depth 1.2 metres.
Kirkenes Airport Høybuktmoen - Operating area	1.0	0.2	24%	Contamination not delimitated in depth.
Florø Airport - BØF1 (active)	1.0	0.6	63%	
Ørsta-Volda Airport Hovden - BØF 1 (old)	0.8	0.2	29%	
Kristiansund Airport Kvernberget - BØF A (active)	0.7	-	-	Not calculated for 0-1 metres, few samples. Contamination not delimitated in depth.
Vardø Airport Svartnes - BØF 1 (old)	0.6	0.6	100%	Examined depth 1 metre. Contamination not delimitated in depth.
Svolvær Airport Helle - BØF B (Not active)	0.5	-	-	Average depth to bedrock 0.7 metres.

Total	**314**	**115**	**37%**	

If the masses can be sorted and coarse fractions (block/stone) are extracted

For remedial action that includes excavating masses, there is the possibility of sieving out coarser masses, and dealing only with the finer masses where the contamination lies. By using a sorting bucket, blocks and large stones can be sorted from the contaminated masses to reduce the amount of masses that need to be delivered to landfill and the amounts of clean masses that need to be transported to the site. This will result in a saving of the cost of excavation measures.

Sites where the masses are considered suitable for sorting with a sorting bucket on an excavator, and estimated proportion that can be reused, are shown in Table9. Unit prices have been used for sorting, and to assess the profitability of sorting, this has been assessed against deductions in transport and landfill fees, as well as deductions in the cost of transporting clean masses. Unit prices are shown in Table 16 Chapter 3.2.3.4. Calculated savings of sorting masses with a sorting bucket (intended for the entire volume examined) are shown in Table 10. At Kirkenes operating area and Bergen BØF 2 there is both a high proportion (30%) which is believed to be reusable, and a large volume of contaminated masses. At Kirkenes BØF 1 there is an assumed lower (10%) proportion of reusable masses, but a large volume of contaminated masses. Fagernes BØF A has masses of rubble, and a high proportion of masses (30%) is expected to be reusable. In addition, the site is not close to the sea, so reusing coarse masses will save significant transport costs. For all these sites, masses that are sorted and reused will represent a large total reduction in costs.

In the cost calculations, it is assumed that fractions over 50 mm can be sorted using a sorting bucket. The proportion of block/stone (> 50 mm) in the masses is set using a discretionary assessment based on the descriptions of the mass type, in the same way as the proportion of fine material (< 20 mm) is used in the calculation of amounts of PFOS/ΣPFAS in the masses. Fractions that can be sorted out are set at > 50 mm based on the fact that it is a fraction that it is considered will be easy to sort from contaminated fine material using a sorting bucket. Although the contamination is believed to sit in fractions less than 20 mm, it will be challenging to separate clean and contaminated fractions < 50 mm. There will be a risk that contaminated fine material will be stuck on the fractions between 20 to 50 mm unless the sieving process is optimal. It should be investigated in detailing remedial action whether it is possible to sieve from fractions greater than 20 mm, but it must then be examined more closely with sampling and analysis of the sieved masses whether they are actually free of fine material.

It is assumed that the proportion of coarse masses that can be sorted out is reduced somewhat for sites where excavation must be carried out below groundwater level. At these sites, masses in unsaturated zones will be suitable for sorting, but probably the wet masses in the saturated zone will not be as suitable.

The use of a sorting bucket will be more time consuming than the use of a screening machine at sites with volume masses over approximately 5,000 m^3. In the case of excavation measures, depending on the volume of excavation at the site, it will be appropriate in the detailed planning to make an assessment of the costs of using a screening machine, either at the site or in a suitable place nearby.

Table9 : Overview of sites with masses suitable for sorting, and estimated proportion that can be sorted out and reused (%).

Airports and sites	Type of masses	Proportion of masses that can be sorted and reused (%)
Tromsø Airport Langnes - BØF 2 (old)	Gravel in the surface, then stone, coarse sand, soil, sand over marsh and/or clay.	0%
Ålesund Airport Vigra - BØF 2 (old)	Sandy soil, sandy gravel, gravel, sand, filler, and soil. Marshland west and south.	0%
Alta Airport - BØF1 (active)	The area is situated on alluvial deposits and primarily comprises sandy masses.	0%
Rørvik Airport Ryum - BØF 2 (younger, but not active)	Limited description, but described as marine deposits from fine sand to clay for the airport in general.	0%
Kirkenes Airport Høybuktmoen - BØF 1 (old)	Glacial stream deposits with sand, gravel and stones.	10%
Kristiansund Airport Kvernberget - BØF B (old)	Stone, gravel, sand, marsh, boulders.	20%
Lakselv Airport Banak - BØF 3 (active)	Sand	0%
Berlevåg Airport - BØF 1 (old)	Sand, thin layer of peat and beach deposits (round pebbles and shell sand). Elements of building refuse.	0%
Molde Airport Årø - BØF 1 (active and old)	Crushed stone, stone, gravel, sand, clay, organic sand. In topsoil at the new part there is crushed stone, sand and gravel.	20%
Tromsø Airport Langnes - BØF 1 (active)	Mainly a layer of stone, gravel and sand over shell sand, clay and silt.	0%
Bergen Airport Flesland - BØF 1 (youngest, not active)	Soil with a lot of organic material and assumed gravel masses in centre of BØF.	0%
Haugesund Airport Karmøy - BØF B (old)	The unconsolidated material generally consists of filled masses of blocks, rubble, sand and gravel.	30%
Stavanger Airport Sola - BØF 2 (old)	Mainly fine sand, as well as some soil, crushed stone and gravel in the description of samples.	10%
Bergen Airport Flesland - BØF 2 (old)	Rubble, stone and gravel.	30%
Mo i Rana Airport Røssvoll - BØF 1 (old)	BØF lies on a thick deposit of unconsolidated material comprising sand and gravel.	0%
Røros Airport - BØF 1 (not active)	Sand, gravel and silt as well as some peat.	0%
Mosjøen Airport Kjærstad - BØF 1 (old)	Gravel, clay and sand.	0%
Hammerfest Airport - BØF 1 (old)	Mix of topsoil, crushed stone, spreading sand, block and bedrock. Marsh to the west.	20%
Sandnessjøen Airport Stokka - BØF 1 (old)	Peat, shell sand and soil.	0%
Leknes Airport - BØF 1 (not active)	Sand, stone, gravel, filler, peat and sandy soil/silt.	10%
Sørkjosen Airport - BØF 1 (old)	Mainly sandy masses, with a layer of stone, gravel and crushed stone on top.	0%
Narvik Airport Framnes - BØF North (not active) and filling	Sand/gravel/rock over rubble to the south, and more sandy masses over soil masses and solid bedrock to the north.	20%

Ålesund Airport Vigra - BØF 1 (active)	The masses are stated to consist of gravel, sand, soil, silty sand, shell sand and filler.	0%
Airports and sites	**Type of masses**	**Proportion of masses that can be sorted and reused (%)**
Fagernes Airport Leirin - BØF A (not active)	Gravel and rubble.	30%
Sogndal Airport Haukåsen - BØF1 (not active)	Mixture of moraine, organic soil, stone, sand, clay, rubble with fine material, marsh soil.	20%
Røst Airport - BØF1 (not active)	Rough gravel over bedrock.	20%
Kirkenes Airport Høybuktmoen - Operating area	Sand, gravel, stone, block, gravel, coarse sand.	30%
Florø Airport - BØF1 (active)	Rubble, and some organic soil over bedrock outside BØF.	30%
Ørsta-Volda Airport Hovden - BØF 1 (old)	Sand	0%
Kristiansund Airport Kvernberget - BØF A (active)	Stone, gravel, sand, boulders, and one sampling point SJ5 in marsh just outside BØF.	20%
Vardø Airport Svartnes - BØF 1 (old)	Sand, gravel, soil and peat and some rock.	0%
Svolvær Airport Helle - BØF B (Not active)	Gravel, rock and sand.	20%

Table 10: Costs saved by sorting masses with sorting bucket on excavator. The calculation is based on the volume of contaminated masses within the entire area of the survey (given in Figure 3 in Chapter 2.2.3.2 and in Appendix A - Reporting forms for Part 1), and unit prices as given in Table 16 Chapter 3.2.3.4.

Sorting – profitability	Total cost of sorting	Total cost of transport and landfill	Reduction in price transport and landfill due to sorting	Total cost transportation of clean masses	Reduction in price transportation	Total reduction in cost of remedial action
Airports and sites	NOK	NOK	NOK	NOK	NOK	NOK
Kirkenes Airport Høybuktmoen - Operating area	3,852,450	95,872,317	28,761,695	10,126,440	3,037,932	27,947,177
Bergen Airport Flesland - BØF 2 (old)	3,293,150	80,776,265	24,232,880	8,656,280	2,596,884	23,536,614
Fagernes Airport Leirin - BØF A (not active)	711,788	22,661,310	6,798,393	1,870,986	561,296	6,647,901
Kirkenes Airport Høybuktmoen - BØF 1 (old)	3,170,076	78,890,714	7,889,071	8,332,771	833,277	5,552,273
Florø Airport - BØF1 (active)	670,656	17,289,157	5,186,747	1,762,867	528,860	5,044,951
Haugesund Airport Karmøy - BØF B (old)	613,116	15,844,669	4,753,401	1,611,619	483,486	4,623,771
Sogndal Airport Haukåsen - BØF1 (not active)	1,032,360	23,996,956	4,799,391	2,713,632	542,726	4,309,758
Molde Airport Årø - BØF 1 (active and old)	890,001	23,097,793	4,619,559	2,339,431	467,886	4,197,444
Narvik Airport Framnes - BØF North (not active) and filling	1,089,270	23,312,337	4,662,467	2,863,224	572,645	4,145,842
Kristiansund Airport Kvernberget - BØF A (active)	566,720	14,665,791	2,933,158	1,489,664	297,933	2,664,371
Hammerfest Airport - BØF 1 (old)	717,108	15,007,688	3,001,538	1,884,970	376,994	2,661,423
Stavanger Airport Sola - BØF 2 (old)	1,704,080	39,145,152	3,914,515	4,479,296	447,930	2,658,365
Leknes Airport - BØF 1 (not active)	2,129,960	40,050,695	4,005,070	5,598,752	559,875	2,434,985
Kristiansund Airport Kvernberget - BØF B (old)	455,525	11,788,245	2,357,649	1,197,380	239,476	2,141,600
Røst Airport - BØF1 (not active)	266,784	5,709,657	1,141,931	701,261	140,252	1,015,400
Svolvær Airport Helle - BØF B (Not active)	165,228	3,780,337	756,067	434,314	86,863	677,702

Distance from landfill

There are currently only three landfills with permission to receive masses containing PFAS;

- Lindum Oredalen in Drammen
- Perpetuum Balsfjord in Tromsø
- Franzefoss Lia in Trondheim

Iris Vikan in Bodø has also submitted an application for permission to receive masses containing PFAS, andit can be assumed that there will be more applications.

Sites with the calculated amount of PFOS in the surveyed area, and the localization of the three landfills with permission are shown in Figure 1. For sites located near the sea and wharfage, the distance to landfill will be of less importance to the cost of transport. Only Røros and Fargernes, located in the inner region of Eastern Norway, have higher transport costs.

3.2.3 Prices and costs

3.2.3.1 Distance from runway

The site's distance to the runway will have an impact on construction work. Avinor has placed restrictions on obstacles based on distance to the centre line of the runway. Within 140 metres of the centre line of the runway there are restrictions on fixed obstacles (building/containers/parked construction machinery etc.), and within 60 metres for moving obstacles (e.g. construction machinery/vehicles in operation). The distance the site has to the runway can therefore affect whether construction work can be carried out in daytime or nighttime, and for larger airports with air traffic,construction work will have to be adapted to this including during the night. A review of the sites' distance to the runway has been carried out, as shown in Table 11. The distance is measured (on maps) from the nearest sampling point with detected PFAS contamination to the centre line of the runway. In Table 11, sites at a distance greater than 140 metres from the centre line of the runway are shown in green, sites between 60 and 140 metres from the runway are shown in yellow, and sites closer than 60 metres are shown in red. For yellow and red sites, it is assumed that there will be additional costs as remedial action must be adapted to air traffic. Additional costs for excavation measures due to a site being close to the runway will be variable, as there are variations in air traffic for each airport. A report on the impact of the runway on construction works for each site is considered part of the detailed planning in the event of possible remedial action. Due to expectations of increased time spent on construction work, stabilization measures, etc., a factor of two on the cost of the construction works for yellow sites, and a factor of three for red sites has been added to the overall cost calculations.

Table 11: Distance of the sites from the runway.

Airports and sites	Distance from runway (m)
Bergen Airport Flesland - BØF 1 (youngest, not active)	650
Alta Airport - BØF1 (active)	500
Lakselv Airport Banak - BØF 3 (active)	320
Tromsø Airport Langnes - BØF 1 (active)	290
Bergen Airport Flesland - BØF 2 (old)	260
Røst Airport - BØF1 (not active)	250
Stavanger Airport Sola - BØF 2 (old)	220
Haugesund Airport Karmøy - BØF B (old)	150
Kristiansund Airport Kvernberget - BØF A (active)	140
Mo i Rana Airport Røssvoll - BØF 1 (old)	100
Fagernes Airport Leirin - BØF A (not active)	100
Molde Airport Årø - BØF 1 (active and old)	90
Florø Airport - BØF1 (active)	75
Kristiansund Airport Kvernberget - BØF B (old)	70
Berlevåg Airport - BØF 1 (old)	70
Ålesund Airport Vigra - BØF 2 (old)	60
Ålesund Airport Vigra - BØF 1 (active)	60
Kirkenes Airport Høybuktmoen - Operating area	60
Vardø Airport Svartnes - BØF 1 (old)	55
Sandnessjøen Airport Stokka - BØF 1 (old)	45
Sørkjosen Airport - BØF 1 (old)	45
Røros Airport - BØF 1 (not active)	40
Hammerfest Airport - BØF 1 (old)	40
Leknes Airport - BØF 1 (not active)	40
Sogndal Airport Haukåsen - BØF1 (not active)	35
Rørvik Airport Ryum - BØF 2 (younger, but not active)	25
Tromsø Airport Langnes - BØF 2 (old)	20
Kirkenes Airport Høybuktmoen - BØF 1 (old)	20
Mosjøen Airport Kjærstad - BØF 1 (old)	20
Narvik Airport Framnes - BØF North (not active) and filling	20
Ørsta-Volda Airport Hovden - BØF 1 (old)	20
Svolvær Airport Helle - BØF B (Not active)	20

3.2.3.2 "Pump and treat"

Calculation of costs for remedial action in contaminated groundwater is conditional on a combination of measures in masses in the unsaturated zone, and will thus become an additional measure for covering or digging and external landfill disposal. If the measure is to be based on natural leaching from the unsaturated zone over time, the measure will have to go over a very long period of time, and a present value calculation must be carried out. To this end, the survey basis is considered to be too poor, and the uncertainty of such a calculation will be too great for there being any purpose in doing so.

Estimated costs for "pump and treat" measures for Lakselv BØF 3 (active) are shown in Table 12 and for Stavanger BØF 2 (old) in Table 13 and Røros Airport in Table 14. The cost of "pump and treat" measures is related to mass type, pumping rates, concentrations and amounts of PFAS contamination in groundwater at the various sites. Calculations of costs have been based on expected pumping rates with the mass type at

the site and hydraulic conductivity (K) (ref. Chapter 3.2.2.1). The pumping rate is limited by the hydraulic conductivity of the masses, and to increase the pumping rate, more wells must be established.

The order of establishment costs for wastewater treatment plants and pumping wells is based on experience figures for a small and large wastewater treatment plant at Oslo Airport Gardermoen (OSL). The figures are adapted to the information available on site-specific conditions at Lakselv BØF 3, Stavanger BØF 2 and Røros Airport. It is expected that the cost of establishing wastewater treatment plants and operation of the plant will increase with increasing pumping rates above 1.5 l/s.

For pumping rates that are 1.5 l/s or lower, the basis is taken in a small wastewater treatment plant consisting of one container, one charcoal filter, one sedimentation container and one online monitoring system. Estimated establishment cost for this plant including an activated charcoal filter with the capacity to clean up to 2 kg of PFAS is approximately MNOK 2.1. Calculated pumping rates at Stavanger BØF 2 and Røros BØF 1 are lower than 1.5 l/s even when pumping 9 wells, and a small wastewater treatment plant is expected to cover this need. The increase in the cost of establishment at these sites is due to more wells and the burial of water lines to avoid frost. For Stavanger BØF 2, PFAS concentrations in groundwater are higher than at the other two sites, and there is a greater estimated amount of -PFAS in the saturated zone (approx. 3 kg). Therefore, an additional cost has been added for an activated charcoal filter with the capacity to clean a total of 4 kg ∑PFAS. For Lakselv BØF 3, the pumping rates are significantly higher, and it is taken into account that there is a need to increase the treatment plant's capacity with an increasing pumping rate.

Operating costs are inclusive electricity and are expected to increase with the number of wells. For Lakselv BØF 3, increased operating costs with increasing size of the wastewater treatment plant have also been taken into account. Costs for maintenance of wells and pumps, as well as analysis costs are not included in the cost calculation, this is considered to be part of the detailed report.

Table 12: Estimated costs of "pump and treat" measures at Lakselv Airport BØF 3 (active).

Lakselv BØF 3		**1 well**	**3 wells**	**6 wells**	**9 wells**
Q (pumping rate)	l/s	0.74	2.2	4.4	6.7
Monitoring wells and groundwater mapping	NOK	500,000	500,000	500,000	500,000
Establishment costs wastewater treatment plants and pumping wells	NOK	2,000,000	3,000,000	6,000,000	10,000,000
Annual Operating Costs	NOK	96,000	192,000	384,000	516,000
One year of operation	NOK	2,596,000	3,692,000	6,884,000	11,016,000
Two years of operation	NOK	2,692,000	3,884,000	7,268,000	11,532,000
Three years of operation	NOK	2,788,000	4,076,000	7,652,000	12,048,000
Five years of operation	NOK	2,980,000	4,460,000	8,420,000	13,080,000
Ten years of operation	NOK	3,460,000	5,420,000	10,340,000	15,660,000
Twenty years of operation	NOK	4,420,000	7,340,000	14,180,000	20,820,000

Table 13: Estimated costs of "pump and treat" measures at Stavanger Airport BØF 2 (old).

Stavanger BØF 2		1 well	3 wells	6 wells	9 wells
Q (pumping rate)	l/s	0.15	0.5	0.9	1.4
Monitoring wells and groundwater mapping	NOK	500,000	500,000	500,000	500,000
Establishment costs wastewater treatment plants and pumping wells	NOK	2,235,000	2,435,000	2,735,000	3,035,000
Annual Operating Costs	NOK	136,000	184,000	232,000	328,000
One year of operation	NOK	2,871,000	3,119,000	3,467,000	3,863,000
Two years of operation	NOK	3,007,000	3,303,000	3,699,000	4,191,000
Three years of operation	NOK	3,143,000	3,487,000	3,931,000	4,519,000
Five years of operation	NOK	3,415,000	3,855,000	4,395,000	5,175,000
Ten years of operation	NOK	4,095,000	4,775,000	5,555,000	6,815,000
Twenty years of operation	NOK	5,455,000	6,615,000	7,875,000	10,095,000

Table 14: Estimated costs of "pump and treat" measures at Røros Airport

Røros Airport		1 well	3 wells	6 wells	9 wells
Q (pumping rate)	l/s	0.015	0.05	0.09	0.14
Monitoring wells and groundwater mapping	NOK	500,000	500,000	500,000	500,000
Establishment costs wastewater treatment plants and pumping wells	NOK	2,117,500	2,317,500	2,617,500	2,917,500
Annual Operating Costs	NOK	136,000	184,000	232,000	328,000
One year of operation	NOK	2,753,500	3,001,500	3,349,500	3,745,500
Two years of operation	NOK	2,889,500	3,185,500	3,581,500	4,073,500
Three years of operation	NOK	3,025,500	3,369,500	3,813,500	4,401,500
Five years of operation	NOK	3,297,500	3,737,500	4,277,500	5,057,500
Ten years of operation	NOK	3,977,500	4,657,500	5,437,500	6,697,500
Twenty years of operation	NOK	5,337,500	6,497,500	7,757,500	9,977,500

3.2.3.3 Coverage/Shielding

For cost calculations for coverage of contaminated material in an unsaturated zone, basis is taken on prices as stated in Table 15.

Table 15: Prices for coverage measures include the levelling of terrain, membrane and excavation and laying of membrane in trenches around BØF.

Part of measures	Levelling of terrain	Transportation of clean material to have under and over membrane	Internal transport and placement of clean material	Membrane including rollout	Excavation and laying of membrane in trenches around BØF
Unit	**NOK/m²**	**NOK/tonne**	**NOK/m³**	**NOK/m²**	**NOK/m²**
Pricing	33	115	100	200	700

Coverage with membrane assumes that the area is relatively flat and that there are no sharp material that can puncture the membrane. It is therefore assumed that a layer of approx. 20 cm of clean suitable substrates must be added and some levelling of the terrain must be carried out before the membrane is laid out. The membrane must then be protected, and costs have been added for laying out approximately 30 cm of clean suitable material over the membrane.

3.2.3.4 Excavation measures

Cost calculations for excavation measures are based on prices as stated in Table 16.

Table 16: Prices for excavation measures, sorting of material, transport and depositing in landfill of contaminated material, and the transportation of clean material.

Part of measures	Excavation of material	Sorting with sorting bucket	Loading up on vehicle	Transport and landfill fee	Transportation of clean material from local gravel pit	Internal transport of clean material, placement and compression
Unit	**NOK/m³**	**NOK/m³**	**NOK/m³**	**NOK/tonne**	**NOK/tonne**	**NOK/m³**
Pricing	30	70	30	930-1310*	115	150

*Transport and landfill fee prices depend on the location of the airport in the country.

Input for prices for transport and landfill fees is provided by Perpetuum and Lindum, and is based on boat transport of the contaminated material. Røros and Fagernes are located in inner Eastern Norway, relatively far away from the sea, and therefore have the highest transport costs.

Water purification when excavating under groundwater level

For 14 of the sites, groundwater levels are reported to be higher than the estimated excavation depth of the measure (Table 17). Water purification will be needed to keep the excavated cavity dry at these sites during the implementation of the measure. Excavation under groundwater level will lead to a mobilization of PFAS compounds and elevated concentrations in water in the excavated cavity. There are estimated costs for the water in the excavated cavity to be cleaned with a mobile (container-based) treatment plant with activated

charcoal filter (Table 18), both for the removal of ∑PFAS to prevent the spread of the compounds, and so that clean material can be put back without significant recontamination. For 13 of the sites, there is an estimated need for purification of PFAS-containing plant water for a month, with an estimated cost of purification of NOK 604,000, while for Ålesund there is an estimated cost of approximately 1.7 MNOK for purification for three months.

Only costs are considered for the sites where it is probable that excavation will take place below groundwater level. Assessments of any costs related to the need to handle pumping water caused by rainfall/surface runoff to the construction cavity are considered as part of the detailed planning for all sites. The space requirement has not been considered, nor whether there are alternative locations for such a facility at the various sites.

The amount of water that needs to be purified depends on the excavation area, the expected excavation depth below groundwater level, inflow of water to the cavity, and the time the excavation takes. The excavation area will depend on the concentration limit set by the limit of remedial action at the various sites. For half of the sites, the excavation depth below groundwater level is expected to be less than 1 metre, for six of the sites it is between 1-1.5 metres, and for Ålesund it is the greatest with 1.9 metres. Ålesund is also the site with the largest surveyed contaminated area (Appendix A - Reporting forms for Part 1), and the highest proven concentrations of ∑PFAS in groundwater (Table 17). Of all the sites, Ålesund will therefore be the one with the need to purify the most water and over the longest term.

Since the water must remain for a certain period in the charcoal, a hydraulic capacity has been assumed in the wastewater treatment plant of 5 l/s. This is assumed to be adequate capacity for purification of water in one month for all sites, with the exception of Ålesund where there is assumed a need to purify water for three months.

The purification capacity for activated charcoal used in the plant will depend on the concentrations of ΣPFAS and any other other contamination or particles in the water that need to be removed and depends on the degree of pretreatment of the water. The concentrations of ΣPFAS in groundwater are expected to have close correlation with particles and organic content in the water. Most of the groundwater wells established in connection with the DP2 project were established in excavation shafts. Sampling of groundwater in newly established groundwater wells in excavation shafts is expected to have elevated concentrations of PFAS due to the mobilization, in the same way as when sampling water in excavation shafts. A review of measured concentrations in groundwater has therefore been carried out for the sites where excavation under groundwater level is appropriate, and those samples that are believed to show concentrations in groundwater with increased mobilization are selected and shown in Table 17. For those sites where no samples have been taken that represent the mobilization of PFAS in groundwater, groundwater samples are shown taken longer after establishment. For four of the sites, no samples of groundwater have been taken. In the cost estimate, it is assumed that the water is first channelled to a pretreatment consisting of sedimentation/leveling and oil separation, and then a fine cloth filter. Based on the concentrations measured in groundwater, in the price for treatment capacity for one month, a treatment capacity is used for activated charcoal of up to 2 kgΣPFAS , for Ålesund (because of the high concentrations in groundwater), a treatment capacity of up to 12 kg ΣPFAS has been used over three months.

Table 17: Sites where the scope of excavations includes digging under groundwater level, and detected concentrations of ΣPFAS in groundwater samples in a shaft, or well in the same year as establishment.

Airports and sites	Approx. depth to groundwater	Estimated excavation depth	Excavation depth under groundwater level	Concentrations of PFAS in groundwater samples	Comments
	Metre	Metre	Metre	ng/l	
Tromsø Airport Langnes - BØF 2 (old)	2	3.35	1.4	58,000-261,000	Samples from two wells taken in May 2012, upon establishment. From 2014 the cons. is between 48,000-175,000.
Lakselv Airport Banak - BØF 3 (active)	2.5	3.2	0.7	30,000-67,500	Based on the four groundwater samples with the highest concentration, one is taken in a shaft the rest in wells.
Røst Airport - BØF1 (not active)	0.55	1.2	0.7		No samples of groundwater.
Vardø Airport Svartnes - BØF 1 (old)	0.5	1	0.5	16-308	Samples from three wells. Uncertain if it is on establishment. Low concentrations, very permeable masses.
Alta Airport - BØF1 (active)	1.75	2.3	0.6		No samples of groundwater.
Rørvik Airport Ryum - BØF 2 (younger, but not active)	0.5	1.1	0.6	527	One sample from shaft.
Kristiansund Airport Kvernberget - BØF B (old)	1	2.5	1.5	7,610-36,600	Three samples from wells immediately after establishment.
Kristiansund Airport Kvernberget - BØF A (active)	2.5	4	1.5		No samples of groundwater.
Ålesund Airport Vigra - BØF 1 (active)	2	3	1.0	4,140-15,400	All samples of groundwater have concentrations at a relatively similar level.
Ålesund Airport Vigra - BØF 2 (old)	2	3.9	1.9	446,000-1,450,000	Two samples taken in the same well, highest cons. on establishment and measured only for PFOS. Lower cons. for total PFAS one year after (446,000 ng/l).
Ørsta-Volda Airport Hovden - BØF 1 (old)	1.8	2.6	0.8	1,030	Groundwater well in shaft one year after establishment, but well slightly "upstream".
Haugesund Airport Karmøy - BØF B (old)	0.5	1.8	1.3	49,800	Groundwater in a shaft near/at BØF.
Sogndal Airport Haukåsen - BØF1 (not active)	1.4	3	1.6	275-658	Groundwater wells in two shafts at BØF, one year after establishment.
Fagernes Airport Leirin - BØF A (not active)	1.5	2.2	0.7		No samples of groundwater.

Table 18: Basis for calculating the price of treatment of PFAS-containing plant water.

Purification of PFAS-containing water requires:	Price for one month (NOK)	Price for three months (NOK)
Mobilisation/demobilisation of mobile plant	250,000	250,000
Monthly rent	65,000	195,000
Activated charcoal	117,500*	705,000*
Fine cloth filter	90,000	270,000
Operator cost	15,000	45,000
Diesel generator	22,500	67,500
Diesel	38,400	115,200
Incineration of coal	3,500	10,500
Landfill disposal of masses from sand filters	735	2,205
Disposal of sludge	1,250	3,750
Total	**603,885**	**1,664,155**

*In the price for treatment for one month, a treatment capacity is used of up to 2 kg PFAS , for Ålesund (because of the high concentrations in groundwater), a treatment capacity of approx.12 kg PFAS has been used over three months.

Active fire training sites

Of the airports covered by the Norwegian Environment Agency's orders, 11 airports currently have active BØF. They are Haugesund, Molde, Alta, Lakselv, Tromsø, Ålesund, Florø, Kristiansund, Stavanger, Kirkenes and Trondheim.

Three of these, Tromsø, Alta and Ålesund, are planned to be closed down after the 2019 training season.

There will be a significant additional cost to carry out excavation measures at sites with active fire training sites that will be continued/re-established afterwards. For excavation measures on active fire training sites, the existing platform must be demolished in whole or in part in order to excavate under the platform, and then be rebuilt. In addition, the training must be relocated somewhere else in the meantime. The cost of this is believed to be relatively constant regardless of whether the measure includes a large or small volume of material. Therefore a fixed cost has been set for excavation measures on active fire training sites that has been added to other costs of remedial action at these sites, regardless of which concentrations one chooses to clean down to. Based on historical figures from Avinor on the cost of building a new fire training site, the additional cost of active fire training sites is set at 80 MNOK. The order of priority will therefore be affected by whether the site is active or not. No such cost has been added for the three active sites that are planned to be closed down during 2020.

Active fire training sites have a significant additional cost for excavation measures. An alternative measure for these sites is the purification of water from oil separators. However, based on estimated annual discharge amounts from oil separators at 12 active BØF in the risk assessment reports (Bergen active was closed down after 2016), this measure will only reduce the Σ PFAS discharge by between 1-50 g/year for PFOS and between 6-155 g/year for ΣPFAS per site. Overall, based on the estimated discharge amounts, it will reduce discharge by approximately 100 g of PFOS per year and approximately 580 g of PFAS per year. Due to the fact that the measures are expected to have a limited effect, no costs have been estimated for purification of water from oil separators at active fire training sites.

3.2.4 Site-specific action limits

3.2.4.1 Sites where data suggests that otherPFAS compounds make up a significant part of the soil contamination

Eight of the sites for which amounts are calculated in soil have been considered to have an indication that the contamination is more than 20% greater due to other PFAS compounds (shown in Table 1). For these sites, 20% has been added to the amount of PFOS in the assessment of action efficiency and site-specific action limits for covering and excavation measures with external landfill disposal. At these sites, the cost per kg of contamination removed will be lower than if one only takes into account PFOS contamination. For amounts in groundwater, a calculation is made for Σ
PFAS.

3.2.4.2 Uncertainty in the calculations

As described in Chapter2.1.3the uncertainty related to calculating the amounts in soil quantify the amounts that are not revealed through the surveys, and amounts that may be over/underestimated based on the survey. Positive uncertainty is evident through a discretionary assessment of the size of the area and depth that is not delimitated by the survey, shown as wedge areas in the map figures in Appendix A - Reporting forms for Part 1. For the sites that are considered appropriate for measures after Avinor has reported on the Norwegian Environment Agency's orders, there will primarily be a need to reduce this uncertainty with supplementary sampling. After supplementary sampling, it can be considered whether the cost of measures for a larger part of the source area will be more or less cost-effective than is assumed here. The cost of cleaning up total amounts ofΣPFAS including positive uncertainty is calculated and shown in Tables 2 and 3 in Appendix E, but is not included in the assessment of site-specific action limits for each site.

Uncertainty for calculating amounts of ∑PFAS in groundwater is high as described in Chapter 3.2.2.1, it has not been attempted to be quantified. Calculated amounts in groundwater as described in Chapter 3.2.2.1 are assumed to be an overestimation. Other sources of error for cost/effect calculations are:

- Concentrations in groundwater. The assumption that all the groundwater pumped up has the average concentration as analyses of groundwater in the wells in the relevant fire training sites shows. This leads to a reduction in cost per kg of ΣPFAS removed.
- Hydraulic conductivity. A slight change in hydraulic conductivity will have a major impact on the amounts of water that can be pumped and the amounts ofΣPFAS that are removed. The assumption that the fine-grained material at Stavanger BØF 2 and Røros Airport has a low hydraulic conductivity will, on the other hand, lead to an increase in cost per kg of -PFAS removed.
- Changes over time. The effectiveness of the treatment measure decreases with time as the concentrations in the groundwater decrease.

3.2.4.3 "Pump and treat"

Table 1 in Appendix E shows the estimated cost of "pump and treat" measures for removal of PFAS contamination in the saturated zones at the sites Lakselv BØF 3, Stavanger BØF 2 and Røros Airport. The table provides an overview of calculated amounts of ∑PFAS (kg) in the groundwater/saturated zone, estimated amounts removed by pumping at different pumping rates (number of wells) and over different periods (number of years), and cost/effect (NOK per kg removed) over time. For Lakselv BØF 3 and Røros BØF 1, it is assumed that the main body of the estimated amounts of contamination in soil are in the unsaturated zone. For Stavanger BØF 2, it is assumed that approximately 30% of the estimated total amount

of PFOS in soil (1.6 kg of 5.4 kg) at BØF 2 is in the saturated zone. The total amount in the saturated zone for this site will then be 3 kg. With the existing mapping basis, the cost/effect calculations are only considered to be a feasibility study in which costs are roughly outlined. As described in Chapter 3.2.3.2 the calculation of the cost of remedial action in contaminated groundwater assumes a combination of measures in material in the unsaturated zone. No site-specific limits have been set for "pump and treat" measures, but highlighted in yellow in Table 1 Appendix E are the scope of action and the scope of operation that are estimated for a 100% clean-up of the saturated zone/groundwater (assuming no new flow from the unsaturated zone).

As shown in Table 19, the calculations show that it will take less than a year to remove the amount of -PFAS in groundwater at Lakselv BØF3, from 1.6-5 years at Stavanger BØF 2 and from 44-132 years at Røros Airport.

Table 19: Number of years to remove ΣPFAS from 3, 6 and 9 wells for the three relevant sites.

Site	Lakselv BØF 3	Stavanger BØF 2	Røros Airport
Pumping rates (Q)	0.74	0.15	0.015
Amount of PFAS in the groundwater/saturated zone	1.1	3.0	1.2
Estimated amount removed per year	0.4	0.2	0.003
Number of years with 3 wells	0.9	5	132
Number of years with 6 wells	0.4	2	66
Number of years with 9 wells	0.3	1.6	44

3.2.4.4 Coverage/Shielding

Coverage will include measures for the amount in the unsaturated zone. Separate calculations have not been made of PFOS in material in the unsaturated and saturated zones (Chapter3.2.2.1).

Costs are estimated for coverage/shielding at the four sites Narvik BØF North and filling, Røros BØF 1, Lakselv BØF 3 and Stavanger BØF 2. At Lakselv BØF 3 and Stavanger BØF 2, coverage is generally believed to be suitable in combination with "pump and treat" measures. For Lakselv this is due to tidal influence and fluctuation of groundwater levels, and for Stavanger a significant part of the contamination in soil is in the saturated zone. For coverage at Lakselv BØF 3, it is assumed that the estimated amount in soil is mainly in the unsaturated zone, and for Stavanger BØF 2 it is assumed that about 70% of the estimated contamination in soil is in the unsaturated zone.

Table 2 inAppendix E shows the estimated costs for covering the amount of PFOS/ΣPFAS above the different concentration limits for the four sites that are deemed suitable. The table provides an overview of calculated amounts of PFOS/ΣPFAS (kg) in soil, contaminated area (m^2) and depth, effectiveness of remedial action (g/m^3), price for covering contamination and cost/effect (NOK per kg removed) above the different concentration limits, as well as the cost of remedial action (total cost). Costs for measures on total amount including positive uncertainty have also been shown, but as described in Chapter 3.2.4.2, this has

not formed part of the assessment of site-specific action limits. Comments are entered in the table for those sites where 20% has been added to the amount of PFOS due to an indication of significant contamination by other PFAS compounds.

The site-specific action limit proposed for each site is set to the concentration limit where the amount of PFOS/ΣPFAS removed is significantly reduced, and/or the cost per kg removed increases significantly. It is highlighted in yellow in Table 2 in Appendix E – Limits of remedial action, where the action limit is proposed for each site. For all sites, the proposed action limit is set for coverage of 150 µg/kg.

3.2.4.5 Excavation measures and external landfill disposal

Table 3 in Appendix E shows the estimated cost of excavation measures for the amount of PFOS/ΣPFAS above the different concentration limits for the 32 sites for which quantities are calculated. The table provides an overview of amounts of PFOS/ΣPFAS (kg), volume masses (m^3), action efficiency (g/m^3), price for removal of contamination and cost/effect (NOK per kg removed) above the different concentration limits, as well as the cost of remedial action (total cost). There are also shown costs for measures on the total amount including positive uncertainty, but as described in Chapter3.2.4.2, this has been part of the assessment of site-specific action limits.

Comments are entered in the table for those sites where 20% has been added to the amount of PFOS due to an indication of significant contamination by other PFAS compounds. Comments have also been entered for those sites where costs have been added for the cleaning of water in excavation pits below groundwater level and additional costs for active fire training sites (except for Tromsø, Ålesund and Alta to be shut down from 2020).

An excerpt from the table for cost calculations in Appendix E is shown in Table 20 for the sites Tromsø BØF 2, Ålesund BØF 2, Molde BØF 1 and Rørvik BØF 2. In addition, a summary for all sites in Part 2 is shown. The summary is the sum of quantities, the sum of volume and total cost of removing quantities above each concentration limit at all sites, as well as average action efficiency and cost/effect.

The site-specific action limit proposed for each site is set to the concentration limit where the amount of PFOS/ΣPFAS removed is significantly reduced, and/or the cost per kg removed increases significantly. It is highlighted in yellow in Table 3 in Appendix E, where the action limit is proposed for each site. For most sites, the proposed action limit is set at 150 µg/kg. It is higher at only two sites (> 500 µg/kg for Rørvik BØF 2 and Kristiansund BØF B), and at two sites (Kirkenes operating area and Ørsta-Volda BØF 1) it is not estimated that there will be masses with amounts above 150 µg/kg so that it is proposed to set the action limit at >30 µg/kg. At Florø BØF 1, the action limit proposed is set to >30 µg/kg on the basis that there are such small amounts of concentrations >150 µg/kg. The summary in Table 20 also shows that the average cost/effect of the different concentration limits is lowest for concentrations > 150 µg/kg, of approximately 8.6 MNOK per kg PFOS/ΣPFAS removed. Figures showing the amount of PFOS/ΣPFAS removed and cost per kg removed for all sites are shown in Appendix E, except for the two that do not have amounts over 150 µg/kg.

For Tromsø BØF 2, Figure 17 shows that at >150 µg/kg, the curve showing the amount of PFOS/ΣPFAS has flattened out, and the cost per kg removed increases significantly. At this limit, it is estimated that 98% (96 of 97 kg) -PFAS in the examined volume can be removed at a price of approximately NOK 533,000 per kg, and a total cost estimated at approximately 51 MNOK. From concentrations >150 µg/kg to >30 µg/kg, costs per kg -of PFAS removed increase by approximately NOK 180,000, which represents an increase in total cost of approximately 18.4 MNOK. The amount of -PFAS removed is only one kg more (from 96 to 97 kg).

For Ålesund BØF 2, Figure 18 shows that at >150 µg/kg, the curve showing the amount of PFOS/ΣPFAS has flattened out, and the cost per kg removed increases significantly. At this limit, it is estimated that 94%

(47 of 51 kg) -PFAS in the examined volume can be removed at a price of approximately 1.86 MNOK per kg, and total cost is estimated at approximately 88 MNOK. From concentrations >150 µg/kg to >30 µg/kg, costs per kg -of PFAS removed increase by approximately NOK 920,000, which represents an increase in total cost of approximately 51.8 MNOK. The amount of -PFAS removed is three kg more (from 47 to 50 kg).

For Rørvik BØF 2, the action limit is set to >500 µg/kg, it is estimated that 94% of PFOS/ΣPFAS is removed at this limit. Figure 19 shows that at >500 µg/kg, the curve showing the amount of PFOS/ΣPFAS starts to flatten out, and the cost per kg removed increases for amounts above higher concentration limits. From concentrations >500µg/kg to >150µg/kg, costs per kg ofΣ PFAS removed increase by approximately NOK 64,000, which represents an increase in total cost of approximately 1.7 MNOK. The amount of ΣPFAS removed is only one kg more (from 21 to 22 kg).

For sites with active fire training sites to be continued after any measures have been taken, a cost of 80 MNOK is added to the total cost of measures at each concentration limit. For Molde BØF 1, which is both old and active in the same place, Figure 20 shows that at >150 µg/kg, the curve showing the amount of PFOS/ΣPFAS flattens out, while the curve for the cost per kg removed has its lowest point.

Table 20: Overview of amounts of PFOS/ΣPFAS (kg), volume masses (m^3), action efficiency (g/m^3), cost of remedial action, price for removal of contamination and cost/effect (NOK per kg removed) above the different concentration limits, for four of the sites. The summary for all sites Part 2 shows the sum of quantities, volume and price of removal for all sites, as well as average action efficiency and cost/effect. The remaining sites are shown in Appendix E.

Airports and sites	**Unit**	**Tromsø Airport Langnes - BØF 2 (old)**	**Ålesund Airport Vigra - BØF 2 (old)**	**Molde Airport Årø - BØF 1 (active and old)**	**Rørvik Airport Ryum - BØF 2 (younger, but not active)**	**Summary all sites Part 2 (n= 32)**
Comments regarding calculations		Added PFAS and water purification	Added water purification	Calculated for PFAS (in Part 1 of the order), added cost for active	Added water purification	Includes added PFAS for eight sites
Amount of PFOS/ΣPFAS including positive uncertainty	kg	223	131	20	55	869
Volume masses	m3	75,849	181,920	26,684	10,610	1,495,542
Action efficiency	g/m3	2.9	0.7	0.8	5.2	0.7
Action price	NOK/m^3	NOK 2,313	NOK 2,122	NOK 2,161	NOK 2,377	
Price for removal of all PFOSΣPFAS	NOK	NOK 176,049,092	NOK 387, 615, 626	NOK 137, 651,702	NOK 25,821,024	NOK 3,569,541,399
Cost/effect	NOK/kg	NOK 789,727	NOK 2,953,452	NOK 6,841,655	NOK 470,073	NOK 16,584,383
Amount of PFOS/ΣPFAS > 3 µg/kg	kg	97	51	9.3	22	338
Volume masses	m3	33,902	71,417	12,714	4,365	641,307
Weight soil total in examined volume	tonnes	54,243	104,983	22,886	6,984	1,042,348
Action efficiency	g/m3	2.9	0.7	0.7	5.1	0.7
Share of total amount of PFOSΣPFAS	%	100%	100%	100%	100%	100%
Action price	NOK/m^3	NOK 2,313	NOK 2,122	NOK 2,161	NOK 2,377	
Price for removal	NOK	NOK 79,021,819	NOK 153,178,018	NOK 107,469,788	NOK 10,977,397	NOK 1,712,547,179
Cost/effect	NOK/kg	NOK 810,634	NOK 3,019,617	NOK 11,506,807	NOK 490,135	NOK 20,402,690
Amount of PFOS/ΣPFAS > 30 µg/kg	kg	97	50	9.2	22	332
Volume masses	m3	29,792	65,153	11,127	4,365	441,582
Action efficiency	g/m3	3.3	0.8	0.8	5.1	0.8

Share of total amount of PFOSΣPFAS	%		100%		99%		98%		100%		94%
Action price	NOK/m³	NOK	2,313	NOK	2,122	NOK	2,161	NOK	2,377		
Price for removal	NOK	NOK	69,514,032	NOK	139,889,941	NOK	104,039,278	NOK	10,977,397	NOK	1,279,537,818
Cost/effect	NOK/kg	NOK	715,210	NOK	2,774,701	NOK	11,347,246	NOK	490,135	NOK	15,932,740

Airports and sites	**Unit**	**Tromsø Airport Langnes - BØF 2 (old)**		**Ålesund Airport Vigra - BØF 2 (old)**		**Molde Airport Årø - BØF 1 (active and old)**		**Rørvik Airport Ryum - BØF 2 (younger, but not active)**		**Summary all sites Part 2 (n= 32)**	
Amount of PFOS/ΣPFAS > 150 µg/kg	kg		96		47		8.9		22		310
Volume masses	m3		21,835		40,747		8,486		3,644		233,477
Action efficiency	g/m3		4.4		1.2		1.0		6.0		1.2
Share of total amount of PFOSΣPFAS	%		98%		94%		95%		98%		78%
Action price	NOK/m³	NOK	2,313	NOK	2,122	NOK	2,161	NOK	2,377		
Price for removal	NOK	NOK	51,110,614	NOK	88,111,121		NOK 98,335,229	NOK	9,265,035	NOK	756,949,224
Cost/effect	NOK/kg	NOK	533,210	NOK	1,857,336		NOK 11,106,693	NOK	420,582	NOK	8,619,239
Amount of PFOS/ΣPFAS > 500 µg/kg	kg		94		42		6.9		21		257
Volume masses	m3		18,810		26,930		4,282		2,915		105,586
Action efficiency	g/m3		5.0		1.5		1.6		7.2		1.9
Share of total amount of PFOSΣPFAS	%		97%		82%		74%		94%		57%
Action price	NOK/m³	NOK	2,313	NOK	2,122	NOK	2,161	NOK	2,377		
Price for removal	NOK	NOK	44,113,440	NOK	58,796,266	NOK	89,252,092	NOK	7,531,760	NOK	398,490,171
Cost/effect	NOK/kg	NOK	467,916	NOK	1,409,705		NOK 12,892,707	NOK	356,957		NOK 12,731,414
Amount of PFOS/ΣPFAS > 1,000 µg/kg	kg		91		30		4.6		16		204
Volume masses	m3		16,261		14,001		1,698		1,329		51,702
Action efficiency	g/m3		5.6		2.1		2.7		12.2		3.3

Share of total amount of PFOSΣPFAS	%		94%		59%		50%		73%		52%
Action price	NOK/m³	NOK	2,313	NOK	2,122	NOK	2,161	NOK	2,377		
Price for removal	NOK	NOK	38,216,598	NOK	31,367,888		NOK 83,669,250	NOK	3,761,950	NOK	277,555,883
Cost/effect	NOK/kg	NOK	419,202	NOK	1,048,489		NOK 18,068,565	NOK	231,147	NOK	25,437,273
Amount of PFOS/ΣPFAS > 3,000 µg/kg	kg		68		5.3		1.4		16		115
Volume masses	m3		8,680		1,158		284		1,329		14,843
Action efficiency	g/m3		7.8		4.6		4.9		12.2		6.8
Share of total amount of PFOSΣPFAS	%		70%		10%		15%		73%		40%
Action price	NOK/m³	NOK	2,313	NOK	2,122	NOK	2,161	NOK	2,377		
Price for removal	NOK	NOK	20,681,046	NOK	4,121,539		NOK 80,613,378	NOK	3,761,950		NOK 117,383,669
Cost/effect	NOK/kg	NOK	304,098	NOK	773,846	NOK	58,171,675	NOK	231,147		NOK 6,196,491

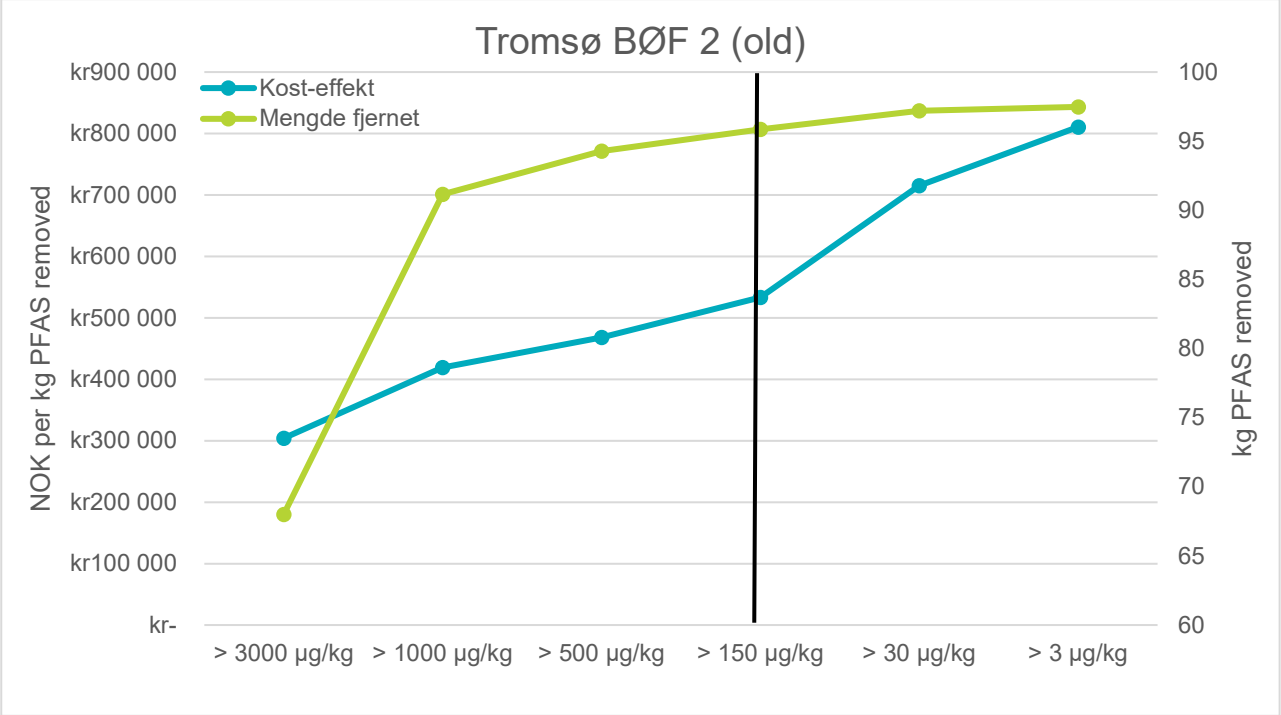


Figure 17: Cost per kg PFAS removed (NOK) and amount of PFAS removed (kg) at the different concentration limits for Tromsø BØF 2. The action limit is marked with a black line.

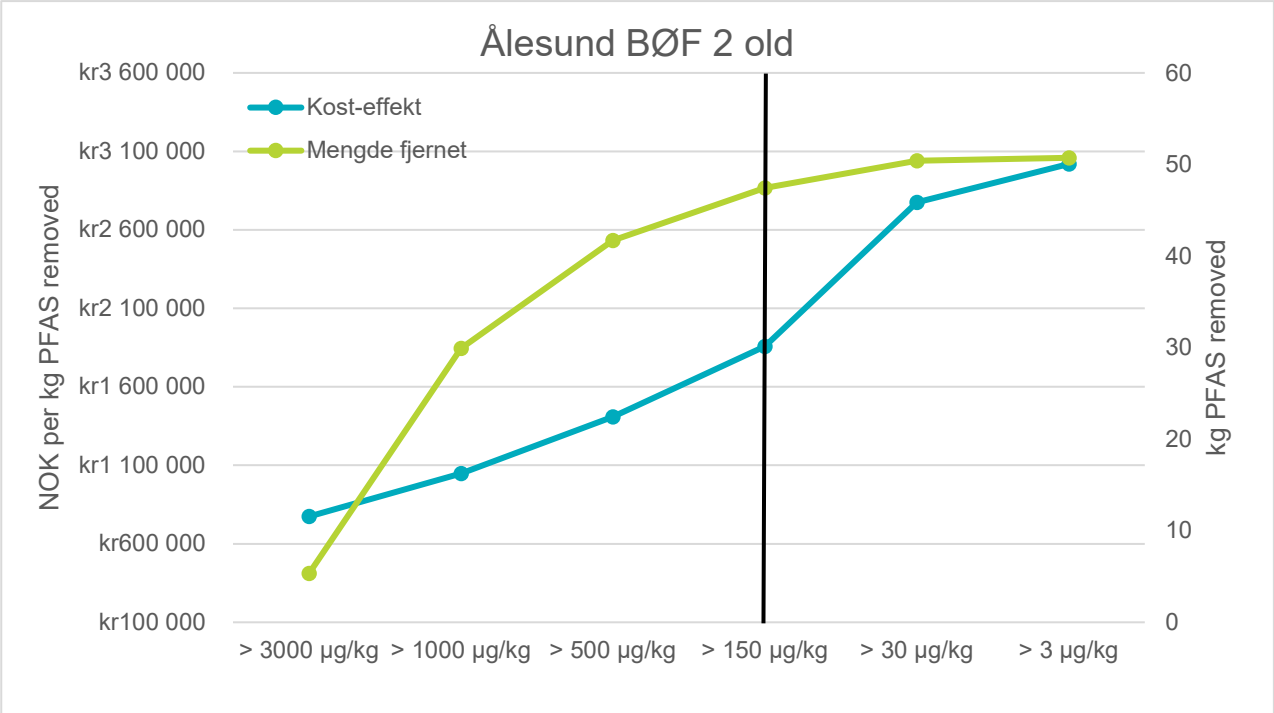


Figure 18: Cost per kg PFAS removed (NOK) and amount of PFAS removed (kg) at the different concentration limits for Ålesund BØF 2. The action limit is marked with a black line.

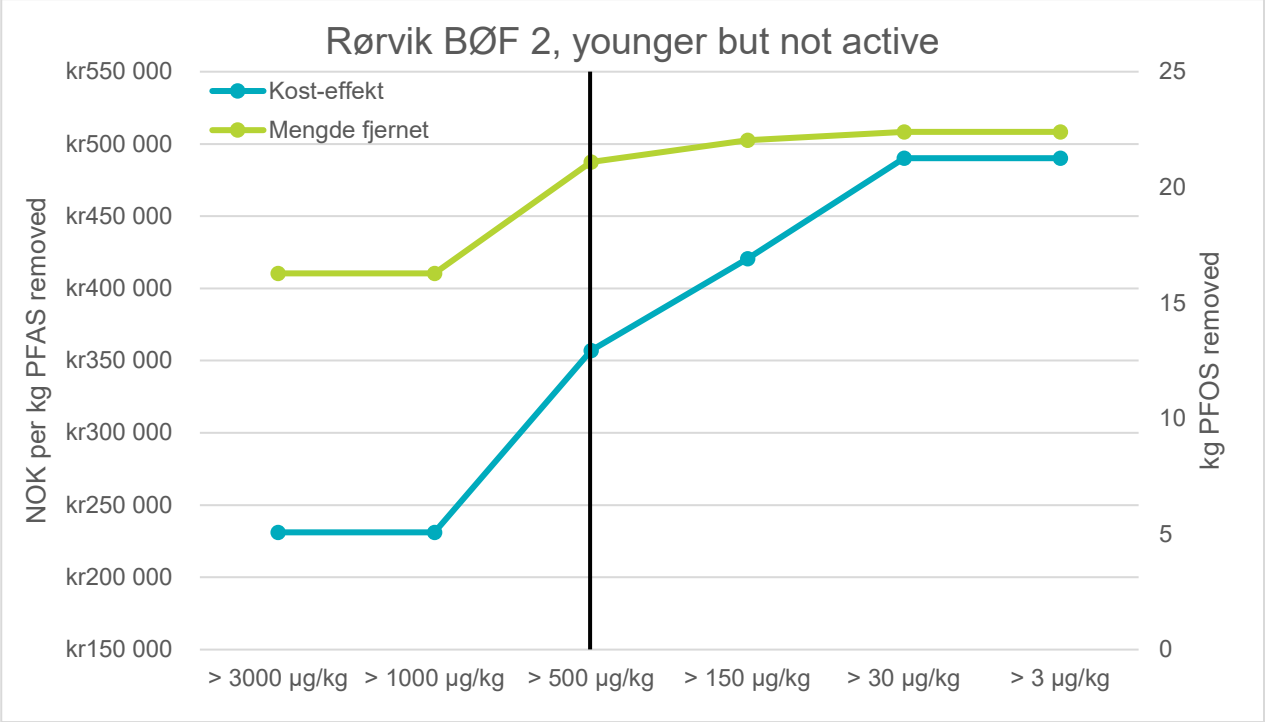


Figure 19: Cost per kg PFAS removed (NOK) and amount of PFAS removed (kg) at the different concentration limits for Rørvik BØF 2.

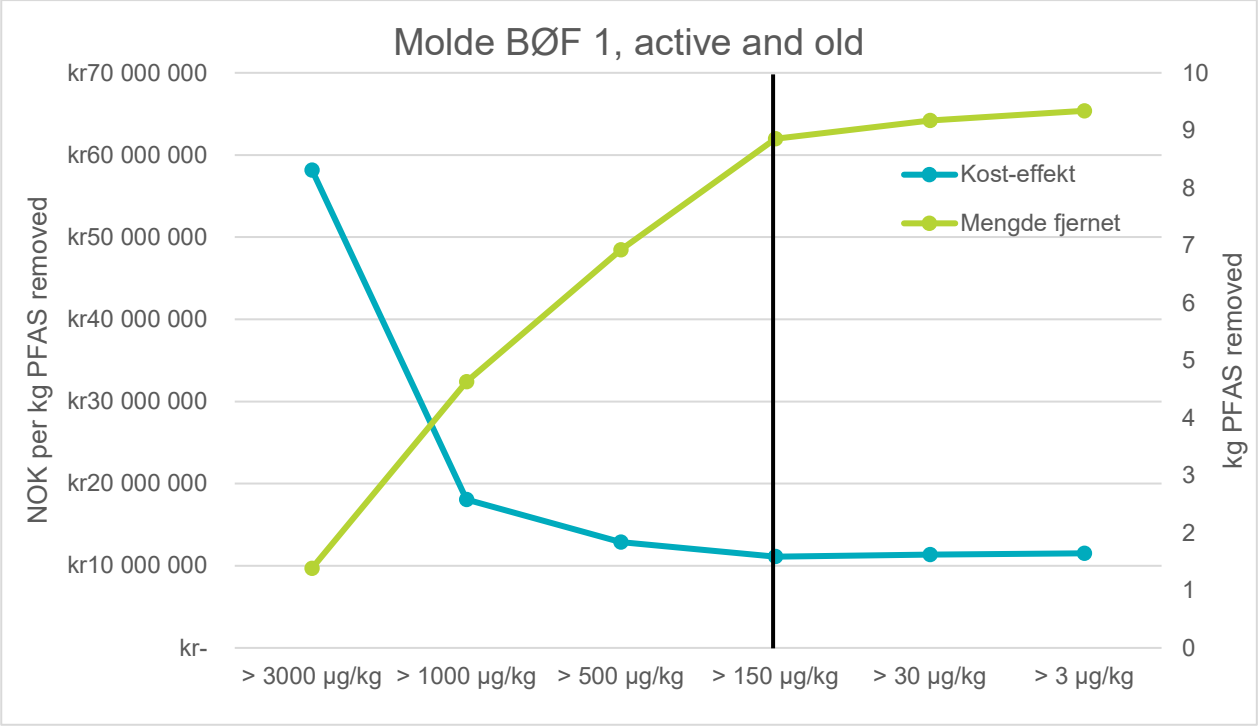


Figure 20: Cost per kg PFAS removed (NOK) and amount of PFAS removed (kg) at the different concentration limits for Molde BØF 1.

3.2.5 Order of priority

Order of priority based on estimated cost per kg PFOS/ΣPFAS removed by measures in examined volume of PFAS contaminated sites at Avinor airports are shown in Table 21.

There are only three sites (Lakselv BØF 3, Stavanger BØF 2 and Røros BØF 1) that, based on the survey, are believed to be suitable for the "pump and treat" method. There is as described in Chapter3.2.2.1 high uncertainty about the calculated amounts Σ of PFAS in the groundwater. Consequently, the uncertainty for calculating costs for implementing pump and treat measures will therefore also be high. The proportion of PFAS contamination in groundwater of the total amount (in soil and groundwater) at the relevant sites is estimated to be approximately 8% for Lakselv BØF 3, approximately 23% for Røros Airport, and for Stavanger BØF 2 in soil in saturated zone and groundwater approximately 56% of the total estimated amount at the site. Only for Stavanger BØF 2, will measures in the saturated zone alone be able to produce a significant action effect compared to excavation and external landfill disposal or coverage. However, due to the high uncertainty, the cost calculation for pump and treat is not directly comparable to coverage and excavation with external landfill disposal. On this basis, as well as in order to obtain the most comparable cost/effect assessment between different sites and scopes of measures, the order of priority of measures is based on covering and excavation with external landfill disposal for PFAS contaminated masses. The costs of "pump and treat" and a combination of measures ("pump and treat" and covering) are a feasibility study in which costs are roughly outlined, which are included in Table 21.

The site with the lowest cost per kg of PFOS/ΣPFAS removed, and the highest priority for measures, is Rørvik BØF 2, followed by Kristiansund BØF B and Tromsø BØF 2. Tromsø BØF 2 is the site with the largest amount of PFOS/ΣPFAS removed (96 kg) of all, and due to a relatively large volume of masses (22,000 m^3) the total cost of measures will also be relatively high.

Figure21 shows the sites in order of priority (as shown in Table 21) with the amount of PFOS/ΣPFAS removed, accumulated amount removed and accumulated cost of measures (uncertainty with regard to quantity is not shown in the figure). By carrying out measures at the ten sites with the highest priority, the total estimated amount removed will be approximately 192 kg, with a total cost of approximately 137 MNOK, approximately NOK 700,000 per kg of ΣPFAS removed. By ranking the sites in order according to the largest expected amount removed, by comparison, the top seven sites on the list (all with amounts above 10 kg) will have 242 kg, but the total cost of measures on these will be approximately 400 MNOK, approximately 1.65 MNOK per kg of -PFAS removed.

The curve for the accumulated quantity removed rises relatively steeply from site no. 1 (Rørvik BØF 2) to site no. 12 (Ålesund BØF 2) in the order of priority. After site no. 12 the total amount removed is 242 kg, and the curve flattens out before making a smaller jump from site no. 16 to 17 (Røst BØF 1 and Kirkenes BØF 1, respectively). After site no. 17 the total amount removed is 271 kg, and the curve flattens out again. Then 37 kg are distributed between the remaining 15 sites.

The curve for the accumulated cost of measures makes a smaller jump between site no. 11 and 12 (Sørkjosen BØF 1 and Ålesund BØF 2), and in the same way as the curve for accumulated quantity, between site nos. 16 and 17 in the order of priority. Accumulated cost after site no. 12 is 230 MNOK, and it rises steadily up to site no. 16. After site no. 17 it flattens out again at approx. 400 MNOK, until it again makes a significant jump from site no. 27 on the list, and the total cost doubles from approx. 450 MNOK to 850 MNOK distributed between the last five sites in the series (Nos. 28 to 32).

For all the sites in the series, there may be conditions that have not been considered and that may cause the price of cleanup to change. This applies, for example, to uncertainty in the calculations of quantities, and distance to the runway. Rørvik BØF 2 and Tromsø BØF 2 are less than 40 metres from the runway's outer edge, and Kristiansund BØF B is between 60-120 metres from the runway.

For sites that have a high priority for measures but have high uncertainty for the calculations of amounts, better mapping and delimitation of contamination can lead to changes in the calculated amount in the soil, limit of measures, price per kg removed and total cost of remedial action.

It should be noted that other remedial action methods than excavation with external landfill disposal and covering, alternatively a combination of measures may be appropriate solutions. New and more suitable technology services may come onto the market, or other types of remedial action methods that are currently at the pilot stage may become effective. By doing a better survey of groundwater and groundwater contamination, for example for Lakselv BØF 3, Stavanger BØF 2 and Røros Airport which have detected relatively high concentrations of -PFAS in groundwater samples, uncertainty may be reduced in the calculations of amounts in groundwater and the cost of remedial action so that prioritisation may be enabled based on this method or a combination of other measures together with this method.

Table 21: Order of priority based on cost per kg of PFOS/ΣPFAS removed by excavation measures or coverage measures at the established limits, and for PFAS-contaminated sites at Avinor's airports. The "pump and treat" measure or measures combined with this do not form part of the priority.

Priority	Airports and sites	Total amount of PFOS/ΣPFAS in soil (kg)	Type of remedial action	Limit of remedial action	Amount removed (kg)	Removed share of total amount of PFOS/ΣPFAS in soil (kg)	Cost (NOK)	Cost per kg of PFOS/ΣPFAS removed (NOK)
1	Rørvik Airport, Ryum- BØF 2 (younger, but not active)	22	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 500 µg/kg	21	94%	NOK 7,531,760	NOK 356,957
2	Kristiansund Airport, Kvernberget- BØF B (old)	17	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 500 µg/kg	15	88%	NOK 7,294,081	NOK 481,846
3	Tromsø Airport Langnes - BØF 2 (old)	97	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 150 µg/kg	96	98%	NOK 51,110,614	NOK 533,210
4	Narvik Airport Framnes - BØF north (not active) and filling	3.2	Coverage	Amount of PFOS/ΣPFAS > 150 µg/kg	2.1	67%	NOK 1,244,716	NOK 584,483
			Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 150 µg/kg	2.1	67%	NOK 6,449,347	NOK 3,028,427
5	Bergen Airport Flesland - BØF 1 (youngest,not active)	9.4	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 150 µg/kg	9.4	100%	NOK 6,656,301	NOK 707,037
6	Tromsø Airport Langnes - BØF 1 (active)	10	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 150 µg/kg	10	96%	NOK 7,521,908	NOK 778,876
7	Røros Airport - BØF 1 (not active) 4.5 and 5.7	4.5	Coverage	Amount of PFOS/ΣPFAS > 150 µg/kg	2.5	56%	NOK 2,163,092	NOK 850,985
			Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 150 µg/kg	2.5	56%	NOK 12,024,042	NOK 4,730,395
		5.7*	"Pump and treat" and coverage		5*	88%*	NOK 12,140,592	NOK 2,413,637

8	Berlevåg Airport - BØF 1 (old)	9.4	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 150 µg/kg	8.4	90%	NOK 9,553,281	NOK 1,132,313
9	Alta Airport - BØF1 (active)	24	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 150 µg/kg	23	96%	NOK 34,657,373	NOK 1,525,122
10	Haugesund Airport Karmøy - BØF B (old)	6.1	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 150 µg/kg	5.8	95%	NOK 9,287,603	NOK 1,596,612
11	Sørkjosen Airport - BØF 1 (old)	2.8	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 150 µg/kg	2.7	99%	NOK 4,980,900	NOK 1,817,672
12	Ålesund Airport Vigra - BØF 2 (old)	51	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 150 µg/kg	47	94%	NOK 88,111,121	NOK 1,857,336
Priority	**Airports and sites**	**Total amount of PFOS/ΣPFAS in soil**	**Type of remedial action**	**Limit of remedial action**	**Amount removed (kg)**	**Removed share of total amount of PFOS/ΣPFAS (kg)**	**Cost (NOK)**	**Cost per kg of PFOS/ΣPFAS removed (NOK)**
13	Hammerfest Airport - BØF 1 (old)	3.2	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 150 µg/kg	2.8	88%	NOK 6,477,516	NOK 2,315,714
14	Sandnessjøen Airport Stokka - BØF 1 (old)	3.1	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 150 µg/kg	2.6	82%	NOK 6,862,373	NOK 2,656,722
15	Mosjøen Airport Kjærstad - BØF 1 (old)	3.4	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 150 µg/kg	2.7	81%	NOK 7,303,552	NOK 2,677,224
16	Røst Airport - BØF1 (not active)	1.0	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 150 µg/kg	0.8	82%	NOK 3,572,446	NOK 4,396,752
17	Kirkenes Airport Høybuktmoen - BØF 1 (old)	21	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 150 µg/kg	19	94%	NOK 85,723,776	NOK 4,422,371
18	Stavanger Airport Sola - BØF 2 (old)	5.4	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 150 µg/kg	4.1	77%	NOK 18,554,370	NOK 4,475,194
		6.8*	"Pump and treat" and coverage		5.9*	87%*	NOK 4,518,140	NOK 765,497

19	Mo i Rana Airport Røssvoll - BØF 1 (old)	3.8	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 150 µg/kg	2.6	70%	NOK 12,908,080	NOK 4,891,245
20	Svolvær Airport Helle - BØF B (Not active)	0.5	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 150 µg/kg	0.3	67%	NOK 1,994,424	NOK 6,090,298
21	Bergen Airport Flesland - BØF 2 (old)	4.5	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 150 µg/kg	2.4	53%	NOK 15,547,282	NOK 6,534,280
22	Ålesund Airport Vigra - BØF 1 (active)	2.5	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 150 µg/kg	1.0	40%	NOK 6,633,500	NOK 6,617,077
23	Fagernes Airport Leirin - BØF A (not active)	2.1	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 150 µg/kg	1.9	88%	NOK 13,056,506	NOK 6,986,301
24	Sogndal Airport Haukåsen - BØF1 (not active)	1.1	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 150 µg/kg	0.6	53%	NOK 5,334,372	NOK 9,006,187
25	Vardø Airport Svartnes - BØF 1 (old)	0.6	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 150 µg/kg	0.1	23%	NOK 1,829,760	NOK 9,647,867
26	Ørsta-Volda Airport Hovden - BØF 1 (old)	0.8	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 150 µg/kg	0.2	23%	NOK 1,829,760	NOK 9,647,867
27	Leknes Airport - BØF 1 (not active)	3.0	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 150 µg/kg	1.6	53%	NOK 15,134,422	NOK 9,701,972

Priority	**Airports and sites**	**Total amount of PFOS/ΣPFAS (kg)**	**Type of remedial action**	**Limit of remedial action**	**Amount removed (kg)**	**Removed share of total amount of PFOS/ΣPFAS (kg)**	**Cost (NOK)**	**Cost per kg of PFOS/ΣPFAS removed (NOK)**
28	Lakselv Airport Banak - BØF 3 (active)	13	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 150 µg/kg	11	84%	NOK 116,347,940	NOK 10,472,890
		14*	"Pump and treat" and coverage		12*	86%*	NOK 5,435,910	NOK 449,249

29	Molde Airport Årø - BØF 1 (active and old)	9.3	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 150 µg/kg	8.9	95%	NOK 98,335,229	NOK 11,106,693
30	Kirkenes Airport Høybuktmoen - Operating area	1.0	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 30 µg/kg	0.3	33%	NOK 20,026,739	NOK 62,360,037
31	Florø Airport - BØF1 (active)	1.1	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 30 µg/kg	1.1	95%	NOK 91,977,436	NOK 85,045,636
32	Kristiansund Airport Kvernberget - BØF A (active)	0.7	Excavation and landfill disposal	Amount of PFOS/ΣPFAS > 30 µg/kg	0.6	96%	NOK 94,202,831	kr 150,261,580

* For "pump and treat" and coverage at Røros BØF 1, Stavanger BØF 2 and Lakselv BØF 3, the estimated total amount in soil and groundwater, the removed amount in soil and groundwater and the removed share of the total amount of PFOS/ΣPFAS in soil and groundwater are stated.

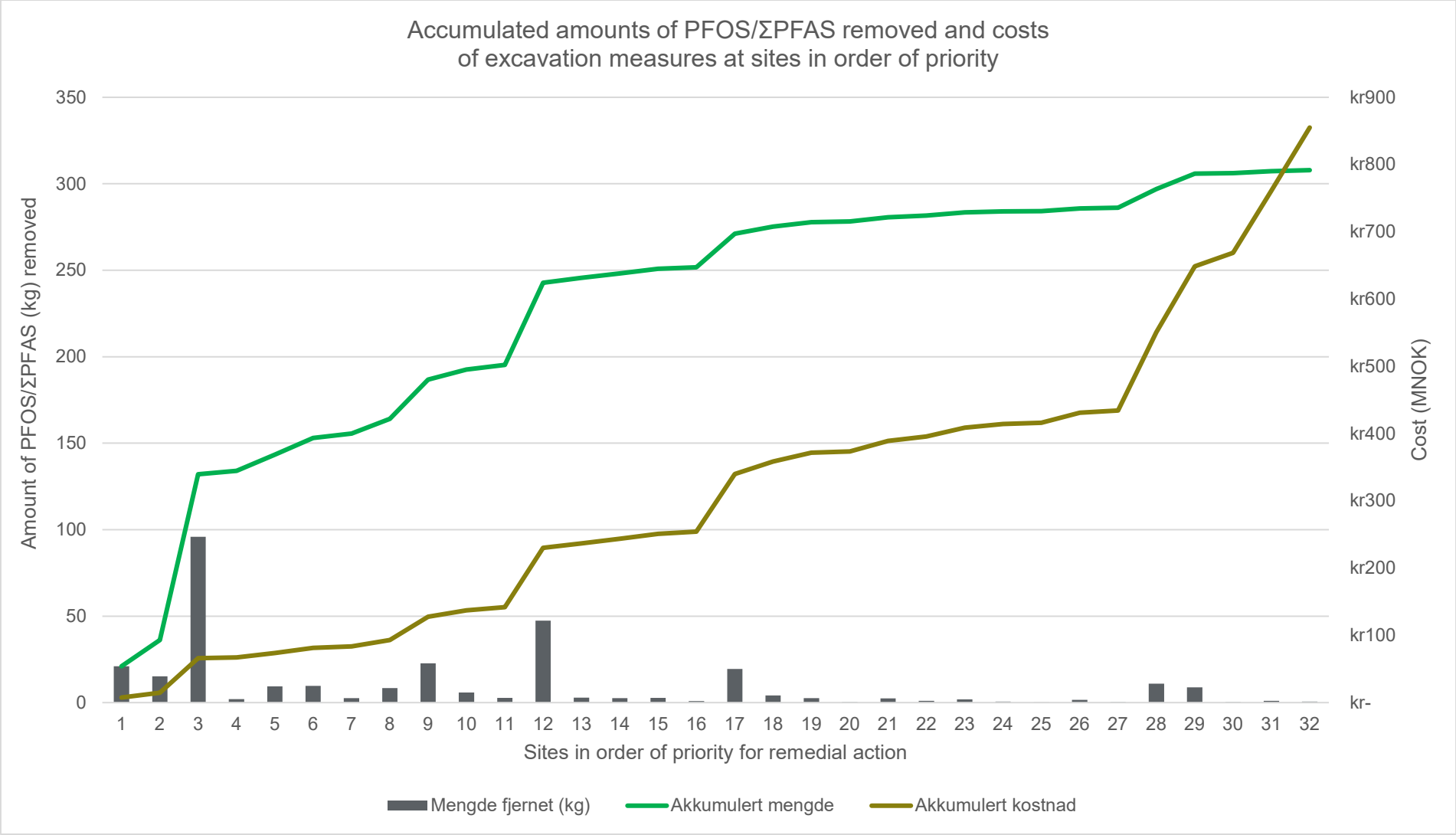


Figure21: Sites at Avinor's airports in order of priority (Table 21) with amount of PFOS/ΣPFAS removed (kg), accumulated amount removed (kg) and accumulated cost (NOK).

4 References

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5 Appendices

All the appendices A-E are in separate documents due to size. The following is an overview:

Appendix A - Reporting forms for Part 1

Appendix B - Map of Norway with calculated amounts of PFOS/ΣPFAS in soil

Appendix C- Remedial action methods

Appendix D - Assessment of the suitability of the sites for "pump and treat" and coverage/shielding

Appendix E – Limits of remedial action

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29 – Stavanger Airport – p. 312-322

30 – Stokmarknes Airport – p. 323-327

31 – Svolvær Airport – p. 328-337

32 – Sørkjosen Airport – p. 338-350

33 – Tromsø Airport – p. 351-369

34 – Trondheim Airport – p. 370-377

35 – Vadsø Airport – p. 378-387

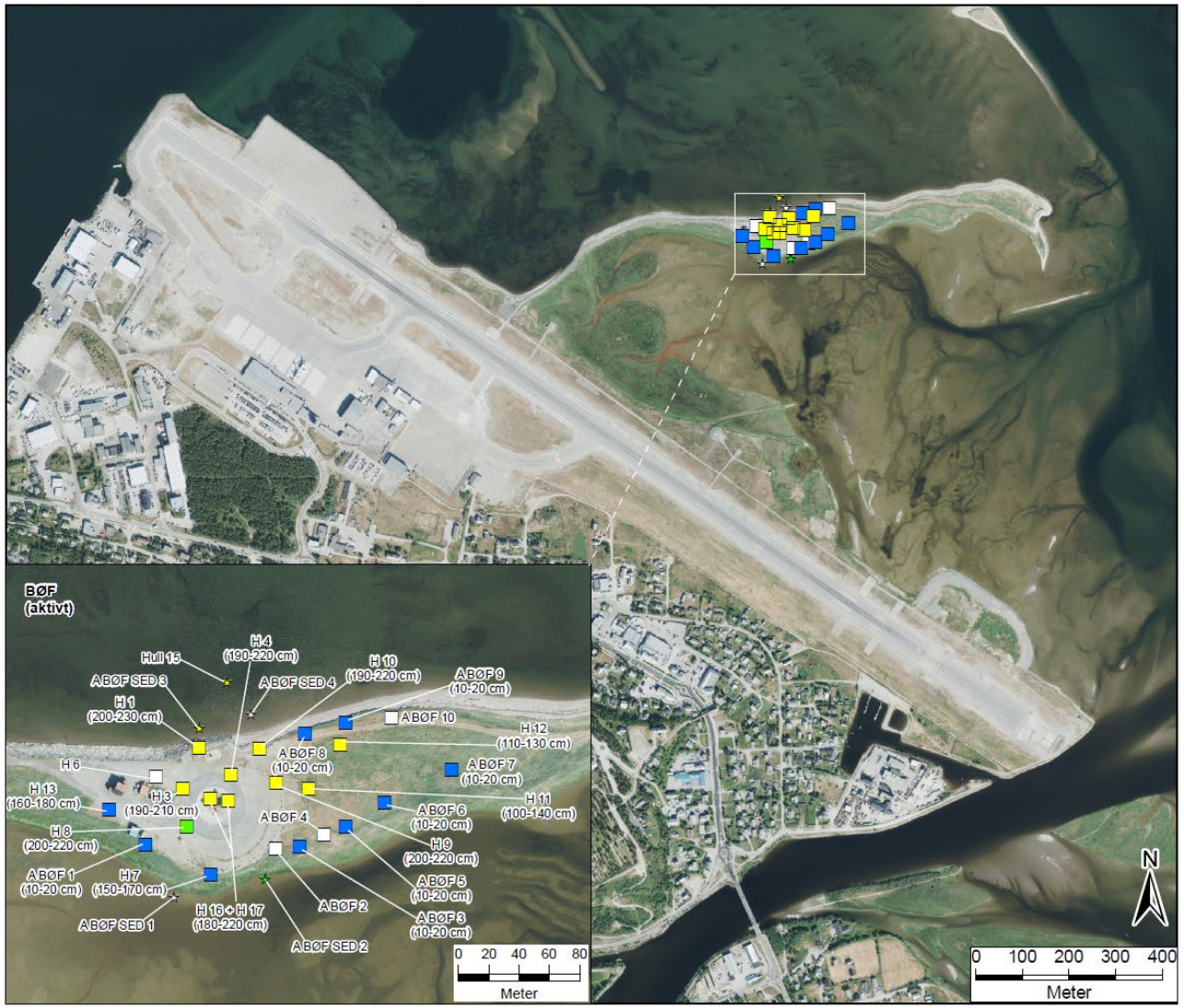
36 – Vardø Airport – p. 388-399

37 – Værøy Airport and Værøy Heliport – p. 400-407

38 – Ørsta/Volda Airport – p. 408-416

39 – Ålesund Airport – p. 417-435

1 Alta airport



Alta lufthavn (ENAT)

Oversiktskart inkl. brannøvingsfelt

Jord og sediment

PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

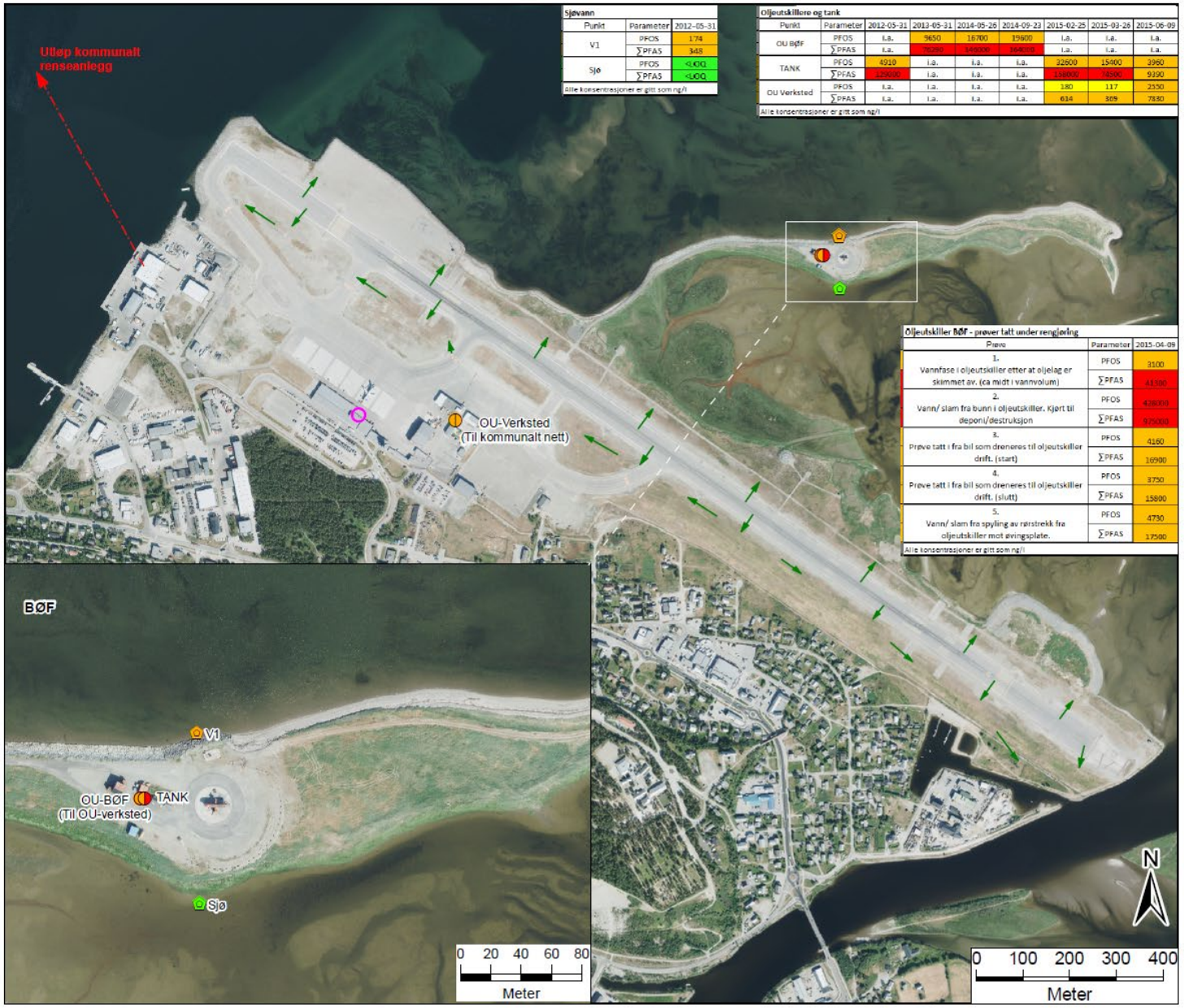
PFOS sediment marint (ug/kg)
- 0
- <LOQ
- LOQ-63
- 63-6300
- >6300
- Ikke analysert

* PFOS er dominerende parameter

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APPENDIX A



Sjøvann

Punkt	Parameter	2012-05-31
V1	PFOS	174
	∑PFAS	348
Sjø	PFOS	<LOQ
	∑PFAS	<LOQ

Alle konsentrasjoner er gitt som ng/l

Oljeutskillere og tank

Punkt	Parameter	2012-05-31	2013-05-31	2014-05-26	2014-09-23	2015-02-25	2015-03-26	2015-06-09
OU BØF	PFOS	i.a.	9650	16700	15800	i.a.	i.a.	i.a.
	∑PFAS	i.a.	76290	146000	164000	i.a.	i.a.	i.a.
TANK	PFOS	4910	i.a.	i.a.	i.a.	32800	15400	3960
	∑PFAS	129000	i.a.	i.a.	i.a.	158000	74500	9190
OU Verksted	PFOS	i.a.	i.a.	i.a.	i.a.	180	117	2350
	∑PFAS	i.a.	i.a.	i.a.	i.a.	614	809	7830

Alle konsentrasjoner er gitt som ng/l

Oljeutskiller BØF - prøver tatt under rengjøring

Prøve	Parameter	2015-04-09
1. Vannfase i oljeutskiller etter at oljelag er skimmet av. (ca midt i vannvolum)	PFOS	3100
	∑PFAS	41300
2. Vann/ slam fra bunn i oljeutskiller. Kjørt til deponi/destruksjon	PFOS	428000
	∑PFAS	975000
3. Prøve tatt i fra bil som dreneres til oljeutskiller drift. (start)	PFOS	4160
	∑PFAS	16900
4. Prøve tatt i fra bil som dreneres til oljeutskiller drift. (slutt)	PFOS	3750
	∑PFAS	15800
5. Vann/ slam fra spyling av rørstrekk fra oljeutskiller mot øvingsplate.	PFOS	4730
	∑PFAS	17500

Alle konsentrasjoner er gitt som ng/l

Alta lufthavn (ENAT)

Oversiktskart inkl. brannøvingsfelt

Vann

PFOS / ∑ PFAS ferskvann (ng/l) *
- Ikke analysert
- 0
- <LOQ
- LOQ-230
- 230-36 000
- >36 000

* Venstre halvdel = PFOS
Høyre halvdel = PFAS

PFOS / ∑ PFAS sjøvann (ng/l) **
- Ikke analysert
- 0
- <LOQ
- LOQ-23
- 23-7 200
- >7 200

** Senter = PFOS
Ytre ramme = PFAS

Avløpsledning
- Avløp annet
- SpillVann
- Pumpespillvannsledning
- Overvann
- Glykolholdig spillvann
- Glykolholdig overvann
- Drensvann
- Avløp felles

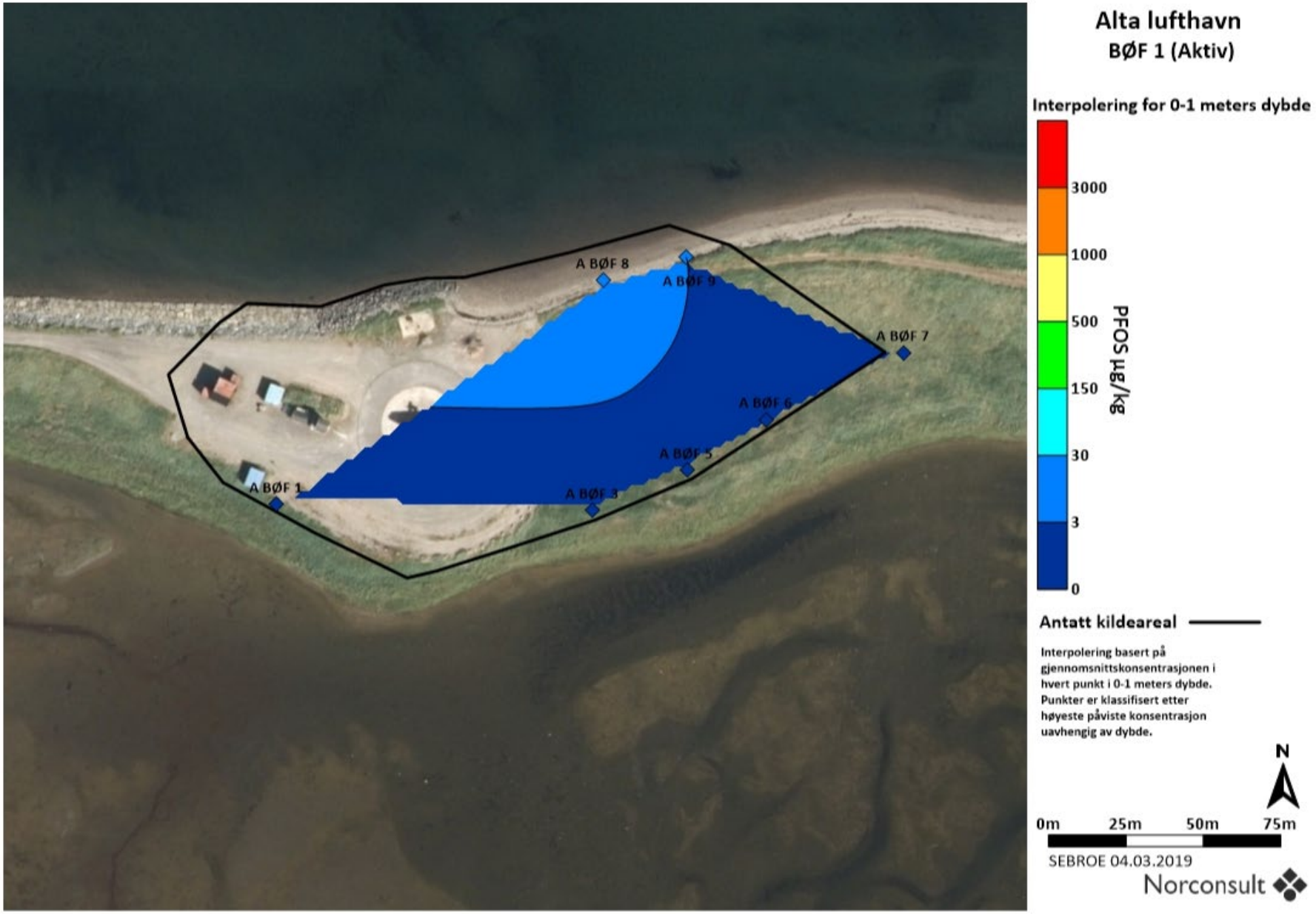
Avrenning
- Deponi glykolforurenset snø
- Overvannsledning
- Avrenningsveg glykol
- Bekkeresipient
- Overvannsystem
- Vannskille rullebane
- Antatt avrenningsveg baneavising

i.a. = ikke analysert
LOQ = rapporteringsgrense

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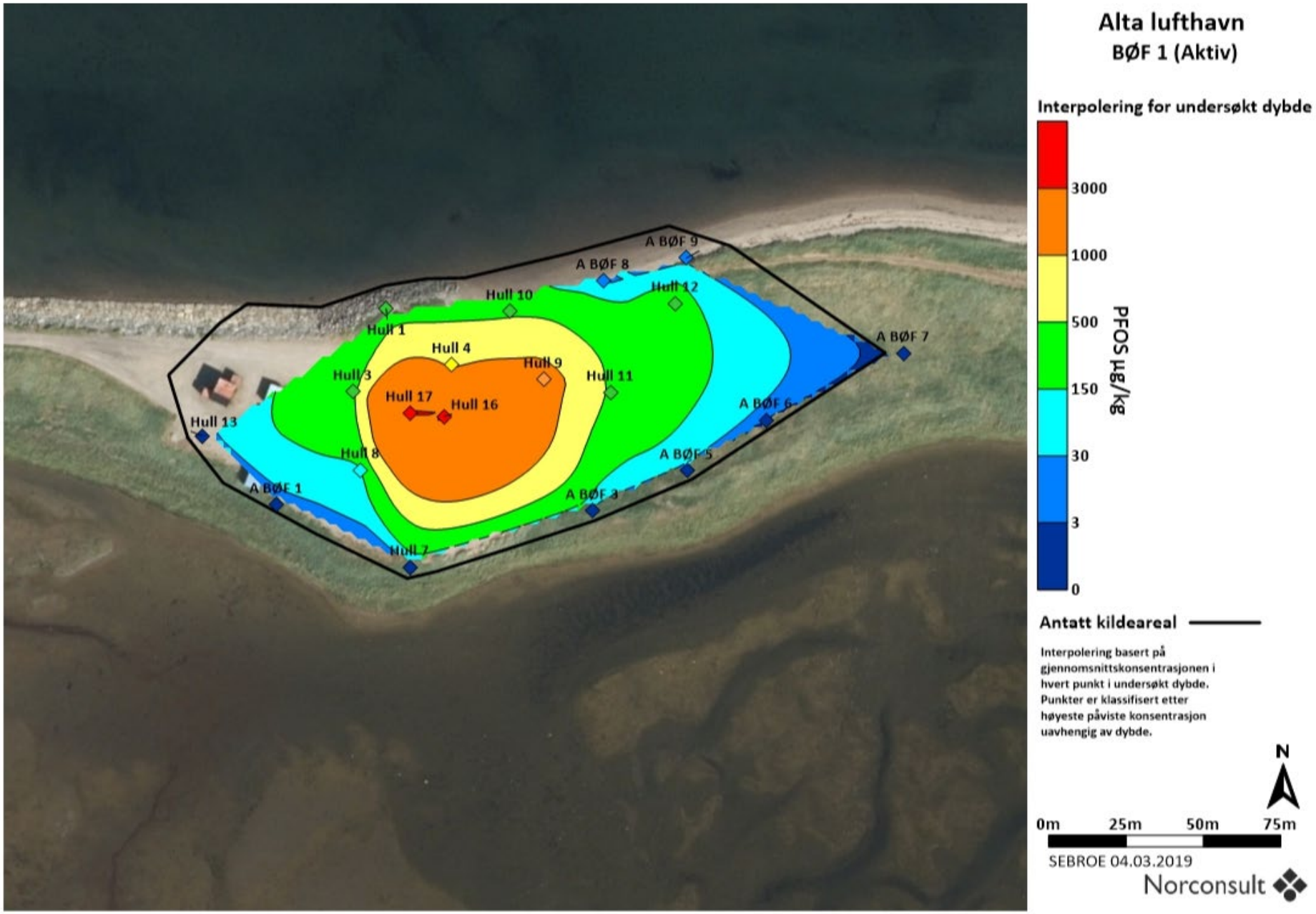
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APPENDIX A



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APPENDIX A



1.1 Fire training site (BØF) / contaminated site

Fire training site (BØF) / contaminated site	BØF1 (active)
	The site has been used since 1968. Asphalt was laid around the concrete slab in 2010. Avinor has decided that the active fire training site at Alta will be closed after the 2019 training season.

1.2 The use of PFOS and other PFAS

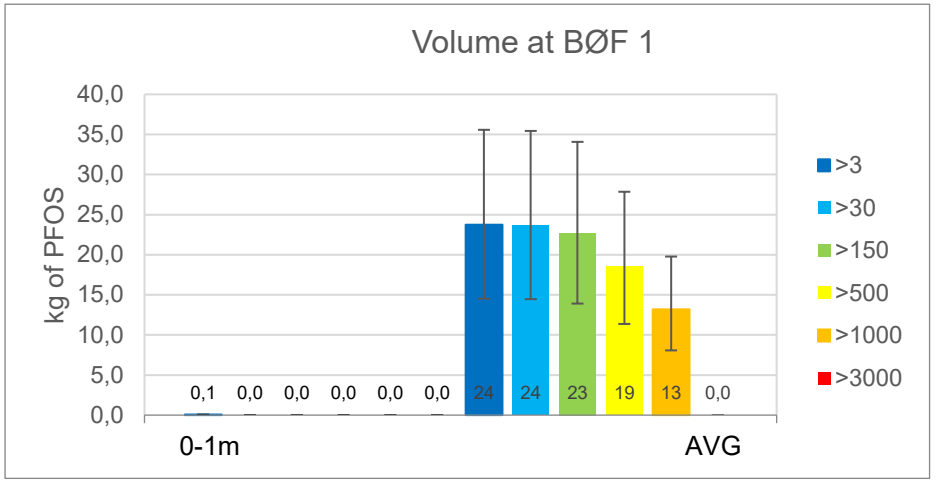
Volume of PFOS used at the site (kg)	900
Comments/uncertainty	Estimated consumption from 1978 up to and including 2001.
Volume of PFAS used at the site (kg)	150
Comments/uncertainty	Estimated consumption from 2002 to 2012. Avinor has not used PFAS-containing foam at its airports after 2012.

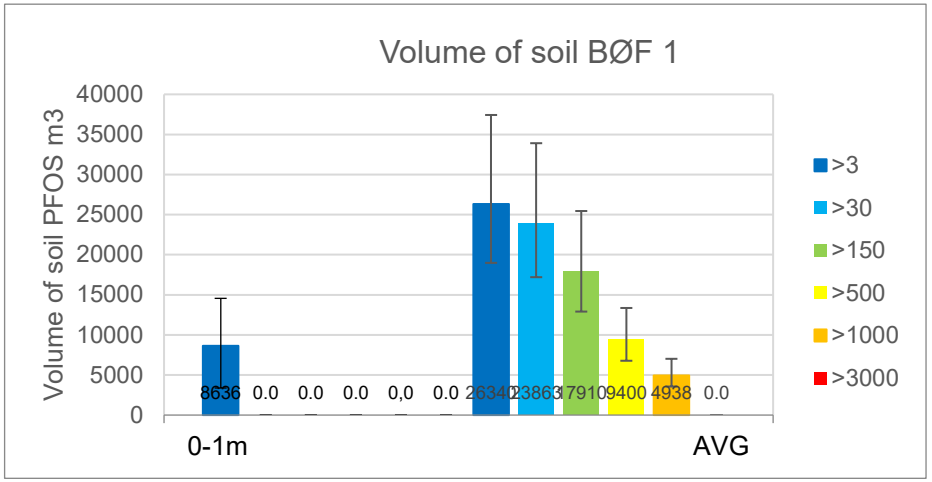
1.3 Soil sampling

Total number of soil samples	18
Comments/uncertainty (for example, 95% of the samples were taken from 0–0.1 m)	A sample of deeper-lying materials are a composite sample from H16 and H17. The seven samples of topsoil were taken at a depth of between 10 and 20 cm. The remaining samples have been taken from varying depths between 100 and 230 cm.
Number of soil samples 0 –1 m beneath the ground	7
Number of soil samples under 1 m	11
Comments/uncertainty	The area is situated on alluvial deposits and primarily comprises sandy materials.
Highest measured soil concentration of PFOS µg/kg	3130
Where	Composite sample, Hull 16 and 17
Highest measured soil concentration of PFAS µg/kg	3143.9
Where	Composite sample, Hull 16 and 17
Comments/uncertainty	The sample "blandprøve hull 16 og 17" has only been analysed for PFOS and PFOA. A total of two samples have been analysed for 11 PFAS compounds. No compounds other than PFOS have been demonstrated in these two samples.

1.4 Volume calculation

PFOS average for all depths and points > 3 µg/kg	
Concentration (µg/kg)	563
Area (m2)	11452
Volume of soil (tonnes)	42143
Volume of PFOS (kg)	24
Uncertainty -	9.2
Uncertainty +	12
PFOS average for all depths and points > 30 µg/kg	
Concentration (µg/kg)	619
Area (m2)	10375
Volume of soil (tonnes)	38180
Volume of PFOS (kg)	24
Uncertainty -	9.2
Uncertainty +	12
PFOS average for all depths and points > 150 µg/kg	
Concentration (µg/kg)	793
Area (m2)	7787
Volume of soil (tonnes)	28656
Volume of PFOS (kg)	23
Uncertainty -	8.8
Uncertainty +	11
PFOS average for all depths and points > 500 µg/kg	
Concentration (µg/kg)	1235
Area (m2)	4087
Volume of soil (tonnes)	15040
Volume of PFOS (kg)	19
Uncertainty -	7.2
Uncertainty +	9.3





PFOS average for all depths and points > 1000 µg/kg	
Concentration (µg/kg)	1669
Area (m2)	2147
Volume of soil (tonnes)	7901
Volume of PFOS (kg)	13
Uncertainty -	5.1
Uncertainty +	6.6
PFOS average for all depths and points > 3000 µg/kg	
Concentration (µg/kg)	
Area (m2)	
Volume of soil (tonnes)	
Volume of PFOS (kg)	
Uncertainty -	
Uncertainty +	

Comments regarding calculations of volume	The risk report from 2016 calculated a residual volume of 20 ± 7 kg of PFOS in the soil. A source area of 11,000 ± 500 m2 and a depth of 2 ± 0.4 metres was used.
Is the extent of the contaminated area limited horizontally?	The BØF is located on Naustneset, which is a tongue/peninsula extending into the Alta fjord. At the BØF, at its widest point, the tongue is 100 metres, meaning that to the north and south, the soils are delineated by the sea. The extreme points to the east and south-east are surface samples (A BØF 3, 5, 6 and 7) that have shown no evidence of PFOS. Nor have the extreme points to the south (Hull 7 at 150 –170 cm) and to the west (Hull 13 at 160 –180 cm and surface samples at A BØF 1) shown any evidence of PFOS. Points to the north have not been delineated.
Is the extent of the contaminated area limited vertically?	No. The BØF is located around 2.5 m above sea level. Samples of materials have been taken at a groundwater depth between 1.5 to 2 m (shown in Rambøll's report from 2011, which is attached to the DP2 report). The highest concentrations are in the deepest sample intervals. It is estimated that the concentrations diminish at a depth beneath the groundwater table.
Comments/uncertainty	No groundwater wells have been installed so the concentration of PFOS/PFAS in the groundwater is not known.

1.5 Water sampling and annual dispersion

Have water samples been taken?	Yes
Where	In seawater on the beach and in the lagoons, oil separators and tank facilities.
Highest measured concentration of PFOS in groundwater (ng/l)	No samples taken
Where	
Highest measured concentration of PFAS in groundwater (ng/l)	No samples taken
Where	
Comments/uncertainty	
Highest measured concentration of PFOS in surface water (ng/l)	174
Where	Seawater from a manually excavated hole in the sand on the beach facing the fjord, V1
Highest measured concentration of PFAS in surface water (ng/l)	348
Where	Seawater from a manually excavated hole in the sand on the beach facing the fjord, V1
Comments/uncertainty	The water samples have been analysed for 11 PFAS compounds. The proven PFAS content in the seawater in the hole excavated on the beach could be attributable to mobilisation when excavating in contaminated sand and/or particles in the water sample. There was no evidence of PFAS in the seawater in the lagoons south of the BØF. At the fire training site, all water (firefighting foam, rainwater, etc.) is led via an oil separator to a sealed tank of approximately 12 m3. This is emptied by a suction vehicle after each exercise, as well as on an as-needs basis. The contents of the tank are emptied via another oil separator in the workshop and then directed to the municipal sewage system, from which it continues out to Bukta in the Alta fjord, to the west of the airport. Water samples from the oil separator are not considered to be representative of the surface water in the area. In samples taken from May 2013 to April 2015, concentrations of PFOS in the water samples from the oil separator at the BØF were between 9650 and 32,780 ng/l and for PFAS were between 74,869 and 164,000 ng/l. Avinor has not used PFAS-containing foam at its airports after 2012 and the oil separators are emptied and cleaned once a year (unless they produce < 1kg oil during the course of a year), or more often, if required. After the oil separator was thoroughly cleaned in 2015, the concentrations have gradually decreased. From June 2015 to October 2017, the average of PFOS in 11 samples was 5239 ng/l and in PFAS was 33,218 ng/l. Six samples from 2018 had an average PFOS of 2133 ng/l and PFAS of 6417 ng/l. 23 PFAS compounds were analysed from 2017, meaning the results are not directly comparable with previous years.

Total annual dispersion of PFOS from the site (g/year)	200–400
Total annual dispersion of PFAS from the site (g/year)	Not calculated (0.58)*
To which recipient	The Alta fjord and the Alta river's delta at Rafsbotn, and the municipal sewage system*
Calculated from water or soil concentration.	Soil concentration, water concentration*
	*Avinor has calculated the dispersion via an oil separator to the municipal sewage system for 2018. The discharge limit is 3 g (from a letter to the County Governor of Troms and Finnmark of 8.2.19).

1.6 Biota sampling

Have biota samples being taken at the airport?	Yes
What kind of biota?	Bristle worm (small and large), flounder (small and large), mussel, cod
How many samples?	48
Highest measured concentration of PFOS in biota (µg/kg wet weight)	110
Where	Bristle worms (large), composite sample n=18, Naustneset north
Highest measured concentration of PFAS in biota (µg/kg wet weight)	247
Where	Bristle worms (large), composite sample n=18, Naustneset north
Median concentration (µg/kg ww) in comparable populations (for example, in a lake)	In two composites samples of bristle worms taken from the sea directly outside the new BØF and in the bay south-west of the runway at Tromsø airport, the average concentration of PFOS is 5.15 µg/kg and PFAS is 19 µg/kg. Extracted from an Avinor report in 2016, Tromsø airport: Surveys of PFAS in soil, water and biota.
Comments/references	Many biota samples have been taken at Alta airport. There are a total of 27 different samples and in the case of flounder and cod, both whole fish and muscle samples have been analysed. Thus, the number of analysed samples is 48. PFAS has been detected in 34 samples. The samples of whole fish generally have higher concentrations than the muscle samples and the average for the whole cod for PFOS is 3.6 µg/kg, and for PFAS is 3.9 µg/kg. The average for the whole flounder for PFOS is 13.3 µg/kg and for PFAS is 15.1 µg/kg.
References and concentrations in other reports.	The average concentration of PFOS in three composite samples of polychaete in the inner Oslo fjord was 1.35 µg/kg ww. Source: Norwegian Environment Agency report M-812, 2017.

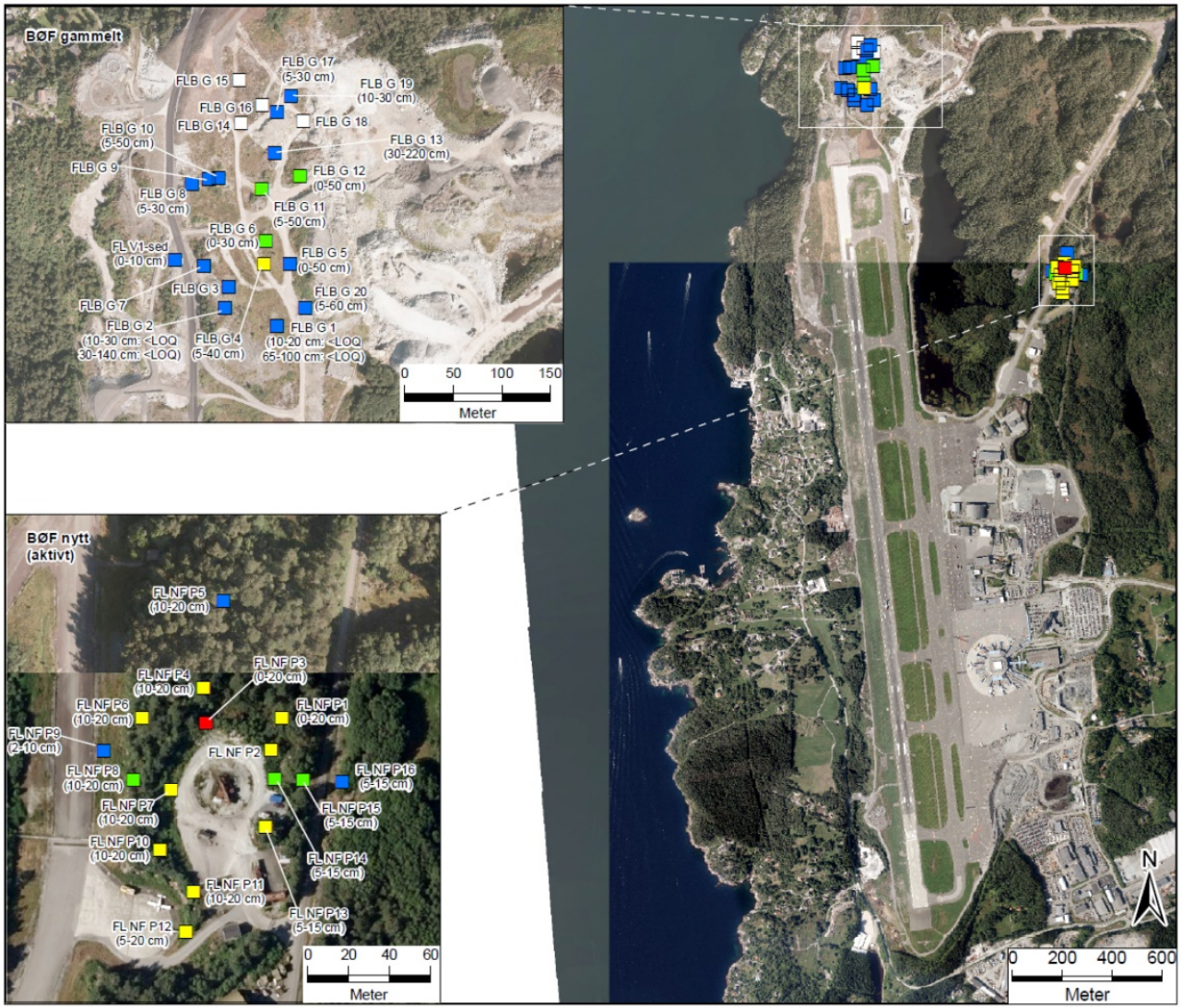
1.7 Uncertainty and other factors

Does the estimate of the volume of PFOS in the ground correspond with the measured concentrations in water and biota?	Cannot be reliably estimated as there are no samples of groundwater. It is probable that there has been – and continues to be – leakage of PFAS into the sea and 34 of the 48 samples of biota taken in the sea close to the FTS show elevated values. The highest concentrations of PFAS in stationary biota (bristle worms) are from the north side of the BØF, compared to samples from the south side. For flounder, which are relatively stationary fish, it would appear that the highest concentrations are at the test station located to the east of the BØF, compared to samples from the station to the north. The station to the east is closer to the outlet of the Alta river.
Evaluations	No samples of groundwater have been taken and, in seawater from which samples have been taken by excavating the sand on the beach to the north (31), it is probable that the proven PFAS content is attributable to the mobilisation of compounds in the sand during excavation. There is also evidence of PFAS in sediment in the sea on the north side of the BØF, and in the soil in the northernmost sampling points in Hull 1 from a depth of 200 to 300 cm (362 µg/kg and from Hull 10 from a depth of 190 to 220 cm (439 µg/kg). This points to a contamination area and/or dispersion to the north. From the 2016 report: Promitek inspected the fire training site in September 2010 and prepared a status report for the oil separator plant. Several faults and deficiencies were found at the plant, including the site having no licence for discharge to the sea and to the Altaosen nature reserve. The airport could not document the water quality of the drainage water being carried to the sea and the Altaosen nature reserve. Nor could the airport document that the fire site was sealed. The site should have been sealed in 2012. The BØF should be designed in such a way that fluid on concrete and asphalt flows into the drains in the concrete area. The asphalt facing the drains has a poor downward gradient and it is likely that fluid can flow both beyond and over the slab. Thus, it is probable that run-off from the site can go directly into the ground surrounding the site, as well as into the sea. A 12 m3 buried tank has been installed in a mound north of the control booth. The drains at the site flow to this tank. The tank is emptied after each exercise and when it is full.
Could there be any additional unknown sources of PFOS at the site with run-off to the recipient?	No other known site of PFAS contamination at the airport have been reported, but this cannot be ruled out.

Has the site been sufficiently mapped with a view to assessing the order of prioritisation?	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the volume of PFOS in the soil with the stipulated level of uncertainty.
Comments/uncertainty	

Other factors of significance to possible cleanup/implementation of measures (for example, planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	The airport is located in the immediate proximity of Altaosen/Rafsbotn. Many important species (a number of birds) and types of nature of significant value are registered here (www.naturbase.no). Black-headed gulls have been registered at Naustneset, where the BØF is located. A protected area, Latharimoen nature reserve, is situated around 1.2 km to the east. There is a particular conservation interest in the swans, geese, ducks, wading birds, gulls and auks that have a breeding, feeding, moulting and/or resting area in the fjord outside the airport. The Alta river's delta and outlet is registered as an important outdoor area on www.naturbase.no. Alta airport is registered with Avinor's vulnerability class 3, which means vulnerable recipients, highest priority and highest level at the facility. The Alta river, which drains into the sea right by the eastern part of the airport, is one of Norway's best rivers for salmon fishing. In Hull 16 and 17 centrally in the BØF, there is evidence of aliphatics in status class 3 in two soil samples and status class 4–5 in five soil samples.

2 Bergen Airport Flesland



Bergen lufthavn Flesland (ENBR)

Oversiktskart

Jord og sediment

PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

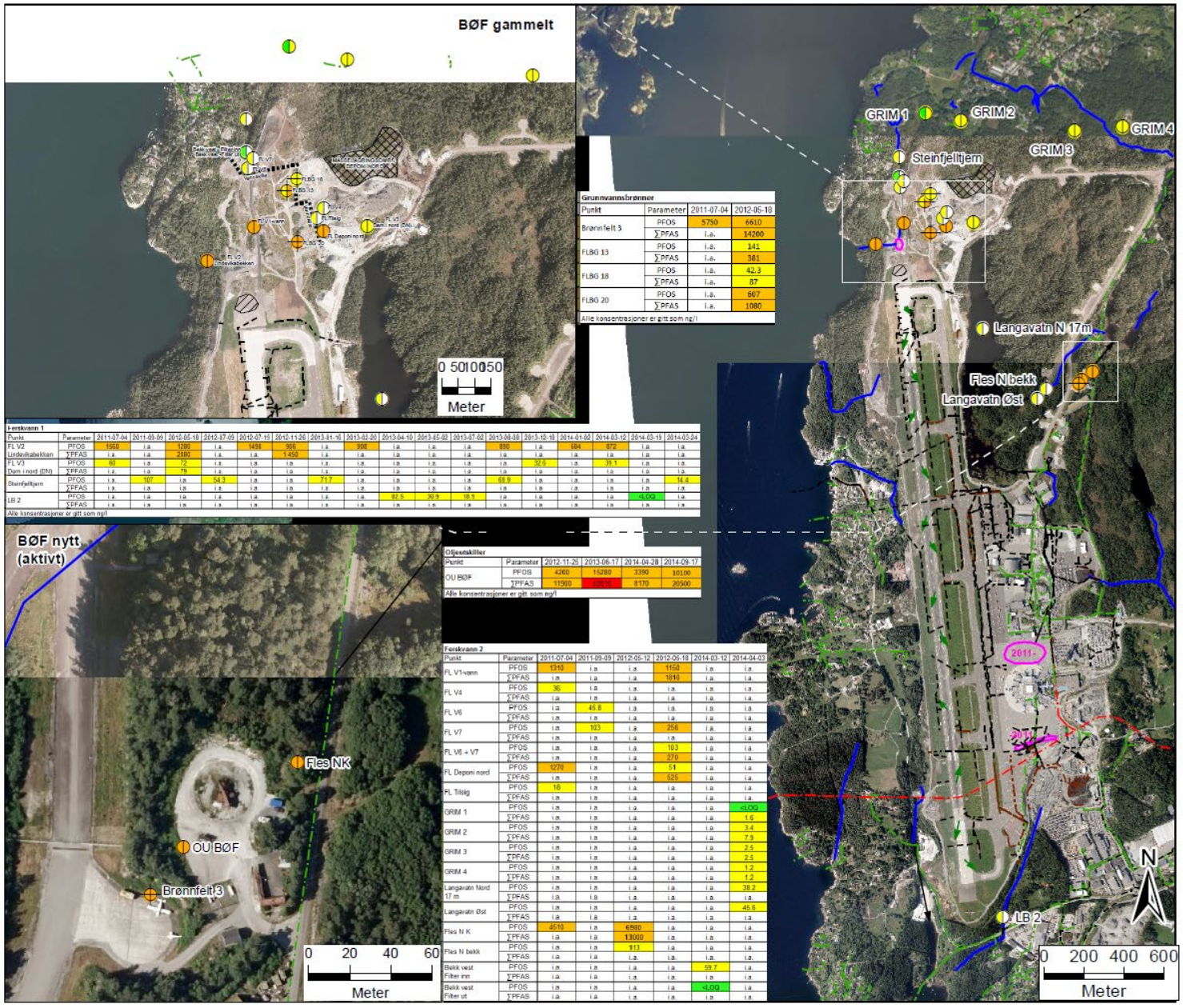
* PFOS er dominerende parameter

LOQ = rapporteringsgrense
i.a. = ikke analysert

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APPENDIX A



Grunnvannsbrønner

Punkt	Parameter	2011-07-04	2012-05-18
Brønnfelt 3	PFOS	5750	6610
	∑PFAS	i.a.	14200
FLBG 13	PFOS	i.a.	141
	∑PFAS	i.a.	381
FLBG 18	PFOS	i.a.	42.3
	∑PFAS	i.a.	87
FLBG 20	PFOS	i.a.	607
	∑PFAS	i.a.	1080

Alle konsentrasjoner er gitt som ng/l

I-erskvann 1

Punkt	Parameter	2011-07-04	2011-09-09	2012-05-18	2012-07-09	2012-07-16	2012-11-26	2013-01-16	2013-02-20	2013-04-10	2013-05-02	2013-07-02	2013-08-06	2013-12-10	2014-01-02	2014-03-12	2014-05-15	2014-03-24
FL V2	PFOS	1660	i.a.	1200	i.a.	1490	906	i.a.	908	i.a.	i.a.	i.a.	890	i.a.	584	872	i.a.	i.a.
Lindevikabekken	∑PFAS	i.a.	i.a.	2080	i.a.	i.a.	1450	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
FL V3	PFOS	80	i.a.	72	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	52.9	i.a.	i.a.	35.1	i.a.	i.a.
Dam i nord (DN)	∑PFAS	i.a.	i.a.	79	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
Steinfjelltjern	PFOS	i.a.	107	i.a.	54.3	i.a.	i.a.	71.7	i.a.	i.a.	i.a.	i.a.	61.9	i.a.	i.a.	i.a.	i.a.	14.4
	∑PFAS	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
LB 2	PFOS	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	82.5	30.9	18.3	i.a.	i.a.	i.a.	<LOQ	i.a.	i.a.	i.a.
	∑PFAS	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.

Alle konsentrasjoner er gitt som ng/l

Oljeutskiller

Punkt	Parameter	2012-11-26	2013-06-17	2014-04-28	2014-09-17
OU BØF	PFOS	4200	15200	3390	10100
	∑PFAS	11500	40010	8170	20500

Alle konsentrasjoner er gitt som ng/l

Ferskvann 2

Punkt	Parameter	2011-07-04	2011-09-09	2012-05-12	2012-05-18	2014-03-12	2014-04-03
FL V1-vann	PFOS	1310	i.a.	i.a.	1150	i.a.	i.a.
	∑PFAS	i.a.	i.a.	i.a.	1810	i.a.	i.a.
FL V4	PFOS	36	i.a.	i.a.	i.a.	i.a.	i.a.
	∑PFAS	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
FL V6	PFOS	i.a.	45.8	i.a.	i.a.	i.a.	i.a.
	∑PFAS	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
FL V7	PFOS	i.a.	103	i.a.	258	i.a.	i.a.
	∑PFAS	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
FL V6 + V7	PFOS	i.a.	i.a.	i.a.	103	i.a.	i.a.
	∑PFAS	i.a.	i.a.	i.a.	270	i.a.	i.a.
FL Deponi nord	PFOS	1270	i.a.	i.a.	51	i.a.	i.a.
	∑PFAS	i.a.	i.a.	i.a.	525	i.a.	i.a.
FL Tilsig	PFOS	16	i.a.	i.a.	i.a.	i.a.	i.a.
	∑PFAS	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
GRIM 1	PFOS	i.a.	i.a.	i.a.	i.a.	i.a.	<LOQ
	∑PFAS	i.a.	i.a.	i.a.	i.a.	i.a.	1.6
GRIM 2	PFOS	i.a.	i.a.	i.a.	i.a.	i.a.	3.4
	∑PFAS	i.a.	i.a.	i.a.	i.a.	i.a.	7.5
GRIM 3	PFOS	i.a.	i.a.	i.a.	i.a.	i.a.	2.5
	∑PFAS	i.a.	i.a.	i.a.	i.a.	i.a.	2.5
GRIM 4	PFOS	i.a.	i.a.	i.a.	i.a.	i.a.	1.2
	∑PFAS	i.a.	i.a.	i.a.	i.a.	i.a.	1.2
Langavatn Nord 17 m	PFOS	i.a.	i.a.	i.a.	i.a.	i.a.	38.2
	∑PFAS	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
Langavatn Øst	PFOS	i.a.	i.a.	i.a.	i.a.	i.a.	45.6
	∑PFAS	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
Fles N K	PFOS	4510	i.a.	6580	i.a.	i.a.	i.a.
	∑PFAS	i.a.	i.a.	13000	i.a.	i.a.	i.a.
Fles N bekk	PFOS	i.a.	i.a.	913	i.a.	i.a.	i.a.
	∑PFAS	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
Bekk vest Filter inn	PFOS	i.a.	i.a.	i.a.	i.a.	59.7	i.a.
	∑PFAS	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
Bekk vest Filter ut	PFOS	i.a.	i.a.	i.a.	i.a.	<LOQ	i.a.
	∑PFAS	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.

Bergen lufthavn Flesland (ENBR)

Oversiktskart

Vann

PFOS / ∑ PFAS grunnvannsbrønn (ng/l) *
- Ikke analysert
- 0
- <LOQ
- LOQ-230
- 230-36 000
- >36 000

PFOS / ∑ PFAS ferskvann (ng/l) *
- Ikke analysert
- 0
- <LOQ
- LOQ-230
- 230-36 000
- >36 000

Avlopsledning
- Avløp annet
- Avløp Felles
- Drensvann
- Glykolholdig overvann
- Glykolholdig spillvann
- Overvann
- Pumpespillvannsledning
- Spillvann

Avrenning
- Deponi glykolforurenset snø
- Overvannsledning
- Avrenningsveg glykol
- Bekkeresipient
- Overvannsystem
- Vannskille rullebane
- Antatt avrenningsveg baneavising
- Mulig PFAS-lokalitet

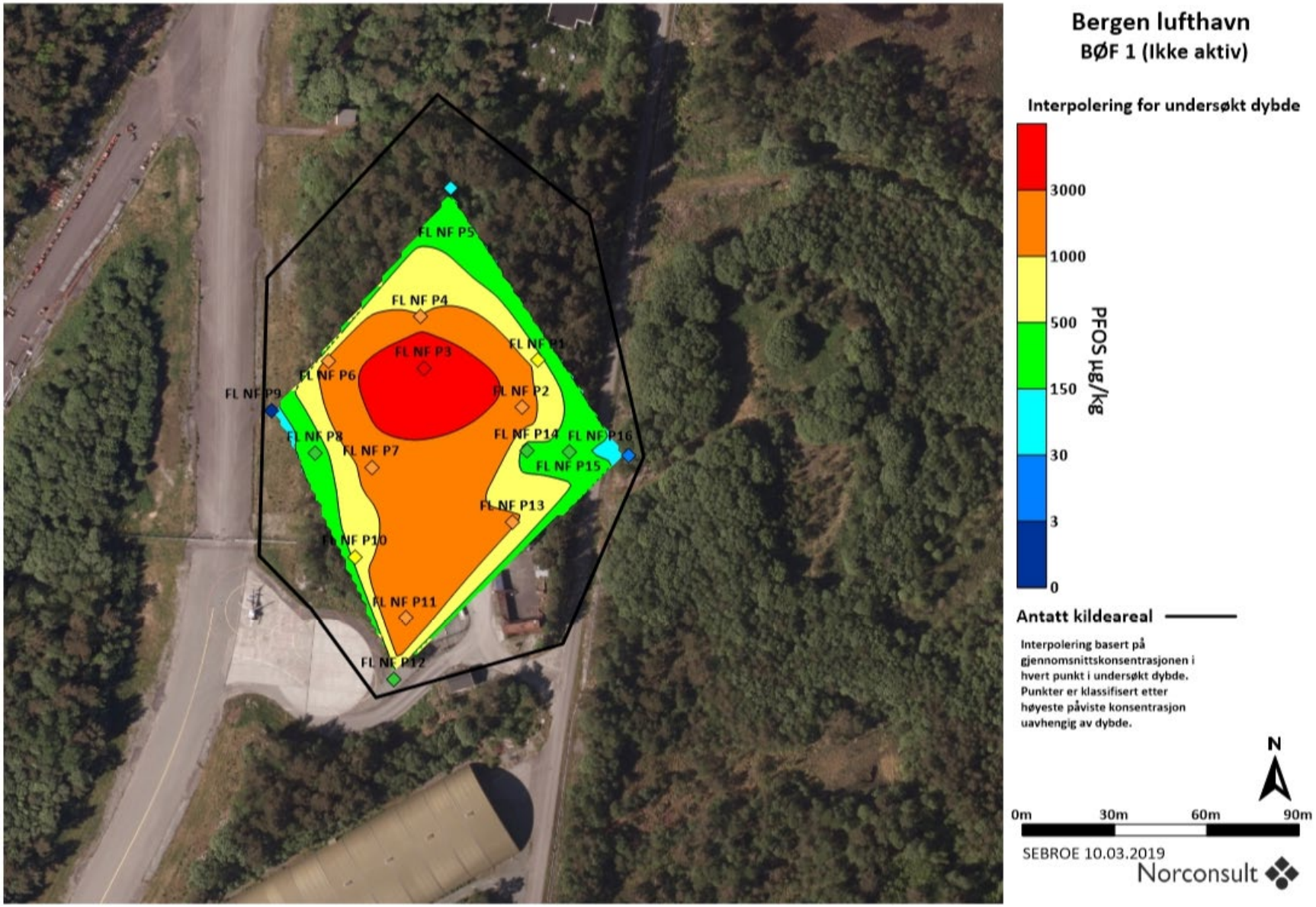
* Venstre halvdel = PFOS
Høyre halvdel = ∑PFAS

i.a. = ikke analysert
LOQ = rapporteringsgrense
(tilsv. ikke påvist for ∑PFAS)

AVINOR Norconsult COWI SWECO

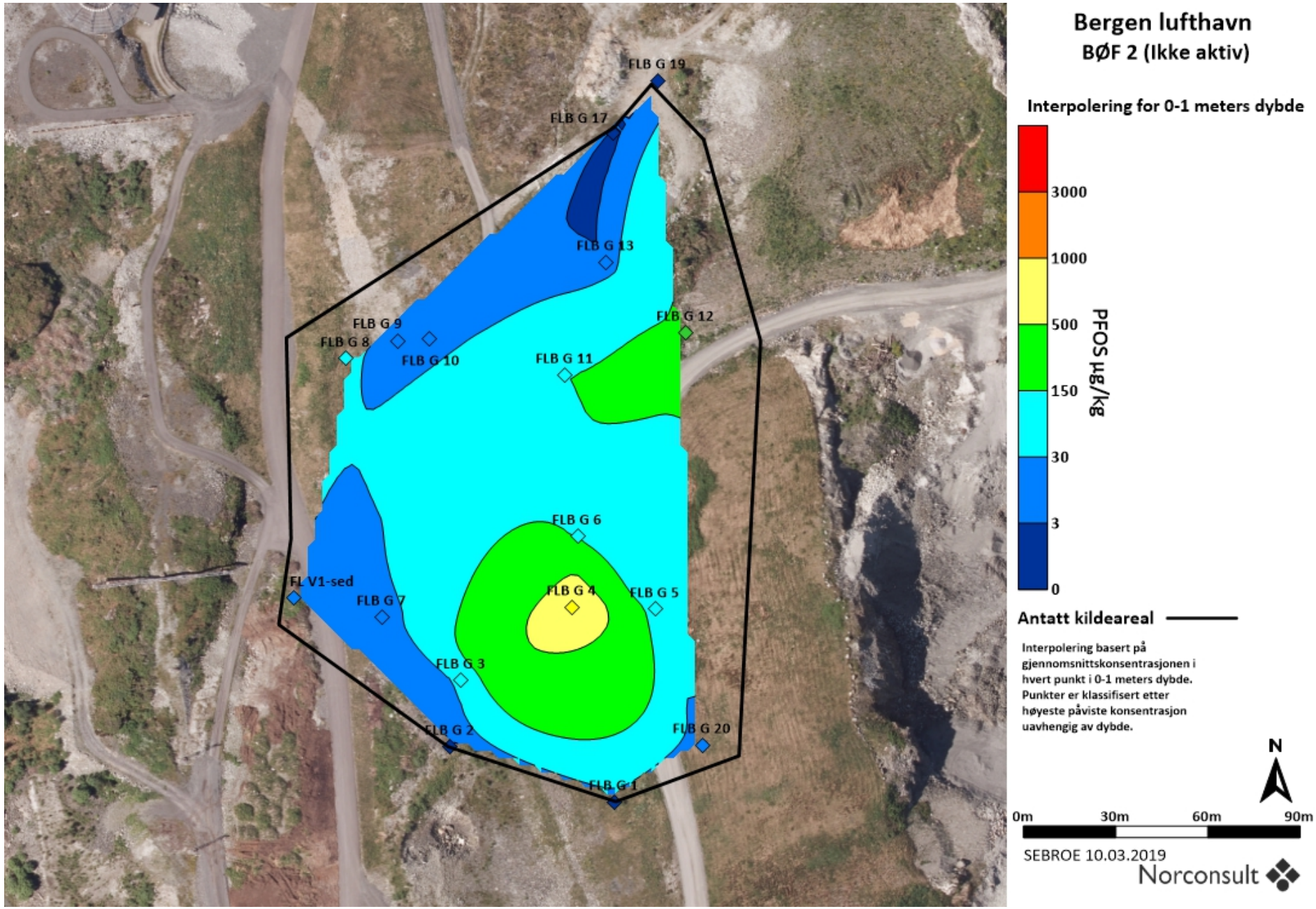
Norconsult

APPENDIX A



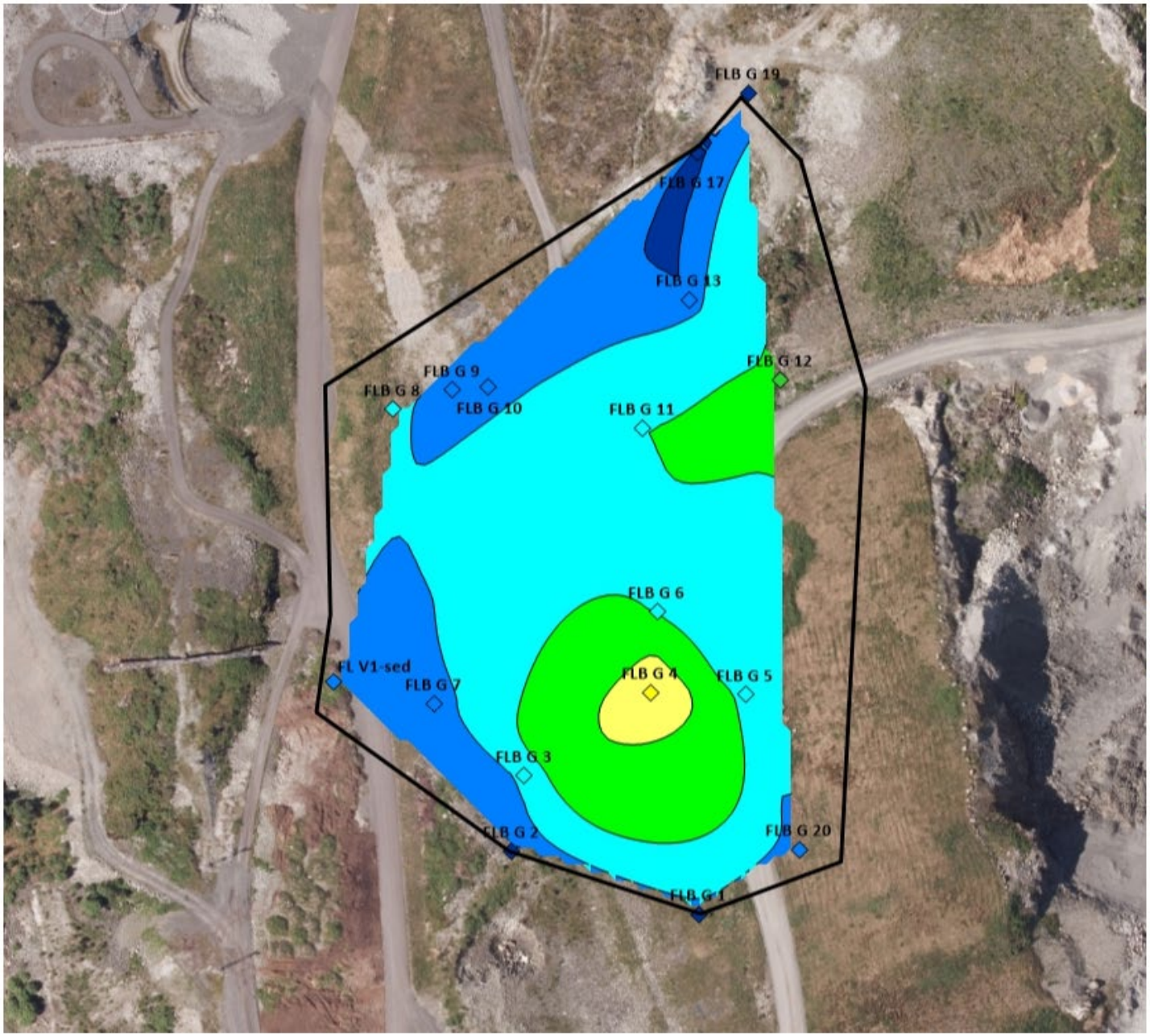
Norconsult

APPENDIX A



Norconsult

APPENDIX A



Bergen lufthavn
BØF 2 (Ikke aktiv)

Interpolering for undersøkt dybde

PFOS µg/kg
3000
1000
500
150
30
3
0

Antatt kildeareal

Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.

N

0m 30m 60m 90m

SEBROE 10.03.2019

Norconsult

2.1 Fire training site (BØF)/contaminated site

Fire training site (BØF)/contaminated site	BØF 1 (youngest, inactive)	BØF 2 (old)
	BØF 1 was in use between 1995 and 2018. BØF 1 was closed in autumn 2018. Infrastructure was installed on the site to collect and transport water and chemicals to an oil separator and then on to the municipal sewage system, which outflows into Raunefjorden. BØF 1 is situated approximately 55 m above sea level.	BØF 2 was in use between 1957 and 1993. BØF 2 was used by the Norwegian Armed Forces and the municipal fire service, in addition to the airport itself. BØF 2 is situated approximately 55 m above sea level.

2.2 Use of PFOS and other PFAS compounds

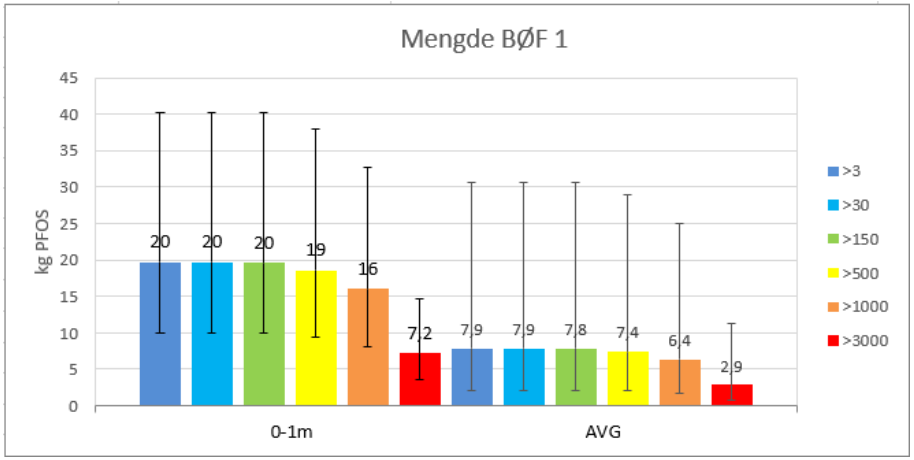
Fire training site (BØF)/contaminated site	BØF 1 (youngest, inactive)	BØF 2 (old)
Quantity of PFOS used at the site (kg)	580	1,450
Comments/uncertainty	Estimated consumption during the period 1995 to 2001. Estimated annual foam consumption is 2,300 litres.	Estimated consumption during the period 1957 to 1993. Estimated annual foam consumption is 2,300 litres.
Quantity of PFAS used at the site (kg)	430	
Comments/uncertainty	Estimated consumption during the period 2001 to 2011/2012. The use of foam containing PFAS compounds at Avinor's airports was phased out in 2012.	More recent types of foam without PFOS as their main component have probably not been used.

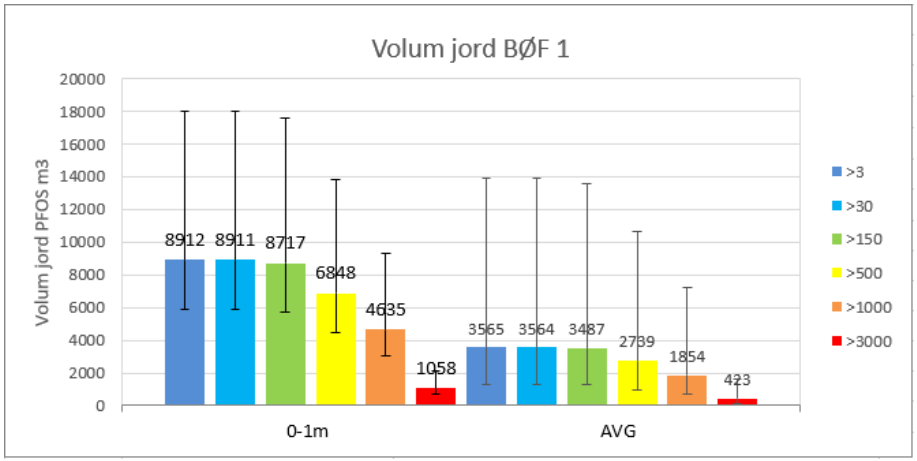
2.3 Soil sampling

Fire training site (BØF)/contaminated site	BØF 1 (youngest, inactive)	BØF 2 (old)
Total number of soil samples	17	23
Comments/uncertainty (e.g. 95% of the samples were taken from 0-0.1 m)	No samples were taken from depths exceeding 0.4 m. 15 of the samples (approx. 90%) were taken at depths between 0-0.2 m below ground level).	7 of the samples (approx. 30%) are surface samples, taken from depths of 0-0.3 metres. The deepest sample was taken at a depth of 2.5 metres.
Number of soil samples 0-1 m below ground level	17	22
Number of soil samples under 1 m	0	5
Comments/uncertainty	The material at the sampling points has been stated as consisting of soil. More specifically, the fire training site area is surrounded by forest, south of a small wooded hill. In addition to the training platform itself, there are only thin layers of organic matter above bedrock.	The total number of soil samples is 27 when the samples which extend over the interval 0-1 m and >1 m are divided up. The material at the sampling points is stated as consisting of soil in Table 7 of the DP2 report, and gravel in Table 9 of the same report. More specifically, the site is situated in a flat area west of a small rounded hill. The bedrock in the area is shallow. The bedrock surface rises towards the east. Towards the west, there is rock fill material, which increases in thickness towards Lindevika.
Highest measured concentration of PFOS in soil µg/kg	8,250	875
Where	FLNF P3 (0-0.2 m). The sample consists of soil.	FL B G 4 (0.05-0.4 m). The sample consists of soil.
Highest measured concentration of PFAS in soil µg/kg	8,250	878
Where	FLNF P3 (0-0.2 m). The sample consists of soil.	FL B G 4 (0.05-0.4 m). The sample consists of soil.
Comments/uncertainty	Sample FL-NF-P3 was only analysed for PFOS and PFOA. Of the 17 samples collected from BØF 1, six samples were analysed for 12 different PFAS compounds, while 11 of the samples were analysed for PFOS and PFOA only. PFOS is the dominant compound in the samples, but there are significant concentrations of other compounds such as 6:2 FTS, 8:2 FTS, PFBA, PFHxS, PFHxA and PFPeA in some of the samples.	Sample FL B G 4 was analysed for PFOS and PFOA only. Of the 23 samples collected from BØF 2, two were analysed for 12 different PFAS compounds. PFOS is the dominant compound, but PFHxS, 8:2 FTS, PFHxA and PFNA have also been detected.

2.4 Quantity calculation

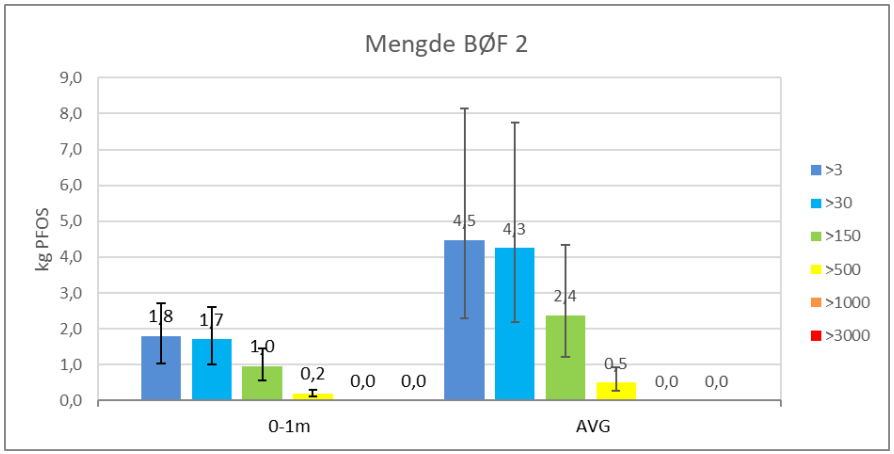
PFOS average for all depths and points > 3 µg/kg	BØF 1	BØF 2
Concentration (µg/kg)	1,471	112
Area (m2)	8,912	18,818
Quantity of soil (tonnes)	5,347	79,977
Quantity of PFOS (kg)	7.9	4.5
Uncertainty -	5.7	2.2
Uncertainty +	23	3.7
PFOS average for all depths and points > 30 µg/kg		
Concentration (µg/kg)	1,471	143
Area (m2)	8,911	14,022
Quantity of soil (tonnes)	5,347	59,594
Quantity of PFOS (kg)	7.9	4.3
Uncertainty -	5.7	2.1
Uncertainty +	23	3.5
PFOS average for all depths and points > 150 µg/kg		
Concentration (µg/kg)	1,500	290
Area (m2)	8,717	3,861
Quantity of soil (tonnes)	5,230	16,409
Quantity of PFOS (kg)	7.8	2
Uncertainty -	5.7	1.2
Uncertainty +	23	2.0
PFOS average for all depths and points > 500 µg/kg		
Concentration (µg/kg)	1,809	608
Area (m2)	6,848	393
Quantity of soil (tonnes)	4,109	1,670
Quantity of PFOS (kg)	7.4	0.5

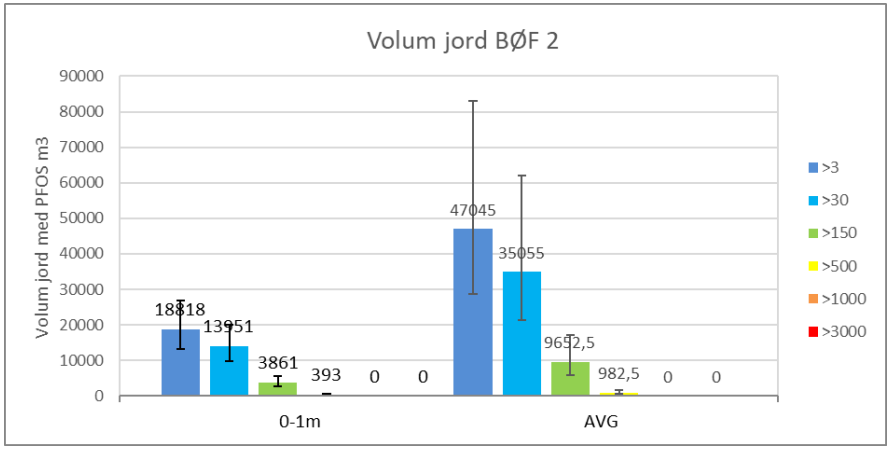




Uncertainty -	5.4	0.2
Uncertainty +	22	0.4

PFOS average for all depths and points > 1000 µg/kg		
Concentration (µg/kg)	2,303	
Area (m2)	4,635	
Quantity of soil (tonnes)	2,781	
Quantity of PFOS (kg)	6.4	
Uncertainty -	4.7	
Uncertainty +	19	
PFOS average for all depths and points > 3000 µg/kg		
Concentration (µg/kg)	4,531	
Area (m2)	1,058	
Quantity of soil (tonnes)	635	
Quantity of PFOS (kg)	2.9	
Uncertainty -	2.1	
Uncertainty +	8.3	





Fire training site (BØF)/contaminated site	BØF 1 (youngest, inactive)	BØF 2 (old)
Comments regarding calculations	The risk assessment assumes that the contaminated area covers an area of between 9,500 and 15,000 m^2. The thickness of the contaminated materials is estimated to be 1 ± 0.25 m. Based on a mean PFOS concentration of 1480 µg/kg and a material density of 1,000 ± 300 kg/m^3, it is estimated that between 10 and 30 kg of PFOS are still present at the site. The 2019 calculation calculates that approximately 8 kg of PFOS remain within the investigated area at the site (approx. 9,000 m^2), and that there may be up to 30 kg in total within the assumed source area (approx. 18,000 m^2). The main reason why the calculation from 2019 gives a slightly lower figure for the remaining quantity of PFOS is that it assumed a depth of 0.4 metres. This is also considered to be a representative mean depth for the thickness of the contaminated materials, as they form a thin cover of unconsolidated sediment on a rounded hill.	The risk assessment assumes that the contaminated area covers an area of 21,000 ± 5,000 m^2. The thickness of the contaminated materials has been set to 3 ± 1 metre. The density of the materials has been set to 1600 ± 400 kg/m^3, and it is estimated that the mean concentration is 112 µg/kg. This gives a quantity of PFOS left in-situ of approx. 10 ± 5 kg. The calculation from 2019 estimates that 4.5 kg of PFOS remain within the investigated area around BØF 2. The 2019 calculation uses approximately the same depth, concentration and area as the risk assessment, but the expected component of larger fractions not contaminated by PFOS has been excluded. The proportion of fine-grained material is set to 50% due to the presence of gravelly filler which consists of blasted stone.
Is the extent of the contaminated area limited horizontally?	No. Only PFOS concentrations below the detection limit at one outer point (FLNF P9) were detected towards the west. At the other extreme points, concentrations of between 30-270 µg/kg were detected. The risk assessment states that the contaminated area was not well-delimited during the sampling. Avinor has stated that foam is dispersed outside the platform during exercises. The highest concentration was detected about 10 metres north of the platform.	The extreme points to the north (surface samples FL B G 17 and 19) and to the south (FL B G 1 and 2, with samples from depths of between 10 and 140 cm) have concentrations of PFOS < 3 µg/kg. At the other extreme points to the east and west, concentrations of between 10.8 and 189 µg/kg have been detected. There has been some relocation of materials in the area, probably including excavation, temporary storage and the addition of new materials.
Is the extent of the contaminated area limited vertically?	The risk assessment states that there is a generally thin layer of unconsolidated material above bedrock in the area where BØF 1 is located. No precise depth to bedrock is known, but it is probably between 0.2-1 metres. There is visible bedrock at the surface immediately north of BØF. The depth to bedrock is uncertain at the BØF, as no excavations have taken place there, but it is assumed that a thin layer of materials has been laid there as part of the development of the area.	No, PFOS concentrations above the detection limit were detected in many of the deepest samples, and it is uncertain how much deeper the contamination extends. The highest concentrations (>100 µg/kg) were detected at sampling points where no samples of deeper materials were taken. There are also relatively few samples of deeper materials.

Comments/uncertainty	No samples were taken from the BØF itself, only surface samples in unconsolidated sediments around the actual platform.	The DP2 report states that three samples were taken from groundwater level, without stating which ones. The deepest specimen was taken from 2.5 metres, which means that groundwater levels are less than 2.5 metres below ground level.

2.5 Water sampling and annual dispersal

Fire training site (BØF)/contaminated site	BØF 1 (youngest, inactive)	BØF 2 (old)
Have water samples been taken?	Yes	Yes
Where	A groundwater well is located in BØF 1. In addition, samples of surface water have been taken from streams and Langavatn.	Three groundwater wells have been drilled in the fire training site itself. These have been sampled on one occasion (18.5.12). In addition, samples of surface water have been taken from streams, a pond, Langavatn and Steinfjelltjern.
Highest measured concentration of PFOS in groundwater (ng/l)	6,610	607
Where	Well field 3 (18.05.2012)	FL B G 20 (sampled 18.5.12)
Highest measured concentration of PFAS in groundwater (ng/l)	14,200	1,080
Where	Well field 3 (18.05.2012)	FL B G 20 (sampled 18.5.12)
Comments/uncertainty	The water sample was analysed for 11 PFAS compounds. In addition to PFOS, high concentrations of 6:2 FTS, PFHxS and PFPeA were detected in groundwater, and the other compounds which were analysed for were also detected.	The water sample was analysed for 11 PFAS compounds. In addition to PFOS, some PFHxS (260 ng/l) was detected in the sample taken from well FL B G 20, and six other PFAS compounds were also detected. In the other two groundwater samples, approximately the same quantities of PFOS and PFHxS were detected.
Highest measured concentration of PFOS in surface water (ng/l)	6,980	1,560
Where	FLES NK (18.05.2012)	FL V2 / Lindevikabekken (04.07.2011)

Highest measured concentration of PFAS in surface water (ng/l)	13,000	2,080
Where	FLES NK (18.05.2012)	FL V2 / Lindevikabekken (18.05.2012)

Comments/uncertainty	The water sample was analysed for 11 PFAS compounds. Sample point FLES NK is situated in a sump located west of BØF 1. The sump has an open bottom and is an installation left over following an accident involving oil pollution in the late 1990s. Samples of surface water have also been taken from a stream (FLES N Bekk), which flows via Aurtjern into Langavatet. Samples have also been taken from Langavtnet. PFOS has been detected in these samples, but in lower concentrations than in the sump west of BØF 1. The water sample from the stream was analysed for 11 PFAS compounds, with PFOS and 6:2 FTS as the dominant compounds. An oil separator has been installed in BØF 1 which is connected to the municipal sewerage network, which discharges into Raunefjorden. Water samples have been taken from the oil separator on four occasions between 2012 and 2014, with all samples showing high concentrations of total PFAS. The compounds 6:2 FTS and PFOS are dominant, with relatively similar concentrations. Concentrations of total PFAS varied between 8,170 and 40,010 µg/kg. Avinor phased out the use of foam containing PFAS in 2012, and the fire training site was closed in 2018.	Sample FL V2 was taken from Lindevikabekken, which flows from the area around BØF 2 and westwards in the direction of Lindevika. The water sample from 2012 is the only one (out of a total of eight samples from this sample point) to be analysed for compounds other than PFOS and PFOA. The sample was analysed for 11 compounds. Water samples have also been taken from Steinfjelltjern, from Langavatnet, from a pond on the landfill in the north, as well as from several small streams and inflows in the area around BØF 2. PFOS has been detected in all samples of surface water, with the exception of one sample from "stream west" in March 2014. "Stream west" flows north from the area around BØF 2, and represents runoff from a small area north of the old fire training site, which flows to Steinfjelltjern via this stream. The runoff from Steinfjelltjern is routed towards the residential area of Kvitura, which uses groundwater as its source of drinking water. This is the reason for the focus on this runoff direction. Bergen Airport has established an organoclay filter to reduce the transport of PFOS/PFAS to Steinfjelltjern (referred to COWI memo of June 2012 in the risk assessment report from 2016).
Total quantity dispersed annually from the site PFOS (g/year)	170 (15)*	180
Total quantity dispersed annually from the site PFAS (g/year)	Not calculated (30)*	Not calculated
To which recipient	Runoff in the areas located east of the runway will flow towards Langavatnet. From Langavatnet, the water passes via an open culvert under the runway to Fleslandselva and out into Raunefjorden.	Much of the runoff from the area around BØF 2 flows into Lindevika and Raunefjorden. A small proportion flows to Steinfjelltjørn and to Langavatnet.

Calculated from water or soil concentration.	Water concentration. The figures marked * are the estimated quantities of PFOS and PFAS which are directed to the municipal sewerage network per year and are based on water concentrations in the oil separator.	Water concentration

2.6 Biota sampling

Fire training site (BØF)/contaminated site	BØF 1 (youngest, inactive)	BØF 2 (old)
Have biota samples being taken at the airport?	Yes	Yes
What kind of biota?	Freshwater species: trout (muscle). Marine species: cod (muscle), pollock (muscle), zooplankton and ocean quahog.	Freshwater species: trout (muscle). Marine species: cod (muscle), pollock (muscle), zooplankton and ocean quahog.
How many samples?	22	22
Highest measured concentration in biota PFOS (µg/kg wet weight)	100	100
Where	B37: trout muscle	B37: trout muscle
Highest measured concentration in biota PFAS (µg/kg wet weight)	105.7	105.7
Where	B37: trout muscle	B37: trout muscle
Median concentration in comparable populations (e.g. in a lake)	The mean concentration of PFOS in muscle from 13 trout at Fagernes Airport Leirin is 12.3 µg/kg. Reference: Fagernes Airport, Leirin. Investigations into PFAS in soil, aquatic environment and biota with risk assessment, Norconsult and Sweco (16.3.16)	The mean concentration of PFOS in muscle from 13 trout at Fagernes Airport Leirin is 12.3 µg/kg. Reference: Fagernes Airport, Leirin. Investigations into PFAS in soil, aquatic environment and biota with risk assessment, Norconsult and Sweco (16.3.16)

Comments/references	A total of nine samples of muscle from trout from Langavatnet were analysed. PFOS was detected in all samples at concentrations of between 33-100 µg/kg, with a mean concentration of 59 µg/kg. Concentrations of total PFAS varied between 34.5 and 105.7 µg/kg, with a mean of 62.4 µg/kg. PFOS was the dominant compound in all samples (amounting to 94.6% on average), but some PFHxS has also been detected. In marine species, sampled just offshore of the outlet of Fleslandselven (cod, pollock, zooplankton and ocean quahog), PFOS was only detected in one sample of muscle from pollock. A PFOS concentration of 1.8 µg/kg was measured.	A total of nine samples of muscle from trout from Langavatnet were analysed. PFOS was detected in all samples at concentrations of between 33-100 µg/kg, with a mean concentration of 59 µg/kg. Concentrations of total PFAS varied between 34.5 and 105.7 µg/kg, with a mean of 62.4 µg/kg. PFOS was the dominant compound in all samples (amounting to 94.6% on average), but some PFHxS has also been detected. In marine species, sampled just offshore of the outlet of Fleslandselven (cod, pollock, zooplankton and ocean quahog), PFOS was only detected in one sample of muscle from pollock. A PFOS concentration of 1.8 µg/kg was measured.
References and concentrations in other reports.	Environmental quality standard in organisms in the Norwegian Environment Agency's guide M-608; 9.1 µg/kg wet weight. The biota samples from Flesland show higher concentrations than this. In a risk assessment dating from 13 December 2018, EFSA altered the tolerability limit (TDI - Tolerable Daily Intake) for PFOS and PFOA, with the result that these are now far lower than the TDI values set in 2018. This may cause EQS for biota to also be lower in the future.	Environmental quality standard in organisms in the Norwegian Environment Agency's guide M-608; 9.1 µg/kg wet weight. The biota samples from Flesland show higher concentrations than this. In a risk assessment dating from 13 December 2018, EFSA altered the tolerability limit (TDI - Tolerable Daily Intake) for PFOS and PFOA, with the result that these are now far lower than the TDI values set in 2018. This may cause EQS for biota to also be lower in the future.

2.7 Uncertainty and other factors

Fire training site (BØF)/contaminated site	BØF 1 (youngest, inactive)	BØF 2 (old)

Does the estimate of the quantity of PFOS in the ground correspond with the measured concentrations in water and biota?	Cannot be reliably evaluated. The assessment shows that it is likely that large quantities of PFOS and other PFASs have been leached from the site over time, and that dispersal is still taking place. This is reflected in the concentrations detected in water and biota in Langavatnet.	Cannot be reliably evaluated. The assessment shows that it is likely that large quantities of PFOS have already been leached out and dispersed to various recipients. Biota samples from the sea show little influence, but they were taken slightly further south than the area which is believed to be affected by the BØF.
Fire training site (BØF)/contaminated site	BØF 1 (youngest, inactive)	BØF 2 (old)

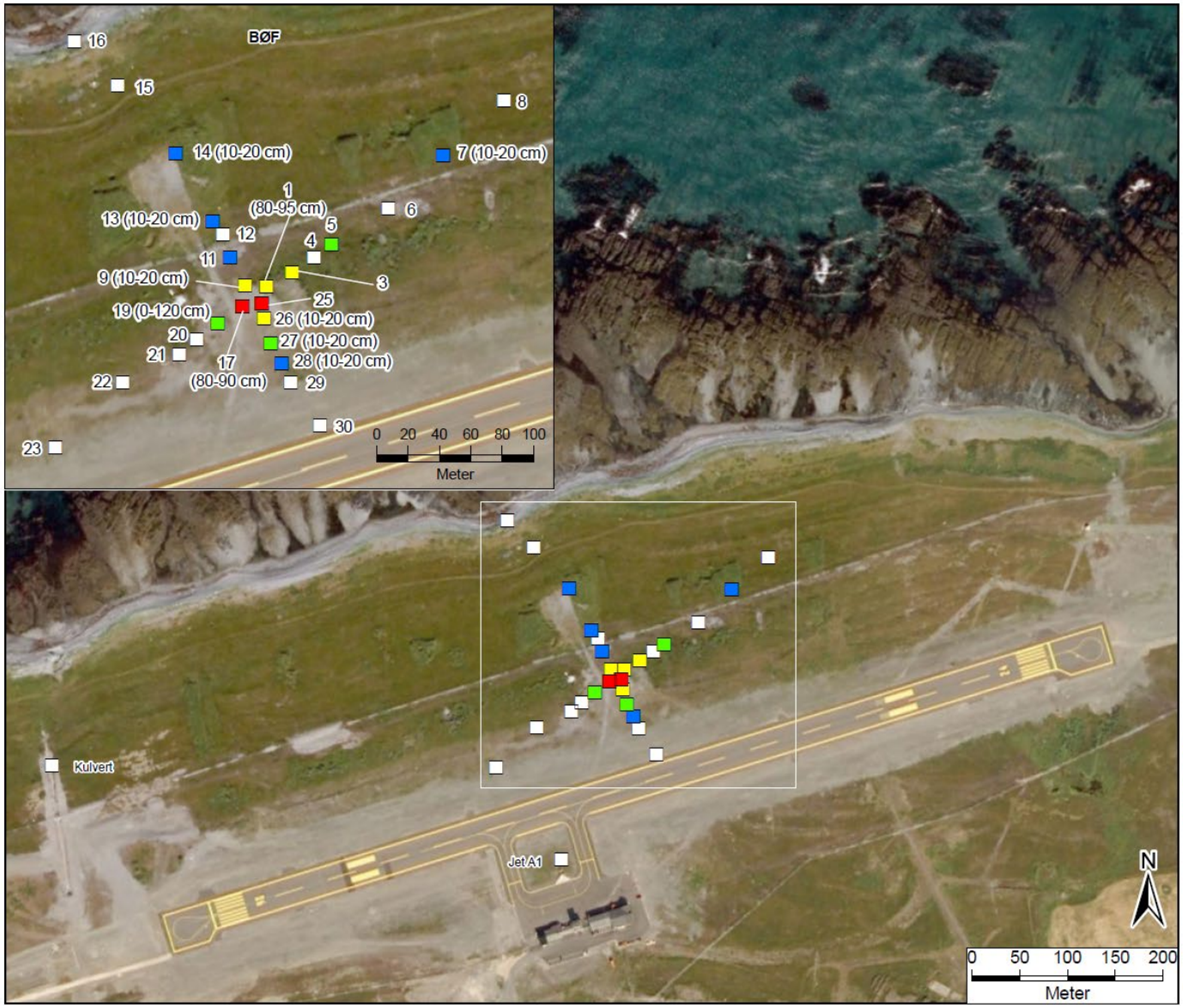
Evaluations	High concentrations of PFOS have been detected in soil; most samples have concentrations above 100 µg/kg; and there are also significant concentrations of other compounds such as 6:2 FTS, 8:2 FTS, PFBA, PFHxS, PFHxA, PFPeA in some of the samples. High concentrations of PFOS, 6:2 FTS, PFHxS and PFPeA have also been detected in the groundwater from the sample "well field 3" at BØF 1. Relatively high concentrations of the same compounds have also been detected in the sample "FLES NK", which was taken from the sump west of the BØF. As well as in the stream from Auretjern, which flows further out into Langavatnet. Samples taken in Langavatnet have only been analysed for PFOS, and PFOS has been detected in these. There is forest floor with a lot of organic material over exposed bedrock around BØF 1. This type of soil will strongly adsorb PFOS, which may cause the dispersal of PFOS from BØF 1 to the stream to be slow. It is likely that most leaching occurs in connection with snowmelt or heavy rainfall. Relatively high concentrations of PFOS have been detected in the biota samples of trout taken from Langavatnet. PFHxS has also been detected in lower concentrations in all samples, and 8:2 FTS has been detected in three of the samples. Concentrations of the compound PFHxS were also high in the groundwater sample and in samples from the stream at BØF 1. Langavatnet receives runoff from the active fire training site, as well as from the landfill areas north of Langavatnet, and from the eastern part of the area of the old BØF site. The trout in Langavatnet are most likely stationary, and considered in the context of the PFAS concentrations in soil and water analyses, there is a clear impact on biota in Langavatnet. The risk assessment report states that it is clear that dispersal of PFAS/PFOS from BØF 1 to biota in Langavatnet is still taking place. It is estimated that 580 kg of PFOS have been used at BØF 1, and that approximately 8 kg remain in the area that has been investigated. This indicates that most of the PFOS has already been leached out and dispersed to recipients and the surface water network.	Relatively low concentrations of PFOS have been detected in soil at BØF 2, but there are four sample points with concentrations above 100 µg/kg, and the highest concentration is 875 µg/kg. Only two of the samples have been analysed for PFAS compounds other than PFOS, and in these samples PFOS is dominant, followed by PFHxS in lower concentrations. The risk assessment states that the low concentrations in soil may be due to the fact that the contamination has been washed down into the soil profile and the coarse blasted stone fill material below. The risk assessment also states that unconsolidated material has been removed from the old BØF site, but it is not specified where. There is groundwater at less than 2.5 metres below ground level, which could mean that much of the contamination has been transported to recipient by the groundwater. PFAS concentrations in the groundwater at BØF 2 are highest in the well (FLBG 20) which is close to the sampling points with the highest concentrations in soil, and lower in the wells located furthest to the north. It is assumed that much of the runoff from the area around BØF 2 flows to Lindevika and Raunefjorden. A small proportion flows to Steinfjelltjørn and to Langavatnet. This is reflected in the many surface water samples taken around the old BØF site, which contained PFOS. Concentrations in the water samples taken west of the BØF site are particularly high. These samples also contain PFHxS in significant concentrations. PFAS has also been detected at low concentrations (total PFAS < 8 ng/l) in water samples taken some distance north of BØF 2, towards the residential area of Grimstad. The area may be affected by the airport operation and it is stated that the Norwegian Armed Forces may have been active here in the past. Little PFOS was detected in the marine biota samples taken at the outlet of Fleslandsbekken, which flows out into Kvernavika. As Fleslandsbekken is located some distance south of BØF 2, it is uncertain how much contamination will spread here. Following the biota sampling, it became clear that it is probably Lindevikabekken which drains BØF 2. No biota samples have been taken around the outlet of Lindevikabekken. It is estimated that 1,450 kg of PFOS have been used in BØF 2, and that approximately 4.5 kg still remains in situ in the area that has been investigated. This shows that most of the PFOS has been leached out of the material, but contaminated unconsolidated material may also have been removed.

Comments/uncertainty (Could there be any additional unknown sources of PFOS at the site with runoff to the recipient?)	The area along the road southwest of BØF 1 (taxiway Bravo) is used for testing and setting foam cannons. Only water was used for this testing, but there is a possibility that there may have been residues of foam in the system. Runoff from here is drained to Langavatnet. Pumps, etc. on the fire vehicles were previously cleaned on the central de-icing platform (solid paving).	In the DP2 project, soil samples were taken in the area specified as the old fire training site. Information later emerged which indicated that an area located below the northern part of the runway was also used for fire training purposes from around 1970 to the early 1990s. No soil samples have been taken in this area. Both areas have runoff towards Lindevikabekken and Lindevika. There is a material storage area east of BØF 2 (old) and north of Langavatnet. Here, there is a small quantity of material/sediments from the area close to the former Lønningtjern, as well as sediments from Langavatnet and Skjenavatnet. Runoff from the landfill area flows to Langavatnet, and PFOS concentrations of 30 – 50 ng/l have been detected in the runoff. For more information about the material storage area/landfill and runoff, refer to Multiconsult's report 613002-RIGm-RAP-002. The area along the road southwest of BØF 1 (taxiway Bravo) is used for testing and setting foam cannons. Only water was used for this testing, but there is a possibility that there may have been residues of foam in the system. Runoff from here is drained to Langavatnet. Pumps, etc. on the fire vehicles were previously cleaned on the central de-icing platform (solid paving).
Has the site been sufficiently mapped with a view to assessing the order of prioritisation?	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the quantity of PFOS in the soil with the stipulated level of uncertainty.	Yes, in accordance with the criteria (in this report for part 1 and part 2, section 2.1.3.1), sampling points and soil samples are sufficient to calculate the volume of PFOS in the soil with the stipulated level of uncertainty.
Comments/uncertainty	The extent of the contaminated area is not well-delineated, and no samples of material have been collected in the centre of the BØF. The use of foam cannons has probably led to the dispersal of foam in the ground.	The extent of the contaminated area is poorly delimited to the east. Low concentrations have been detected in soil relative to the quantity of PFOS used on the site. It is uncertain whether this is due to contaminated material being moved to another location, or whether it is due to the fact that most of the PFOS has been leached out into the

		recipient. No biota samples have been taken around the outlet of Lindevikabekken.

General information about the airport	
Other factors of significance to possible cleanup/implementation of measures (for example, planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	From Naturbase: Many species of high and particularly high management interest have been recorded around the airport, as well as in the marine area off the airport. An area with the habitat type "natural pasture" has been recorded east of the terminal area. In addition, several large old trees and hollow oaks have been recorded both east and west of the airport. In the sea west of the airport, there are important habitat types such as kelp forest (around Alvøyna). South of the airport, there are also kelp forests and major scallop occurrences. In the east, west, north and south, very important outdoor recreation areas have been registered, both on land and at sea. A number of localities with cultural heritage sites have been registered at Fleslandsvika, Setevikneset and south and east of the airport. Northwest of BØF 2, in Kvitura, there is a residential area. In connection with the sampling of BØF 2 in 2011, samples of drinking water were taken from both drilled wells and surface wells. PFOS was detected in some of these wells. Water quality was assessed by the municipal health service in 2011, and it was concluded that, although PFOS/PFAS levels in the water were not worryingly high, the water was unsatisfactory as a result of its bacteriological properties. Avinor has provided bottled water for households in the affected area, and has cooperated with Bergen municipality concerning the provision of a public water supply for Kvitura (completed in 2014). A filter has also been installed for treating runoff containing PFOS to the surface source (Steinfjelltjern). Blood samples were also taken from residents of Kvitura. The results showed that these residents did not have higher levels of PFAS in their blood than were found in other studies from across Norway and Europe.

3 Berlevåg Airport



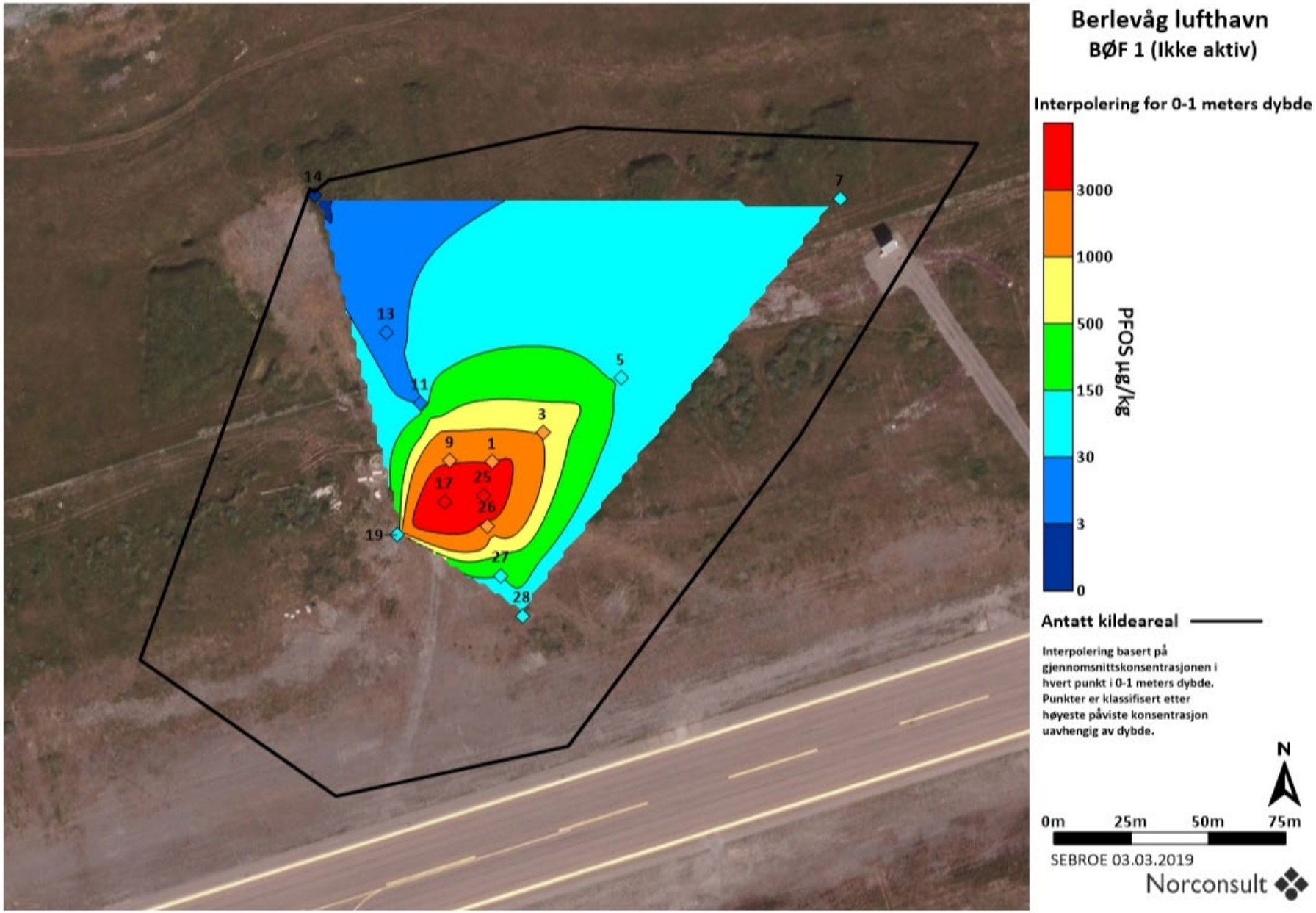
Berlevåg lufthavn (ENBV)

Oversiktskart

PFOS/PFOA jord (ug/kg)
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

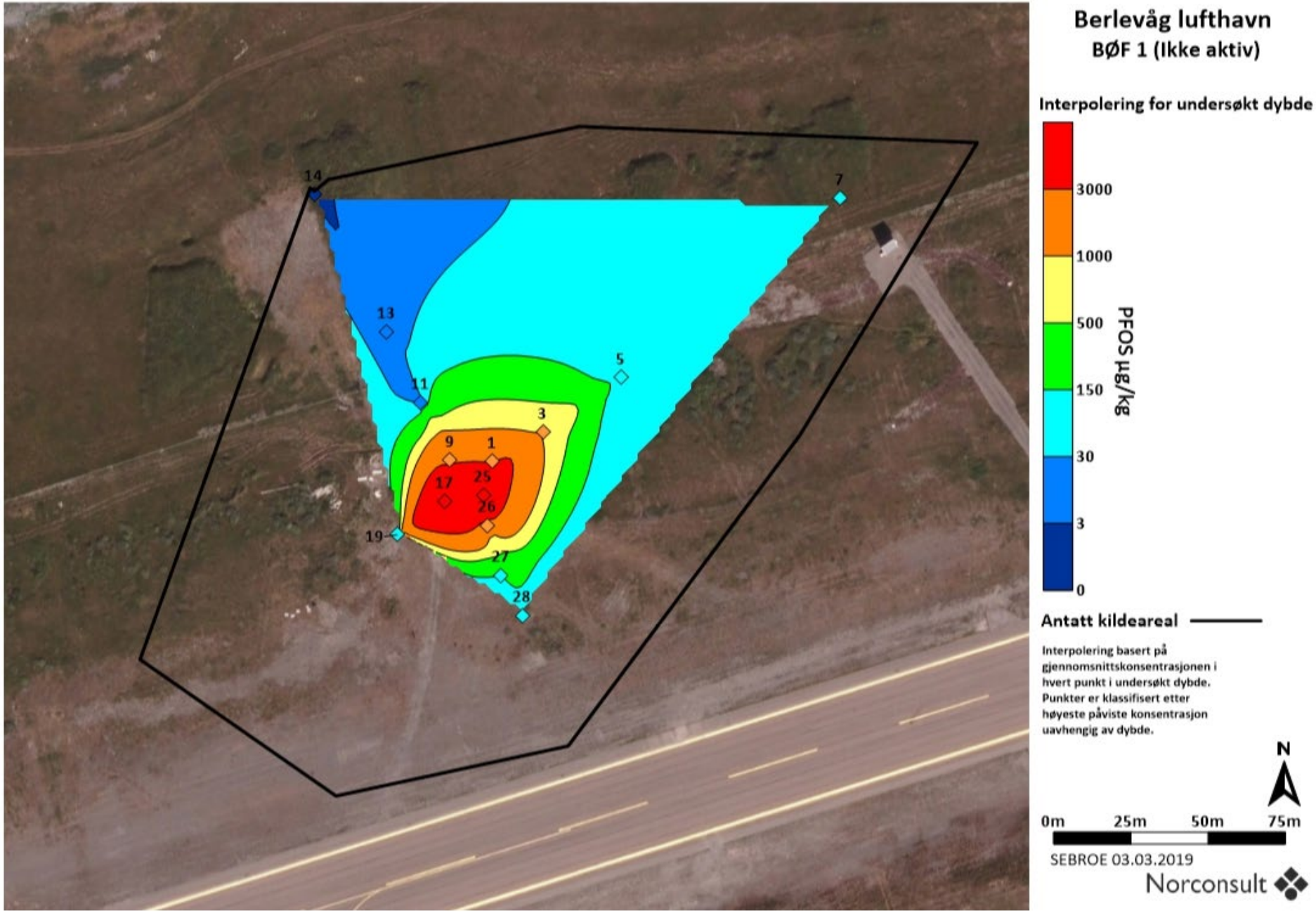
Norconsult

APPENDIX A



Norconsult

APPENDIX A



3.1 Fire training site (BØF)/contaminated site

Fire training site (BØF)/contaminated site	BØF 1 (old)
	The fire training site field has not been used since 2000.

3.2 Use of PFOS and other PFAS

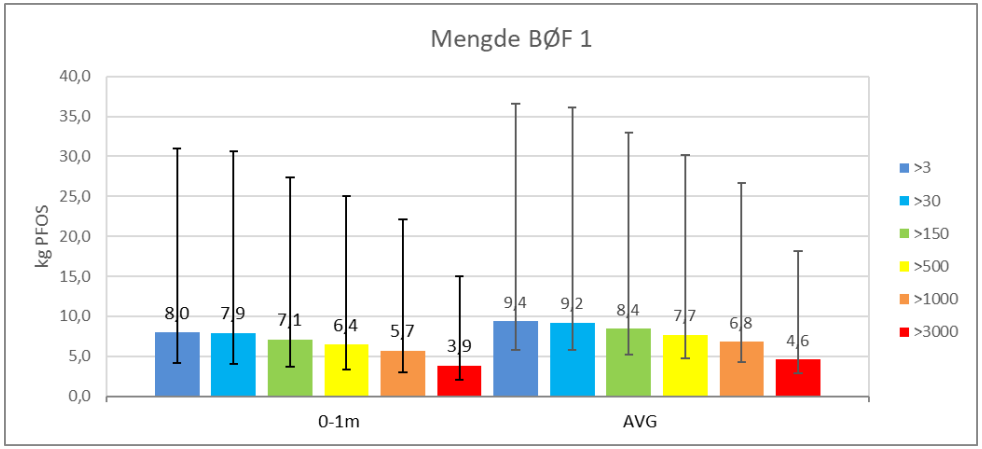
Volume of PFOS used at the site (kg)	Not stated/calculated
Comments/uncertainty	
Volume of PFAS used at the site (kg)	Not stated/calculated
Comments/uncertainty	

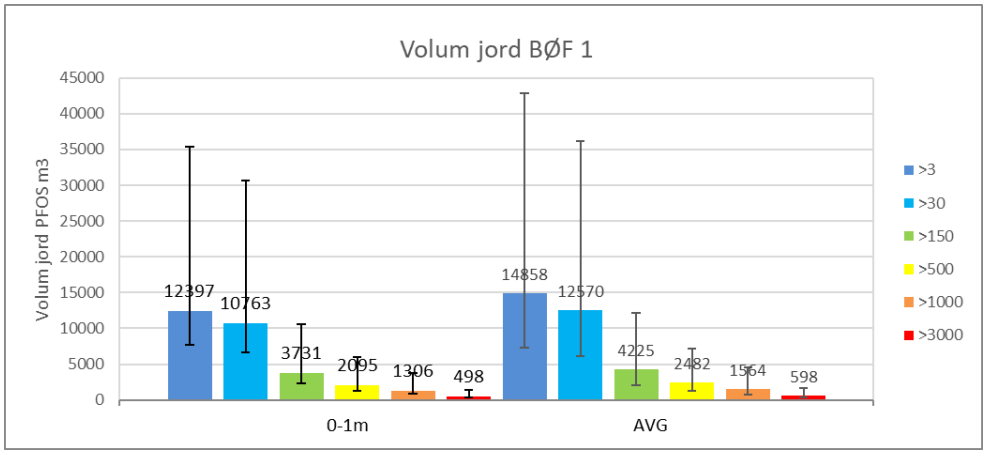
3.3 Soil sampling

Total number of soil samples	18
Comments/uncertainty (for example, 95% of the samples were taken from 0–0.1 m)	11 of the samples were taken from 10-20 cm below ground level.
Number of soil samples 0-1 m below ground level	16
Number of soil samples under 1 m	3
Comments/uncertainty	The total number becomes 19 when the sample which extends over the interval 0-1 m and >1 m (Sample 19) is divided up.
Highest measured soil concentration PFOS µg/kg	31,000
Where	25-2 (90-100 cm). The sample consists of sand/peat.
Highest measured soil concentration PFAS µg/kg	31,041
Where	25-2 (90-100 cm). The sample consists of sand/peat.
Comments/uncertainty	All the soil samples were analysed for PFOS/PFOA. In addition, five of the samples were analysed for an additional 9 PFAS compounds. Sample 25-2 was only analysed for PFOS/PFOA, but still had the highest concentration.

3.4 Quantity calculation

PFOS average for all depths and points > 3 µg/kg	
Concentration (µg/kg)	529
Area (m2)	12,382
Quantity of soil (tonnes)	25,259
Quantity of PFOS (kg)	9.4
Uncertainty -	5.8
Uncertainty +	18
PFOS average for all depths and points > 30 µg/kg	
Concentration (µg/kg)	617
Area (m2)	10,475
Quantity of soil (tonnes)	21,369
Quantity of PFOS (kg)	9.2
Uncertainty -	5.7
Uncertainty +	18
PFOS average for all depths and points > 150 µg/kg	
Concentration (µg/kg)	1,678
Area (m2)	3,521
Quantity of soil (tonnes)	7,183
Quantity of PFOS (kg)	8.4
Uncertainty -	5.3
Uncertainty +	16
PFOS average for all depths and points > 500 µg/kg	
Concentration (µg/kg)	2,608
Area (m2)	2,068
Quantity of soil (tonnes)	4,219
Quantity of PFOS (kg)	7.7
Uncertainty -	4.8





Uncertainty +	15
PFOS average for all depths and points > 1000 µg/kg	
Concentration (µg/kg)	3,670
Area (m2)	1,303
Quantity of soil (tonnes)	2,658
Quantity of PFOS (kg)	6.8
Uncertainty -	4.3
Uncertainty +	13
PFOS average for all depths and points > 3000 µg/kg	
Concentration (µg/kg)	6,521
Area (m2)	498
Quantity of soil (tonnes)	1,016
Quantity of PFOS (kg)	4.6
Uncertainty -	2.9
Uncertainty +	8.9

Comments regarding the quantity calculations	The DP2 report states the following: The analysis results indicate that the most contaminated area is located within an area of approximately 120 * 60 m. The calculated quantity of PFOS in this area is 3.36 kg, based on a thickness of 10 cm (peat layer only). The calculation performed in 2019 is based on a much larger area in order to delimit contamination down to <3 µg/kg and takes into account the fact that the sand layers above the peat are also contaminated. The uncertainty includes the possibility that the shell sand beneath the peat, which has not been sampled in the most heavily contaminated area, may also be contaminated.
Is the extent of the contaminated area limited horizontally?	No. The contaminated area is least delimited towards the west. The extreme point towards the north (point 14) is below the detection limit. The extreme point towards the east is 80 µg/kg (point 7). The extreme point towards the south (point 28) is 54 µg/kg. The extreme point towards the west (point 19) is 100 µg/kg.
Is the extent of the contaminated area limited vertically?	No. The only point which appears to have a vertical delimitation is point 11. Few samples have been taken of deeper material.
Comments/uncertainty	It appears that the highest PFOS concentrations are located in the peat material. PFOS has also been detected in the sand layers. Low concentrations of PFOS have been detected in the shell sand, which may indicate that PFOS has seeped through the peat layer above to a limited extent. However, only samples of shell sand have been collected at sampling points 5 and 11, where samples from overlying material do not contain particularly high concentrations of PFOS (110 and 7 µg/kg respectively). There are no samples of shell sand at sampling points which contain higher PFOS concentrations in overlying layers of sand and peat (500-31,000 µg/kg).

3.5 Water sampling and annual dispersal

Have water samples been taken?	No
Where	
Highest measured concentration of PFOS in groundwater (ng/l)	
Where	
Highest measured concentration of PFAS in groundwater (ng/l)	
Where	
Comments/uncertainty	No groundwater was encountered during the excavation.
Highest measured concentration of PFOS in surface water (ng/l)	
Where	
Highest measured concentration of PFAS in surface water (ng/l)	
Where	
Comments/uncertainty	
Total annual dispersal of PFOS from the site (g/year)	5
Total annual dispersal of PFAS from the site (g/year)	Not calculated
To which recipient	Austhavet
Calculated from water or soil concentration.	Soil concentrations
	The DP2 report calculates a mean PFOS concentration in groundwater based on mean soil concentration. The annual quantity being discharged was calculated based on this and a Kd value of 100.

3.6 Biota sampling

Have biota samples being taken at the airport?	No
What kind of biota?	
How many samples?	
Highest measured concentration of PFOS in biota (µg/kg wet weight)	
Where	
Highest measured concentration of PFAS in biota (µg/kg wet weight)	
Where	
Median concentration in comparable populations (e.g. in a lake)	

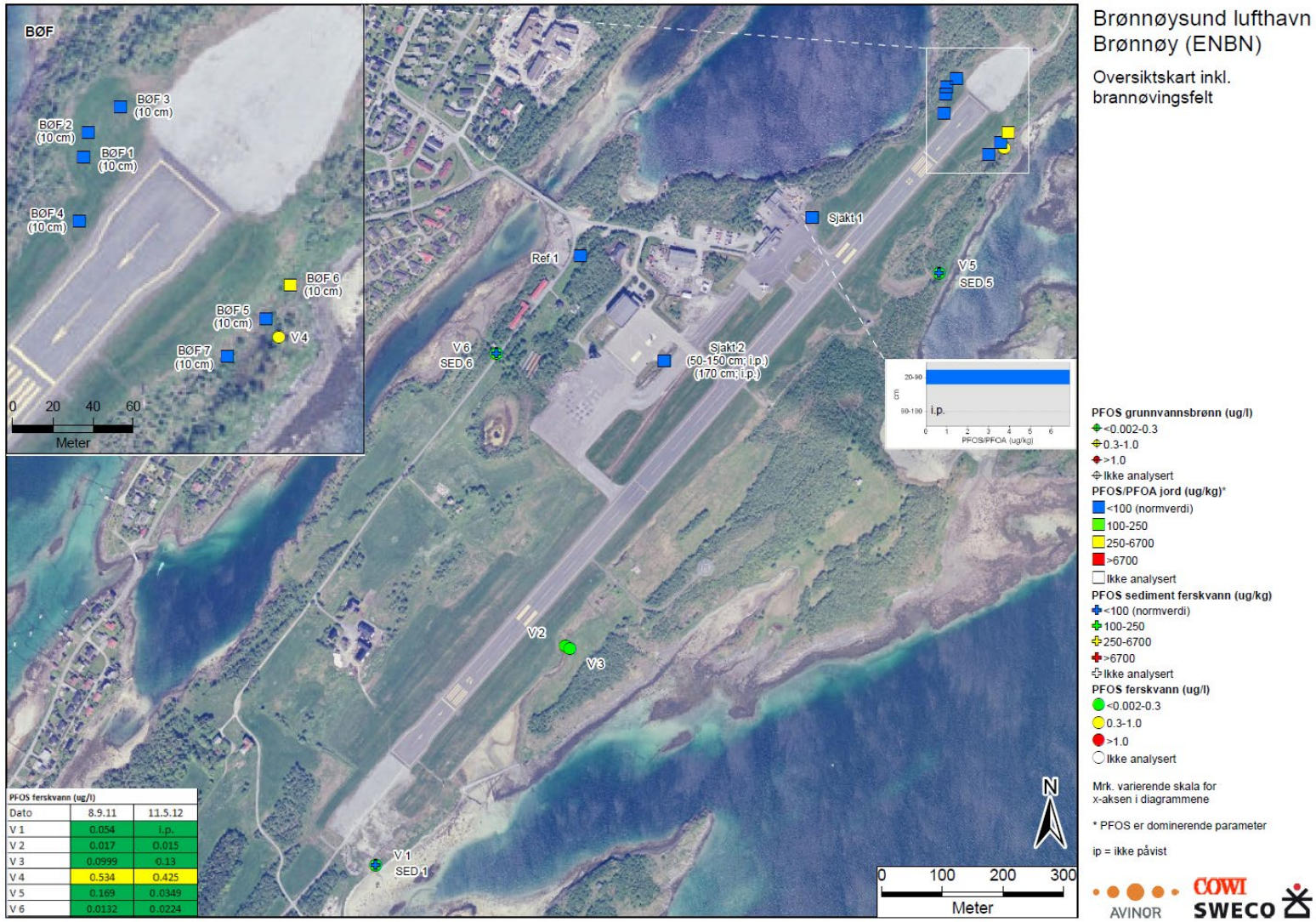
Comments/references	
References and concentrations in other reports.	

3.7 Uncertainty and other factors

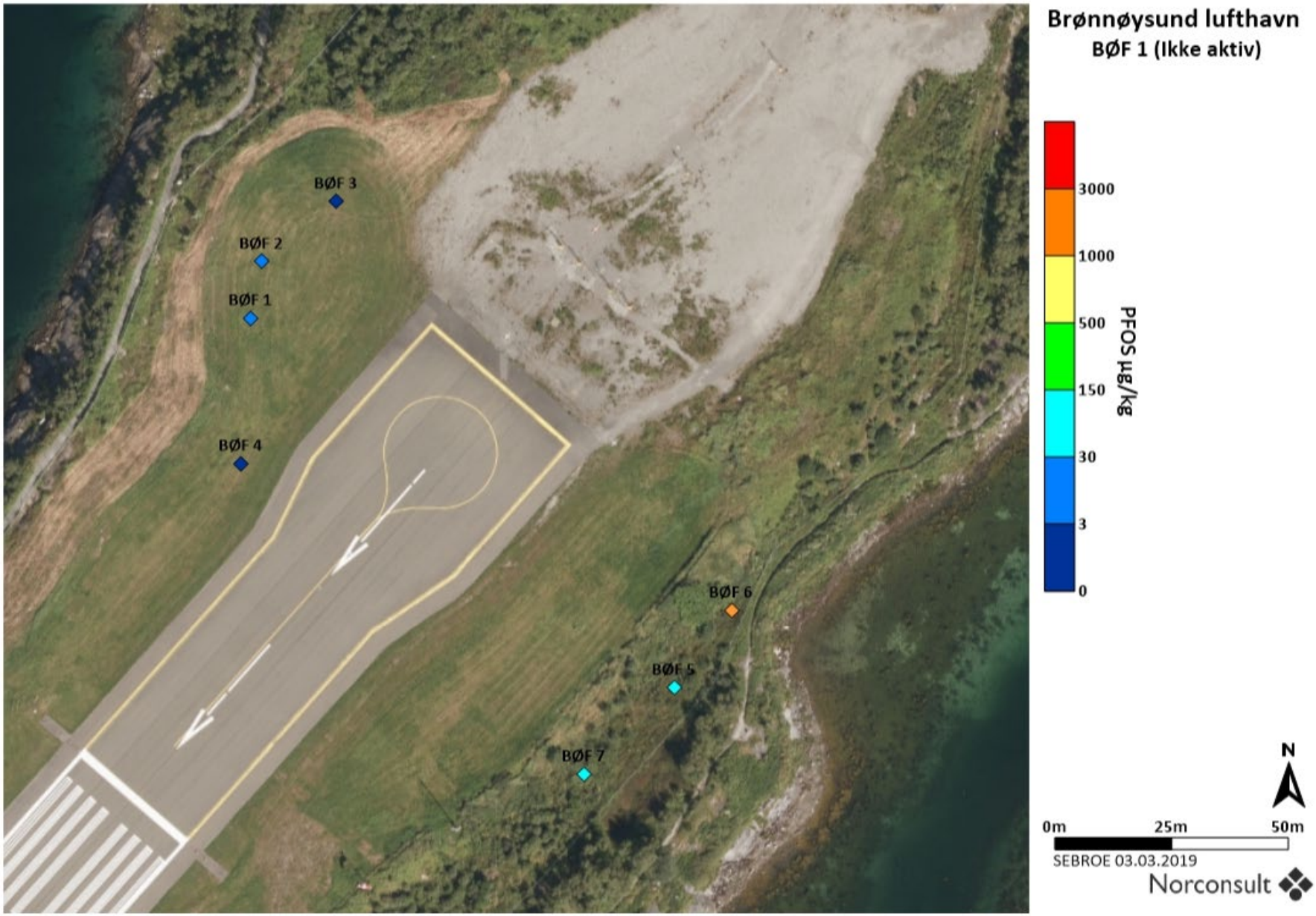
Does the estimate of the quantity of PFOS in the ground correspond to the concentrations measured in water and biota?	Cannot be assessed, as no samples of water or biota have been collected.
Evaluations	
Comments/uncertainty (Could there be any additional unknown sources of PFOS at the site with runoff to the recipient?)	It is not stated that there are additional sources of PFOS at the site or elsewhere at the airport, but the possibility of this cannot be ruled out.
Has the site been sufficiently mapped with a view to assessing the order of prioritisation?	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the volume of PFOS in the soil with the stipulated level of uncertainty.
Comments/uncertainty	The contamination is not very well-mapped in the western/southwesterly direction, or at depth at the most heavily contaminated sampling points.
Other factors of significance to possible clean-up/implementation of measures (e.g. planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	No recorded protected areas in Naturbase. The BØF is located in the habitat type "mountainous lime-rich areas". Numerous bird species of particularly high management interest have been recorded in the area where the BØF is located, and in the sea/beach area around the airport. Just east of the airport is Nikolaivatnet-Kålvatnet, which is an important habitat type. At the BØF, THC was detected in environmental condition classes 2-3 in six samples, and in environmental condition class 4 in two samples. There is peat in all samples except one, and it is uncertain whether humus removal was carried out prior to analysis, or whether the analyses show elevated concentrations of THC due to the presence of organic matter.

APPENDIX A

4 Brønnøysund Airport Brønnøy



PFOS ferskvann (ug/l)		
Dato	8.9.11	11.5.12
V 1	0.054	i.p.
V 2	0.017	0.015
V 3	0.0999	0.13
V 4	0.534	0.425
V 5	0.169	0.0349
V 6	0.0132	0.0224


Brønnøysund lufthavn
BØF 1 (Ikke aktiv)
BØF 3
BØF 2
BØF 1
BØF 4
BØF 6
BØF 5
BØF 7
3000
1000
500
150
30
3
0
PFOS µg/kg
N
0m
25m
50m
SEBROE 03.03.2019
Norconsult

4.1 Fire training site (BØF)/contaminated site

Fire training site (BØF contaminated site	BØF 1 (not active)
	No period of use has been specified for the site, but it is no longer in use because the northeastern part of the runway is now situated over the BØF.

4.2 Use of PFOS and other PFASs

Volume of PFOS used at the site (kg)	Not stated/calculated
Comments/uncertainty	
Volume of PFAS used at the site (kg)	Not stated/calculated
Comments/uncertainty	

4.3 Soil sampling

Total number of soil samples	7
Comments/uncertainty (for example, 95% of the samples were taken from 0–0.1 m)	It was not possible to collect samples from the fire training site itself, as the site is now situated under the current runway. The samples were therefore taken from surface material off the runway and outside the BØF itself.
Number of soil samples 0-1 m below ground level	7
Number of soil samples under 1 m	0
Comments/uncertainty	All the samples are surface samples taken from a depth of 0-0.1 metres. The material is described as consisting entirely of gravel.
Highest measured soil concentration of PFOS µg/kg	2,060
Where	BØF 6 (0-0.1 m). The material consists of gravel
Highest measured soil concentration of PFAS µg/kg	2,065
Where	BØF 6 (0-0.1 m). The material consists of gravel
Comments/uncertainty	Sample BØF 6 was analysed for PFOS and PFOA, which also applies to the other soil samples.

4.4 Quantity calculation

No quantity has been calculated.	No quantity been calculated for this site, because the BØF is situated beneath the runway and it has not been investigated sufficiently.
Comments	The DP2 report assumes that the most contaminated area is situated within a circle with an area of 1,963 m2 metres, and that the contaminated material is 2 metres thick. It is estimated that 14.7 kg of PFOS and 0.036 kg PFOA remain in situ in this material. These calculations are based solely on the concentration in soil sample BØF 6. This sample has the highest detected PFOS concentration (2,060 ug/kg). By comparison, the other samples contain PFOS concentrations of between <1.9-57 ug/kg.
Is the extent of the contaminated area limited horizontally?	No. It is believed that the sampling points are located on the northwestern and southeastern sides of BØF. To the northwest, no PFOS was detected at points BØF 3 and 4, while concentrations < 9 ug/kg were detected in BØF 1 and 2. To the southeast, PFOS concentrations of between 40-60 ug/kg were detected in BØF 5 and 7. However, a concentration of 2,060 ug/kg was detected at point BØF 6, and it is uncertain how much further this contamination extends. No samples have been taken southwest or northeast of the BOF site, so the contaminated area has also not been delimited in these directions.
Is the extent of the contaminated area limited vertically?	No. Because the BØF site is situated beneath the runway, no samples have been collected from the centre of the site, and only surface samples were taken at the sampling points which have been investigated. It is therefore not possible to say anything about vertical dispersal.
Comments/uncertainty	

4.5 Water sampling and annual dispersion

Have water samples been taken?	Yes
Where	One sampling point (V4) is located downstream of the BØF site. Four sampling points are situated next to a drain and the drain outlet on the southern side of the runway. One sampling point is situated on the north side of the runway.
Highest measured concentration of PFOS in groundwater (ng/l)	No groundwater samples were taken
Where	
Highest measured concentration of PFAS in groundwater (ng/l)	
Where	
Comments/uncertainty	
Highest measured concentration of PFOS in surface water (ng/l)	534
Where	V4 (downstream of the BØF). The sample was taken on 05.10.11
Highest measured concentration of PFAS in surface water (ng/l)	553
Where	V4 (downstream of the BØF). The sample was taken on 05.10.11. The sample was analysed for PFOS and PFOA.
Comments/uncertainty	PFOS concentrations (of between 15 and 169 ng/l) have also been detected in the other water samples (V1-V3, V5 and V6) taken at the airport, although some of these are situated a long way from the BØF site.
Total annual dispersal of PFOS from the site (g/year)	2.8 (0.43)*
Total annual dispersal of PFAS from the site (g/year)	(0.57)*
To which recipient	Skillbotnfjorden/Ytrefjorden. It is believed that the BØF may have runoff towards both the northwest to Svarthopen, and southwest to Ytrefjorden.
Calculated from water or soil concentration.	Soil concentrations and water concentrations*
	The DP2 report calculates groundwater concentrations based on mean soil concentration and a Kd of 10. Based on this, the quantity of substance being discharged via groundwater has been calculated at 2.8 g/year. *The figure shown in parentheses and with an asterisk is the calculated quantity of substance being discharged via surface water based on concentrations in water sample V4 downstream of the BØF site.

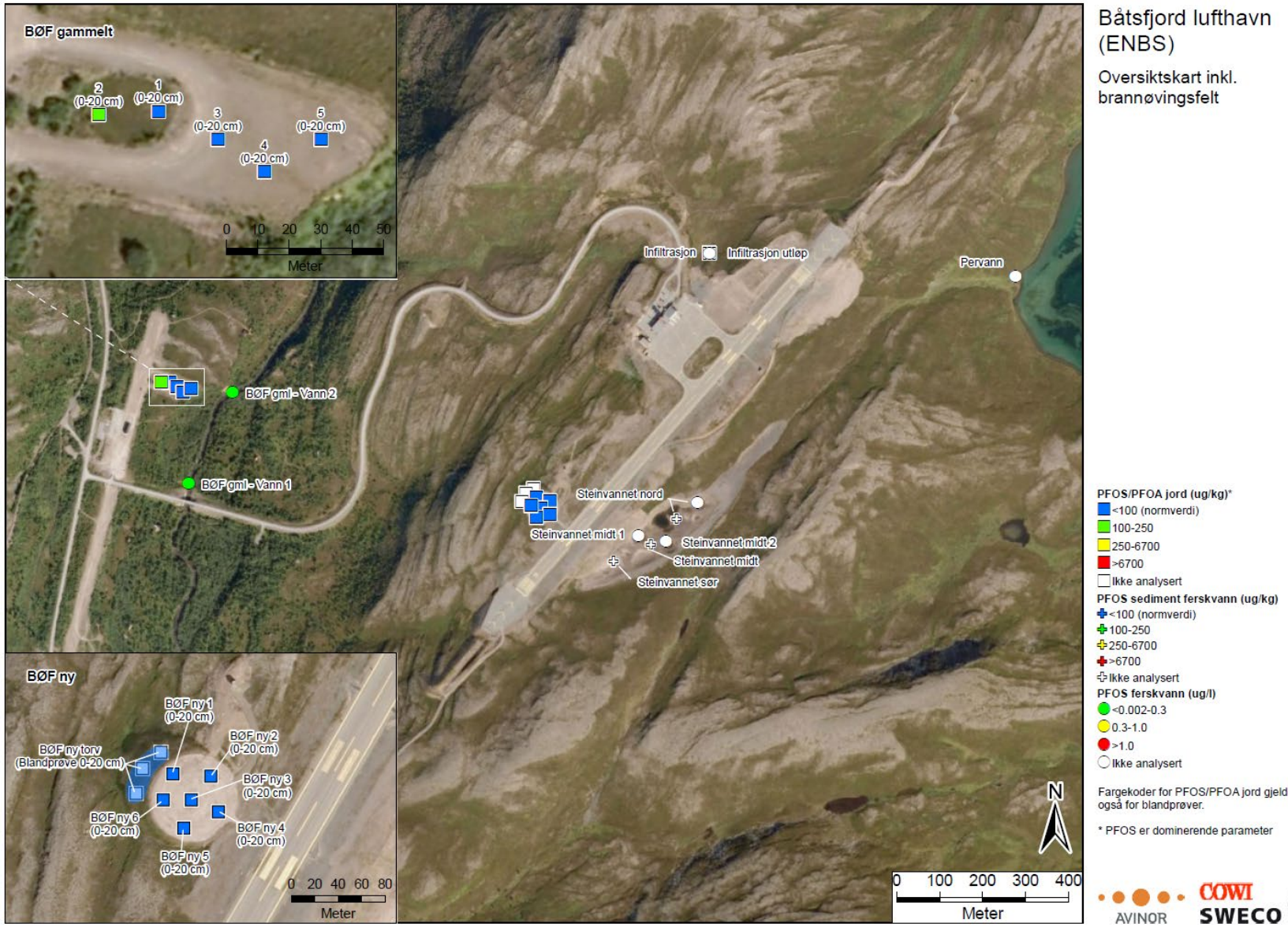
4.6 Biota sampling

Have biota samples being taken at the airport?	No
What kind of biota?	
How many samples?	
Highest measured concentration of PFOS in biota (µg/kg wet weight)	
Where	
Highest measured concentration of PFAS in biota (µg/kg wet weight)	
Where	
Median concentration in comparable populations (e.g. in a lake)	
Comments/references	
References and concentrations in other reports.	

4.7 Uncertainty and other factors

Does the estimate of the volume of PFOS in the ground correspond with the measured concentrations in water and biota?	Cannot be evaluated for biota, because no biota samples have been collected. There is considerable uncertainty regarding the quantity of PFOS in the ground, as it has not been possible to collect samples from the fire training site itself. It is therefore difficult to conclude whether there is any link between concentrations in soil and concentrations in water.
Evaluations	Soil sample BØF 6 and water sample V4, which are the samples with the highest PFOS concentrations, are situated relatively close together. It is therefore assumed that the contamination at these points originates from the same source.
Comments/uncertainty (Could there be any additional unknown sources of PFOS at the site with runoff to the recipient?)	Concentrations of PFOS have been detected in the water samples taken at the other end of the runway (V1, 54 ng/l, V2, 15-17 ng/l, and V3 100-123 ng/l), and west of the terminal area (V6, 13-22 ng/l) and approximately 380 metres southwest of the BØF site (V5, 32-169 ng/l). Due to the distance involved, it is uncertain whether the concentrations at V5 are due to dispersal from the BØF site or another source. For the other water samples, the BØF site is not a likely source of the concentrations that have been detected. A concentration of approx. 7 µg/kg PFOS was also measured in a soil sample taken from the area of the aircraft fuel facility located about 350 metres southeast of the BØF site. The sample was taken from shaft 1 at a depth of 20-90 cm.
Has the site been sufficiently mapped with a view to assessing the order of priority?	No, the site is too poorly mapped (ref. this report for parts 1 and 2, section 2.1.1.6 and section 2.1.3.1). No samples have been taken from the BØF itself, and no deeper samples have been collected either.
Comments/uncertainty	
Other factors of significance to possible clean-up/implementation of measures (e.g. planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	There are no registered protected areas in close proximity to the airport. A number of species of high and particularly high management interest have been recorded around the airport (bird species, fungi). There is also one habitat (calcareous lake) southwest of the airport buildings. Breivika and Svarthopen (immediately west and east of the airport respectively) are considered to be very important outdoor recreation areas.

5 Båtsfjord Airport



Båtsfjord lufthavn (ENBS)

Oversiktskart inkl. brannøvingsfelt

PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

PFOS sediment ferskvann (ug/kg)
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

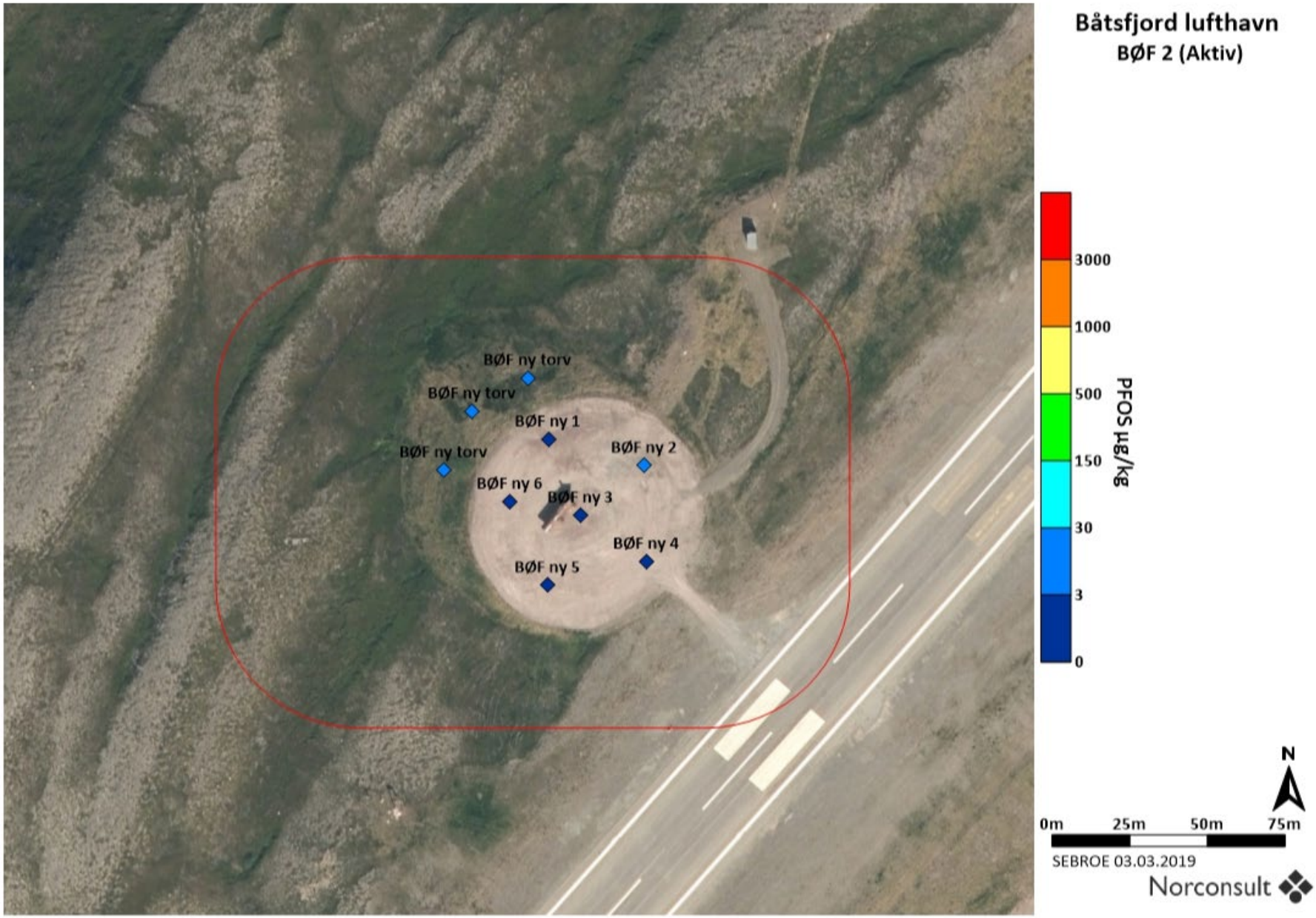
PFOS ferskvann (ug/l)
- <0.002-0.3
- 0.3-1.0
- >1.0
- Ikke analysert

Fargekoder for PFOS/PFOA jord gjelder også for blandprøver.

* PFOS er dominerende parameter

AVINOR COWI SWECO


Båtsfjord lufthavn
BØF 1 (Ikke aktiv)
3000
1000
500
150
30
3
0
PFOS µg/kg
2
1
3
5
4
N
0m
25m
50m
75m
SEBROE 03.03.2019
Norconsult


Båtsfjord lufthavn
BØF 2 (Aktiv)
BØF ny torv
BØF ny torv
BØF ny 1
BØF ny torv
BØF ny 2
BØF ny 6
BØF ny 3
BØF ny 4
BØF ny 5
3000
1000
500
150
30
3
0
PFOS µg/kg
N
0m
25m
50m
75m
SEBROE 03.03.2019
Norconsult

5.1 Fire training site (BØF)/contaminated site

Fire training site (BØF)/contaminated site	BØF 1 (old)	BØF 2 (younger, inactive)
	Båtsfjord Airport was previously located along national road Rv 981. BØF 1 (old) is situated adjacent to the old airport. The municipality owns the area, but Avinor also uses it for exercises. No operating period has been specified for this site.	The current airport opened to traffic in 1999. The date on which BØF 2 opened is not specified. BØF 2 is believed to have rarely been used and chemicals have never been involved. The airport does not have a permit to carry out fire drills using chemicals on this site. However, there may be residues of PFOS or other PFAS compounds in the equipment that has been used.

5.2 Use of PFOS and other PFAS

Volume of PFOS used at the site (kg)	Not stated/calculated	Not stated/calculated
Comments/uncertainty		
Volume of PFAS used at the site (kg)	Not stated/calculated	Not stated/calculated
Comments/uncertainty		Avinor completely phased out firefighting foam containing PFAS in 2012 and now uses only PFAS-free firefighting foam.

5.3 Soil sampling

Fire training site (BØF)/contaminated site	BØF 1 (old)	BØF 2 (younger, inactive)
Total number of soil samples	5	7
Comments/uncertainty (for example, 95% of the samples were taken from 0–0.1 m)	All samples were taken from depths of 0.0 - 0.2 m.	All samples were taken from depths of 0.0 - 0.2 m.
Number of soil samples 0-1 m below ground level	5	7
Number of soil samples under 1 m	0	0
Comments/uncertainty	It is stated that the material consists of gravel and sand at three of the points, peat and sand at one point, and peat at another.	One sample is a composite sample of peat taken from three points on the slope immediately west of the BØF. The other samples were taken from the BØF and are described as consisting of gravel.
Highest measured soil concentration of PFOS µg/kg	115	17
Where	2 (0-0.2 m). The material consists of peat.	BØF new 2 (0-0.2 m). The material consists of gravel.
Highest measured soil concentration of PFAS µg/kg	115	17
Where	2 (0-0.2 m). The material consists of peat.	BØF new 2 (0-0.2 m). The material consists of gravel.
Comments/uncertainty	All samples from BØF 1 were analysed for PFOS and PFOA. No PFOA has been detected in any of the samples. BØF 1 has no clear centre point for the fire drills. The samples were taken on the basis of a presumed centre point, and in the direction of dispersal for the drills, even though this is not known in any detail. The sampling points are therefore located in a line, from west to east.	All samples from BØF 2 were analysed for 11 PFAS compounds. The concentrations in BØF new 2 are the highest. For compounds other than PFOS, only the peat sample contains PFBA just above the detection limit, and sample BØF new 5 contains PFBA and PFOA just above the detection limit.

5.4 Quantity calculation

Fire training site (BØF)/contaminated site	BØF 1 (old)	BØF 2 (younger, inactive)
No quantities have been calculated for any of the fire training sites.	Not calculated. It is uncertain as to whether the samples were taken from the centre of the BØF (five samples).	Not calculated. Low concentrations of PFOS and PFAS (7 samples)
Comments	From the DP2 report: Based on the mean PFOS concentration, it is estimated that 71 g of the PFOS is located in the material at BØF 1. It is thus assumed that the contaminated area measures 40 X 80 m, and that the contaminated material is 0.5 m thick.	No residual quantities of PFOS/PFAS in the ground are calculated in the DP2 report, as concentrations of PFOS have only been detected at two of the points (17 µg/kg in BØF-new-2 and 6.4 µg/kg in BØF-new-peat). Only PFOA has been detected at one point (1.8 µg/kg) and PFBA at two points. No 6:2 FTS has been detected at any of the points.
Is the extent of the contaminated area limited horizontally?	The sampling points are located in a line, with point 2 furthest to the west and point 5 furthest to the east. The highest concentration (115 µg/kg) was measured at point 2 located furthest to the west. The contamination detected at point 2 has not been delimited further to the south, north or west. Some PFOS has also been detected at the other points, but in low concentrations (between 4-8 µg/kg). This has also not been delimited.	Some contamination has been detected in the composite sample taken from the peat. However, the concentrations here are low (6.4 µg/kg) and there is no reason to believe that the contamination extends horizontally to any great extent. At sampling point BØF new 2, a concentration of 17 µg/kg was measured. This contamination has not been delimited in an easterly or northerly direction.

Is the extent of the contaminated area limited vertically?	No. No samples have been taken at depths of greater than 0.2 m, so there is no information on how far down the contamination extends, or on any levels of contamination in deeper layers.	No. No samples have been taken at depths of greater than 0.2 m, so there is no information on how far down the contamination extends, or on any levels of contamination at depths of >0.2 metres. The unconsolidated material is assumed to be relatively thin, as there is only exposed bedrock immediately south, west and north of the BØF.
Comments/uncertainty		The composite sample does not provide any information about the variations in concentrations at the three points from which it was collected.

5.5 Water sampling and annual dispersal

Fire training site (BØF)/contaminated site	BØF 1 (old)	BØF 2 (younger, inactive)
Have water samples been taken?	Yes	No
Where	In Storelva, both upstream and downstream of BØF 1	
Highest measured concentration of PFOS in groundwater (ng/l)	No groundwater samples were taken	
Where		
Highest measured concentration of PFAS in groundwater (ng/l)		
Where		
Comments/uncertainty		
Highest measured concentration of PFOS in surface water (ng/l)	123	
Where	Water 2 (Storelva downstream of BØF 1)	
Highest measured concentration of PFAS in surface water (ng/l)	123	
Where	Water 2 (Storelva downstream of BØF 1)	
Comments/uncertainty	The samples were analysed for 11 PFAS compounds.	
Total annual dispersal of PFOS from the site (g/year)	123	Not calculated
Total annual dispersal of PFAS from the site (g/year)	Not calculated	Not calculated
To which recipient	To Storelva. Storelva continues to Straumsnesvatnet, and from there through Straumen to Båtsfjorden.	
Calculated from water or soil concentration.	Calculated based on water concentrations	

5.6 Biota sampling

Have biota samples being taken at the airport?	No	No
What kind of biota?		
How many samples?		
Highest measured concentration of PFOS in biota (µg/kg wet weight)		
Where		
Highest measured concentration of PFAS in biota (µg/kg wet weight)		
Where		
Median concentration in comparable populations (e.g. in a lake)		

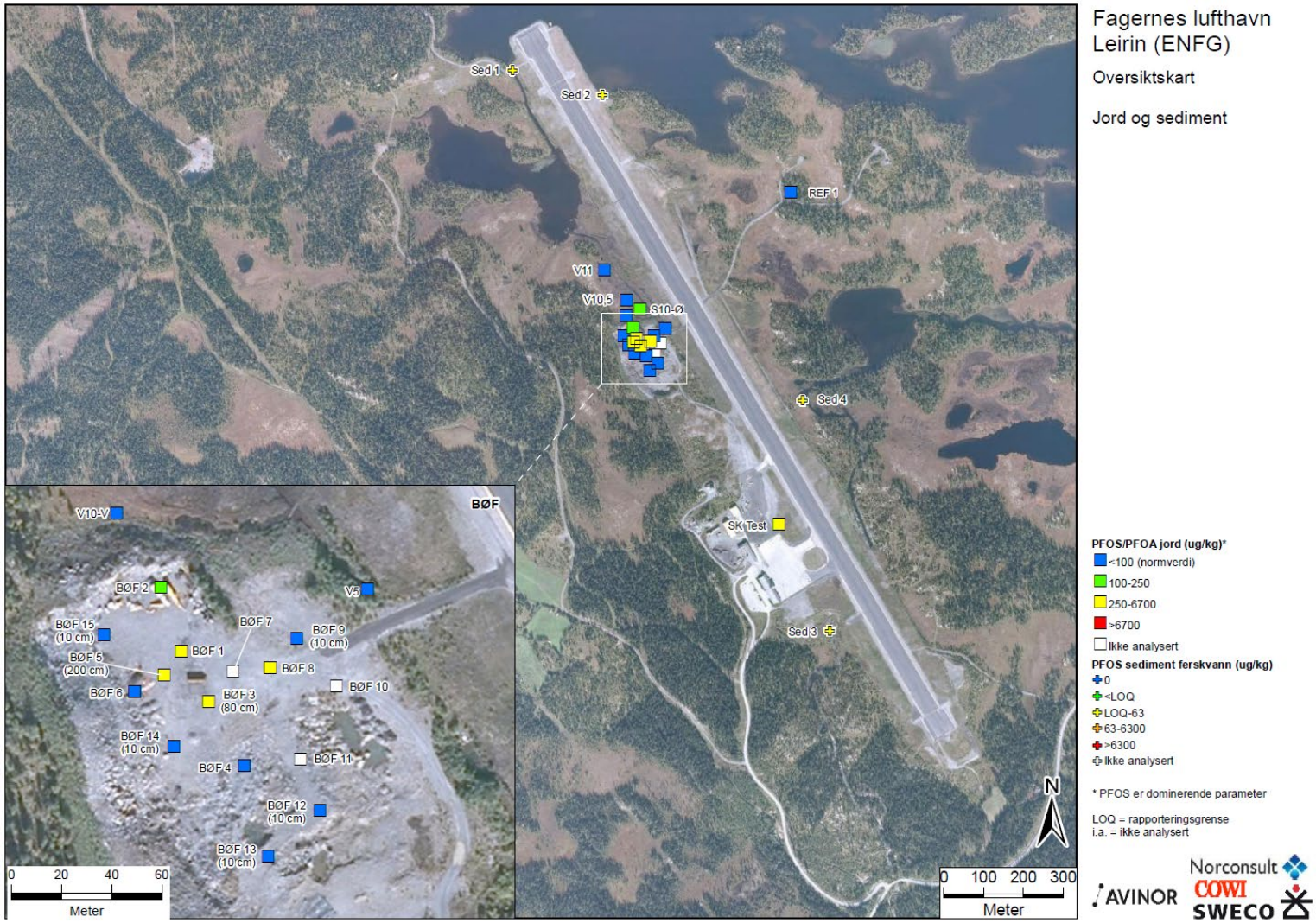
Comments/references		
References and concentrations in other reports.		

5.7 Uncertainty and other factors

Fire training site (BØF)/contaminated site	BØF 1 (old)	BØF 2 (younger, inactive)
Does the estimate of the quantity of PFOS in the ground correspond with the concentrations measured in water and biota?	Insufficient soil samples are available to calculate quantities of PFOS in the soil. No biota samples were taken. The water sample taken downstream of BØF 1 clearly shows higher concentrations of PFOS than the sample which was taken upstream of BØF1. This indicates that leaching of PFOS is taking place from BØF 1 into Storelva.	Cannot be assessed, as no samples of water or biota have been collected from BØF 2.
Evaluations		
Comments/uncertainty (Could there be any additional unknown sources of PFOS at the site with runoff to the recipient?)	No evidence has been found which indicates that there are any other sources of PFOS at the site, but the possibility cannot be ruled out.	It is not stated that there are additional sources of PFOS at the site or elsewhere at the airport, but the possibility cannot be ruled out. Accident drills have on occasions been carried out off the runway. These are stated to have taken place without the use of chemicals, but there may be residues of PFOS or other PFASs present in the equipment that was used.
Has the site been sufficiently mapped with a view to assessing the order of priority?	No, the site is too poorly mapped (ref. this report for parts 1 and 2, section 2.1.1.6 and section 2.1.3.1). There are only five soil samples in total, and these are all surface samples. The sampling indicates that there are small quantities of PFOS in the ground, but it is uncertain whether the sampling that has been carried out took place in the most heavily contaminated areas at BØF 1, as BØF 1 has no clear centre point.	Yes. Only seven soil samples have been analysed in total, all of which were surface samples (0.2 metres). However, these have been spread widely across the BØF area, and the unconsolidated material in the area is believed to be thin. PFOS has only been detected in three samples, and the sampling indicates that there are low concentrations of PFOS and other PFASs in the ground. The site will therefore not be prioritised for measures based on a cost-benefit perspective (ref. this report for parts 1 and 2, section 2.1.1.6 and section 2.1.3.1).
Comments/uncertainty	There is exposed bedrock approx. 260 metres northwest of the BØF, and the area has been recorded as consisting of exposed bedrock and variable unconsolidated sediment cover in the Geological Survey of Norway's unconsolidated sediment database. The unconsolidated sediment is therefore assumed to not be particularly thick.	BØF is surrounded by exposed bedrock and variable unconsolidated sediment cover towards the southwest, west and north. The runway, which is situated south/southeast of the BØF, has been constructed on rock fill on blasted bedrock. The depth to bedrock is therefore believed to be low and limited with contaminated unconsolidated material at the BØF. Aerial photographs show that there is no platform at BØF, so foam will infiltrate into the gravel material that has been laid out across the BØF site.
Other factors of significance to possible clean-up/implementation of measures (e.g. planned rebuilding works at the	No protected areas have been registered near the airport, but species of particularly high national management interest have been recorded	There are no entries in Naturbase from the immediate vicinity. The DP2 report states that a rare copepod has been recorded in Persvannet. Species of particularly high national management

airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	immediately southwest of the old BØF, and in Båtsfjorden approx. 1.5 km north of BØF.	interest have been recorded in Båtsfjorden, approx. 1.7 km north of BØF.

6 Fagernes Airport Leirin



Fagernes lufthavn
Leirin (ENFG)

Oversiktskart

Jord og sediment

PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

PFOS sediment ferskvann (ug/kg)
- 0
- <LOQ
- LOQ-63
- 63-6300
- >6300
- Ikke analysert

* PFOS er dominerende parameter

LOQ = rapporteringsgrense
i.a. = ikke analysert

AVINOR Norconsult COWI SWECO

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APPENDIX A

Ferskvann

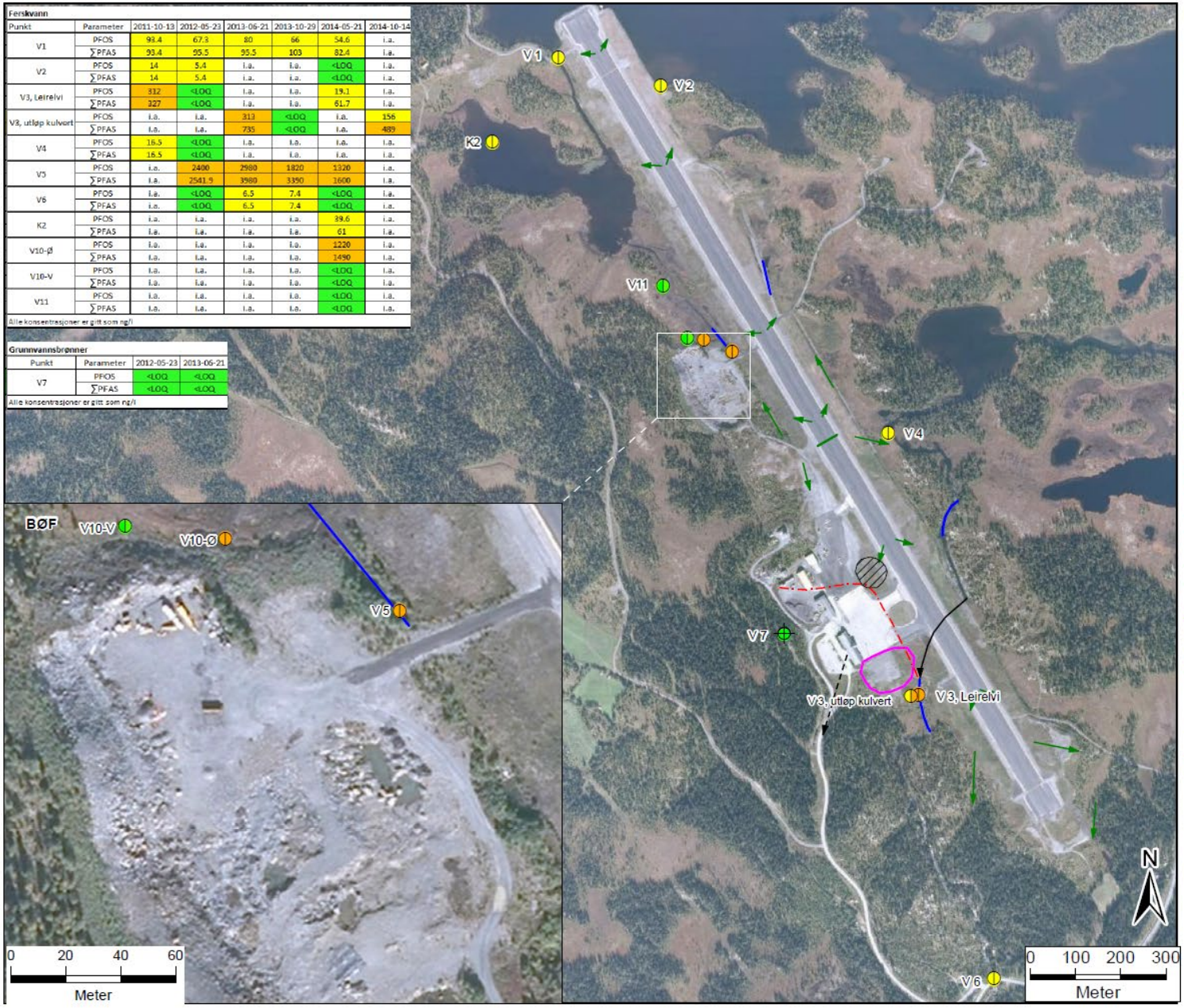
Punkt	Parameter	2011-10-13	2012-05-23	2013-06-21	2013-10-29	2014-05-21	2014-10-14
V1	PFOS	93.4	67.3	80	66	54.6	i.a.
	∑PFAS	93.4	95.5	95.5	103	82.4	i.a.
V2	PFOS	14	5.4	i.a.	i.a.	<LOQ	i.a.
	∑PFAS	14	5.4	i.a.	i.a.	<LOQ	i.a.
V3, Leirelvi	PFOS	312	<LOQ	i.a.	i.a.	19.1	i.a.
	∑PFAS	327	<LOQ	i.a.	i.a.	61.7	i.a.
V3, utløp kulvert	PFOS	i.a.	i.a.	313	<LOQ	i.a.	156
	∑PFAS	i.a.	i.a.	735	<LOQ	i.a.	489
V4	PFOS	16.5	<LOQ	i.a.	i.a.	i.a.	i.a.
	∑PFAS	16.5	<LOQ	i.a.	i.a.	i.a.	i.a.
V5	PFOS	i.a.	2400	2980	1820	1320	i.a.
	∑PFAS	i.a.	2541.9	3980	3390	1600	i.a.
V6	PFOS	i.a.	<LOQ	6.5	7.4	<LOQ	i.a.
	∑PFAS	i.a.	<LOQ	6.5	7.4	<LOQ	i.a.
K2	PFOS	i.a.	i.a.	i.a.	i.a.	39.6	i.a.
	∑PFAS	i.a.	i.a.	i.a.	i.a.	61	i.a.
V10-Ø	PFOS	i.a.	i.a.	i.a.	i.a.	1220	i.a.
	∑PFAS	i.a.	i.a.	i.a.	i.a.	1490	i.a.
V10-V	PFOS	i.a.	i.a.	i.a.	i.a.	<LOQ	i.a.
	∑PFAS	i.a.	i.a.	i.a.	i.a.	<LOQ	i.a.
V11	PFOS	i.a.	i.a.	i.a.	i.a.	<LOQ	i.a.
	∑PFAS	i.a.	i.a.	i.a.	i.a.	<LOQ	i.a.

Alle konsentrasjoner er gitt som ng/l

Grunnvannsbrønner

Punkt	Parameter	2012-05-23	2013-06-21
V7	PFOS	<LOQ	<LOQ
	∑PFAS	<LOQ	<LOQ

Alle konsentrasjoner er gitt som ng/l



Fagernes lufthavn
Leirin (ENFG)

Oversiktskart

Vann

PFOS / ∑ PFAS grunnvannsbrønn (ng/l) *
- Ikke analysert
- 0
- <LOQ
- LOQ-230
- 230-36 000
- >36 000

PFOS / ∑ PFAS ferskvann (ng/l) *
- Ikke analysert
- 0
- <LOQ
- LOQ-230
- 230-36 000
- >36 000

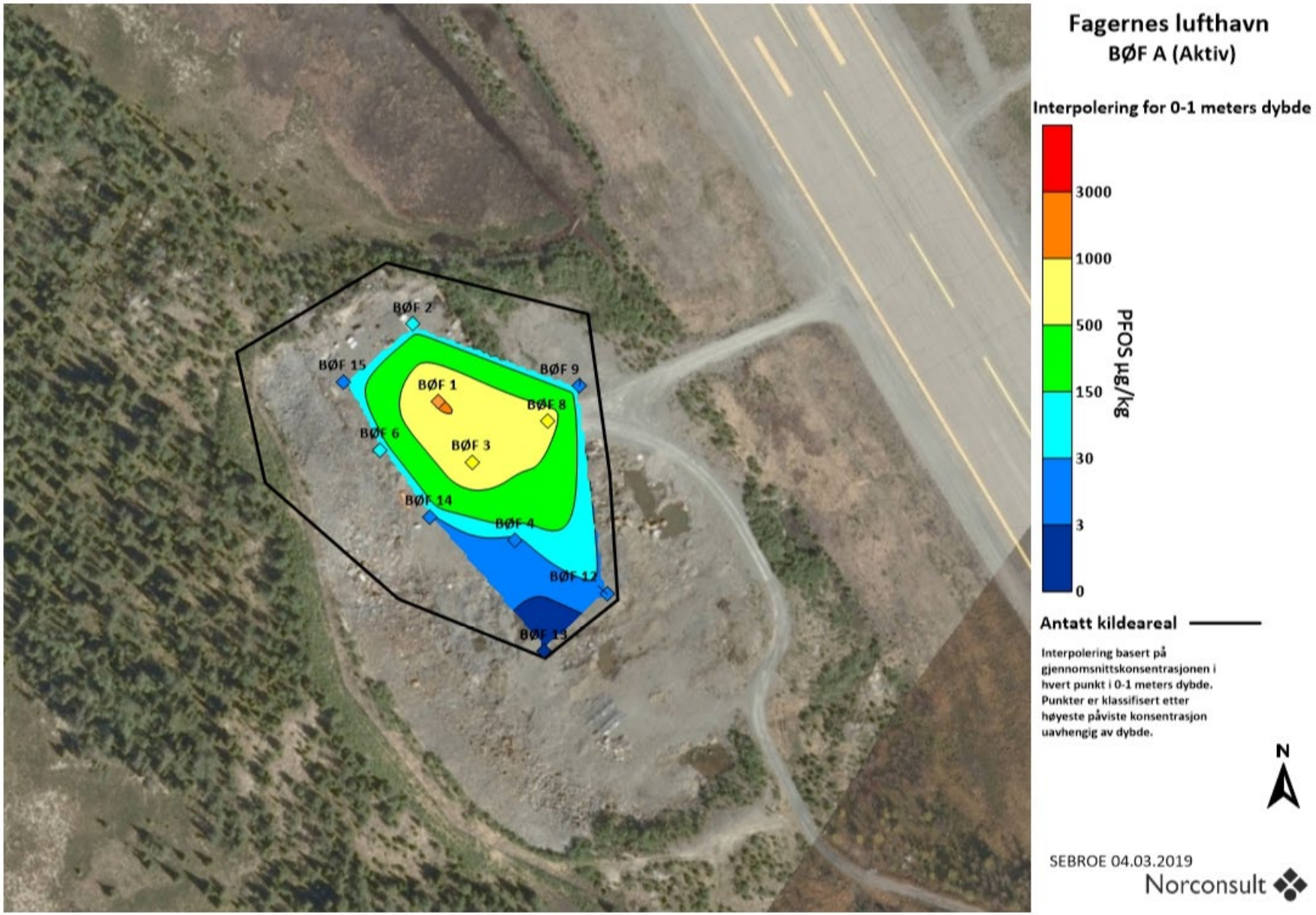
Avlopsledning
- Avløp annet
- Avløp Felles
- Drensvann
- Glykolholdig overvann
- Glykolholdig spillvann
- Overvann
- Pumpespillvannsledning
- Spillvann

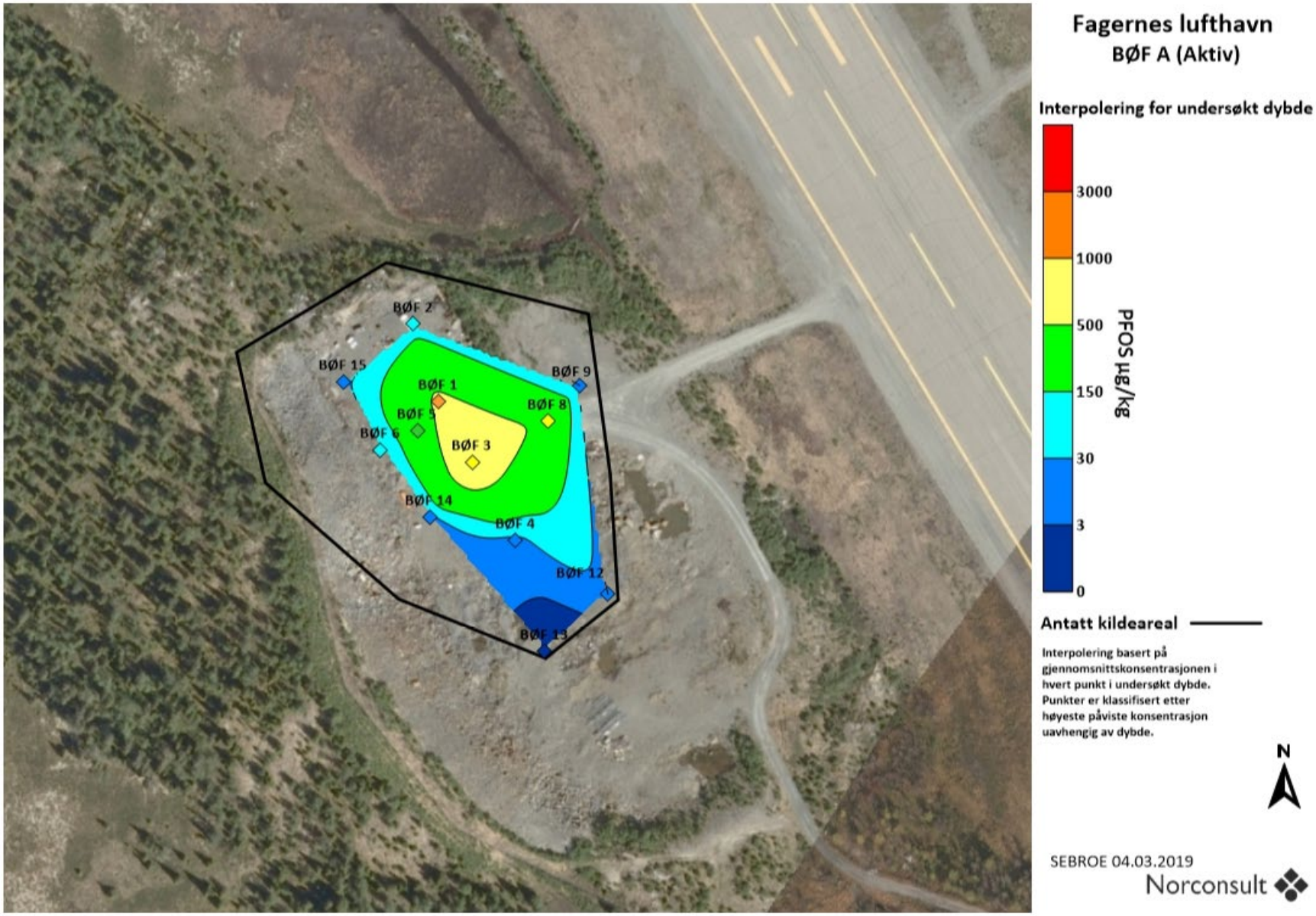
Avrenning
- Deponi glykolforurenset snø
- Overvannsledning
- Avrenningsveg glykol
- Bekkeresipient
- Overvannsystem
- Vannskille rullebane
- Antatt avrenningsveg baneavising
- Mulig PFAS-lokalitet

* Venstre halvdel = PFOS
Høyre halvdel = ∑PFAS

i.a. = ikke analysert
LOQ = rapporteringsgrense
(tilsv. ikke påvist for ∑PFAS)

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Fagernes lufthavn
BØF A (Aktiv)
Interpolering for 0-1 meters dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i 0-1 meters dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
SEBROE 04.03.2019
Norconsult
BØF 2
BØF 15
BØF 9
BØF 1
BØF 8
BØF 6
BØF 3
BØF 14
BØF 4
BØF 12
BØF 13


Fagernes lufthavn
BØF A (Aktiv)
Interpolering for undersøkt dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
SEBROE 04.03.2019
Norconsult
BØF 2
BØF 15
BØF 9
BØF 1
BØF 8
BØF 5
BØF 6
BØF 3
BØF 14
BØF 4
BØF 12
BØF 13

6.1 Fire training site (BØF)/contaminated site

Fire training site (BØF)/contaminated site	BØF A (inactive)
	Fagernes Airport has been closed since the summer of 2018. The airport is located 820 metres above sea level. The fire training site (BØF) at Fagernes Airport has been in use since the airport was built in 1987, and can now be used to a limited extent with the permission of the County Governor. Three or four drills are carried out every year, along with regular testing of the foam canons. The site is only used by Avinor.

6.2 Use of PFOS and other PFASs

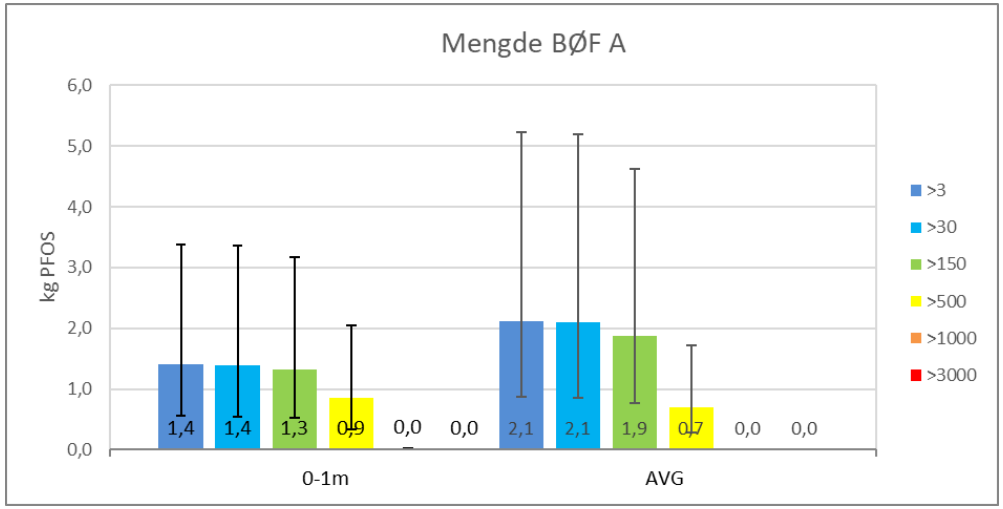
Quantity of PFOS used at the site (kg)	76
Comments/uncertainty	Calculation is based on use during the period 1987 to 2001
Quantity of PFAS used at the site (kg)	24
Comments/uncertainty	Calculation is based on use during the period 2001 to 2012

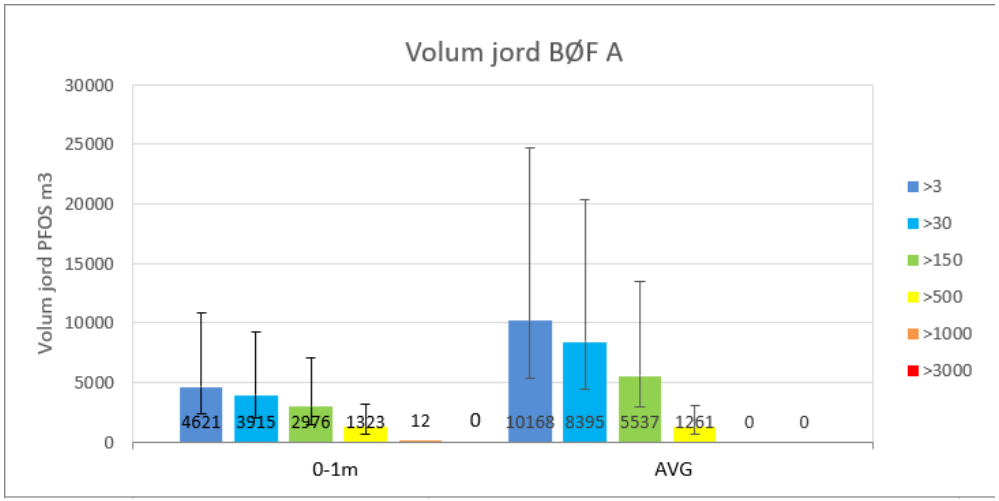
6.3 Soil sampling

Total number of soil samples	17
Comments/uncertainty (for example, 95% of the samples were taken from 0–0.1 m)	All samples from the top soil were taken from depths of 0-10 cm, except for one, which was taken from a depth of 80 cm. The other samples were taking at varying depths of between 100 and 220 cm.
Number of soil samples 0-1 m below ground level	11
Number of soil samples under 1 m	6
Comments/uncertainty	The material is stated as consisting of gravel and blasted rock.
Highest measured soil concentration of PFOS µg/kg	1,070
Where	BØF 1-1 in the uppermost layer 10 cm below ground level. The material consists of blasted stone.
Highest measured soil concentration of PFAS µg/kg	1,079
Where	BØF 1-1 in the uppermost layer 10 cm below ground level. The material consists of blasted stone.
Comments/uncertainty	Only PFOA and PFOS have been analysed for in the soil samples.

6.4 Quantity calculation

PFOS average for all depths and points > 3 µg/kg	
Concentration (µg/kg)	231
Area (m2)	4,622
Quantity of soil (tonnes)	18,303
Quantity of PFOS (kg)	2.1
Uncertainty -	1.2
Uncertainty +	3.1
PFOS average for all depths and points > 30 µg/kg	
Concentration (µg/kg)	278
Area (m2)	3,816
Quantity of soil (tonnes)	15,111
Quantity of PFOS (kg)	2.1
Uncertainty -	1.2
Uncertainty +	3.1
PFOS average for all depths and points > 150 µg/kg	
Concentration (µg/kg)	375
Area (m2)	2,517
Quantity of soil (tonnes)	9,967
Quantity of PFOS (kg)	1.9
Uncertainty -	1.1
Uncertainty +	2.7
PFOS average for all depths and points > 500 µg/kg	
Concentration (µg/kg)	612
Area (m2)	573
Quantity of soil (tonnes)	2,269
Quantity of PFOS (kg)	0.7
Uncertainty -	0.4
Uncertainty +	1.0





PFOS average for all depths and points > 1000 µg/kg	
Concentration (µg/kg)	
Area (m2)	
Volume of soil (tonnes)	
Volume of PFOS (kg)	
Uncertainty -	
Uncertainty +	
PFOS average for all depths and points > 3000 µg/kg	
Concentration (µg/kg)	
Area (m2)	
Volume of soil (tonnes)	
Volume of PFOS (kg)	
Uncertainty -	
Uncertainty +	

Comments regarding the quantity calculations	The risk assessment for BØF A carried out in 2016 estimated that there is a residual quantity of 8.5 kg ± 3 kg of PFOS in the ground distributed across an area of 5,300 m^2 to a depth of 3 metres. The difference between the assessment in 2016 and the current one in 2019 is largely due to the fact that the proportion of fine material is taken into account in the 2019 assessment. The actual size of this proportion is subject to some uncertainty.
Is the extent of the contaminated area limited horizontally?	No, only in the south around shaft BØF 13 are there concentrations of PFOS below 3 µg/kg. The extreme points to the northwest (BØF 15) and to the southeast (BØF 12) have concentrations of <5 µg/kg.
Is the extent of the contaminated area limited vertically?	No, there are PFOS concentrations of in excess of 100 µg/kg in the deepest samples in a number of shafts. However, the unconsolidated sediment is of limited thickness, as the site was constructed in an area that had been blasted out of rock. The DP2 report states that the bedrock is shallow, and bedrock is described as occurring at a depth of 80 and 200 cm in five of the shafts.
Comments/uncertainty	At five of the sampling points, only samples of the uppermost layer were taken. Many of the samples are stated as being taken from bedrock. This may mean that the bedrock surface has been observed in these shafts, but this is uncertain. PFOS and PFOA have only been analysed for there.

6.5 Water sampling and annual dispersal

Have water samples been taken?	Yes
Where	In runoff areas towards the recipient, near the BØF site, as well as around the terminal area.
Highest measured concentration of PFOS in groundwater (ng/l)	Not detected
Where	V7, which is a sample taken from the airport's water supply well situated west of the terminal area
Highest measured concentration of PFAS in groundwater (ng/l)	Not detected
Where	V7, which is a sample taken from the airport's water supply well situated west of the terminal area
Comments/uncertainty	Analysed for 12 PFAS compounds.
Highest measured concentration of PFOS in surface water (ng/l)	2,980
Where	Surface water V5 northeast of the BØF (21.06.2013)
Highest measured concentration of PFAS in surface water (ng/l)	3,980
Where	Surface water V5 northeast of the BØF (21.06.2013)
Comments/uncertainty	Analysed for 12 PFAS compounds. Point V5 represents surface water and groundwater from the fire training site and the marshland which flows into lake Kalken.
Total annual dispersal of PFOS from the site (g/year)	40
Total annual dispersal of PFAS from the site (g/year)	Not calculated
To which recipient	BØF has runoff via lake Kalken and on to lake Leirin.
Calculated from water or soil concentration.	Water concentration

6.6 Biota sampling

Have biota samples being taken at the airport?	Yes
What kind of biota?	Whitefish, trout, perch and minnow
How many samples?	90
Highest measured concentration of PFOS in biota (µg/kg wet weight)	1,700
Where	2.2L Perch, liver, station 2, Kalken
Highest measured concentration of PFAS in biota (µg/kg wet weight)	1,709
Where	2.2L Perch, liver, station 2, Kalken
Median concentration (µg/kg wet weight) in comparable populations (e.g. in a lake)	787
Comments/references	The following concentrations have been reported in liver from Perch in Tyrifjorden: 322, 486, 787, 848, 1110 µg/kg (median 787 µg/kg). Source tracing of PFAS to Tyrifjorden, NGI 2017.
References and concentrations in other reports.	

6.7 Uncertainty and other factors

Does the estimate of the volume of PFOS in the ground correspond with the measured concentrations in water and biota?	Cannot be reliably evaluated. There are high concentrations in biota in lake Kalken and relatively low estimated quantities of PFOS in the volume investigated at the BØF.
Evaluations	It is estimated that 76 kg of PFOS and 24 kg of PFAS were used at the site between 1987 and 2012. There is no paved or landscaped collection system for chemicals. The groundwater level is situated 1-2 m below ground level. The ground under the BØF largely consists of blasted rock, which is highly permeable. A high rate of leaching could explain why relatively little PFOS (approx. 2.1 kg) is estimated in the material at BØF, as well as the high PFOS concentrations in biota in lake Kalken and the relatively high concentrations of PFOS/PFAS at sampling point V5 in surface water immediately downstream of the BØF.
Calculation	No basis for calculating k_d as no groundwater samples have been collected.
Could there be any additional unknown sources of PFOS at the site with runoff to the recipient?	Cleaning of fire vehicles and testing of the cannon/setting of the foam spread on the cannon has been carried out regularly on the grass areas in the terminal area. Point V3, Leirelvi, is located south of the terminal area and the sample was taken along the riverbank in Leirelvi. In addition, water has been sampled from a culvert which drains the snow depot around the terminal area (V3 outlet culvert) and flows into Leirelvi. Both points show low to moderate concentrations of PFOS (from not detected to 313 ng/l) and PFAS (from not detected to 735 ng/l). The water can receive PFOS/PFAS from the grass areas of the terminal area that have been used for cleaning fire vehicles/testing of cannons, as well as from activities in and around the workshop area. PFOS accounts for the majority of the PFAS concentration in the runoff, but concentrations of 6:2 FTS have also been detected. Low concentrations (<10 ng/l) of PFOS/PFAS have been detected in Leirelvi downstream of the airport (V6).
Has the site been sufficiently mapped with a view to assessing the order of priority?	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the volume of PFOS in the soil with the stipulated level of uncertainty.
Comments/uncertainty	
Other factors of significance to possible clean-up/implementation of measures (e.g. planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	The County Governor of Oppland mentions Nord-Aurdal as one municipality with marshland complexes which are of particular value as regards biodiversity. There may be endangered bird species in the surrounding area. Species of particularly high management interest have been recorded approx. 1 km east of the airport. Leirin is a fishing lake. At the BØF, THC was detected in environmental condition classes 2-3 in three soil samples, and in environmental condition class 4 in one soil sample.

7 Florø Airport



Florø lufthamn (ENFL)

Oversiktskart inkl. brannøvingsfelt

Jord og sediment

PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

PFOS sediment marint (ug/kg)
- 0
- <LOQ
- LOQ-63
- 63-6300
- >6300
- Ikke analysert

* PFOS er dominerende parameter

LOQ = rapporteringsgrense
i.a. = ikke analysert

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Florø lufthamn (ENFL)

Oversiktskart inkl. brannøvingsfelt

Vann

PFOS / ∑ PFAS ferskvann (ng/l) *
- Ikke analysert
- 0
- <LOQ
- LOQ-230
- 230-36 000
- >36 000

* Venstre halvdel = PFOS
Høyre halvdel = PFAS

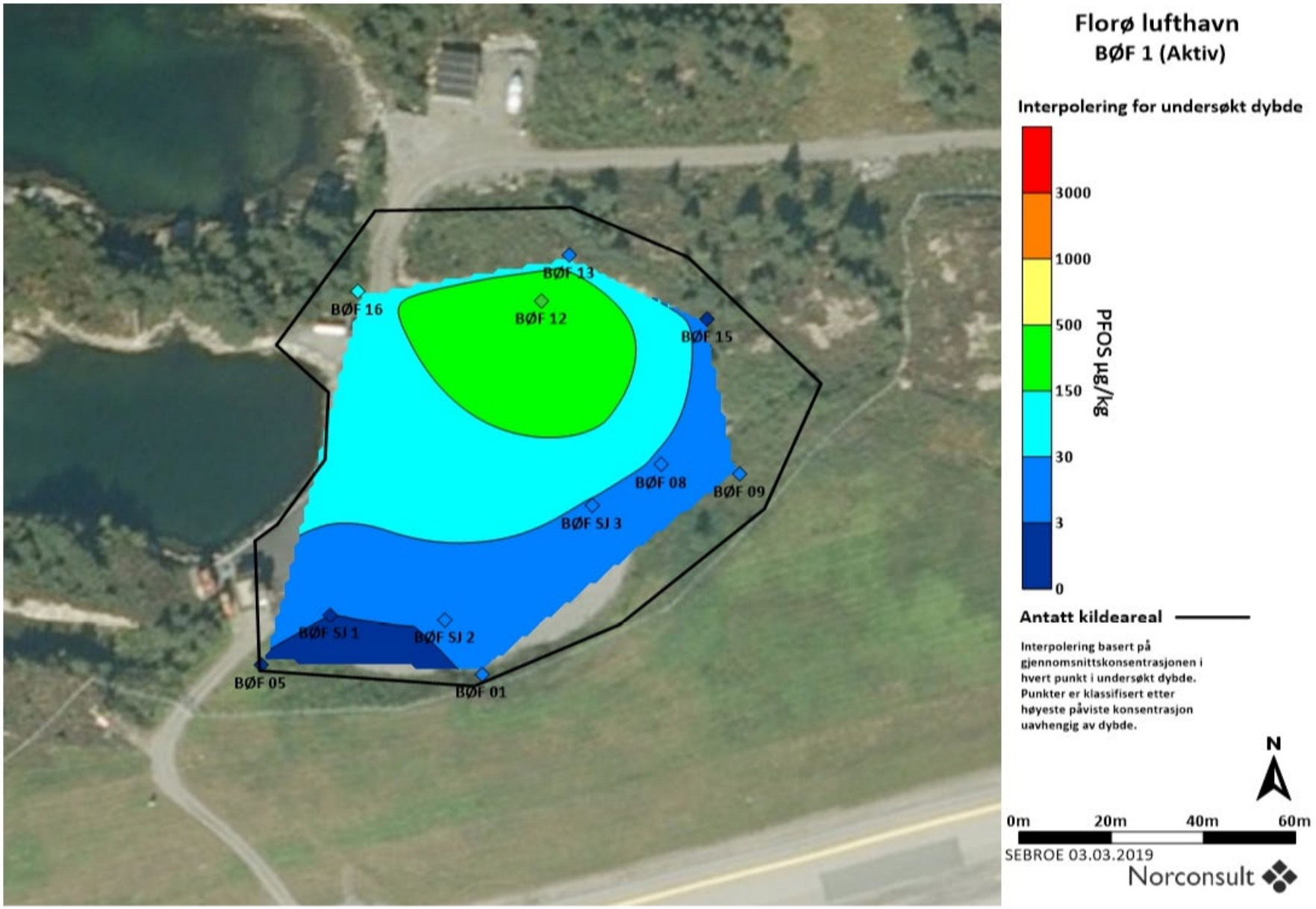
PFOS / ∑ PFAS sjøvann (ng/l) **
- Ikke analysert
- 0
- <LOQ
- LOQ-23
- 23-7 200
- >7 200

** Senter = PFOS
Ytre ramme = PFAS

Avlopsledning
- Avløp annet
- Avløp Felles
- Drensvann
- Glykolholdig overvann
- Glykolholdig spillvann
- Overvann
- Pumpespillvannsledning
- Spillvann

Avrenning
- Deponi glykolforurenset snø
- Overvannsledning
- Avrenningsveg glykol
- Bekkeresipient
- Overvannsystem
- Vannskille rullebane
- Antatt avrenningsveg baneavising

i.a. = ikke analysert
LOQ = rapporteringsgrense
(tilsv. ikke påvist for ∑PFAS)



Florø lufthavn
BØF 1 (Aktiv)

Interpolering for undersøkt dybde

PFOS µg/kg
3000
1000
500
150
30
3
0

Antatt kildeareal

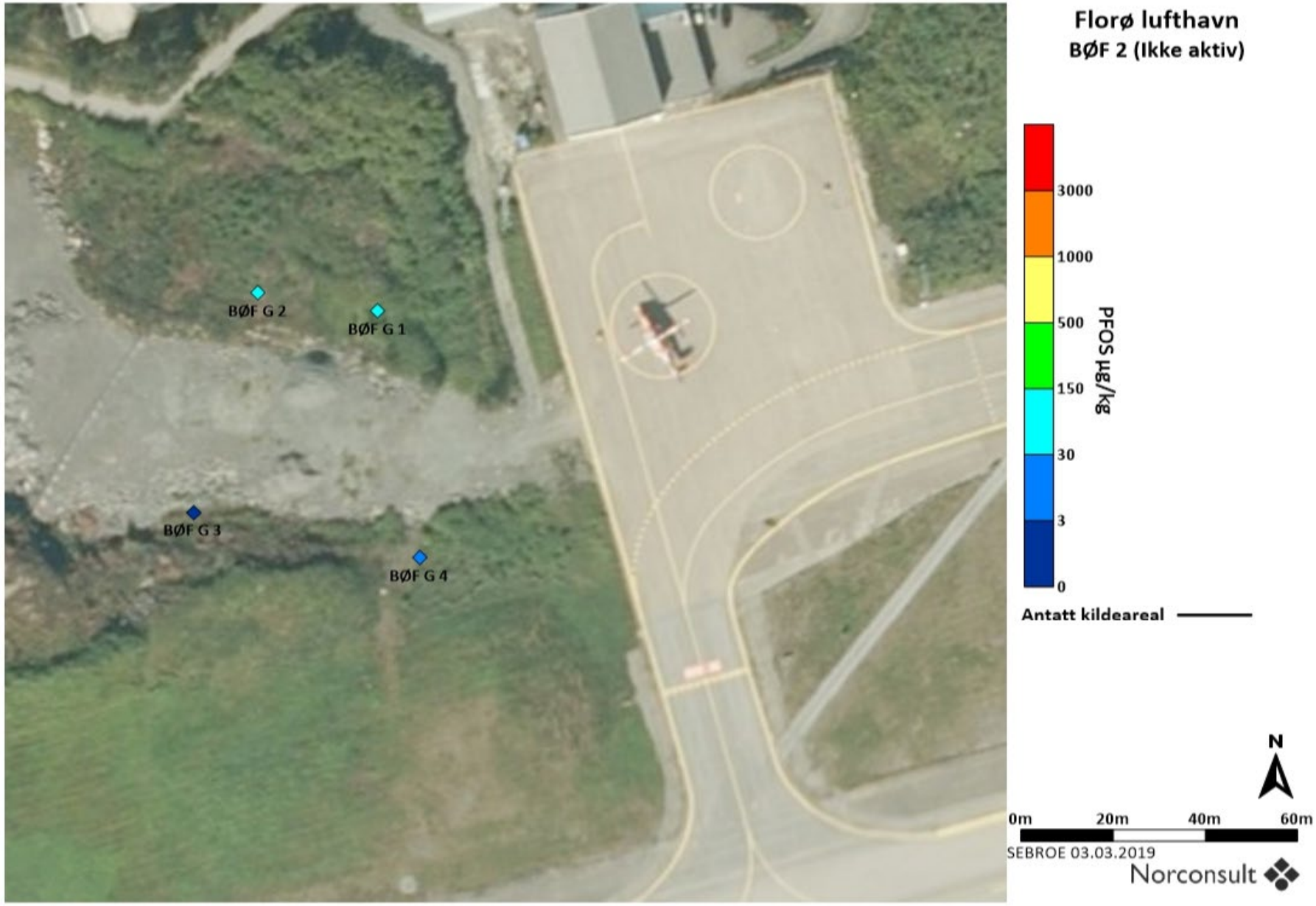
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.

N

0m 20m 40m 60m

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Florø lufthavn
BØF 2 (Ikke aktiv)
BØF G 2
BØF G 1
BØF G 3
BØF G 4
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
N
0m
20m
40m
60m
SEBROE 03.03.2019
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7.1 Fire training site (BØF)/contaminated site

Fire training site (BØF)/contaminated site	BØF1 (active)	BØF2 (old)
	The site was taken into use in 2007/2008	BØF2 was in use from 1971 to 2007

7.2 Use of PFOS and other PFASs

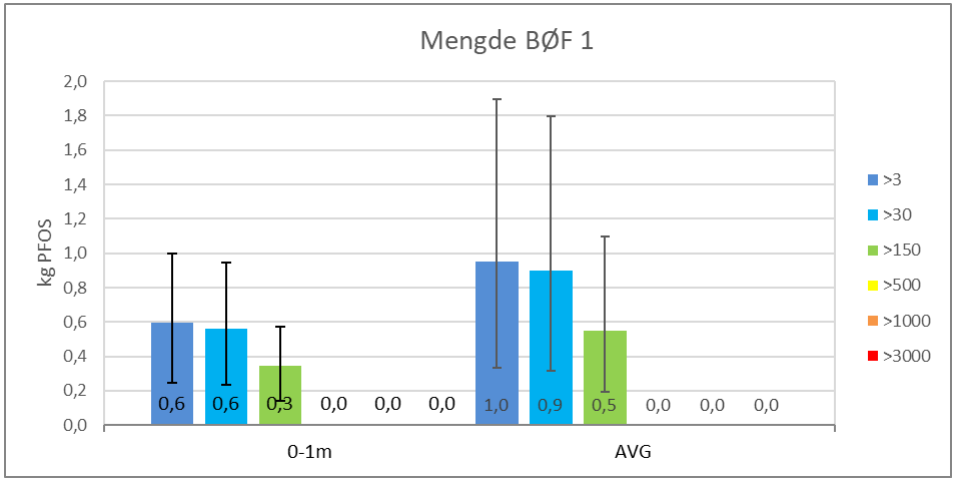
Quantity of PFOS used at the site (kg)	0	820
Comments/uncertainty	Foam containing PFOS as its main PFAS component has probably not been used.	Estimated consumption during the period 1978 to 2002.
Quantity of PFAS used at the site (kg)	70	70
Comments/uncertainty	Estimated consumption of PFAS during the period 2007 to 2011. Avinor completely phased out firefighting foam containing PFAS in 2012 and now only uses PFAS-free firefighting foam.	Estimated consumption during the period 2002 to 2007.

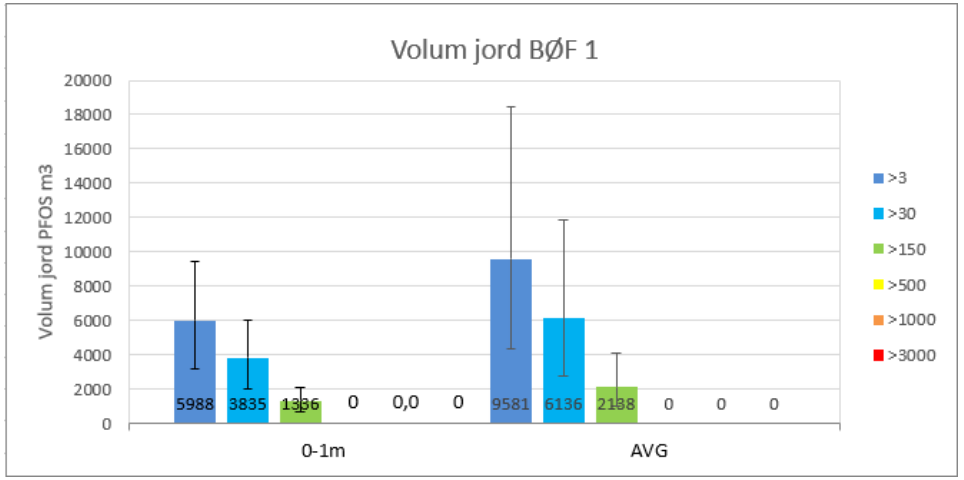
7.3 Soil sampling

Fire training site (BØF)/site	BØF1 (active)	BØF2 (old)
Total number of soil samples	12	4
Comments/uncertainty (e.g. 95% of the samples were taken from 0-0.1 m)	Approx. 60% of samples were taken from depths of between 5 and 10 cm. One of the samples is of sludge from 0-5 cm; the rest are of organic soil or blasted rock.	All of the samples were taken from depths of 5-10 cm.
Number of soil samples 0-1 m below ground level	12	4
Number of soil samples under 1 m	2	0
Comments/uncertainty	A total of 14 soil samples when splitting up samples in the intervals of 0-1 m and > 1 m.	
Highest measured soil concentration of PFOS µg/kg	482	45.6
Where	Sampling point BØF12 (0-5 cm). BØF16 (5-10 cm) of organic soil has the second highest concentration (88.2 µg/kg).	BØF G2. Only analysed for PFOS and PFOA
Highest measured soil concentration of PFAS µg/kg	482	45.6
Where	Sampling point BØF12 (0-5 cm). The sample was only analysed for PFOS and PFOA, but this sample has a higher PFOS concentration than the total PFAS in samples analysed for multiple compounds. Only four samples have been analysed for more (11) compounds than PFOS/PFOA. No 6:2 FTS has been detected, even though it is often expected at more recent BØFs. BØF16 (5-10 cm) of organic soil has the second highest concentration of total PFAS (150 µg/kg).	BØF G2. The sample was only analysed for PFOS and PFOA.
Comments/uncertainty	BØF 12 is a sample of sludge, and not of organic soil and blasted rock, like the other samples.	

7.4 Quantity calculation

PFOS average for all depths and points > 3 µg/kg		No quantities have been calculated for BØF 2
Concentration (µg/kg)	92	
Area (m2)	5,988	
Quantity of soil (tonnes)	17,245	
Quantity of PFOS (kg)	1.0	
Uncertainty -	0.6	
Uncertainty +	0.9	
PFOS average for all depths and points > 30 µg/kg		
Concentration (µg/kg)	136	
Area (m2)	3,835	
Quantity of soil (tonnes)	11,045	
Quantity of PFOS (kg)	0.9	
Uncertainty -	0.6	
Uncertainty +	0.9	
PFOS average for all depths and points > 150 µg/kg		
Concentration (µg/kg)	238	
Area (m2)	1,336	
Quantity of soil (tonnes)	3,848	
Quantity of PFOS (kg)	0.5	
Uncertainty -	0.4	
Uncertainty +	0.5	
PFOS average for all depths and points > 500 µg/kg		
Concentration (µg/kg)		
Area (m2)		
Volume of soil (tonnes)		
Volume of PFOS (kg)		





Uncertainty -		
Uncertainty +		

PFOS average for all depths and points > 1000 µg/kg		
Concentration (µg/kg)		
Area (m2)		
Volume of soil (tonnes)		
Volume of PFOS (kg)		
Uncertainty -		
Uncertainty +		
PFOS average for all depths and points > 3000 µg/kg		
Concentration (µg/kg)		
Area (m2)		
Volume of soil (tonnes)		
Volume of PFOS (kg)		
Uncertainty -		
Uncertainty +		

Fire training site (BØF)/site	BØF1 (active)	BØF2 (old)
Comments regarding calculations	The risk assessment for BØF 1 carried out in 2016 estimated that there is a residual quantity of 0.65 kg ± 0.3 kg of PFOS in situ in the ground. A calculation has also been performed without including the sample from point BØF12, as it is uncertain whether this sample is representative. The residual quantity is then estimated at 0.2 kg ± 0.086 kg. The calculations are based on an area of approx. 3,500 m^2 and a homogeneous contamination depth of 1.6 metres.	
Is the extent of the contaminated area limited horizontally?	The contamination appears to be delimited to the south, as no PFAS has been detected at extreme point BØF05, and the highest concentrations at extreme points BØFSJ1 and BØF01 are 2.8 and 3.3 µg/kg respectively. To the west, there is sea.	The samples were collected at the perimeter of what was formerly BØF 2. Two of the sampling points lie to the north, one to the southwest and one to the southeast. The sample to the southwest is below the detection limit, while the sample to the southeast has a concentration of 9.9 µg/kg, which may indicate a delimitation of contamination at the surface in these directions. To the north, the concentration at both sampling points is approx. 40 µg/kg.
Is the extent of the contaminated area limited vertically?	No. The thickness of the unconsolidated sediments is not clearly described, but BØF 1 is located between contour + 3 to the west and + 5 to the east, so that the unconsolidated sediments are in contact with groundwater/seawater at a maximum depth of 3 metres to the west. Based on historical aerial photographs, the eastern part of the site is constructed on exposed bedrock, while the western part has been constructed on fill material in the sea. The thickness of the unconsolidated material above bedrock to the east is estimated to be between 1-3 metres.	No. Insufficient samples have been taken.
Comments/uncertainty	To the east and north, the highest concentration at the extreme points is < 20 µg/kg (BØF09, BØF15, BØF13). Not delimited to the northwest (BØF16 with 88 µg/kg).	

7.5 Water sampling and annual dispersal

Fire training site (BØF)/contaminated site	BØF1 (active)	BØF2 (old)
Have water samples been taken?	Yes	No
Where	Oil separator connected to the surface water system, seawater and groundwater in shaft	
Highest measured concentration of PFOS in groundwater (ng/l)	102	
Where	V2 (03.11.2011) groundwater in shaft	
Highest measured concentration of PFAS in groundwater (ng/l)	174	
Where	V2 (03.11.2011) groundwater in shaft	
Comments/uncertainty	Only analysed for PFOS and PFOA.	
Highest measured concentration of PFOS in surface water (ng/l)		
Where		
Highest measured concentration of PFAS in surface water (ng/l)		
Where		
	No PFAS has been detected in seawater, and over and above this, there are only samples from the oil separator which is connected to the municipal surface water network. Water samples from the oil separator are not considered to be representative of the surface water in the area. The five water samples from the oil separator were taken between 2011 and 2015, and show high concentrations of total PFAS (2,000-30,000 ng/l), especially for 8:2 FTS (200-28,000 ng/l), 6:2 FTS (700-9,000 ng/l) and PFOS (300-3,600 ng/l). In the event of heavy rainfall, the surface water system and oil separator can overflow into Gunhildvågen just offshore of the BØF. Avinor has not used PFAS foam at its airports since 2012 and the oil separators are emptied and cleaned once a year (unless they produce < 1kg oil during the course of a year), or more often if necessary. Water sample from the oil separator taken in 2018 has a concentration of PFAS of less than 7,000 ng/l.	

Total annual dispersal of PFOS from the site (g/year)	4.6 (2)*	Not calculated
Total annual dispersal of PFAS from the site (g/year)	Not estimated (15)*	Not calculated
To which recipient	Sea, Gunhildvågen. (oil separator)*	Sea, Gunhildvågen
Calculated from water or soil concentration.	Water concentration groundwater, and water samples from oil separator.	
	* Based on concentrations measured in water samples from the oil separator, quantities of PFOS and PFAS dispersed to the municipal sewerage system via the oil separator have been calculated; these are stated in parentheses. The calculation dates from 2016, and it is uncertain whether it is representative of the current situation.	

7.6 Biota sampling

Fire training site (BØF)/contaminated site	BØF1 (active)	BØF2 (old)
Have biota samples being collected at the site?	Yes	Yes
What kind of biota?	Lugworm, rockpool prawn, common limpet, mussels	Rockpool prawn, common limpet
How many samples?	5	2
Highest measured concentration of PFOS in biota (µg/kg wet weight)	94	4.5
Where	Station 2, composite sample, whole individual common limpet	Station 3, composite sample, whole individual common limpet
Highest measured concentration of PFAS in biota (µg/kg wet weight)	124	4.5
Where	Station 1, composite sample, common limpet. Total of 14 PFAS compounds.	Station 3, composite sample, whole animal common limpet. Total of 14 PFAS compounds.
Median concentration (µg/kg wet weight) in comparable populations (e.g. in a lake)	33.75	7.2
Comments/references	Median concentration of total PFAS in common limpet (n=6) in a bay just offshore of the BØF at Statoil Mongstad in 2015. The median concentration of PFOS in the same samples was 7.2 µg/kg. Taken from Statoil Petroleum report; "Environmental contaminants in biota at Statoil Mongstad 2015, SAM e-report no: 35-2015.	Median concentration of total PFOS in common limpet (n=6) in a bay just off the BØF at Statoil Mongstad in 2015. The median concentration of PFAS in the same samples was 33.75 µg/kg. Taken from Statoil Petroleum report; "Environmental contaminants in biota at Statoil Mongstad 2015, SAM e-report no: 35-2015.

References and concentrations in other reports.		

7.7 Uncertainty and other factors

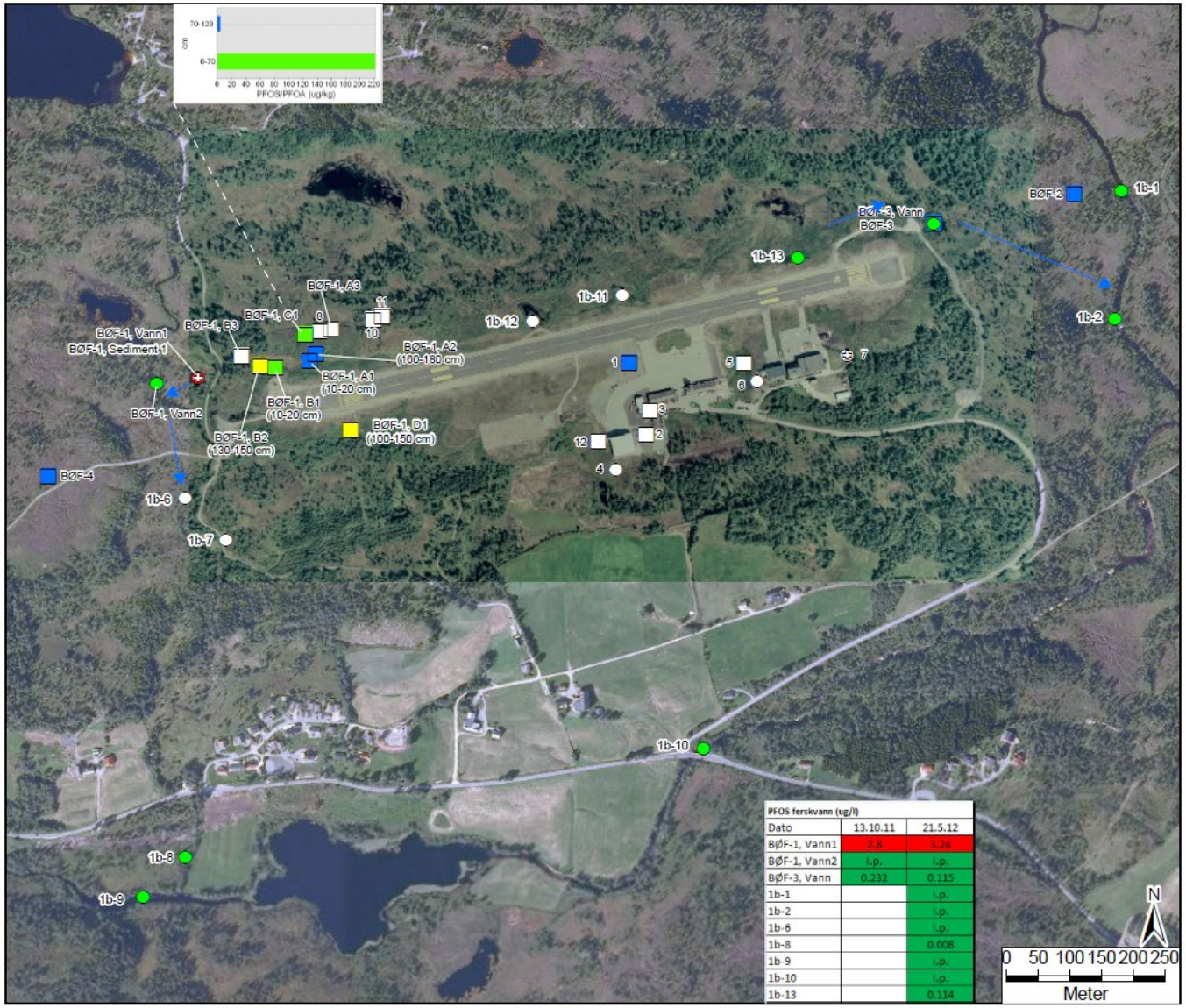
Fire training site (BØF)/contaminated site	BØF1 (active)	BØF2 (old)
Does the estimate of the quantity of PFOS in the ground correspond with the concentrations measured in water and biota?	Uncertain, but it is considered likely that the material does not contain large quantities of PFAS, due to asphalt/collection system and blasted rock material. Insufficient water samples have been collected from the site to assess the concentrations measured in water. There are relatively high concentrations in the studied biota, and the soil surveys indicate that there is little PFAS in the material. The blasted rock material below the asphalt in the centre of the BØF has not been investigated, which adds uncertainty to the quantity calculation regarding PFOS (specified as an uncertainty factor for area in the calculation). It should be investigated whether biota could be affected by other sources of PFAS contamination in Gunhildvågen (e.g. the industrial area 300 metres to the northwest), as the biota around BØF 1 (active) has clearly been affected to a greater extent than that around BØF 2, and the bay into which BØF 2 drains is far less exposed to external influences due to the presence of the breakwater. In addition, no compounds such as 6:2 FTS or 8:2 FTS in biota have been detected around the active BØF, which are the main components of foam used from 2001-2012.	No quantities have been calculated due to the site being insufficiently mapped.

Evaluations	Total PFAS concentrations in four out of five biota samples (all of different types of biota) range between 20.6 and 124 µg/kg. This may indicate that dispersal into the sea has taken place, either through surface runoff from asphalt or leaching through the ground. Low concentrations of PFOS/PFAS have generally been detected in soil at the investigated sampling points in the ground around the paved area of BØF 1. The fire training site is more recent, and has a collection system for water and chemicals on the platform. Water collected from paved areas is directed to the municipal treatment plant and then to Solheimsfjorden. In the event of heavy rainfall, the oil separator can overflow into Gunhildvågen, just offshore of BØF 1. Elevated PFAS concentrations have been detected in the soil to the north and northwest of the paved area. The sample of groundwater in the shaft contains low concentrations, but was taken to the south, where the lowest concentrations in soil have also been detected. As there is blasted rock material beneath the BØF, any leaching into the ground through cracks in the asphalt runoff, surface water runoff which flows to the edges of the asphalt or the use/spillage of PFAS outside the platform area will not be retained in the material to any great extent. Based on a contour map and photographs of the BØF in the DP2 report, it appears that the asphalt falls towards the sea in a northwesterly direction to some extent, so that any runoff can flow directly into the sea. Furthermore, historical aerial photographs show that the paved area around the training fuselage originally covered an area of approx. 650 m^2 in 2007, and was then expanded to its present size sometime before 2010. There may therefore have been a greater degree of dispersal to the ground (in areas that are now paved), as well as to the sea during this period. It is considered likely that any contamination in the material in the central areas of the BØF will largely have been leached out into groundwater/the sea.	Biota is clearly influenced to a greater extent at BØF 1 (active) than at BØF 2. Because BØF 2 is little mapped, this may be due to many different factors, such as water displacement, the degree of leaching from the BØF, quantities of PFAS in soil, etc. Another possible cause may be if the presence of PFAS in the bay at BØF 1 is due to the influence of another source of PFAS in Gunnhildvågen. There is an extensive industrial estate about 700 metres west of BØF 2, directly on the other side of Gunnhildvågen. This area includes the world's largest fish feed factory, Ewos AS, and a large pier facility. The harbour into which BØF 2 drains is less exposed to any influence from the outside due to the presence of the breakwater, which means that there is only a small opening out of the harbour, and there are low concentrations in the biota. The bay offshore of BØF 1 is more exposed to external influences, and also has much higher concentrations in biota.

Comments/uncertainty (Could there be any additional unknown sources of PFOS at the site with run-off to the recipient?)	Information from the airport indicates that there may be PFAS contamination outside the garage facility as a result of the cleaning of fire trucks both outside and inside the facility. The fire trucks have been filled with firefighting foam inside the garage. There is also a large industrial estate about 300 metres west of BØF 1, directly on the other side of Gunnhildvågen. This area includes the world's largest fish factory, Ewos AS, and Norway Pelagic, which produces fish products. The area has a large pier facility with six piers.	There is an extensive industrial estate about 700 metres west of BØF 2, directly on the other side of Gunnhildvågen. This area includes the world's largest fish factory, Ewos AS, and Norway Pelagic, which produces fish products. The area has a large pier facility with six piers. The harbour into which BØF 2 drains is less exposed to any influence from the outside due to the presence of the breakwater, which means that there is only a small opening out of the harbour.

Has the site been sufficiently mapped with a view to assessing the order of priority?	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the quantity of PFOS in the soil with the stipulated level of uncertainty.	No, the site is insufficiently mapped (ref. this report for parts 1 and 2, section 2.1.1.6 and section 2.1.3.1). Insufficient samples have been collected, and the area has only been investigated around what is believed to be the centre of the BØF, as blasted rock material has been laid across the centre of the BØF.
Comments/uncertainty	All sampling points are from the outer perimeter of the site (south/east and north). To the west, there is sea. There are no samples from the centre of BØF, which is paved, and the material beneath the site consists of blasted rock. It is unlikely that large quantities of PFOS are still present in the blasted rock material beneath the asphalt, but there is still considerable uncertainty relating to this site linked to the fact that the centre of the BØF has not been investigated, particularly because the entire site was not paved from the time of its construction in 2007 through to sometime before 2010.	It can be assumed that what was the centre of BØF 2 may have higher concentrations of PFAS compounds in the ground, but the blasted rock material that lay across the site prevented sampling from the underlying soils.
General information about the airport		
Other factors of significance to possible clean-up/implementation of measures (e.g. planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	There are several protected areas for seabirds, wetlands and fauna around the airport, including those at Nærøyane, Nekkøytåa, Indre Ånnøy, Kvalsteinane and Timberøyholmane. All of these areas are situated more than 3 km in a straight line from the airport. Special habitat types have been recorded in the area: in Austvika just east of the airport ,there are "Soft-bottomed areas in the coastal zone", and a "Rich cultural landscape lake" at Svartvatnet, north of the airport. Two bird species with a status in the Norwegian Red List were recorded in 2010 in the area of the airport: black-headed gull and common gull. In addition, white-tailed eagles (species of responsibility) and moss carder bee (near threatened (NT) are included in the Norwegian Red List 2010, but old observation - 1963) in proximity to Gunhildvågen. Two important marine habitats (occurrence of oysters, and extensive marine mud and soft bottom areas) were also recorded during the collection of biota in 2013 (www.naturbasen.no, www.artskart.no). At BØF 1, THC was detected in environmental condition class 2 in three soil samples, and in environmental condition class 4 in one soil sample (BØF 12).	

8 Førde Airport Bringeland



Førde lufthavn Bringeland (ENBL)

Oversiktskart inkl. brannøvingsfelt

PFOS sediment ferskvann (ug/kg)
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

PFOS ferskvann (ug/l)
- <0.002-0.3
- 0.3-1.0
- >1.0
- Ikke analysert

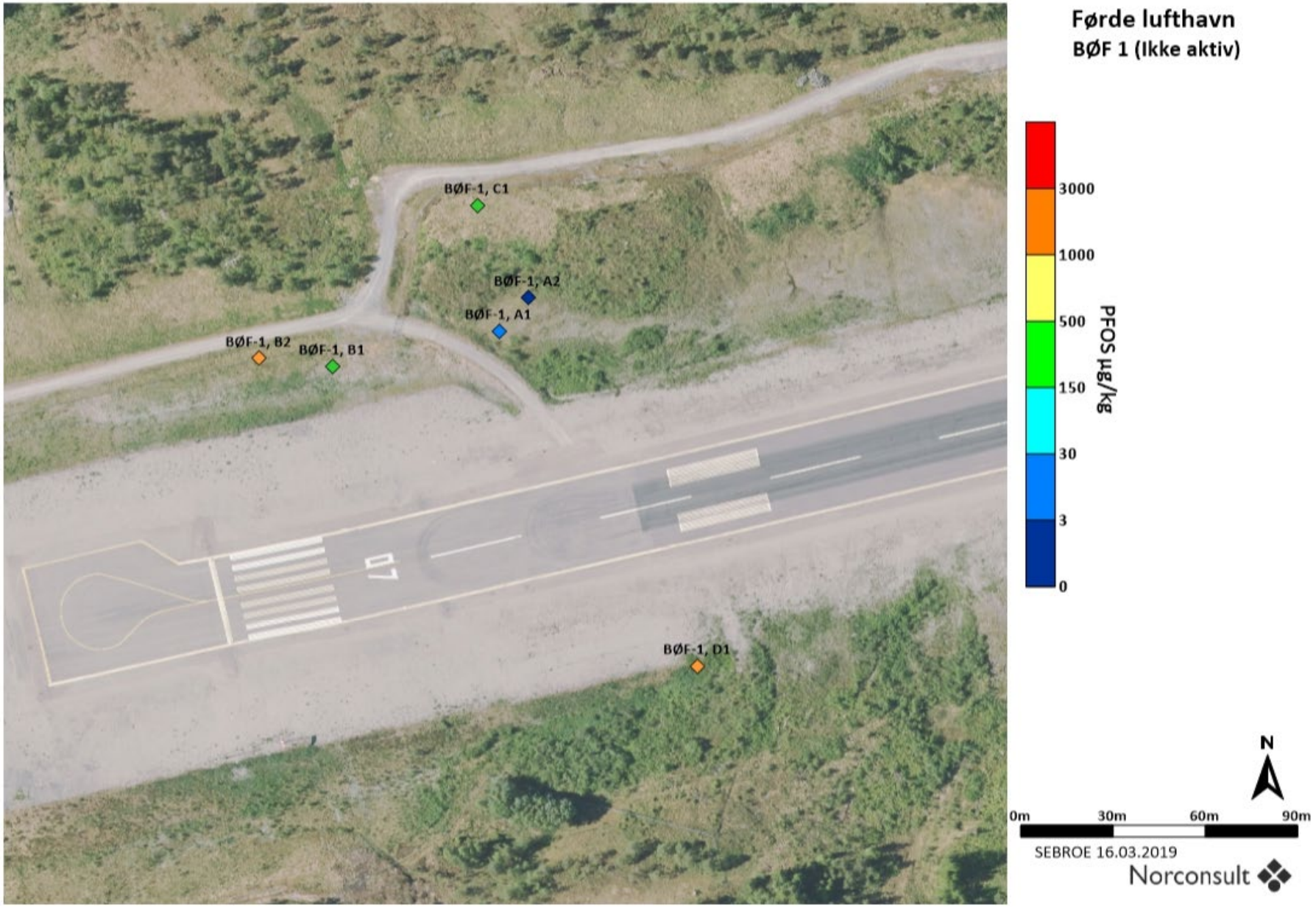
PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

Mrk. varierende skala for x-aksen i diagrammene

* PFOS er dominerende parameter

ip = ikke påvist

AVINOR COWI SWECO


Førde lufthavn
BØF 1 (Ikke aktiv)
BØF-1, C1
BØF-1, A2
BØF-1, A1
BØF-1, B2
BØF-1, B1
BØF-1, D1
07
3000
1000
500
150
30
3
0
PFOS µg/kg
N
0m
30m
60m
90m
SEBROE 16.03.2019
Norconsult

8.1 Fire training site (BØF)/contaminated site

Fire training site (BØF)/contaminated site	BØF 1 (old)
	BØF is not active, but the testing of fire engines and six-monthly accident drills are carried out at the airport. From the DP2 report: "Førde completed an expansion of the runway in 2009 as part of the S&L project. As part of this project, the old fire training site was covered with stone material several metres thick. Førde Airport is not currently permitted to carry out fire drills and therefore primarily conducts drills at Florø Airport. However, the civil aviation regulations (BSL) require the monthly testing of fire engines (canon) and six-monthly accident drills, which are carried out locally. This entails the regular use of chemicals in the form of small quantities of firefighting foam in the airport area (Avinor phased out foam containing PFAS at its airports in 2012). According to the S&L project, the surface material from the fire training site was significantly contaminated with oil in connection with the runway expansion. In accordance with recommendations issued by the environmental consultant, 36 m^3 of surface material on the old fire training site was removed, ventilated and deposited on the southern side of the eastern part of the runway, before the fire training site was then covered with stone material". Comment on the above excerpt: the photographs in the DP2 report indicate that the final sentence should read "the western part of the runway", rather than "the eastern part".

8.2 Use of PFOS and other PFAS

Volume of PFOS used at the site (kg)	Not stated/calculated
Comments/uncertainty	
Volume of PFAS used at the site (kg)	Not stated/calculated
Comments/uncertainty	

8.3 Soil sampling

Total number of soil samples	7
Comments/uncertainty (e.g. 95% of the samples were taken from 0-0.1 m)	Number of samples analysed from the BØF 1 area. A sample of deposited material from the fire training site (BØF 1 D1 on the southern side of the runway) was also analysed, along with three samples of material from areas used for accident drills (marked BØF 2, 3 and 4). The material is described as soil, peat, sand and silt.
Number of soil samples 0-1 m below ground level	3
Number of soil samples under 1 m	4
Comments/uncertainty	
Highest measured soil concentration of PFOS µg/kg	1,800
Where	BØF 1, B2-2, soil, peat and silt - filler
Highest measured soil concentration PFAS µg/kg	1,800
Where	BØF 1, B2-2, soil, peat and silt - filler
Comments/uncertainty	Sample "BØF 1, B2-2" was only analysed for PFOS and PFOA. Only one soil sample was analysed for 6:2 FTS and a number of PFAS. The table shows that total PFC (11.9 µg/kg) for this sample was higher than the sum of PFOS, PFOA and 6:2 FTS (5.8 µg/kg), but no analyses are enclosed for this sample, so it is not known which other compounds were analysed for or detected.

8.4 Quantity calculation

No quantity has been calculated.	No quantity been calculated, because the BØF is situated beneath the runway and it has not been investigated sufficiently.
Comments	It is calculated in the DP2 report that the residual quantities in the BØF area and in dumped/relocated materials from the BØF amount to approx. 1400 g PFOS.
Is the extent of the contaminated area limited horizontally?	No, because the material has been moved and the BØF was buried in connection with the expansion of the runway.
Is the extent of the contaminated area limited vertically?	No, because the material has been moved and the BØF was buried in connection with the expansion of the runway. The highest concentrations of > 1000 µg/kg were detected in material taken from depths of 100-150 cm on either side of the runway.
Comments/uncertainty	

8.5 Water sampling and annual dispersal

Water sampling and annual dispersal	
Have water samples been taken?	Yes
Where	Water samples have been taken from the stream in the eastern part of the airport before the outflow into Gjøsetelva (1b-13 and BØF3 Water), as well as upstream and downstream of the outflow of the stream into Gjøsetelva (1b-1 and 1b-2). Water samples of the ditch water have been taken by the airport fence in the west (BØF-1 vann1) which drains the area where the BØF is/was located, as well as upstream of the outflow of the ditch into the stream west of the airport (BØF-1 vann2), and a good distance downstream of the ditch's outflow into the stream (1b-8). In addition, water samples have also been taken from Storelva downstream of Bringedalsvatnet (1b-9).
Highest measured concentration of PFOS in groundwater (ng/l)	
Where	
Highest measured concentration of PFAS in groundwater (ng/l)	
Where	
Comments/uncertainty	No groundwater samples were taken.
Highest measured concentration of PFOS in surface water (ng/l)	3,000
Where	BØF 1, water 1 (1b-4) - Ditch which drains the area where the old BØF was located (21.05.12)
Highest measured concentration of PFAS in surface water (ng/l)	5,400
Where	BØF 1, water 1 (1b-4) - Ditch which drains the area where the old BØF was located (21.05.12)
Comments/uncertainty	
Total annual dispersal of PFOS from the site (g/year)	10,797
Total annual dispersal of PFAS from the site (g/year)	19.74

To which recipient	From the DP2 report: Runoff from the runway drains into the ground. Surface water which infiltrates along the runway drains to three separate streams, all of which flow into the river Gjøsetelva to the east. Surface water also probably infiltrates into the ground before it is drained via drains and natural flow to depressions/wetlands adjacent to and north of the service building. From here, the water continues to Gjøsetelva and then on to Dalsfjorden. Runoff of contaminated groundwater from the old fire training site will flow into the stream west of the airport and on to Storelva. This water also continues on to Dalsfjorden.
Calculated from water or soil concentration.	Water concentration in ditch water east and west of the airport.

8.6 Biota sampling

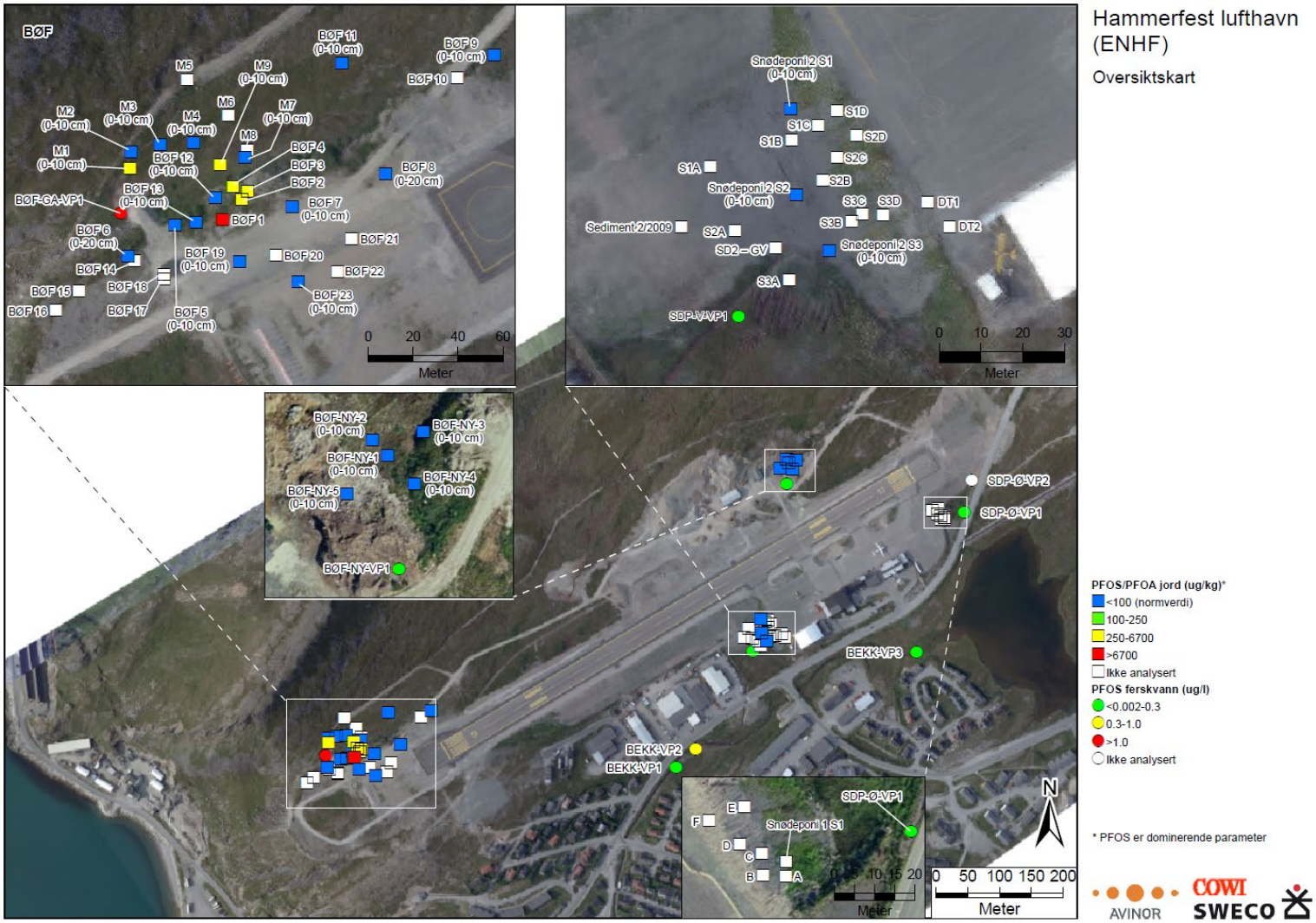
Have biota samples being taken at the airport?	No
What kind of biota?	
How many samples?	
Highest measured concentration of PFOS in biota (µg/kg wet weight)	
Where	
Highest measured concentration of PFAS in biota (µg/kg wet weight)	
Where	
Median concentration in comparable populations (e.g. in a lake)	
Comments/references	
References and concentrations in other reports.	

8.7 Uncertainty and other factors

Does the estimate of the quantity of PFOS in the ground correspond with the measured concentrations in water and biota?	Cannot be assessed, as the actual area of the BØF has not been investigated. No groundwater samples have been taken, and more soil samples will be needed to determine the location of the sources of PFAS. Concentrations > 100 ug/kg have been detected in four of seven samples. Two of the samples have > 1000 µg/kg. Water samples in a ditch which drains the area where the BØF was located have high concentrations, and streams to the west and east of the airport also contain PFAS. A concentration of 8 ng/l PFOS has been detected in a water sample taken from the river which flows into Storelva at point 1b-8, which is located 750 metres southwest of the airport.
Evaluations	
Comments/uncertainty (Could there be any additional unknown sources of PFOS at the site with runoff to the recipient?)	As annual functional testing and accident drills are carried out at the airport, it is also possible that there are other contaminated areas and/or diffuse contamination. From the DP2 report: "The airport manager stated during the inspection that some accident drills have been carried out both within and outside the airport area involving the use of firefighting foam. This concerned two areas east of the airport (BØF 2 and BØF 3), and one area west of the airport (BØF 4). At BØF 2, a drill was carried out in 2010 where AFFF foam was used. According to product data, this product contains very little PFOS. A PFOS concentration 7.8 µg/kg was measured in the soil sample taken from BØF 2 (10-20 cm deep)". At BØF 3, a drill was carried out in 2008. In this area, material was later laid on the surface as part of the expansion of the runway. It is not known where this material was obtained from. At BØF 3, 20 µg/kg PFOS was detected in the soil sample taken from a depth of 10-20 cm. Water samples have been taken from a stream at two points in this area. The sample collected at point 1b-3 showed 230 ng/l in 2011, while the sample from 2012 contained 120 ng/l. The sample taken in 2012 slightly further west (1b-13) from the same stream contained 110 ng/l. BØF 4 consists of a marsh area adjacent to a road. Here, it is stated that the fire engine was parked on the road and blew foam towards the marsh. Here, 10 µg/kg PFOS was detected in the soil sample taken from a depth of 10-20 cm.
Has the site been sufficiently mapped with a view to assessing the order of priority?	No, the site is insufficiently mapped (ref. this report for parts 1 and 2, section 2.1.1.6 and section 2.1.3.1). The source area is covered and lies beneath the runway, and has not been adequately investigated or delimited.
Comments/uncertainty	

Other factors of significance to possible clean-up/implementation of measures (e.g. planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	Svartliåsmyra, Skilbreivatnet and Espelandsvatnet are protected areas situated about 1 km southeast of the airport. To the southwest, there is another protected area, Osen, which is located about 5 km away. Reindeer have been recorded in the airport area, and bird species of high and particularly management interest have been recorded south of the airport, in Bringelandsvatnet and Storelva. Habitat types have been recorded northwest, east, west and southwest of the airport. The Gaular watercourse is a protected watercourse situated south and east of the airport. Bringelandsvatnet and Storelva are located just outside this protected watercourse. The streams on either side of the airport are trout streams. The DP2 report recommends that the situation be monitored by collecting and analysing stream samples. Runoff of contaminated groundwater from the old fire training site will flow into the stream west of the airport and on to Storelva. It must be assumed that the entire watercourse is inhabited by trout. The airport is registered under Avinor's vulnerability class 2, which means 'somewhat less vulnerable recipients, moderate priority and level of facilities'. THC has been detected in environmental condition classes 2-3 in four of the samples taken at the BØF, and in environmental condition class 4 in two of the samples. Three of the samples are of peat, and it is uncertain whether humus removal was carried out prior to analysis.

9 Hammerfest Airport



Hammerfest lufthavn (ENHF)

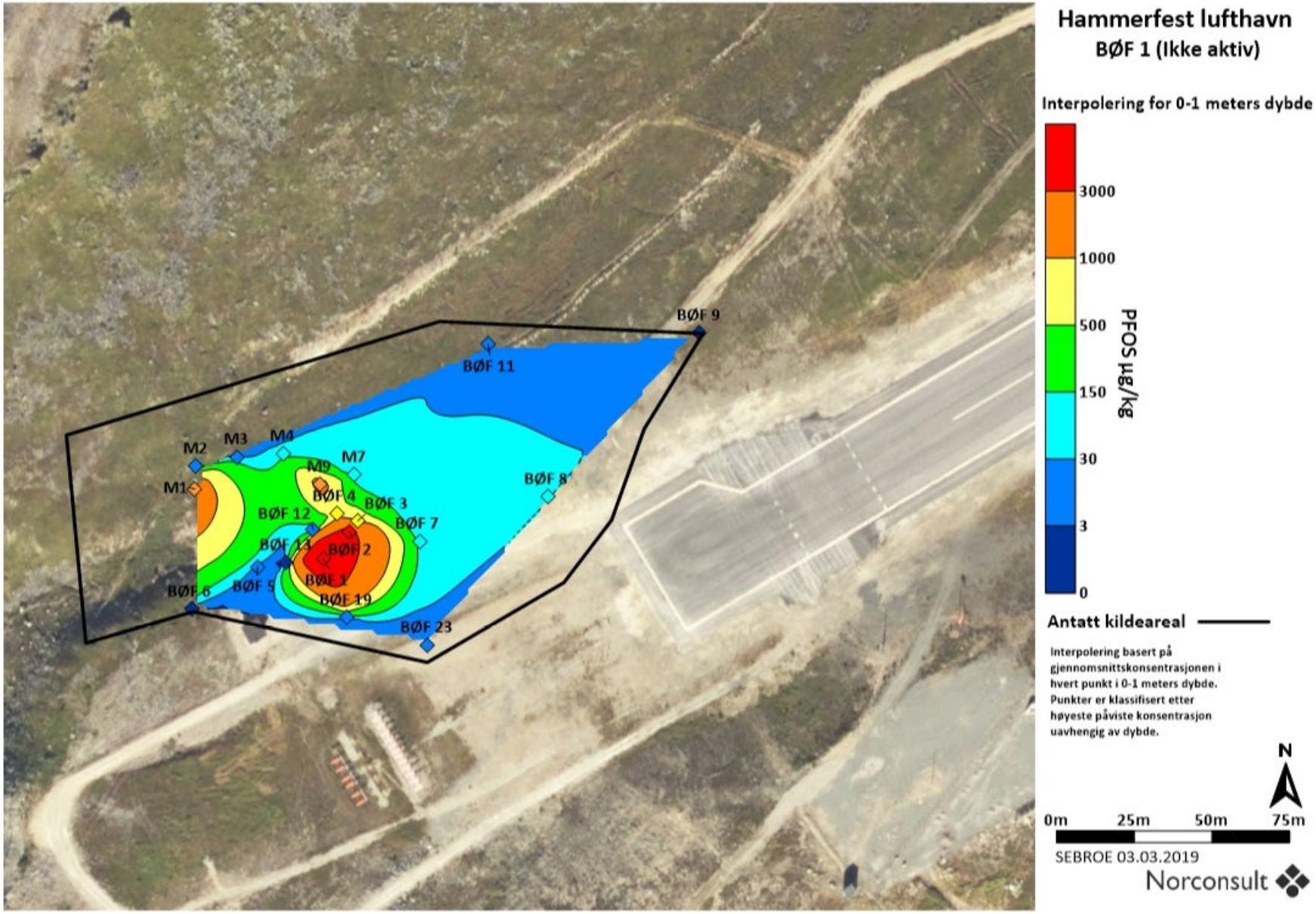
Oversiktskart

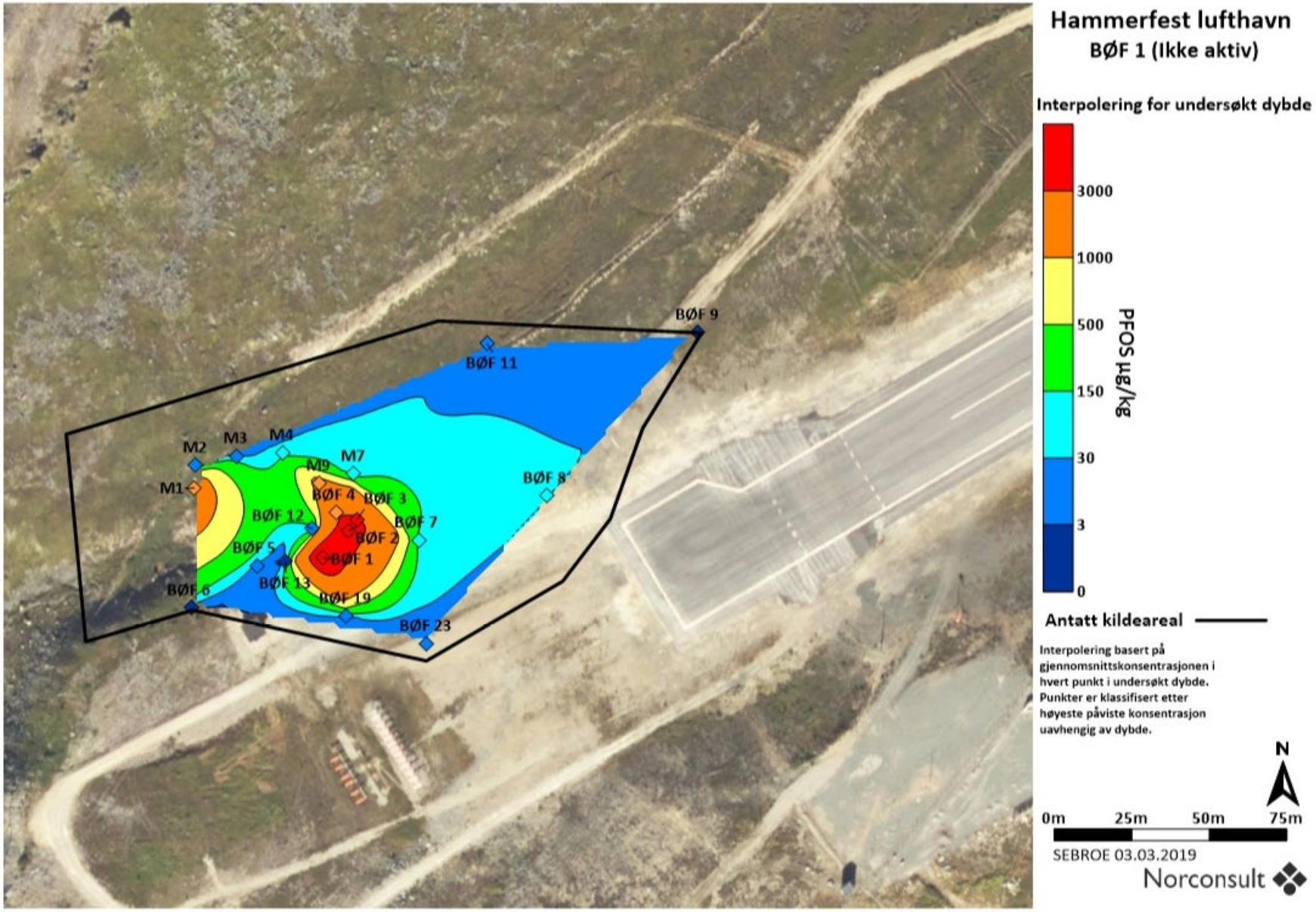
PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

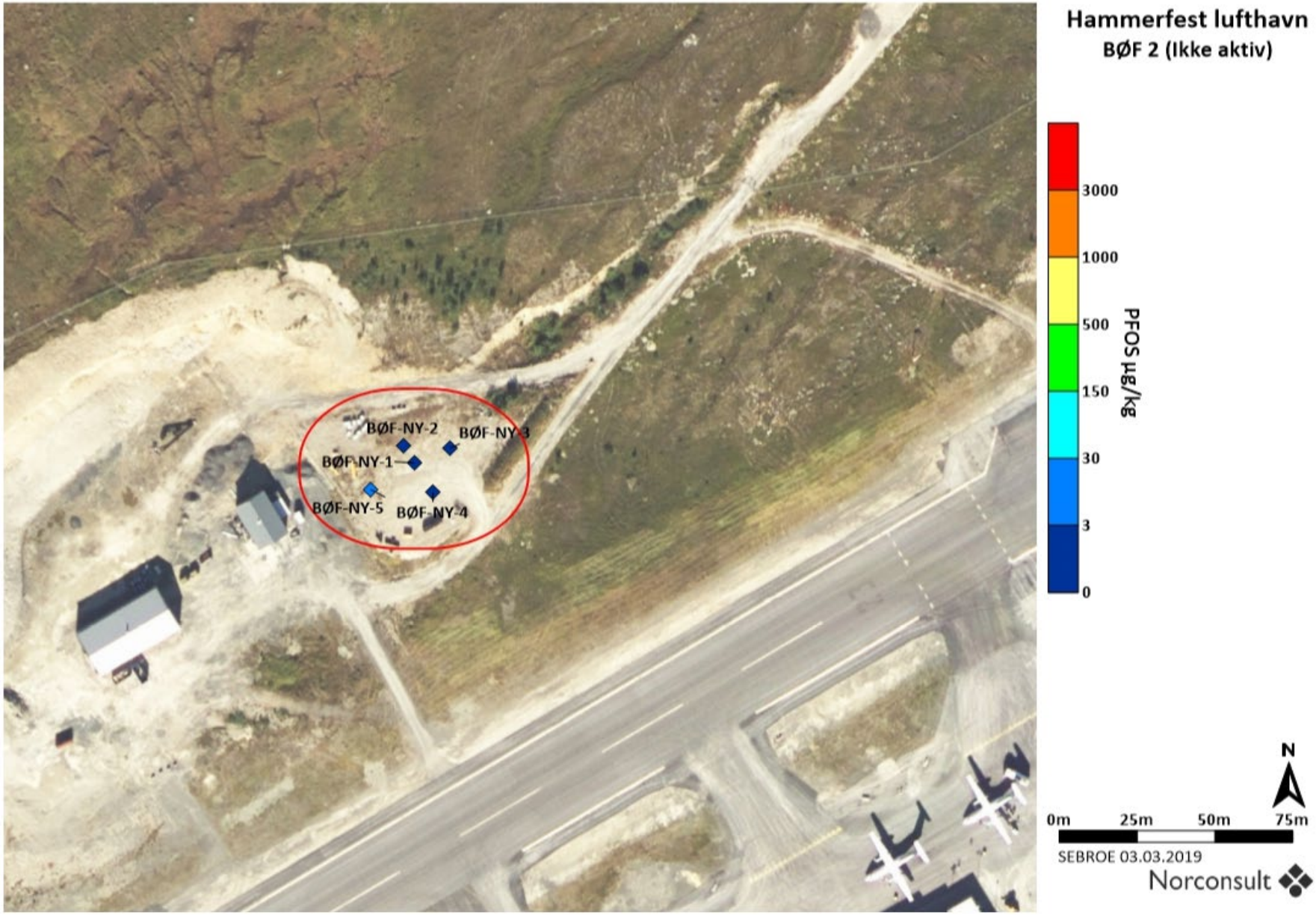
PFOS ferskvann (ug/l)
- <0.002-0.3
- 0.3-1.0
- >1.0
- Ikke analysert

* PFOS er dominerende parameter

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Hammerfest lufthavn
BØF 1 (Ikke aktiv)
Interpolering for 0-1 meters dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i 0-1 meters dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m 25m 50m 75m
SEBROE 03.03.2019
Norconsult
BØF 9
BØF 11
M2
M3
M4
M7
M9
M1
BØF 4
BØF 3
BØF 8
BØF 12
BØF 7
BØF 13
BØF 2
BØF 1
BØF 5
BØF 6
BØF 19
BØF 23


Hammerfest lufthavn
BØF 1 (Ikke aktiv)
Interpolering for undersøkt dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m 25m 50m 75m
SEBROE 03.03.2019
Norconsult
BØF 9
BØF 11
M2
M3
M4
M7
M9
M1
BØF 8
BØF 4
BØF 3
BØF 12
BØF 7
BØF 2
BØF 5
BØF 1
BØF 13
BØF 6
BØF 19
BØF 23


Hammerfest lufthavn
BØF 2 (Ikke aktiv)
BØF-NY-2
BØF-NY-3
BØF-NY-1
BØF-NY-5
BØF-NY-4
3000
1000
500
150
30
3
0
PFOS µg/kg
N
0m
25m
50m
75m
SEBROE 03.03.2019
Norconsult

9.1 Fire training site (BØF)/contaminated site

Fire training site (BØF)/contaminated site	BØF 1 (old)	BØF 2 (inactive)
	BØF 1 was established during the 1990s, but was taken out of use around 2006 (or earlier). BØF 1 is located at the western end of the runway.	This was established in 2011/2012 and was in operation during sampling in June 2012, but it is stated in the DP2 report that it will cease to be used in the future. Furthermore, the report also notes that the airport has stated that only the municipal fire service has conducted drills at BØF 2. No information is available concerning the type of fire drill or the foam type used. BØF 2 is located approx. 60 meters north of the runway.

9.2 Use of PFOS and other PFAS

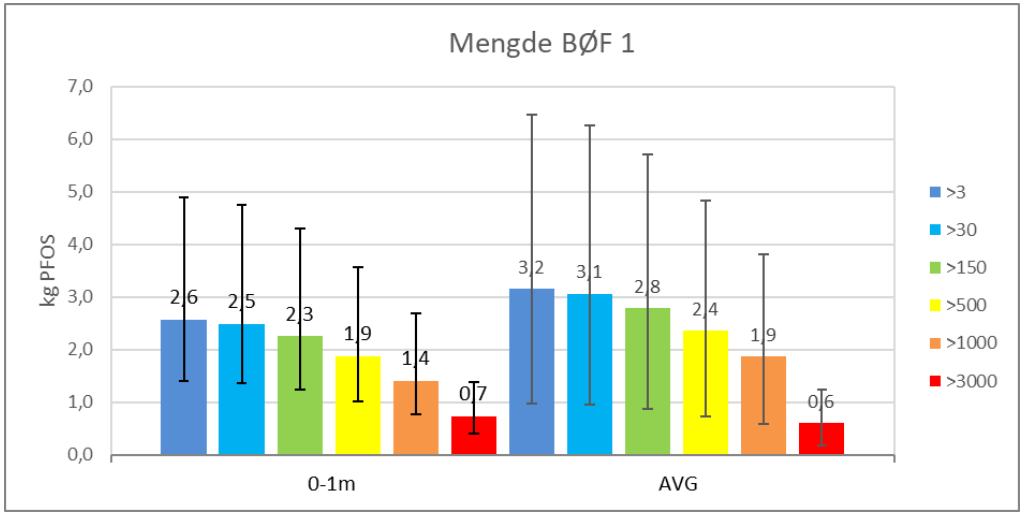
Volume of PFOS used at the site (kg)	Not stated/calculated	Not stated/calculated
Comments/uncertainty		
Volume of PFAS used at the site (kg)	Not stated/calculated	Not stated/calculated
Comments/uncertainty		Avinor completely phased out firefighting foam containing PFAS in 2012 and now uses only PFAS-free firefighting foam.

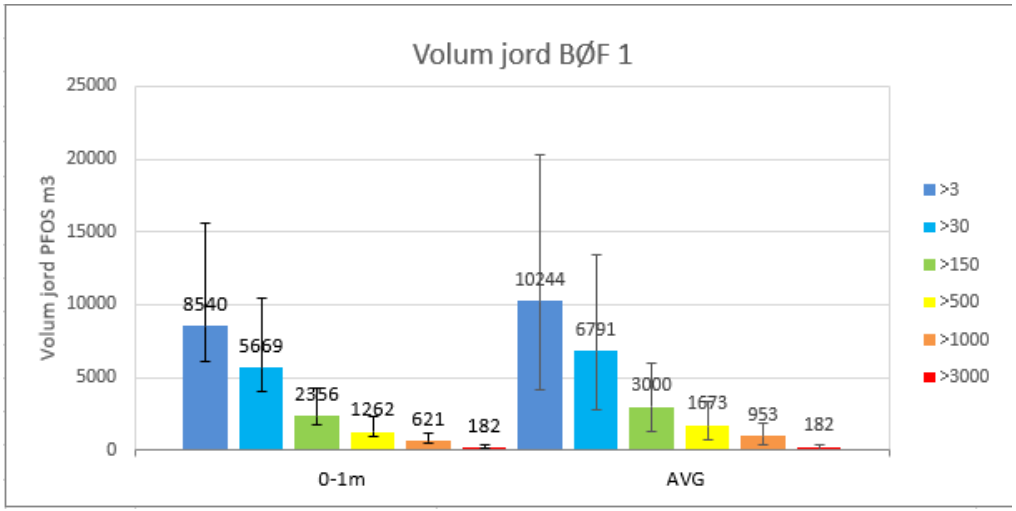
9.3 Soil sampling

Fire training site (BØF)/contaminated site	BØF 1 (old)	BØF 2 (inactive)
Total number of soil samples	24	5
Comments/uncertainty (e.g. 95% of the samples were taken from 0-0.1 m)	16 of the samples were taken from 0-0.1 m, and four of the samples were taken from 0-0.2 m. Four of the samples were taken from bedrock which was encountered at depths ranging between 1.2 and 1.9 m. No samples were taken in the interval 0.2-1.2 m.	Only surface samples were taken (0-0.1 m)
Number of soil samples 0-1 m below ground level	20	5
Number of soil samples under 1 m	4	0
Comments/uncertainty	The material is stated as consisting of agricultural soil, sand, aggregate, boulders, blasted rock, peat and some soil.	The material is stated as consisting of aggregate, sand and gravel fill.
Highest measured soil concentration of PFOS µg/kg	7,960	3.7
Where	BØF 1-1 (0-0.1 m) The material consists of agricultural soil and sand	BØF-NY-5 (0-0.1 m) The material consists of aggregate, sand and gravel fill
Highest measured soil concentration of PFAS µg/kg	7,982	3.7
Where	BØF 1-1 (0-0.1 m) The material consists of agricultural soil and sand	BØF-NY-5 (0-0.1 m) The material consists of aggregate, sand and gravel fill
Comments/uncertainty	All the samples were analysed for PFOS and PFOA. None of the samples were analysed for other PFAS compounds.	Only PFOS was detected in sample BØF-NY-5. All samples were analysed for 11 PFAS compounds. None of the other 10 PFAS compounds were detected in any of the samples collected at BØF 2.

9.4 Quantity calculation

PFOS average for all depths and points > 3 µg/kg		Not calculated for BØF 2
Concentration (µg/kg)	343	
Area (m2)	8,537	
Quantity of soil (tonnes)	15,367	
Quantity of PFOS (kg)	3.2	
Uncertainty -	2.2	
Uncertainty +	3.3	
PFOS average for all depths and points > 30 µg/kg		
Concentration (µg/kg)	502	
Area (m2)	5,659	
Quantity of soil (tonnes)	10,186	
Quantity of PFOS (kg)	3.1	
Uncertainty -	2.1	
Uncertainty +	3.2	
PFOS average for all depths and points > 150 µg/kg		
Concentration (µg/kg)	1,036	
Area (m2)	2,500	
Quantity of soil (tonnes)	4,500	
Quantity of PFOS (kg)	2.8	
Uncertainty -	1.9	
Uncertainty +	2.9	
PFOS average for all depths and points > 500 µg/kg		
Concentration (µg/kg)	1,570	
Area (m2)	1,394	
Quantity of soil (tonnes)	2,509	
Quantity of PFOS (kg)	2.4	
Uncertainty -	1.6	
Uncertainty +	2.5	





PFOS average for all depths and points > 1000 µg/kg		
Concentration (µg/kg)	2,176	
Area (m2)	794	
Quantity of soil (tonnes)	1,429	
Quantity of PFOS (kg)	1.9	
Uncertainty -	1.3	
Uncertainty +	1.9	
PFOS average for all depths and points > 3000 µg/kg		
Concentration (µg/kg)	3,718	
Area (m2)	152	
Quantity of soil (tonnes)	274	
Quantity of PFOS (kg)	0.6	
Uncertainty -	0.4	
Uncertainty +	0.6	

	BØF 1 (old)	BØF 2 (inactive)
Comments regarding calculations of volume	In the DP2 report, it is calculated that 3,377 g of PFOS and 20 g of PFOA remain in the ground at BØF 1. This assumes that the most contaminated area lies within an area of 30 x 30 metres, and that the thickness of the contaminated material is 2 metres.	No calculations have been performed of how much PFOS/PFAS is left in the ground, as only a low concentration of PFOS was detected at one of the points.
Is the extent of the contaminated area limited horizontally?	No, it may appear that there is dispersal towards the west which has not been delimited. PFOS has been detected at concentrations above the detection limit at all of the sampled points, but concentrations of/below 3 µg/kg have been detected at the extreme points BØF 6 to the west, BØF 23 to the south, and BØF 9 to the northeast. The extreme points to the north (BØF 11 and M3) had concentrations below 20 µg/kg, while the extreme point (BØF 8) to the east has 40 µg/kg.	PFOS has only been detected above the detection limit at one point, BØF-NY-5, in BØF 2. It is possible that this contamination has a horizontal distribution to the north, south or west, but because a concentration of only 3.7 µg/kg has been detected, it is assumed that the distribution will be limited.
Is the extent of the contaminated area limited vertically?	BØF is located on top of fill material which was laid over a number of bedrock knolls in order to level the terrain. Bedrock has been encountered at varying depths in the shafts, at depths of between 1.2 and 1.9 metres. The thickness of the unconsolidated sediment is therefore assumed to be limited to a maximum of approx. 2 metres at the BØF. The marsh area to the west is about 2-3 metres lower in the terrain, and the terrain further to the west dips relatively steeply towards the sea (which is about situated 300 metres west). From the DP2 report: after assessing the overall picture, we can conclude that the PFOS contamination at the old fire training site in Hammerfest is moving downwards (understood as in the depth profile) at varying rates, without the rate of movement being related to specific soil types.	No, no samples have been taken at depths exceeding 0.1 m below ground level. However, the DP2 report concludes that "there is no reason to believe that there is more contamination in deeper layers". This is believed to be linked to information in the report that the subsoil consists of a layer of fill layer with gravel and aggregate layers, as well as blasted rock, and lies on bedrock. In this type of material, the contamination will leach out rapidly.

9.5 Water sampling and annual dispersal

	BØF 1 (old)	BØF 2 (inactive)
Have water samples been taken?	Yes	Yes
Where	Water infiltration from the BØF area flows out into a marshland just west of the BØF. From there, the water drains to a small stream (uncertain whether this is what is also referred in the report to as a 'ditch with leachate'), which occasionally runs dry. One sample of ditch water has been taken just west of the BØF. This was not flowing water.	Sample of water which flows out of the southern slope down from BØF 2.
Highest measured concentration in groundwater PFOS (ng/l)	No groundwater samples were taken	No groundwater samples were taken
Where	-	
Highest measured concentration in groundwater PFAS (ng/l)	No groundwater samples were taken	No groundwater samples were taken
Where	-	
Comments/uncertainty		
Highest measured concentration in surface water PFOS (ng/l)	11,000	34.5
Where	BØF-GA-VP1	BØF-NY-VP1
Highest measured concentration in surface water PFAS (ng/l)	12,300	48.1
Where	BØF-GA-VP1	BØF-NY-VP1
Comments/uncertainty	Only this one water sample was taken near BØF 1. The sample was analysed for 11 PFAS compounds. Concentrations above the detection limit were detected for all of the compounds, except PFDA. It is by far the highest concentration of PFOS.	Only one water sample was taken adjacent to BØF 2. The sample was analysed for 11 PFAS compounds. Only PFHxA, PFOS and PFPeA were detected in the sample above the detection limit.
Total annual dispersal from the site PFOS (g/year)	1.3	Not calculated
Total annual dispersal from the site PFAS (g/year)	1.4	Not calculated
To which recipient	Rypefjorden (final recipient)	

Calculated from water or soil concentration.	Water concentration	
	The quantity of PFAS dispersed was calculated for PFOS, PFOA and 6:2 FTS only. In the groundwater flow direction, the recipients are marshland, streams and Rypefjord, in the aforementioned order. There is little or no surface runoff from the BØF.	

9.6 Biota sampling

Have biota samples being taken at the airport?	No	No
What kind of biota?		
How many samples?		
Highest measured concentration of PFOS in biota (µg/kg wet weight)		
Where		
Highest measured concentration of PFAS in biota (µg/kg wet weight)		
Where		
Median concentration in comparable populations (e.g. in a lake)		
Comments/references		
References and concentrations in other reports.		

9.7 Uncertainty and other factors

	BØF 1 (old)	BØF 2 (inactive)
Does the estimate of the quantity of PFOS in the ground correspond with the concentrations measured in water and biota?	The high concentrations in leachate are associated with the high concentrations in the soils, which apparently have a high degree of leaching. However, only one water sample was taken, and there is insufficient basis for assessing leaching with any certainty. Nor have biota samples been taken which can be assessed.	No estimate has been made of the quantity of PFOS in the ground.

Evaluations	Moderate to strong contamination has been detected in the soil samples taken from BØF 1, and the water sample shows that dispersal is taking place via leachate just west of the BØF. However, there is only one water sample,, and no water samples have been collected further away from the BØF. It is therefore uncertain how and to what extent dispersal will continue to the west. It is approx. 300 metres to the sea with relatively steep terrain.	Low concentrations of PFAS have been detected in the soil samples taken from BØF 2 and in the water sample taken directly downstream. There is a high probability that the contamination detected in the water sample originates from BØF 2.

Comments/uncertainty (Could there be any additional unknown sources of PFOS at the site with runoff to the recipient?)	The conclusion in the DP2 report states that there may be an older BØF southwest of the parking stand, by snow depot 2. The precise location of this is not known. In the DP2 survey, PFOS was detected in the soil and in ditch water in this area. In the sample of ditch water (SDP-V-VP1) taken adjacent to snow depot 2, a concentration of PFOS of 113 ng/l and PFAS of 140 ng/l was detected. One composite sample of soil from snow depot 2 was analysed, which showed a concentration of 18.6 µg/kg PFOS in the soils. The concentrations may be due to the fact that fire drills were carried out in this area. If snow containing PFAS has been dumped at this snow depot, this may also have led to dispersal into the ground and on to groundwater. No PFAS above the detection limit was detected in the water sample (SDP-Ø-VP1) taken at snow depot 1. In autumn 2018, an environmental survey was conducted in conjunction with the construction of a new helicopter parking stand. Analyses were then carried out on 27 soil samples taken from west of the terminal area, which includes the area at snow depot 2 and slightly further south of it. PFOS concentrations above the detection limit were detected at all extreme points. PFOS concentrations lay between 0.13 µg/kg - 250 µg/kg, while PFAS concentrations ranged between 3.9 µg/kg - 280 µg/kg. Nine of the soil samples had total PFAS concentrations of between 20 and 280 µg/kg. The contamination detected in the terminal area may be the older BØF to which the DP2 report refers. In connection with the helicopter parking stand, material with a concentration above 20 µg/kg has been moved to an temporary storage facility. No PFAS was detected above the detection limit in sample BEKK-VP3, which was taken from the stream at the outlet of Mellomvannet. Sample BEKK-VP2 was taken where the discharge water from the airport flows into this stream (also downstream of snow depot 2), and has a concentration of PFOS of 507 ng/l and PFAS of 599 ng/l. Sample BEKK-VP1 was taken from the same stream, but slightly further downstream (also downstream of snow depot 2). In this sample, a concentration of PFOS of 43.4 ng/l and PFAS of 65.2 ng/l was detected. Samples BEKK-VP1 and BEKK-VP2 were situated relatively far away from BØF 1. It is likely that the soil contamination detected west of the terminal area leaches into the stream via groundwater, and causes or contributes to the contamination in these water samples. The stream partly flows in drains and probably flows out into Rossmolbukta.	See the description for BØF 1. Samples BEKK-VP1 and BEKK-VP2 have higher concentrations than sample BØF-NY-VP1 from BØF 2, so there is reason to believe that there is another source of contamination in these water samples. As no PFAS was detected in sample BEKK-VP3, it is likely that the soil contamination detected west of the terminal area is leached out into the stream via groundwater, and causes or contributes to the contamination in these water samples. This may be the older BØF to which the DP2 report refers.

Has the site been sufficiently mapped with a view to assessing the order of priority?	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the quantity of PFOS in the soil with the stipulated level of uncertainty.	Five surface samples have been taken distributed across the BØF. The soil and water samples indicate that there are small quantities of PFOS in the ground, and the site will not be prioritised for measures regarding PFOS based on a cost-benefit perspective (see this report for parts 1 and 2, section 2.1.1.6 and section 2.1.3.1).

Comments/uncertainty	No soil samples have been analysed for compounds other than PFOS and PFOA. No soil samples were taken at depths of between 0.2 and 1.2 metres. There is therefore some uncertainty regarding the extent of contamination in this layer.	The deeper lying layers have not been studied. In the DP2 report, these are referred to as coarse material with a high degree of leaching.
General information about the airport		

Other factors of significance to possible clean-up/implementation of measures (e.g. planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	Several species of high and particularly high management interest have been recorded around the airport. The habitat type "mountainous lime-rich areas" has been recorded southeast of the runway. At BØF 1, THC in environmental condition classes 2-3 was demonstrated in eight of the samples (seven from top soil and one from material at a depth of 120 cm), as well as one sample in environmental condition class 4 taken from a depth of 0-10 cm. As described above, nine of the soil samples taken during the ground survey west of the terminal area in 2018 contained total PFAS concentrations of between 20 and 280 µg/kg. In connection with the initiative relating to the new helicopter parking stand, the County Governor of Finnmark applied for permission to temporarily store up to 1170 m^3 of material with a PFAS concentration of between 20-280 µg/kg in a quarry north of the runway. The temporary storage facility was to be constructed with an underlying sand/gravel cushion before an impermeable membrane, followed by an impermeable membrane over the PFAS material. Avinor was granted permission for this storage facility. Materials with a concentration of below 20 µg/kg have been left at the helicopter parking stand.

10 Hasvik Airport



Hasvik lufthavn (ENHK)

Oversiktskart inkl. brannøvingsfelt

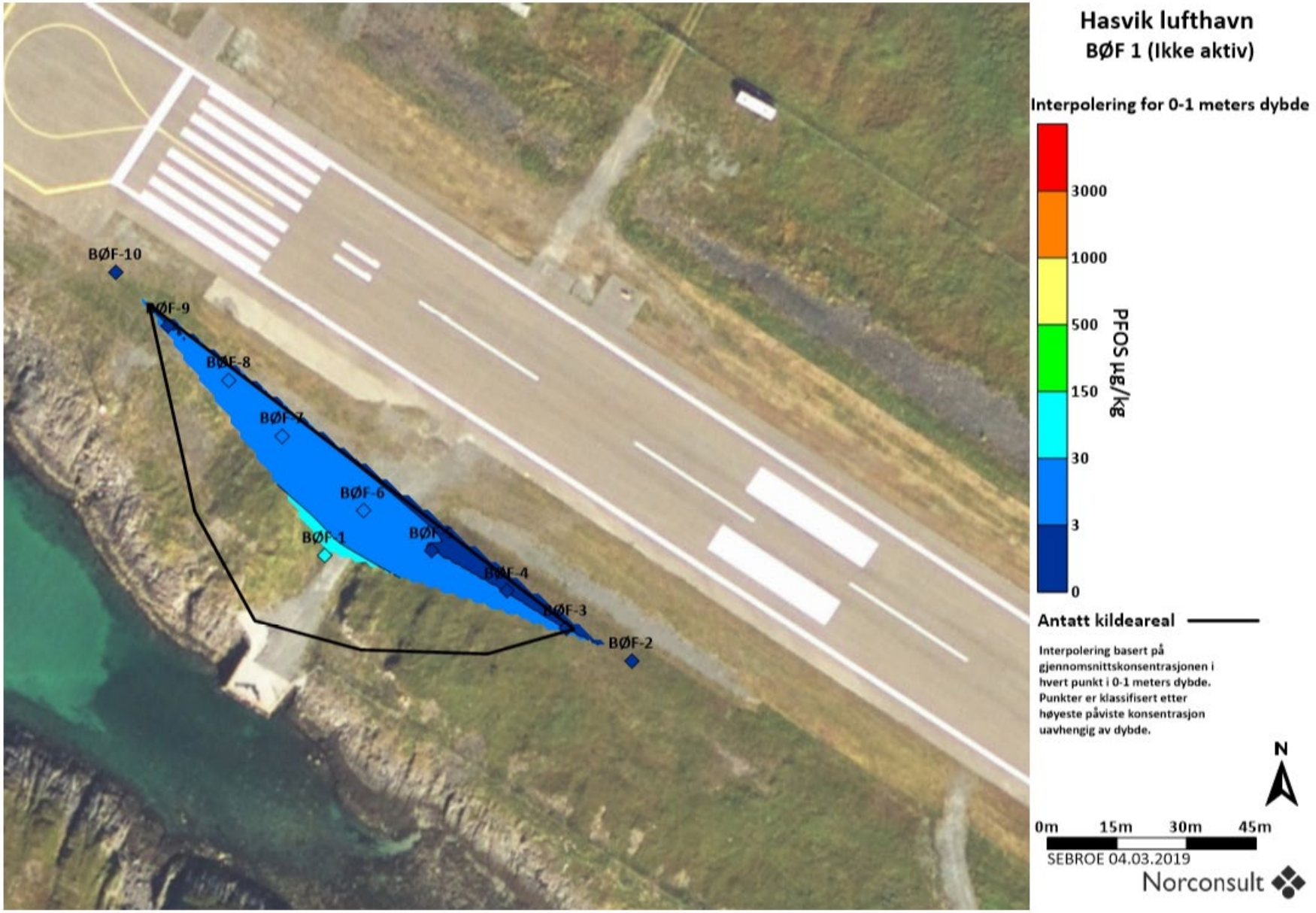
PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

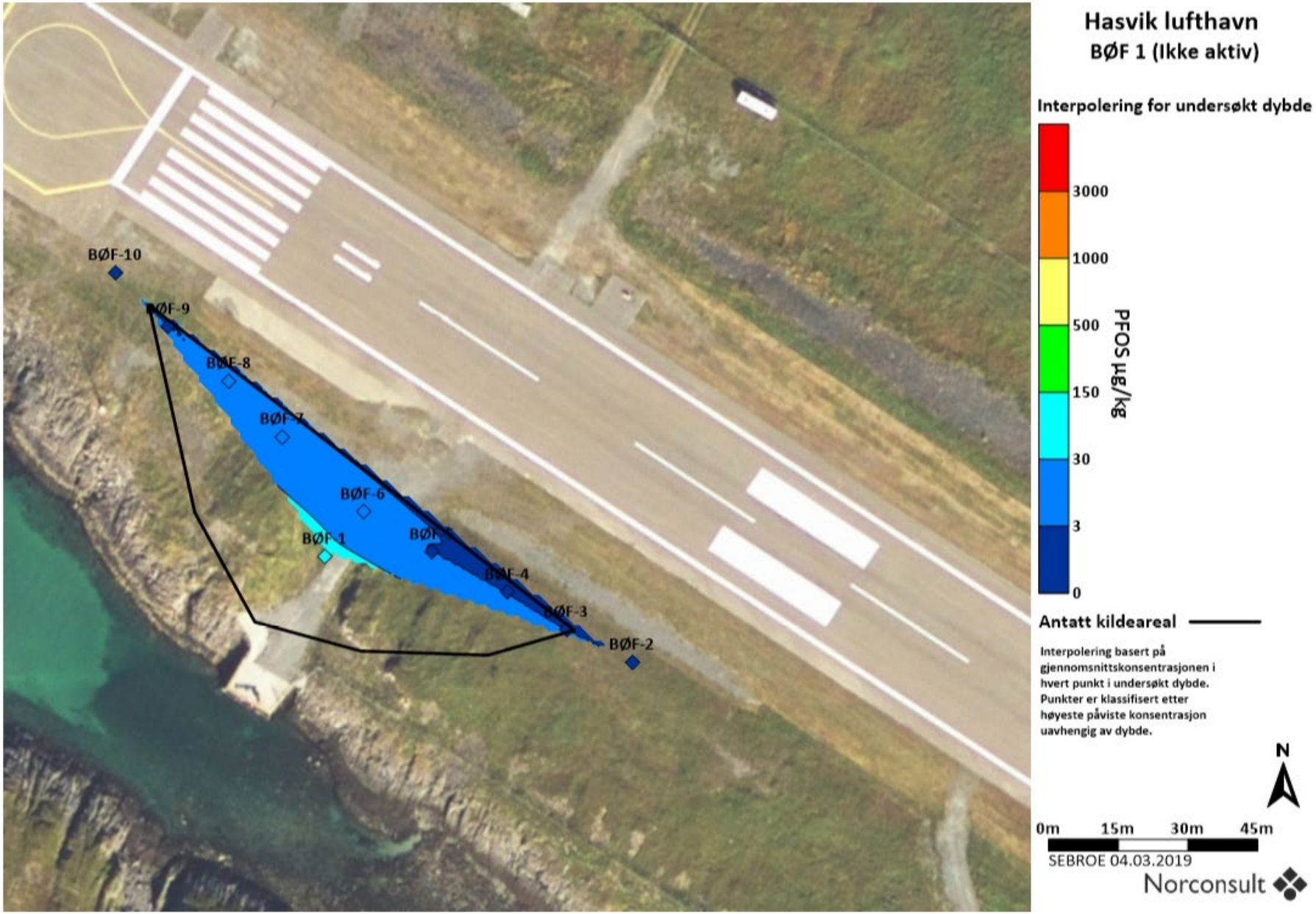
Mrk. varierende skala for x-aksen i diagrammene

* PFOS er dominerende parameter

ip = ikke påvist

AVINOR COWI SWECO


Hasvik lufthavn
BØF 1 (Ikke aktiv)
Interpolering for 0-1 meters dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i 0-1 meters dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m 15m 30m 45m
SEBROE 04.03.2019
Norconsult
BØF-10
BØF-9
BØF-8
BØF-7
BØF-6
BØF-1
BØF-4
BØF-3
BØF-2



Hasvik lufthavn
BØF 1 (Ikke aktiv)

Interpolering for undersøkt dybde

3000
1000
500
150
30
3
0

PFOS µg/kg

Antatt kildeareal

Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.

N

0m 15m 30m 45m

SEBROE 04.03.2019

Norconsult

10.1 Fire training site (BØF)/contaminated site

Fire training site (BØF)/contaminated site	BØF 1 (old)
	Hasvik Airport was constructed in 1983, as a gravel ambulance strip. The runway was paved in 1995. No information is available on when the fire training site was established, but the site was closed in the middle of the 20th century.

10.2 Use of PFOS and other PFAS

Volume of PFOS used at the site (kg)	Not stated/calculated
Comments/uncertainty	
Volume of PFAS used at the site (kg)	Not stated/calculated
Comments/uncertainty	-

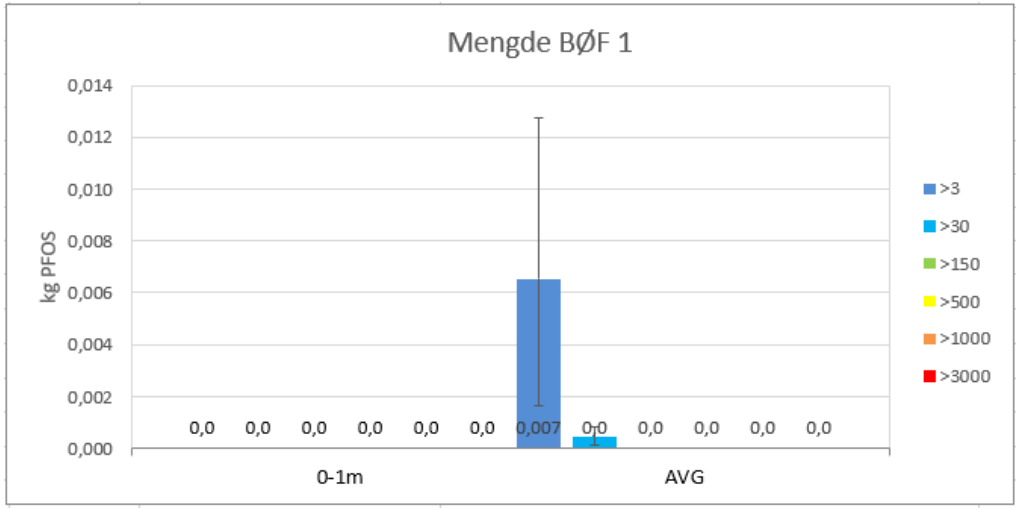
10.3 Soil sampling

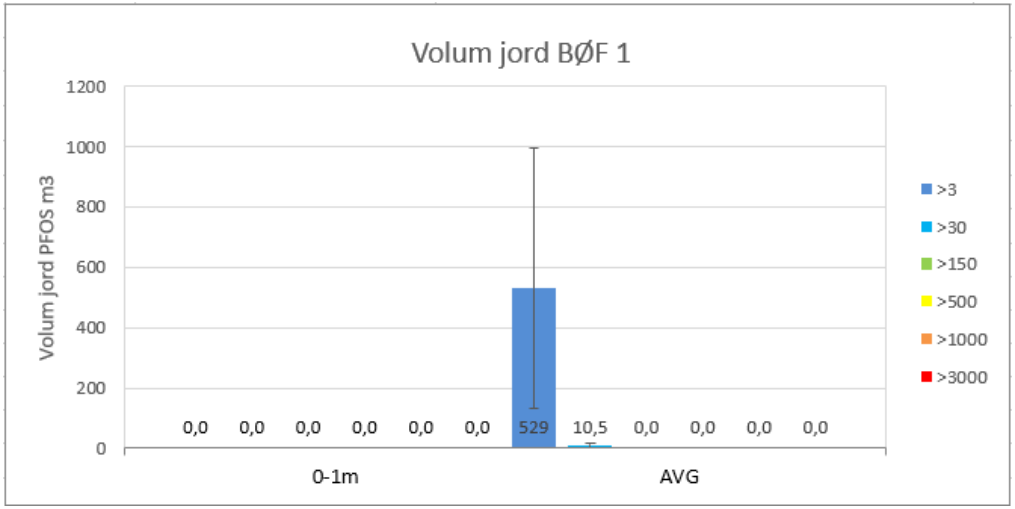
Total number of soil samples	12
Comments/uncertainty (e.g. 95% of the samples were taken from 0–0.1 m)	It was not possible to excavate many shafts because the fire training site is mainly located on exposed bedrock. The prevailing wind direction is parallel to the runway. Therefore, the sampling (surface samples) was expanded parallel along the runway to delimit possible PFOS dispersal. No samples were taken from depths exceeding 50 m. One shaft was excavated (BØF-1, down to a depth of 0.5 m) and 10 surface samples were taken.
Number of soil samples 0-1 m below ground level	12
Number of soil samples under 1 m	0
Comments/uncertainty	The material in the surface samples is described as consisting of sandy soil layers above bedrock. In the shaft, the material consisted of sand and gravel with blasted rock.
Highest measured soil concentration of PFOS µg/kg	46.8
Where	BØF1-1 (0-0.1 m). The material consists of sand (fill)
Highest measured soil concentration of PFAS µg/kg	52.8
Where	BØF1-1 (0-0.1 m). The material consists of sand (fill)

Comments/uncertainty	The samples were only analysed for PFOS/PFOA

10.4 Quantity calculation

PFOS average for all depths and points > 3 µg/kg	
Concentration (µg/kg)	10
Area (m2)	1,057
Quantity of soil (tonnes)	898
Quantity of PFOS (kg)	0.007
Uncertainty -	0.005
Uncertainty +	0.006
PFOS average for all depths and points > 30 µg/kg	
Concentration (µg/kg)	34
Area (m2)	21
Quantity of soil (tonnes)	18
Quantity of PFOS (kg)	0.0004
Uncertainty -	0.0003
Uncertainty +	0.0004
PFOS average for all depths and points > 150 µg/kg	
Concentration (µg/kg)	
Area (m2)	
Volume of soil (tonnes)	
Volume of PFOS (kg)	
Uncertainty -	
Uncertainty +	
PFOS average for all depths and points > 500 µg/kg	
Concentration (µg/kg)	
Area (m2)	
Volume of soil (tonnes)	
Volume of PFOS (kg)	
Uncertainty -	





Uncertainty +	

PFOS average for all depths and points > 1000 µg/kg	
Concentration (µg/kg)	
Area (m2)	
Volume of soil (tonnes)	
Volume of PFOS (kg)	
Uncertainty -	
Uncertainty +	
PFOS average for all depths and points > 3000 µg/kg	
Concentration (µg/kg)	
Area (m2)	
Volume of soil (tonnes)	
Volume of PFOS (kg)	
Uncertainty -	
Uncertainty +	

Comments regarding calculations	In the DP2 report, it is estimated that the contaminated area where there is unconsolidated material measures approx. 80 x 20 metres, with an average depth of 0.3 m. The residual quantities of PFOS have been calculated at 18 g and the residual quantity of PFOA has been calculated at 3 g in this area.
Is the extent of the contaminated area limited horizontally?	The contaminated area is apparently delimited to the northwest (BØF 9 and 10) and southeast (BØF 2, 3, 4, and 5), as samples taken from these points are below the detection limit. Only concentrations above 30 µg/kg have been detected at one point in the survey area (BØF 1). The area with concentrations above 30 µg/kg has not been delimited, but there is sea approx. 20 metres to the south, and BØF 6 to the north has 3.7 ug/kg.
Is the extent of the contaminated area limited vertically?	Yes. There is bedrock at a depth of approx. 0.5 m.
Comments/uncertainty	

10.5 Water sampling and annual dispersion

Have water samples been taken?	No
Where	
Highest measured concentration of PFOS in groundwater (ng/l)	
Where	
Highest measured concentration of PFAS in groundwater (ng/l)	
Where	
Comments/uncertainty	
Highest measured concentration of PFOS in surface water (ng/l)	
Where	
Highest measured concentration of PFAS in surface water (ng/l)	
Where	
Comments/uncertainty	
Total annual dispersal of PFOS from the site (g/year)	Not calculated
Total annual dispersal of PFAS from the site (g/year)	< 1
To which recipient	Rottvågen
Calculated from water or soil concentration	Not calculated, only estimated in the DP2 report*
	From the DP2 report: Based on experience and calculations from other airports, the discharge of PFC can be estimated to be significantly less than 1 g/year.

10.6 Biota sampling

Have biota samples being taken at the airport?	No
What kind of biota?	
How many samples?	
Highest measured concentration of PFOS in biota (µg/kg wet weight)	
Where	
Highest measured concentration of PFAS in biota (µg/kg wet weight)	
Where	

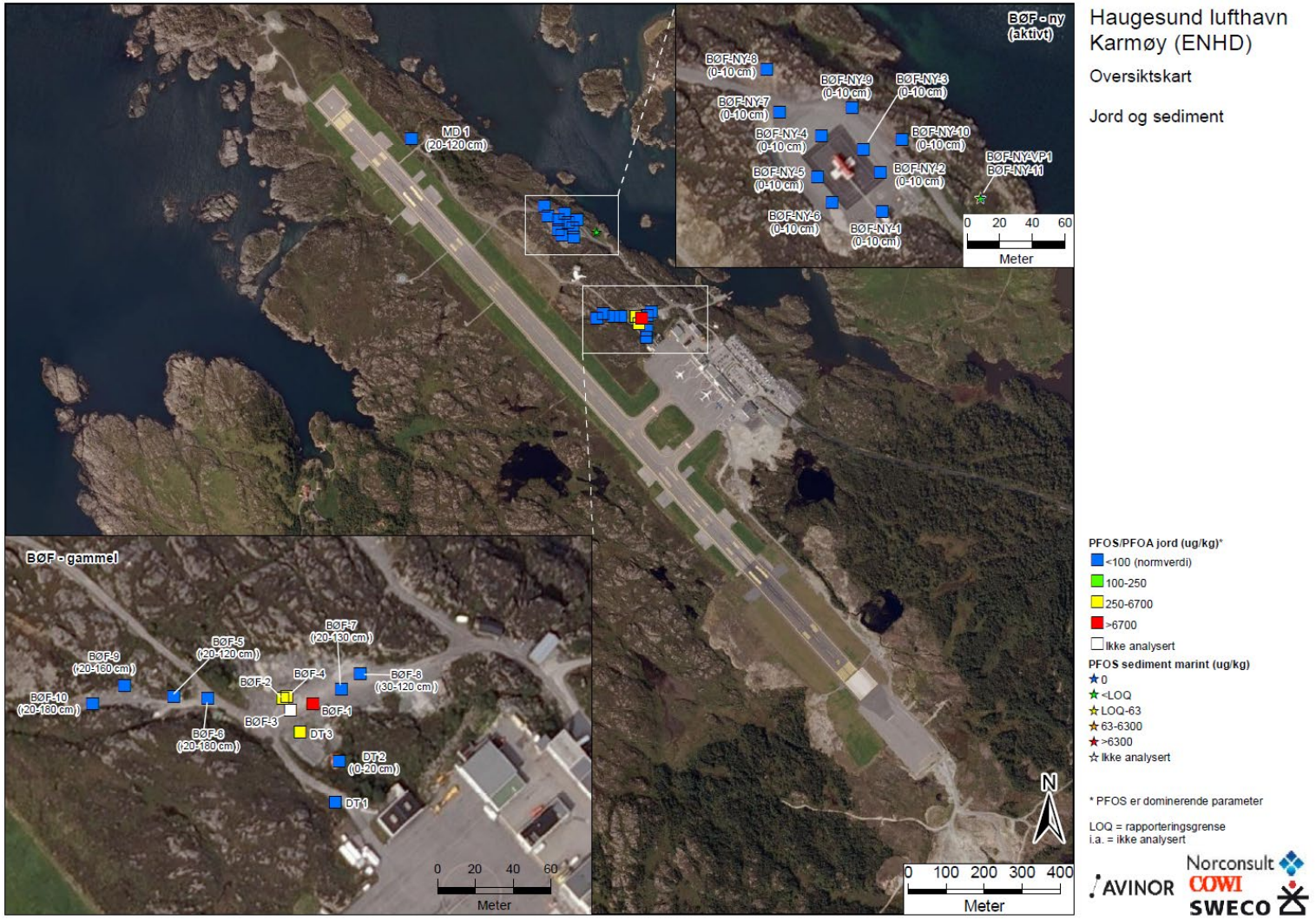
Median concentration in comparable populations (e.g. in a lake)	
Comments/references	
References and concentrations in other reports.	

10.7 Uncertainty and other factors

Does the estimate of the quantity of PFOS in the ground correspond with the concentrations measured in water and biota?	Cannot be assessed, as no samples of water or biota have been collected.
Evaluations	
Calculation	
Comments/uncertainty (Could there be any additional unknown sources of PFOS at the site with runoff to the recipient?)	It is not stated that there are additional sources of PFOS at the site or elsewhere at the airport, but the possibility cannot be ruled out.
Has the site been sufficiently mapped with a view to assessing the order of priority?	The site is considered to have been sufficiently well-mapped as regards PFOS to be considered in the order of priority, but PFOS was only detected in low concentrations in seven out of 12 samples (2.5-46.8 µg/kg). Three of the samples contained concentrations above 20 µg/kg. Calculated quantities are < 0.5 kg, and the site will therefore not be prioritised for measures based on a cost-benefit perspective (ref. this report for parts 1 and 2, section 2.1.1.6 and section 2.1.3.1).
Comments/uncertainty	Samples have only been taken in a northwesterly-southeasterly direction, due to the presence of extensive exposed bedrock in the area. No samples have been taken under the runway, which is situated northeast of the BØF. The runway was not paved until in 1995 (it is stated that the BØF was closed in the mid-1990s), which means that the BØF was probably in use for several years before the runway was paved. It cannot be ruled out that there may have been some dispersal of firefighting foam to the runway, which means that there may be some contamination in the gravel material beneath the runway.

Other factors of significance to possible clean-up/implementation of measures (e.g. planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	Hasvik Airport is located adjacent to Lopphavet, which is a proposed marine protected area. Rottvågen is part of this. Several habitat types have also been registered around the airport: At Rottvågen, in the general area of the BØF, mountainous lime-rich areas have been registered. There is a sand dune south of the runway. North of the runway is an area with fields and natural pasture. East of the runway, in Hasvik harbour, is Sanden, an important outdoor recreation area. Rottvågen in the west is registered as a resting area for wading birds, the area covers the end of the runway in the west. Hasvik Havn is located outside Avinor's site, but a pipeline from the airport extends out into the sea here. Hasvik harbour is registered as an overwintering site for ducks, particularly common eider and long-tailed duck. A number of species of high and particularly high management interest have been recorded in and around the airport (birds and plants). The dune meadows and dune heathland south of the runway are potential habitats for red-listed species of insects, mosses and fungi. The red-listed species Eurasian curlew (vulnerable - VU) nests at the airport. The airport site is a resting and overwintering area for many bird species of particularly high management interest.

11 Haugesund Airport, Karmøy



Haugesund lufthavn
Karmøy (ENHD)

Oversiktskart

Jord og sediment

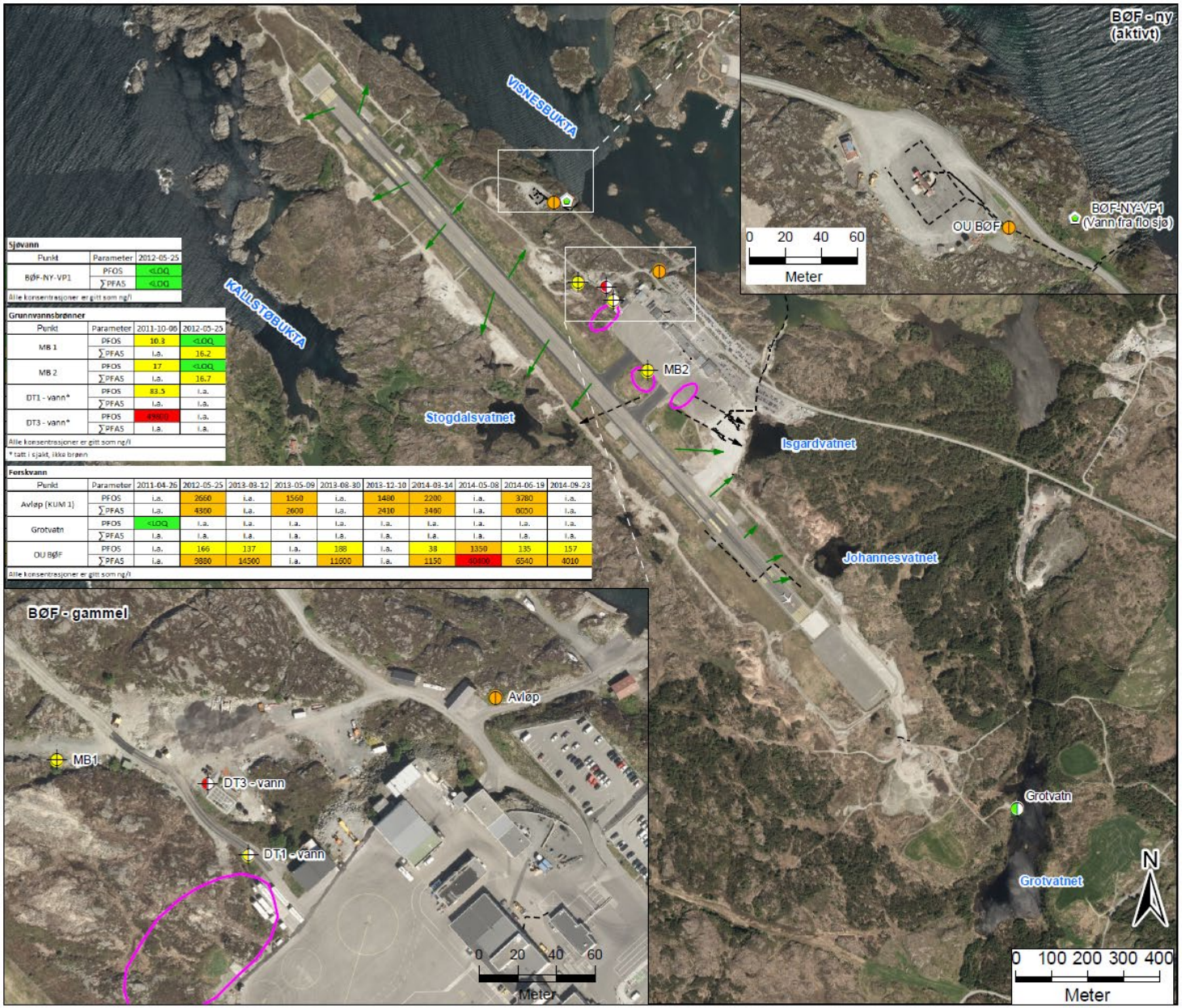
PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

PFOS sediment marint (ug/kg)
- 0
- <LOQ
- LOQ-63
- 63-6300
- >6300
- Ikke analysert

* PFOS er dominerende parameter

LOQ = rapporteringsgrense
i.a. = ikke analysert

AVINOR Norconsult COWI SWECO



Sjøvann

Punkt	Parameter	2012-05-25
BØF-NY-VP1	PFOS	<LOQ
	∑PFAS	<LOQ

Alle konsentrasjoner er gitt som ng/l

Grunnvannsbrønner

Punkt	Parameter	2011-10-06	2012-05-25
MB 1	PFOS	10.3	<LOQ
	∑PFAS	i.a.	16.2
MB 2	PFOS	17	<LOQ
	∑PFAS	i.a.	16.7
DT1 - vann*	PFOS	83.5	i.a.
	∑PFAS	i.a.	i.a.
DT3 - vann*	PFOS	49800	i.a.
	∑PFAS	i.a.	i.a.

Alle konsentrasjoner er gitt som ng/l
* tatt i sjakt, ikke brønn

Ferskvann

Punkt	Parameter	2011-04-26	2012-05-25	2013-03-12	2013-05-09	2013-08-30	2013-12-10	2014-03-14	2014-05-08	2014-06-19	2014-09-23
Avløp (KUM 1)	PFOS	i.a.	2660	i.a.	1560	i.a.	1480	2200	i.a.	3780	i.a.
	∑PFAS	i.a.	4300	i.a.	2600	i.a.	2410	3460	i.a.	6030	i.a.
Grotvatn	PFOS	<LOQ	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
	∑PFAS	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
OU BØF	PFOS	i.a.	166	137	i.a.	188	i.a.	38	1350	135	157
	∑PFAS	i.a.	9880	14500	i.a.	11600	i.a.	1150	49800	6540	4010

Alle konsentrasjoner er gitt som ng/l

Haugesund lufthavn Karmøy (ENHD)

Oversiktskart

Vann

PFOS / ∑ PFAS grunnvannsbrønn (ng/l) *
- Ikke analysert
- 0
- <LOQ
- LOQ-230
- 230-36 000
- >36 000

* Venstre halvdel = PFOS
Høyre halvdel = PFAS

PFOS / ∑ PFAS ferskvann (ng/l) *
- Ikke analysert
- 0
- <LOQ
- LOQ-230
- 230-36 000
- >36 000

* Venstre halvdel = PFOS
Høyre halvdel = PFAS

PFOS / ∑ PFAS sjøvann (ng/l) **
- Ikke analysert
- 0
- <LOQ
- LOQ-23
- 23-7 200
- >7 200

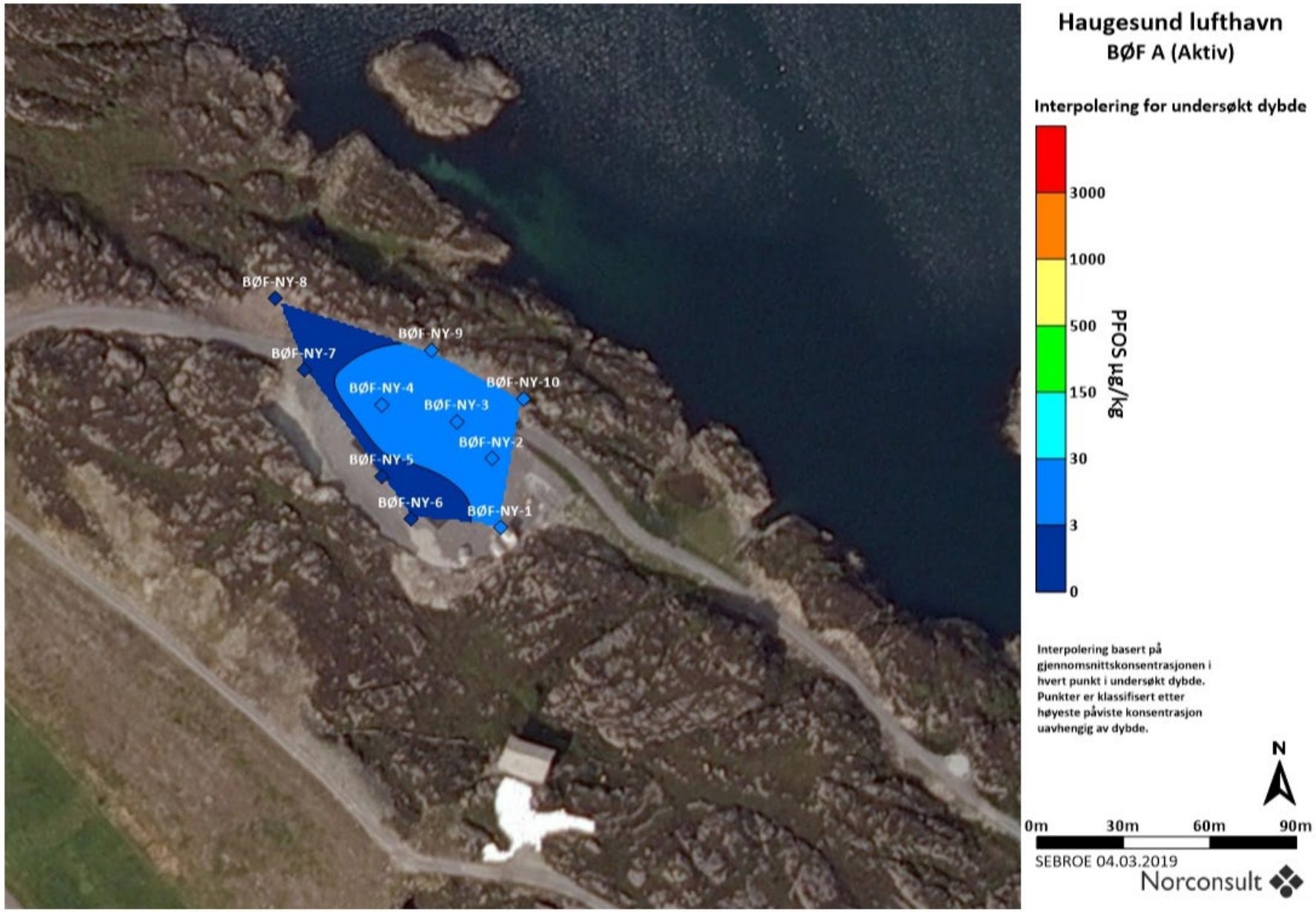
** Senter = PFOS
Ytre ramme = PFAS

Avlopsledning
- Avløp annet
- Avløp Felles
- Drensvann
- Glykolholdig overvann
- Glykolholdig spillvann
- Overvann
- Pumpespillvannsledning
- Spillvann

Avrenning
- Deponi glykolforurenset snø
- Overvannsledning
- Avrenningsveg glykol
- Bekkeresipient
- Overvannsystem
- Vannskille rullebane
- Antatt avrenningsveg baneavising

i.a. = ikke analysert
LOQ = rapporteringsgrense
(tilsv. ikke påvist for ∑PFAS)

AVINOR Norconsult COWI SWECO



Haugesund lufthavn
BØF A (Aktiv)

Interpolering for undersøkt dybde

3000
1000
500
150
30
3
0

PFOS µg/kg

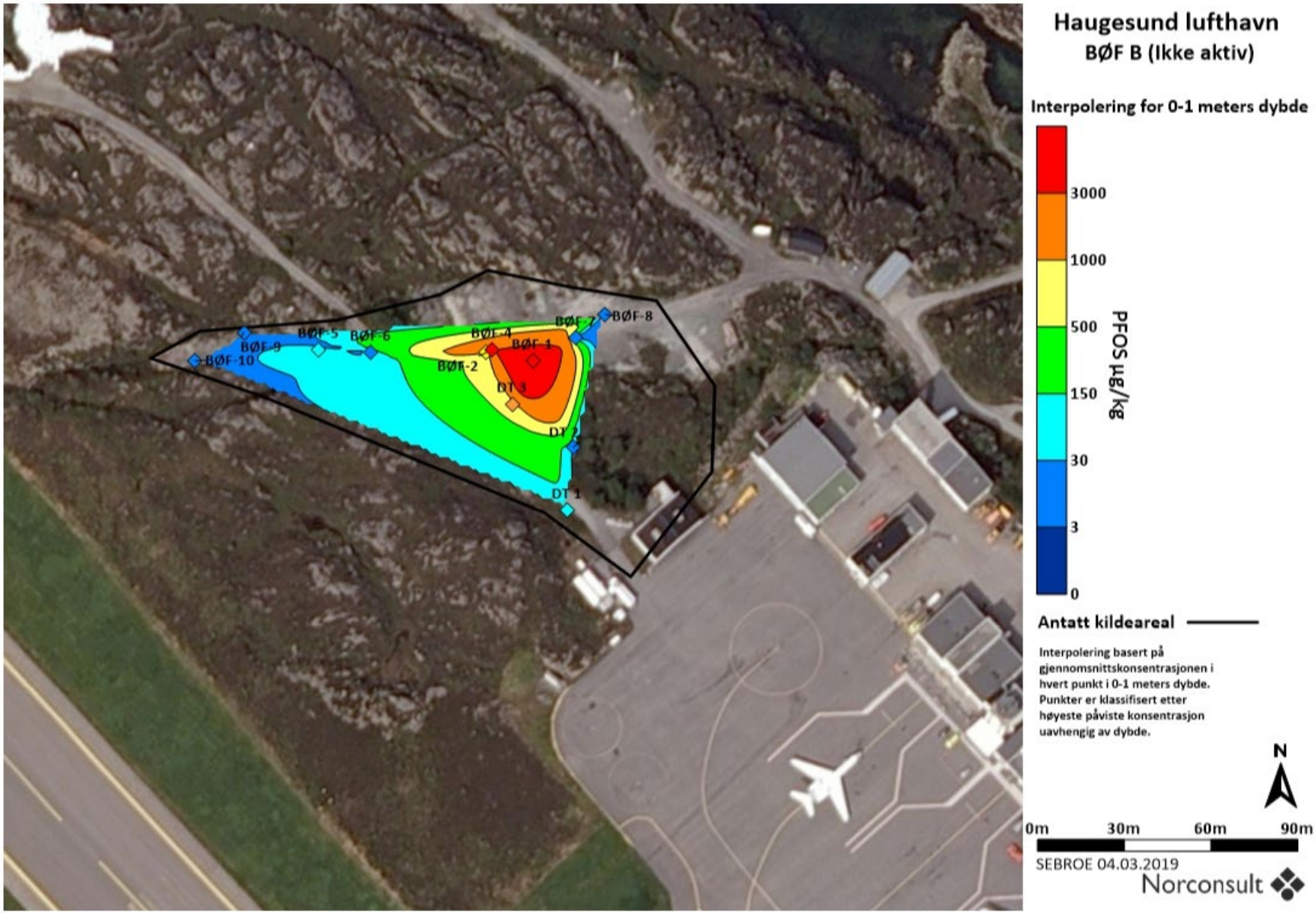
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.

N

0m 30m 60m 90m

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Haugesund lufthavn
BØF B (Ikke aktiv)

Interpolering for 0-1 meters dybde

PFOS µg/kg
3000
1000
500
150
30
3
0

Antatt kildeareal

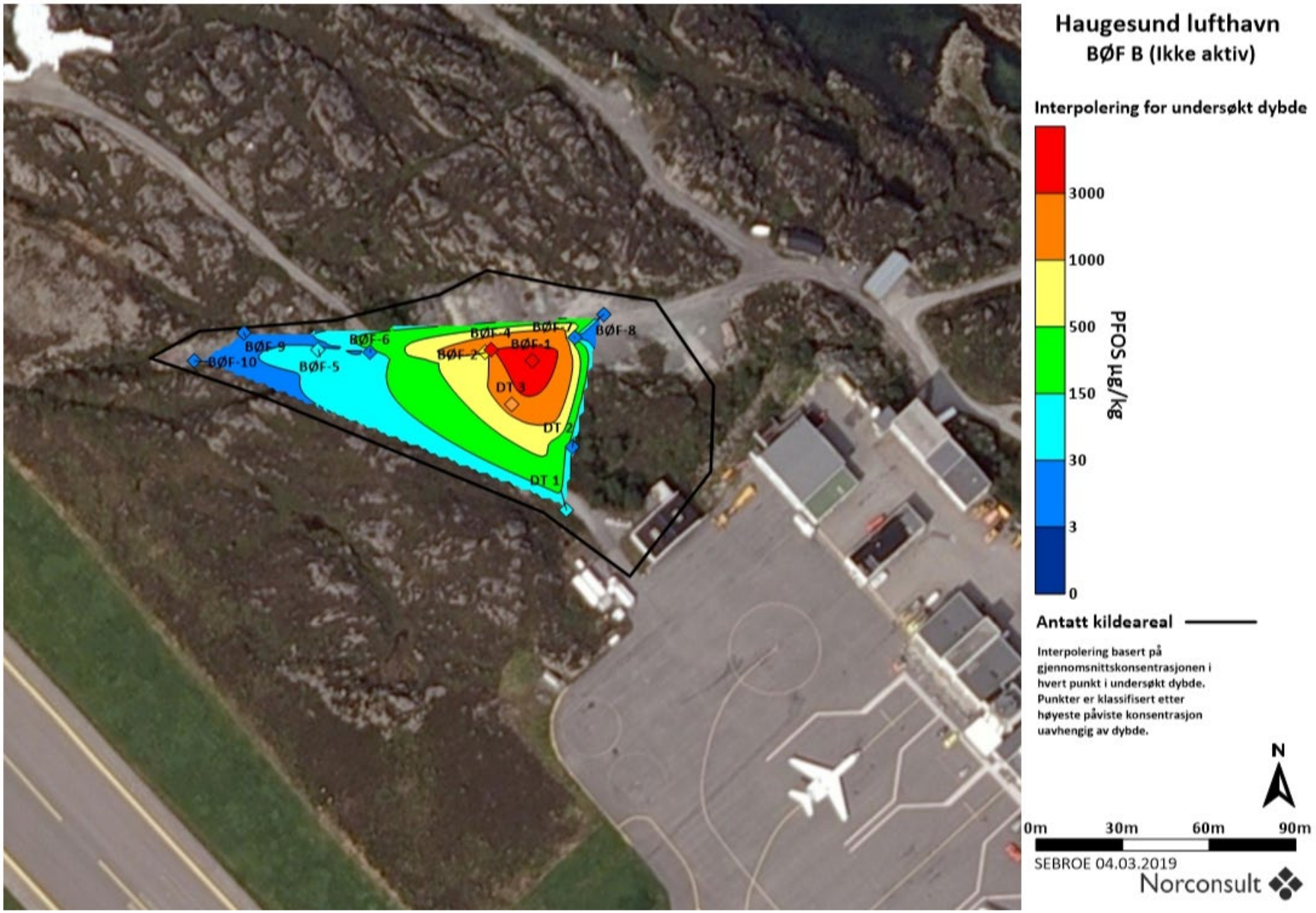
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i 0-1 meters dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.

N

0m 30m 60m 90m

SEBROE 04.03.2019

Norconsult



Haugesund lufthavn
BØF B (Ikke aktiv)

Interpolering for undersøkt dybde

PFOS µg/kg
3000
1000
500
150
30
3
0

Antatt kildeareal

Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.

N

0m 30m 60m 90m

SEBROE 04.03.2019
Norconsult

11.1 Fire training site (BØF)/contaminated site

Fire training site (BØF)/contaminated site	BØF A (active)	BØF B (old)
	BØF A was established when the old BØF was taken out of use in 2004. BØF A is active, but will cease to be operated by Avinor with effect from 21 April 2019, when Lufthavndrift AS will take over operation of the airport. BØF A is situated 14-15 metres above sea level.	BØF B was taken out of use around 2004. Avinor will cease operations at Haugesund Airport on 21 April 2019.

11.2 Use of PFOS and other PFAS

Quantity of PFOS used at the site (kg)		220
Comments/uncertainty	Foam containing PFOS as its main PFAS component has probably not been used, as the BØF opened after 2004.	
Quantity of PFAS used at the site (kg)	30	7
Comments/uncertainty	Avinor completely phased out firefighting foam containing PFAS in 2012 and now uses only PFAS-free firefighting foam.	

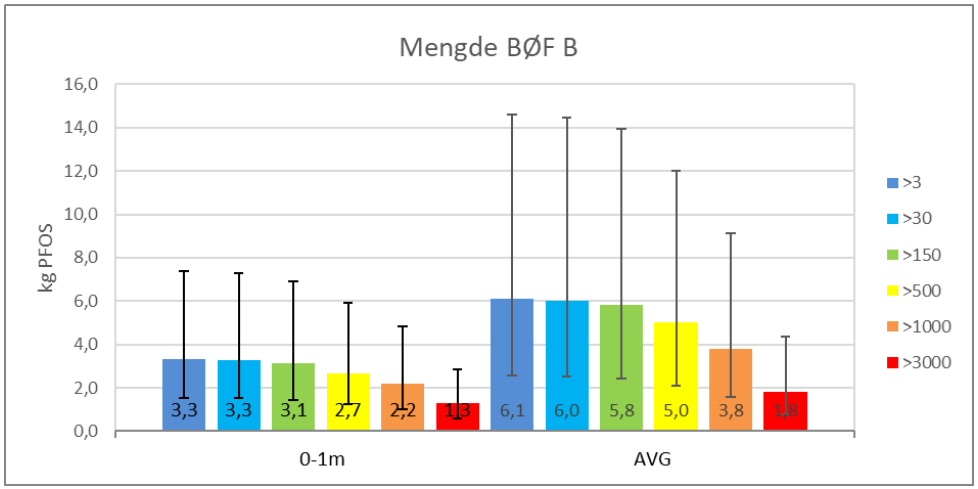
11.3 Soil sampling

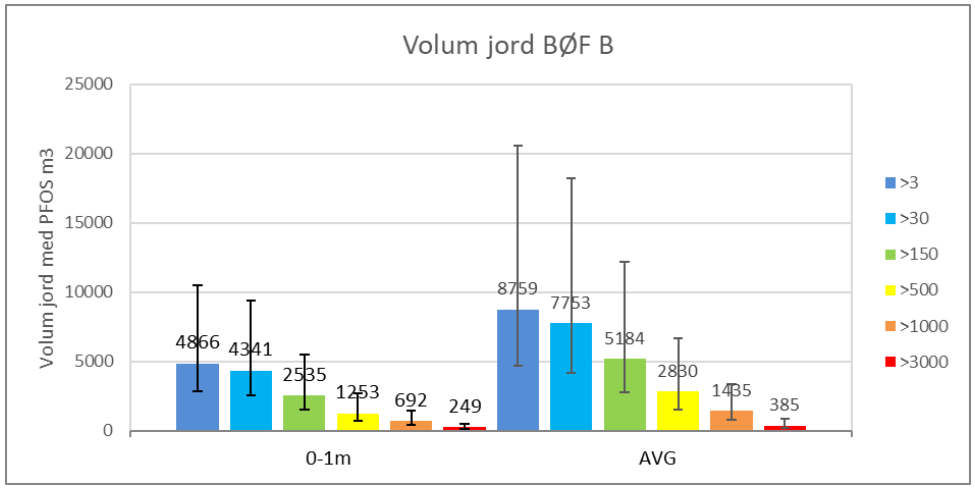
Fire training site (BØF)/site	BØF A (active)	BØF B (old)
Total number of soil samples	10	21
Comments/uncertainty (e.g. 95% of the samples were taken from 0-0.1 m)	All of the samples were taken from depths of 0-10 cm.	Five of the samples were taken from the upper 0-20 cm, and the other samples have varying depth intervals down to the deepest sample, which was taken from a depth of 180 cm. For eight of these samples, the sampling interval is stated as representing a thickness of more than 1 metre.
Number of soil samples 0-1 m below ground level	10	17
Number of soil samples under 1 m	0	15
Comments/uncertainty	The material is described as fill material consisting of sand, gravel and crushed stone in seven of the samples, while the other three samples (taken from the perimeter of the investigated area) consisted of sand, gravel and agricultural soil.	Total of 32 soil samples when splitting up samples in the intervals of 0-1 m and > 1 m. The investigated material is stated as primarily consisting of blasted rock, crushed stone, sand and gravel.
Highest measured soil concentration of PFOS µg/kg	13.4	17,400
Where	BØF-NY-10 (0-0.1 m), sample of sand, gravel and agricultural soil.	BØF-1-2, from a depth of 20-160 cm. Blasted rock with sand, gravel, stones, wood, plastic and water at a depth of 150 cm. Odour of mineral oil (THC detected in environmental condition class 5). The sample was otherwise only analysed for PFOS and PFOA.
Highest measured soil concentration of PFAS µg/kg	217	17,416
Where	BØF-NY-1 (0-0.1 m), sample of sand, gravel and crushed rock (fill material).	BØF-1-2, from a depth of 20-160 cm. Blasted rock with sand, gravel, stones, wood, plastic and water from a depth of 170 cm. Odour of mineral oil (THC detected in environmental condition class 5). The sample was otherwise only analysed for PFOS and PFOA.

Comments/uncertainty	All of the soil samples were analysed for 11 PFAS compounds. PFOS and 6:2 FTS were the main contaminants detected in the soil samples, along with PFBA and PFPeA in some samples. The concentration of PFAS in BØF-NY-1 is due to the presence of 6:2 FTS and PFOS.	All soil samples were only analysed for PFOS and PFOA.

11.4 Quantity calculation

PFOS average for all depths and points > 3 µg/kg	No quantities were calculated for BØF A.	
Concentration (µg/kg)		645
Area (m2)		4,866
Quantity of soil (tonnes)		15,766
Quantity PFOS (kg)		6.1
Uncertainty -		3.5
Uncertainty +		8.5
PFOS average for all depths and points > 30 µg/kg		
Concentration (µg/kg)		721
Area (m2)		4,307
Quantity of soil (tonnes)		13,955
Quantity PFOS (kg)		6.0
Uncertainty -		3.5
Uncertainty +		8.4
PFOS average for all depths and points > 150 µg/kg		
Concentration (µg/kg)		1,039
Area (m2)		2,880
Quantity of soil (tonnes)		9,331
Quantity PFOS (kg)		5.8
Uncertainty -		3.4
Uncertainty +		8.1
PFOS average for all depths and points > 500 µg/kg		
Concentration (µg/kg)		1,637
Area (m2)		1,572
Quantity of soil (tonnes)		5,093
Quantity PFOS (kg)		5.0





Uncertainty -		2.9
Uncertainty +		7.0
PFOS average for all depths and points > 1000 µg/kg		
Concentration (µg/kg)		2,457
Area (m2)		797
Quantity of soil (tonnes)		2,582
Quantity PFOS (kg)		3.8
Uncertainty -		2.2
Uncertainty +		5.3
PFOS average for all depths and points > 3000 µg/kg		
Concentration (µg/kg)		4,360
Area (m2)		214
Quantity of soil (tonnes)		693
Quantity PFOS (kg)		1.8
Uncertainty -		1.1
Uncertainty +		2.5

Fire training site (BØF)/site	BØF A (active)	BØF B (old)
Comments regarding the quantity calculations	In the 2016 risk assessment report, a residual quantity of PFOS of 0.05 ± 0.02 kg was calculated. This calculation was based on an area of 5,200 m^2 and a depth of 0.5 metres.	In the 2016 risk assessment report, a residual quantity of PFOS of 12 ± 4 kg was calculated. This calculation was based on an area of 4,000 m^2 and a depth of 3 metres. No account has been taken of the fact that the material contains some blasted rock and coarser fractions, with the result that the new calculation from 2019 produces lower quantities.
Is the extent of the contaminated area limited horizontally?	There is bedrock at the surface across the entire BØF, and the extent of the contamination is therefore believed to be limited to the immediate vicinity of the sand and gravel material which was laid across the BØF. At extreme point BØF-NY-8 to the northwest and BØF-NY-5 to the west, only 10 µg/kg PFBA has been detected, and no other PFAS compounds have been detected. The highest concentration of PFAS occurs at the extreme point to the southeast, BØF-NY-1 (217 µg/kg), which is delimited by bedrock to the south and southeast. The extreme points to the north and east (BØF-NY 9 and 10) recorded PFAS concentrations of < 15 µg/kg.	The extreme points to the west (BØF-9 and 10) have PFAS concentrations of < 25 µg/kg. The extreme point to the east (BØF-8) has a PFOS concentration of 3.2 µg/kg, while the extreme points to the south (DT1 and DT2) have PFOS concentrations of < 40 µg/kg. PFOS concentrations are highest around the centre of the site. BØF B is located in a small valley. There is bedrock at the surface north, west and south of BØF, and the terrain slopes upwards in these directions. It can therefore be assumed that the terrain will be the limiting factor as regards horizontal dispersal.
Is the extent of the contaminated area limited vertically?	No, no samples have been taken of material at depths exceeding 0.1 metres. However, the unconsolidated sediment cover is thin and there is bedrock visible at the surface across the whole of the BØF. The distribution of the contamination is therefore believed to be limited to depths of < 1 metre.	No. Soil samples have been collected from depths of down to 1.8 metres, and the unconsolidated cover is stated in the reports as being between 1-3 metres thick. It is likely that contamination is present down to the bedrock in the centre of the BØF, as there are high concentrations in the deepest samples.
Comments/uncertainty		

11.5 Water sampling and annual dispersal

Fire training site (BØF)/contaminated site	BØF A (active)	BØF B (old)
Have water samples been taken?	Yes	Yes
Where	In seawater and in oil separator.	In groundwater well MB1 in the far west of the BØF, in shafts DT1 and DT3 and in drainage sump.
Highest measured concentration of PFOS in groundwater (ng/l)		49,800
Where	No groundwater samples have been collected from the site.	DT3 groundwater in shaft
Highest measured concentration of PFAS in groundwater (ng/l)		50,000
Where		DT3 groundwater in shaft
Comments/uncertainty		Sample dt3 was only analysed for PFOS/PFOA, but contained the highest concentrations. Water in the shaft generally has a high content of particles to which PFOS can be bound, and PFOS can be mobilised by excavation below the water level. It is therefore uncertain whether the sample is representative of groundwater elsewhere on the site. Samples DT1-water and DT3-water were taken from shafts investigated in connection with a diesel leak adjacent to the old BØF. There is a groundwater well (MB1) at BØF B, but this is situated west of the area which had the highest concentrations in soil, and is believed to be located in the opposite direction to the groundwater flow. In groundwater well MB1, concentrations of PFOS in two samples were 10.3 ng/l (sampled 06.10.11) and Not detected (sampled 25.05.12) respectively. Total PFAS was only analysed for in one of the samples (the sample taken on 25.05.12) and was 16.2 ng/l (in this sample, only PFHxS was detected above the detection limit). Both the water samples from shaft and groundwater well MB1 have THC concentrations of between 350-7300 ug/l. For THC, the highest concentrations in water are from DT3 and MB1.
Highest measured concentration of PFOS in surface water (ng/l)		3,780
Where	Not detected in seawater (analysed for 11 PFAS compounds)	Drain (sump 1) 19.06.2014
Highest measured concentration of PFAS in surface water (ng/l)		6,050

Where	Not detected in seawater (analysed for 11 PFAS compounds)	Drain (sump 1) 19.06.2014
Comments/uncertainty	Water from the oil separator is stated as discharging into the sea in Fannefjorden through a sewerage pipe. Water samples from the oil separator are not considered to be representative of the surface water in the area. Seven water samples were taken from the oil separator between 2011 and 2014, and the concentrations of PFOS measured ranged between 38 and 1350 ng/l, and of PFAS between 1,150 and 40,400 ng/l. The sample with the highest concentrations dates from September 2014. The dominant compound in the water samples is 6:2 FTS, followed by 8:2 FTS in most samples. This is due to the fact that no foam with PFOS as its main compound has been used at this BØF. Avinor has not used PFAS foam at its airports since 2012 and the oil separators are emptied and cleaned once a year (unless they produce < 1kg oil over the course of a year), or more often if necessary. Measurements from November 2014 through to April 2018 (two measurements a year) show varying concentrations of total PFAS (between approx. 1,000 and 7,500 ng/l), but there is apparently a downward trend in concentrations in the oil separator over time during the period (taken from Figure 17 in Avinor's letter to the County Governor of Rogaland on 05.02.2019).	No official information is available concerning sewerage systems from BØF B, but a drainage sump (sampling point "Drain") has been observed approx. 100 m east of BØF B, which probably drains the fire training site via a sewerage pipe. From this drainage sump, the water is fed to a small stream and ultimately into Visnesbukta. Water samples taken from this sump contain PFOS concentrations of between 1,480 and 3,780 ng/l, and PFAS concentrations of between 2,410 and 6,050 ng/l.
Total annual dispersal quantity from the site (g/year)	2-3	50
Total annual dispersal quantity from the site PFAS (g/year)	110	Not calculated
To which recipient	Sea, Visnesbukta which is located approx. 40 metres to the northeast.	The natural runoff direction from BØF B is towards the sea. Based on flow assessments, the natural dispersal path for groundwater will be north towards the sea. No official information is available on drainage systems for BØF B, but it is believed that a sewerage pipe has been installed from BØF B which collects groundwater in a sump located east of BØF B. This sump also receives water from other drains, before the water is discharged into a small stream and out into Visnesbukta. Sea, Visnesbukta is located approx. 125 metres to the east-northeast.

Calculated from water or soil concentration.	Water concentrations in oil separators. The calculation is based on measurements taken before 2015.	Water concentrations at sampling point "Drain" sump 1

11.6 Biota sampling

Have biota samples being taken at the airport?	Yes* – the biota samples are common to both sites as they have runoff to the same recipient.
What kind of biota?	Ocean quahog, scallop, Pacific oyster, ballan wrasse, lemon sole, flounder, cod and zooplankton.
How many samples?	44
Highest measured concentration in biota PFOS (µg/kg wet weight)	9.1
Where	9: Lemon sole, individual sample from muscle
Highest measured concentration in biota PFAS (µg/kg wet weight)	17.9
Where	9: Lemon sole, individual sample muscle (analysed for 11 PFAS compounds)
Median concentration (µg/kg wet weight) in comparable populations (e.g. in a lake)	The total PFAS concentration in the fillet of a lemon sole caught in Radsundet offshore of the factory belonging to Solberg Scandinavian (firefighting foam manufacturer) was 492 µg/kg plumb. A PFOS concentration of 462 µg/kg was measured. Obtained from Cowi's 2015 annual report, Monitoring carried out for Solberg Scandinavian AS.
Comments/references	Reference samples were collected at a sampling station at Skudneshavn in connection with the biota sampling. Ten samples of ocean quahog were collected. No PFOS/PFAS was detected in any of these biota samples.

References and concentrations in other reports.	The concentration of total PFAS was 2 µg/kg in a sample of muscle from lemon sole caught in Tårstadosen/Stunesosen off Harstad Airport Evenes, a site that has significant PFAS pollution in the ground from a fire training site. Taken from Avinor's report from 2015: Harstad/Narvik Airport, Investigations into PFAS in soil, aquatic environment and biota with risk assessment.

11.7 Uncertainty and other factors

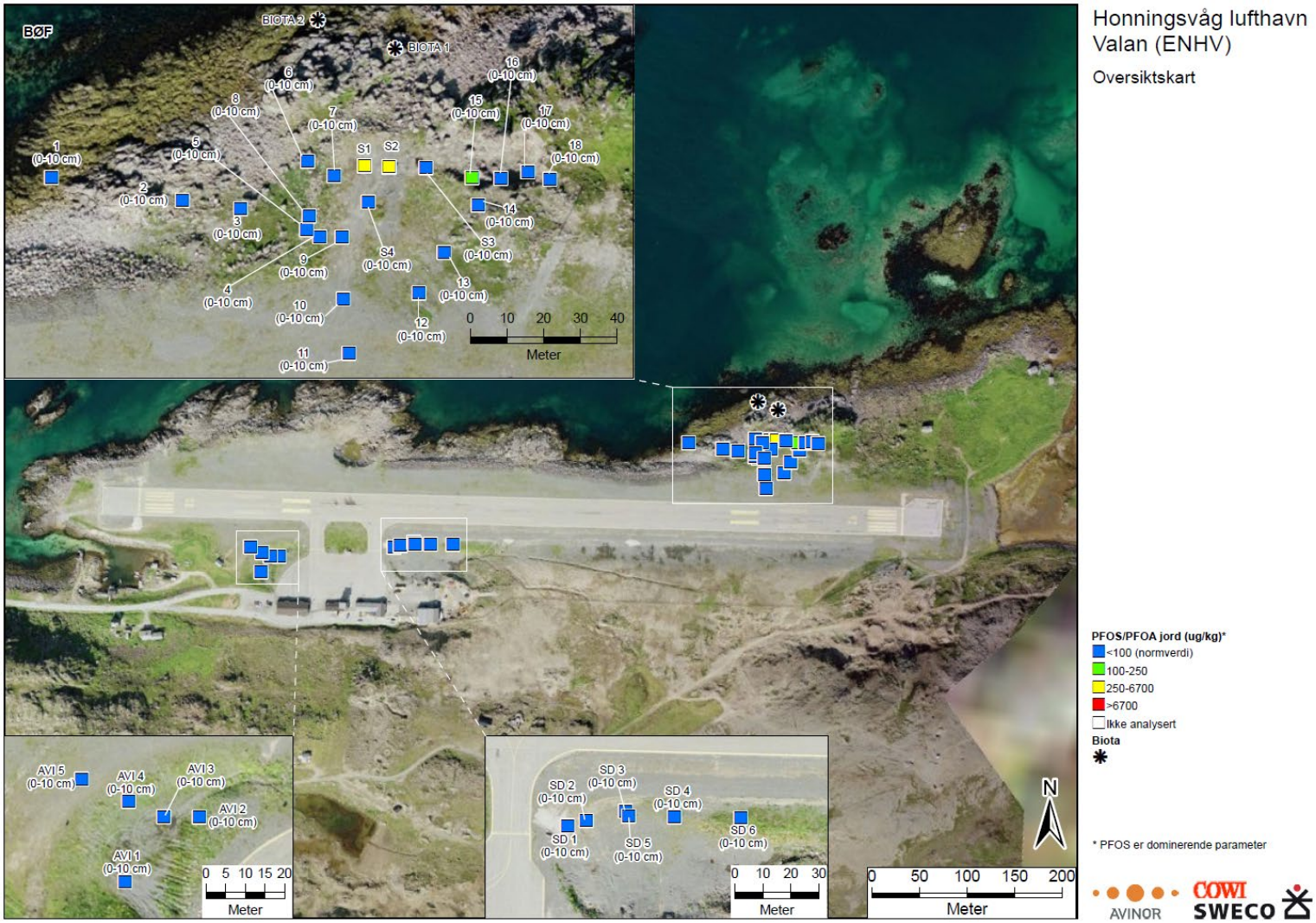
Fire training site (BØF)/contaminated site	BØF A (active)	BØF B (old)
Does the estimate of the quantity of PFOS in the ground correspond with the concentrations measured in water and biota?	No quantities have been calculated for PFOS or PFAS in the ground. The concentrations in soil samples are low, and there are expected to be small quantities of PFOS/PFAS in the ground at this site. Both fire training sites at Haugesund Airport will have runoff to Visnesbukta, and the degree of impact on biota from each of the sites cannot be evaluated with any certainty. Contributions from the active BØF are expected to gradually reduce after foam containing PFAS was phased out in 2012.	It is not known with any certainty whether any of the water samples which have been taken are representative. PFOS has been detected in all the water samples (four points and nine samples), but the concentrations vary considerably between the sampling points. However, the water samples show that it is likely that leaching is taking place from BØF B. Biota in which PFAS has been detected are bottom-dwelling fish, and it is not possible to determine with any certainty whether these are also affected by any other contamination in Visnesbukta. Both fire training sites at Haugesund Airport will have runoff to Visnesbukta, and the degree of impact on biota from each of the sites cannot be evaluated with any certainty.

Evaluations	The centre of the BØF is paved and surface water from the BØF is drained to an oil separator. High PFAS concentrations have been detected in water samples taken from the oil separator, due to the presence of 6:2 FTS. It is stated in the 2016 report that surface water is drained in pipes to the sea. PFAS compounds have therefore been dispersed to Visnesbukta via sewerage pipes. It is also stated that, in spring 2014, Promitek recommended that the oil separator facility adjacent to the BØF be emptied and cleaned in the same spring in order to reduce the dispersal of PFAS. According to Avinor, oil separators at active BØFs are emptied and cleaned annually. No 6:2 FTS has been detected in biota, which was one of the main components of foam used during the period 2001-2012.	From the 2016 report: The depth of the filler is 1-3 m. The site probably drains straight to groundwater. Groundwater has been recorded approx. 0.5 metres below ground level. No official information is available concerning sewerage systems from BØF B, but a drainage sump (sampling point "Drain") has been observed approx. 100 m east of BØF B, which probably drains the fire training site via a sewerage pipe. From this drainage sump, the water is fed to a small stream and ultimately into Visnesbukta. It is also stated that other drains from the airport area are collected in the sump for onward transport to the sea. Water samples should be taken from the stream which flows into Visnesbukta to determine the onward dispersal of PFAS via water from the sump. For biota, PFAS has been detected in six out of ten samples of lemon sole (total PFAS between 1.1 and 5.9 µg/kg, and one sample with 17.9 µg/kg) in Visnesbukta north of the fire training sites. PFAS has also been detected in a sample of flounder (muscle); otherwise, the remaining 23 biota samples are below the detection limit. It is estimated that approximately 6 kg PFOS remains in situ at BØF B. It is estimated that 220 kg of PFOS have been used at the site. This shows that most of the PFOS has already been leached out to the recipient.

Comments/uncertainty (Could there be any additional unknown sources of PFOS at the site with runoff to the recipient?)	The risk assessment report states that no drills using firefighting foam are known to have been carried out outside the fire training sites. No cleaning of vehicles is believed to have taken place outside the vehicle washing facility either. At the vehicle washing facility, water is transported to an oil separator and on to a septic tank in the sea. In the groundwater well (bedrock well) MB2 located at the site of the middle snow depot (west/southwest of the terminal area), low PFAS concentrations have been detected (PFOS of 17 ng/l in one sample from 2011 and 16.2 ng/l of PFAS in one sample from 2012). No dispersal from here has been documented, although it is possible that this will be dispersed towards Stogdalsvatnet and Kallstøbukta and/or towards Isgardsvatnet and Visnesbukta. Two closed landfill sites/dumps have been recorded in the airport area. One is situated in the north on the eastern side of the runway, while the other is immediately adjacent to the disused fire training site. One soil sample has been taken some distance northwest of the active fire training site (sample MD1), which is believed to have been taken from one area used for landfill/dumping. The sample contained a low concentration of PFOS (23.7 µg/kg).	The risk assessment report states that no drills using firefighting foam are known to have been carried out outside the fire training sites. No cleaning of vehicles is believed to have taken place outside the vehicle washing facility either. At the vehicle washing facility, water is transported to an oil separator and on to a septic tank in the sea. In the groundwater well (bedrock well) MB2 located at the site of the middle snow depot, low PFAS concentrations have been detected (PFOS of 17 ng/l in a sample from 2011 and 16.2 ng/l of PFAS in a sample from 2012). No dispersal from here has been documented, although it is possible that this will be dispersed towards Stogdalsvatnet and Kallstøbukta and/or towards Isgardsvatnet and Visnesbukta. Two closed landfill sites/dumps have been recorded in the airport area. One is situated in the north on the eastern side of the runway, while the other is immediately adjacent to the closed fire training site, at sampling point BØF 9 (20 - 160) and BØF 10 (20-180), which has PFOS concentrations of 8 and 24 µg/kg.
Has the site been sufficiently mapped with a view to assessing the order of priority?	The site is considered to have been sufficiently well-mapped as regards PFAS to be considered in the order of priority, but PFOS was only detected in low concentrations in six out of 10 samples (3.5-13.4 µg/kg). PFAS has been detected in nine out of ten samples, with concentrations of between 10.8 and 31.5, with the exception of sample BØF-NY-1, which contains 217 mg/kg. It has therefore been concluded that the sampling indicates that there are small quantities of PFOS/PFAS in the ground, and that the site will not be prioritised for measures regarding PFOS based on a cost-benefit perspective (see this report for parts 1 and 2, section 2.1.1.6 and section 2.1.3.1).	Yes, in accordance with the criteria (in this report for part 1 and part 2, section 2.1.3.1), sampling points and soil samples are sufficient to calculate the volume of PFOS in the soil with the stipulated level of uncertainty.
Comments/uncertainty	No samples have been taken of deeper-lying material, but there is only a thin layer of unconsolidated material above the bedrock at this site.	

General information about the airport	
Other factors of significance to possible clean-up/implementation of measures (e.g. planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	No information is available concerning specific designated nature conservation areas in the vicinity of the airport, but several habitat types have been registered within a radius of approx. 1 km, including marine shell sand areas (which can for example be found in Visnesbukta immediately northeast of the BØFs) and coastal heathland. Several areas with species occurrences have also been registered in the same sector. The species here include deer, waders, gulls and ducks, black grouse and sparrows. Several bird species have been registered with a status in the Red List in the area of the airport and the surrounding area, including lapwing, Eurasian curlew, common linnet, twite, red-backed shrike, northern goshawk and Eurasian eagle-owl. Visnesbukta is used as a fishing area to some extent If any construction/excavation works come into contact with ground contaminated with PFOS, the airport's new operator "Lufthavndrift AS" will have to apply to the Norwegian Environment Agency for a permit. Of the 21 soil samples from BØF B which have been analysed, THC in environmental condition classes 2-3 has been detected in five of the samples, and in environmental condition classes 4-5 in 12 of the samples.

12 Honningsvåg Airport Valan



Honningsvåg lufthavn
Valan (ENHV)

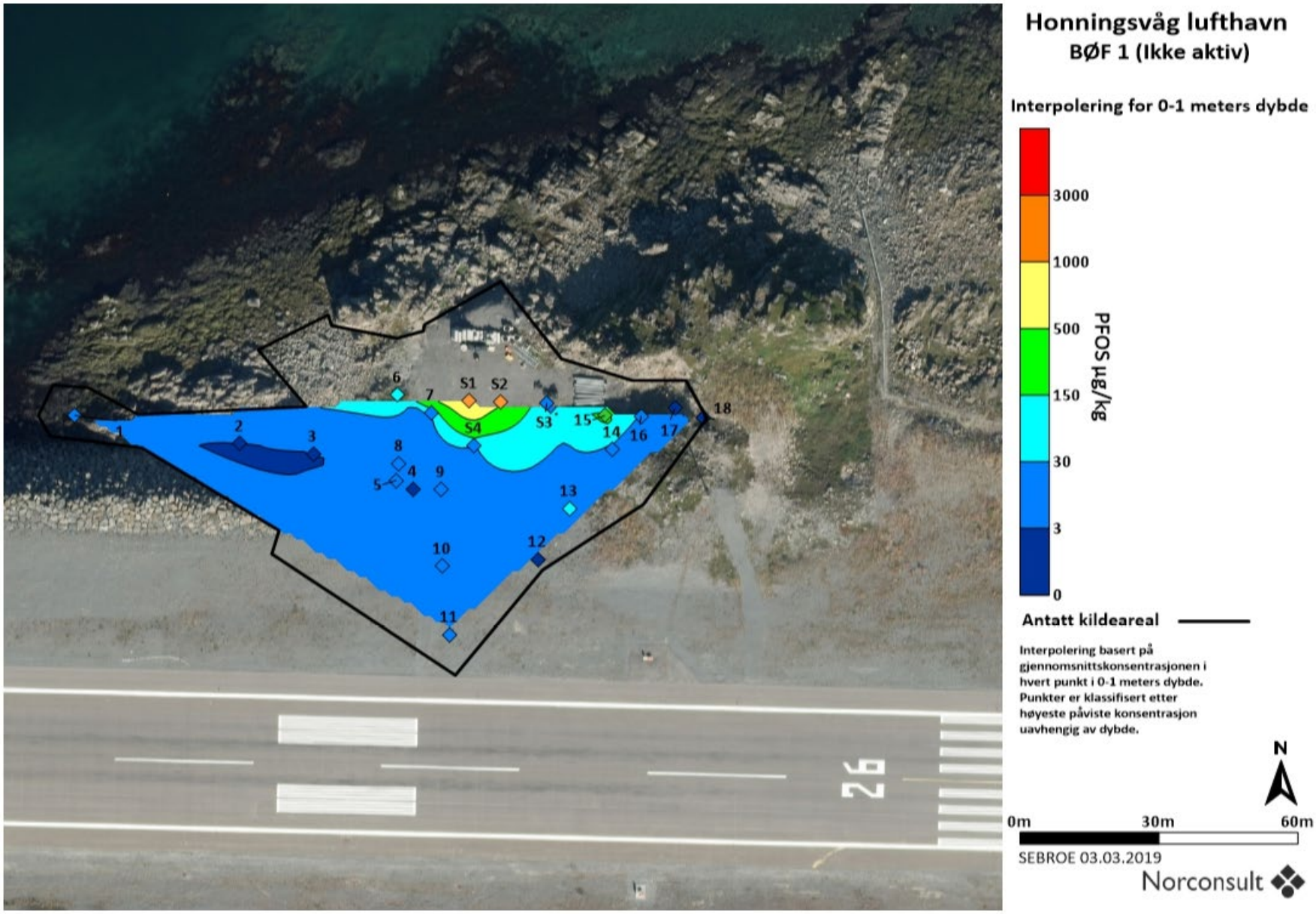
Oversiktskart

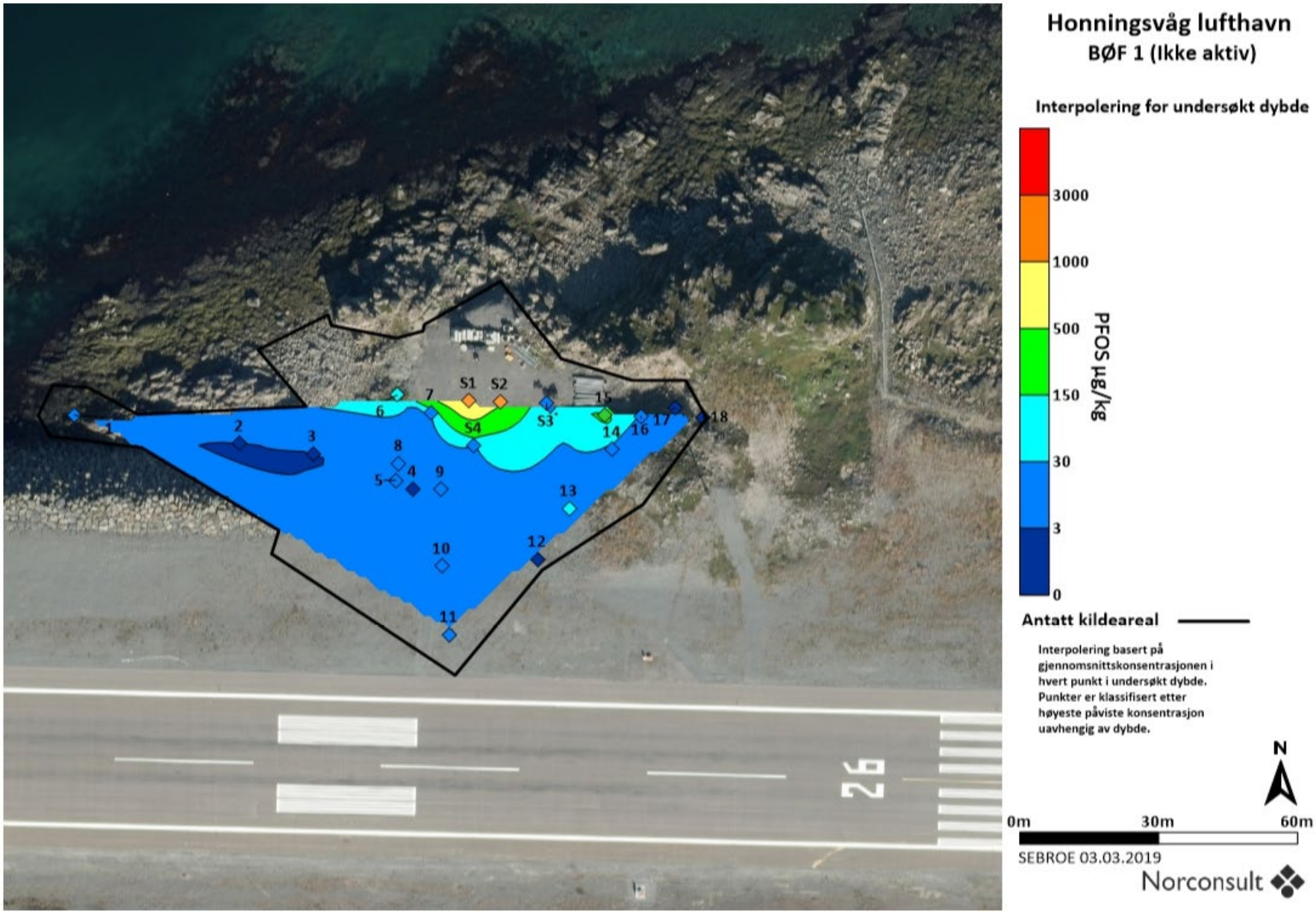
PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

Biota
*

* PFOS er dominerende parameter

AVINOR COWI SWECO


Honningsvåg lufthavn
BØF 1 (Ikke aktiv)
Interpolering for 0-1 meters dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i 0-1 meters dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m
30m
60m
SEBROE 03.03.2019
Norconsult
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
S1
S2
S3
S4
26


Honningsvåg lufthavn
BØF 1 (Ikke aktiv)
Interpolering for undersøkt dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m
30m
60m
SEBROE 03.03.2019
Norconsult
S1
S2
S3
S4
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
26

12.1 Fire training site (BØF)/contaminated site

Fire training site (BØF)/contaminated site	BØF 1 (old)
	The airport was opened in 1977. There is an old fire training site which was taken out of use around 2006, but it is not known whether it has been operational since the airport opened. There are no fire training sites still in use today. The old BØF is located north of the runway, and the Barents Sea/Skipsfjorden is located about 30 m south of the BØF. The DP2 report states the following: The BØF is stated as having an area of approximately 2800 m^2, and there is no written information on the use of the BØF.

12.2 Use of PFOS and other PFAS

Volume of PFOS used at the site (kg)	Not stated/calculated
Comments/uncertainty	
Volume of PFAS used at the site (kg)	Not stated/calculated
Comments/uncertainty	

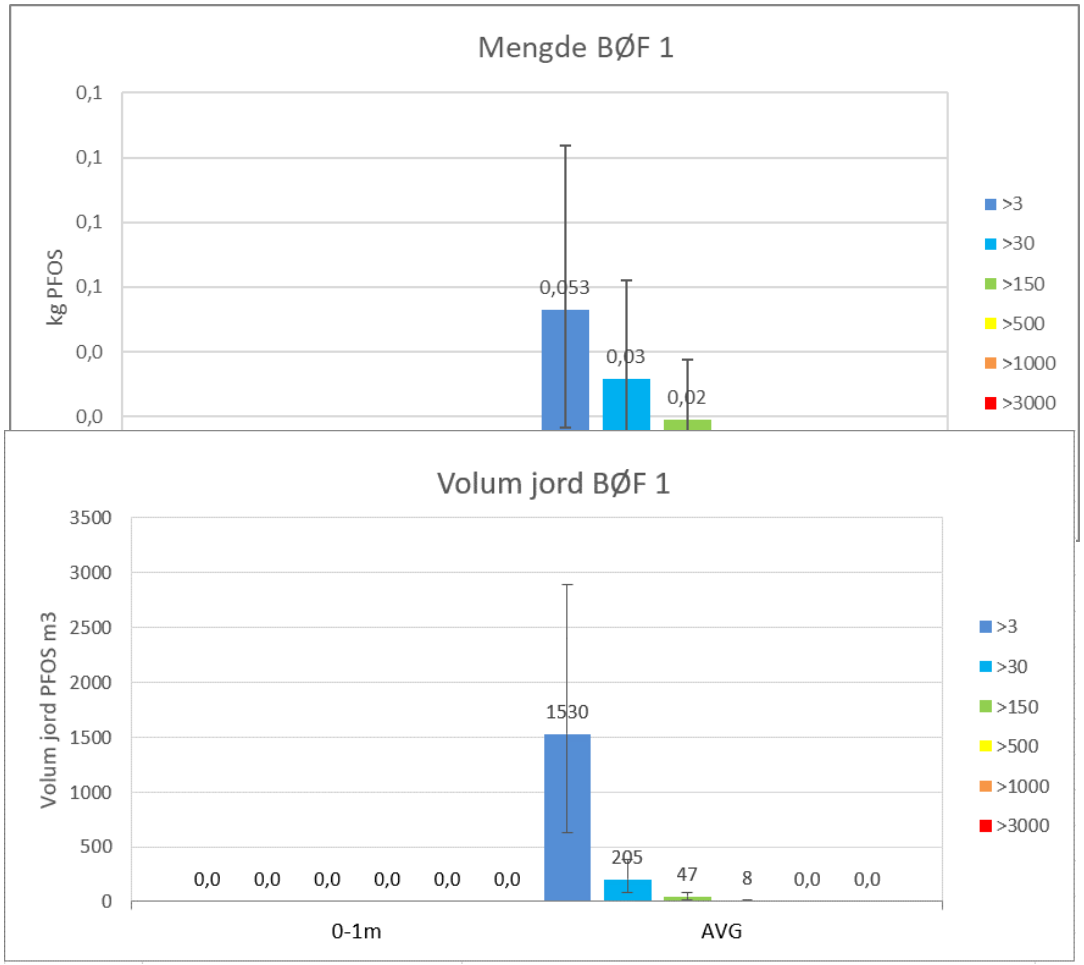
12.3 Soil sampling

Total number of soil samples	26
Comments/uncertainty (e.g. 95% of the samples were taken from 0–0.1 m)	21 of the samples were collected from 0-10 cm (surface samples). The deepest samples were taken at depths down to 75 cm.
Number of soil samples 0-1 m below ground level	26
Number of soil samples under 1 m	0
Comments/uncertainty	The material that was investigated is all stated as consisting of fill.
Highest measured soil concentration of PFOS µg/kg	2,040
Where	S1-2 (5-75 cm). Fill material
Highest measured soil concentration of PFAS µg/kg	2,050
Where	S1-2 (5-75 cm). Fill material

Comments/uncertainty	All soil samples were only analysed for PFOS and PFOA. Due to the laying of asphalt fill material in 2010, PFOS contamination has been encountered in the material at depths below 10 cm below the surface. The samples were also analysed for THC. A THC concentration corresponding to environmental condition class 4 (health-based environmental condition classes) was detected in five of the 26 samples. Four of the samples were from 0-10 cm and one was from 0-50 cm, so this is probably related to the fact that crushed asphalt was laid as fill material.

12.4 Quantity calculation

PFOS average for all depths and points > 3 µg/kg	
Concentration (µg/kg)	32
Area (m2)	3,060
Quantity of soil (tonnes)	2,754
Quantity of PFOS (kg)	0.05
Uncertainty -	0.04
Uncertainty +	0.05
PFOS average for all depths and points > 30 µg/kg	
Concentration (µg/kg)	143
Area (m2)	410
Quantity of soil (tonnes)	369
Quantity of PFOS (kg)	0.03
Uncertainty -	0.02
Uncertainty +	0.03
PFOS average for all depths and points > 150 µg/kg	
Concentration (µg/kg)	381
Area (m2)	93
Quantity of soil (tonnes)	84
Quantity of PFOS (kg)	0.02
Uncertainty -	0.01
Uncertainty +	0.02
PFOS average for all depths and points > 500 µg/kg	



Concentration (µg/kg)	703
Area (m2)	16
Quantity of soil (tonnes)	14
Quantity of PFOS (kg)	0.01
Uncertainty -	0.004
Uncertainty +	0.01

PFOS average for all depths and points > 1000 µg/kg	
Concentration (µg/kg)	
Area (m2)	
Volume of soil (tonnes)	
Volume of PFOS (kg)	
Uncertainty -	
Uncertainty +	
PFOS average for all depths and points > 3000 µg/kg	
Concentration (µg/kg)	
Area (m2)	
Volume of soil (tonnes)	
Volume of PFOS (kg)	
Uncertainty -	
Uncertainty +	

Comments regarding the calculations	In the DP2 report, it is calculated that 52 g of PFOS and 0.01 g of PFOA remain in situ in the material. No area or depth is specified for the calculation.
Is the extent of the contaminated area limited horizontally?	No. It appears that the most heavily contaminated area is located immediately north of the northernmost sampling points (S1 and S2). The contamination has also not been completely delimited in a southerly/southwesterly direction, as extreme points 1 and 11 contain between 4-6 µg/kg. No PFOS has been detected at extreme points 12, 17 and 18 to the east.

Is the extent of the contaminated area limited vertically?	Yes, the bedrock at a depth of between 50-75 cm in shafts S1-S4.
Comments/uncertainty	These samples were only analysed for PFOS and PFOA

12.5 Water sampling and quantity dispersed annually

Have water samples been taken?	No
Where	
Highest measured concentration of PFOS in groundwater (ng/l)	
Where	
Highest measured concentration of PFAS in groundwater (ng/l)	
Where	
Comments/uncertainty	
Highest measured concentration of PFOS in surface water (ng/l)	
Where	
Highest measured concentration of PFAS in surface water (ng/l)	
Where	
Comments/uncertainty	
Total quantity dispersed annually from the site PFOS (g/year)	2.99
Total quantity dispersed annually from the site PFAS (g/year)	3.595
To which recipient	Skipsfjorden (Barentshavet)
Calculated from water or soil concentration.	From soil concentration. Groundwater concentrations have been calculated based on soil concentrations. Annual discharge quantity was calculated based on the estimated concentration in groundwater. The quantity of PFAS dispersed applies to the calculation for PFOS and PFOA.

12.6 Biota sampling

Have biota samples being taken at the airport?	Yes

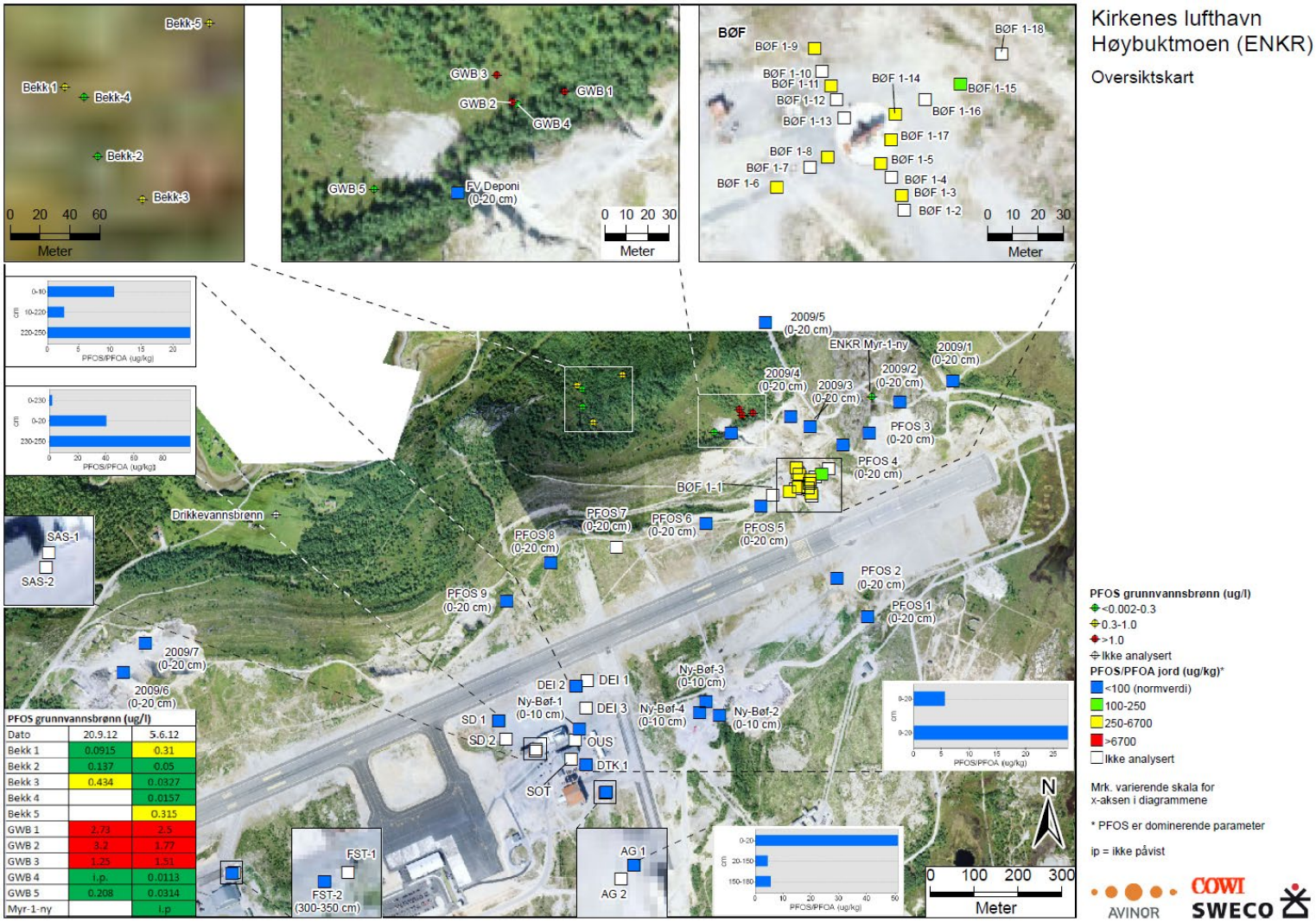
What kind of biota?	Kelp
How many samples?	2
Highest measured concentration of PFOS in biota (µg/kg wet weight)	18.4
Where	BIOTA 1
Highest measured concentration of PFAS in biota (µg/kg wet weight)	19.1
Where	BIOTA 1
Median concentration in comparable populations (e.g. in a lake)	In 2016, two biota samples of kelp were analysed from a location offshore of Longyearbyen Airport, which has an old and an active fire training site. No PFOS or PFAS was detected in any of these samples. Reference: Avinor 2016, Action plan for PFAS-contaminated land as a result of fire training.
Comments/references	The biota samples were analysed for PFOS and PFOA.
References and concentrations in other reports.	Environmental quality standard in organisms in the Norwegian Environment Agency's supervisor M-608: 9.1 µg/kg wet weight. The biota samples from kelp show concentrations above this.

12.7 Uncertainty and other factors

Does the estimate of the quantity of PFOS in the ground correspond with the concentrations measured in water and biota?	Cannot be evaluated for water, as no water samples have been taken. This also causes uncertainty as regards assessments of concentrations in biota. No reliable evaluation for biota can be carried out, but it is possible that the PFOS concentration measured in the kelp samples is due to runoff/dispersal from the BØF.
Evaluations	Runoff from the BØF will drain through the gravel fill and/or via the surface to Skipsfjorden. The distance from the BØF to the area where the biota samples were taken is about 30 metres, and the height difference is 7-9 metres.
Comments/uncertainty (Could there be any additional unknown sources of PFOS at the site with runoff to the recipient?)	It is not stated that there are additional sources of PFOS at the site or elsewhere at the airport, but the possibility cannot be ruled out.
Has the site been sufficiently mapped with a view to assessing the order of priority?	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the quantity of PFOS in the soil with the stipulated level of uncertainty. However, the quantities of PFOS in the ground are small (< 0.5 kg), due to the thin layer of consolidated material above the bedrock. The site will therefore not be prioritised for measures based on a cost/benefit perspective (ref. this report for parts 1 and 2, section 2.1.1.6 and section 2.1.3.1).

Comments/uncertainty	The BØF was taken out of use around 2006. A comparison of aerial photographs from 2007 and 2016 indicates that fill material was laid across the BØF area during this period. It is stated in the DP2 report that the crushed asphalt on the BØF was laid out in 2010, meaning that this material was probably laid after the BØF was taken out of use. This may explain why the highest concentrations of PFOS (380-2040 µg/kg) have been detected in the deepest samples which were taken from immediately above the bedrock at depths of 50 and 75 cm, in addition to a sample from a depth interval of 5-75 cm and one from a depth of 10-50 cm. Samples taken from depths of 0-10 and 0-50 cm contain low concentrations (2.9-40 µg/kg), except for one sample which is believed to have been collected from outside the fill area (15 which contains 208 µg/kg). The contamination is not well-mapped in the northerly direction, and it is possible that "the majority" of the contamination is located just north of the area that has been sampled. However, material has also been laid in the northern part, and material laid after 2006 in this area of the BØF is also considered to contain low concentrations. Bedrock is visible at the surface approx. 20 metres north of the most northerly shafts (S1 and S2), which means that the thickness of any material which is heavily contaminated with PFOS in the northern part of the BØF would be expected to be low (approx. 0.5 m).
Other factors of significance to possible clean-up/implementation of measures (e.g. planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	It is stated in the DP2 report that there is a small wetland area east of the airport, outside the airport's delimitation. There is no runoff from the airport to this area. A number of species of high and particularly high management interest have been recorded in and around the airport (plants, birds). In the area where the BØF is located, field gentian and the habitat type "coastal health" have been recorded. An area of coastal heath has also been recorded south of the airport. THC contamination corresponding to environmental condition class 4 (health-based environmental condition classes) has been detected in the surface material at the BØF. It is likely that this is related to the fact that crushed asphalt was laid across the site in 2010.

13 Kirkenes Airport Høybuktmoen



Kirkenes lufthavn
Høybuktmoen (ENKR)

Oversiktskart

PFOS grunnvannsbrønn (ug/l)
- <0.002-0.3
- 0.3-1.0
- >1.0
- Ikke analysert

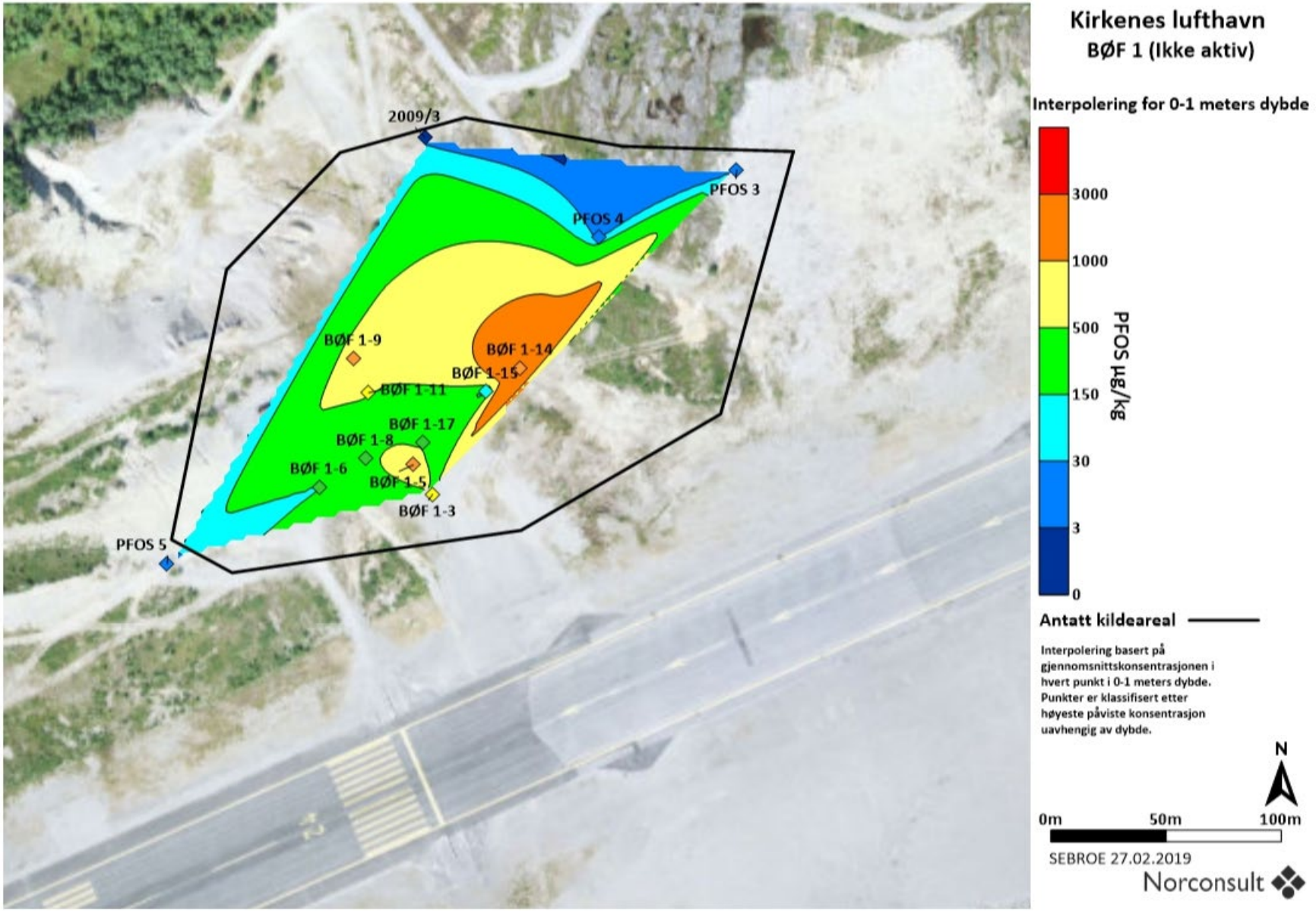
PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

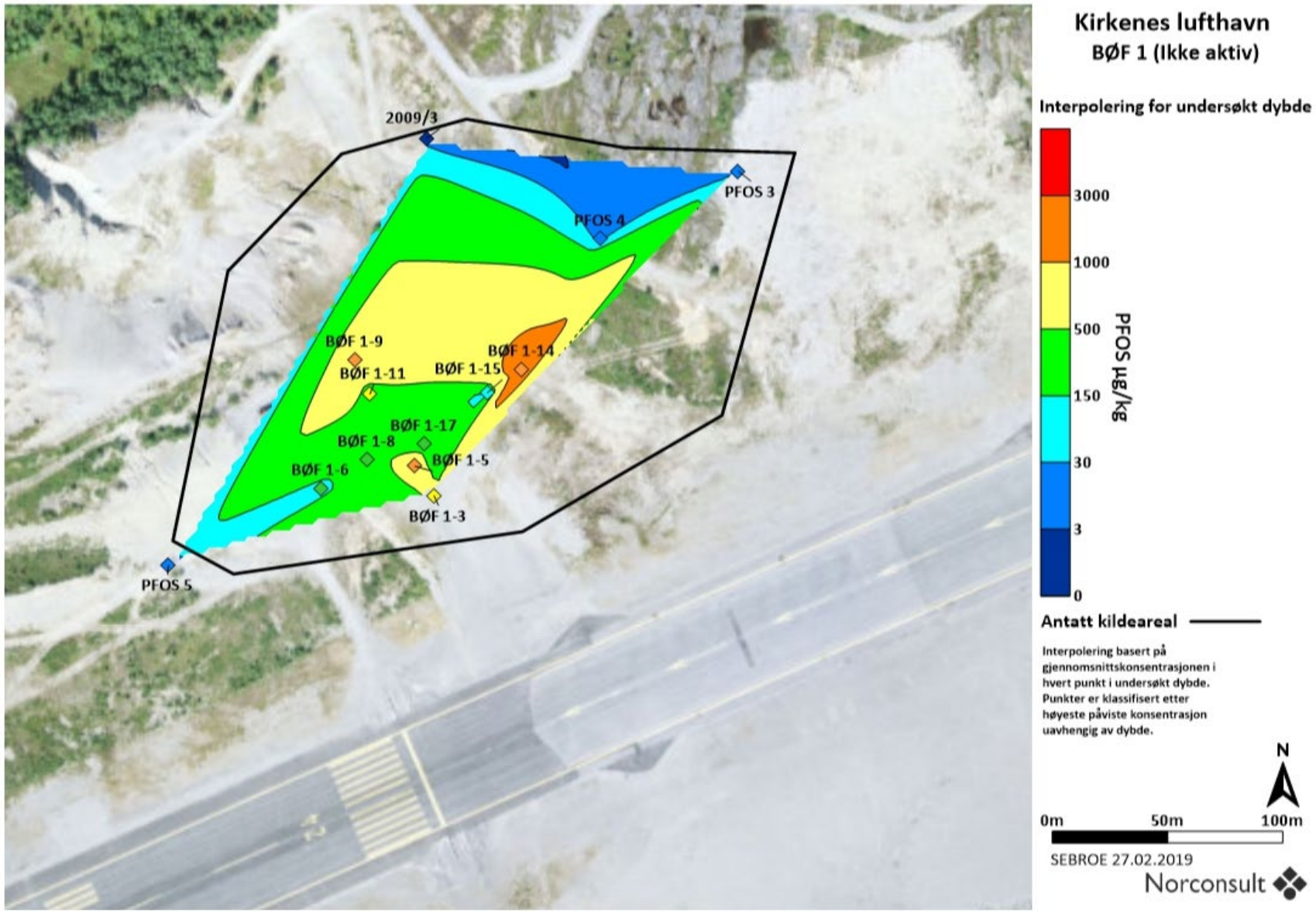
Mrk. varierende skala for x-aksen i diagrammene

* PFOS er dominerende parameter

ip = ikke påvist

AVINOR COWI SWECO


Kirkenes lufthavn
BØF 1 (Ikke aktiv)
Interpolering for 0-1 meters dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i 0-1 meters dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m
50m
100m
SEBROE 27.02.2019
Norconsult
2009/3
PFOS 3
PFOS 4
BØF 1-9
BØF 1-14
BØF 1-15
BØF 1-11
BØF 1-17
BØF 1-8
BØF 1-6
BØF 1-5
BØF 1-3
PFOS 5



Kirkenes lufthavn
BØF 1 (Ikke aktiv)

Interpolering for undersøkt dybde

PFOS µg/kg
3000
1000
500
150
30
3
0

Antatt kildeareal

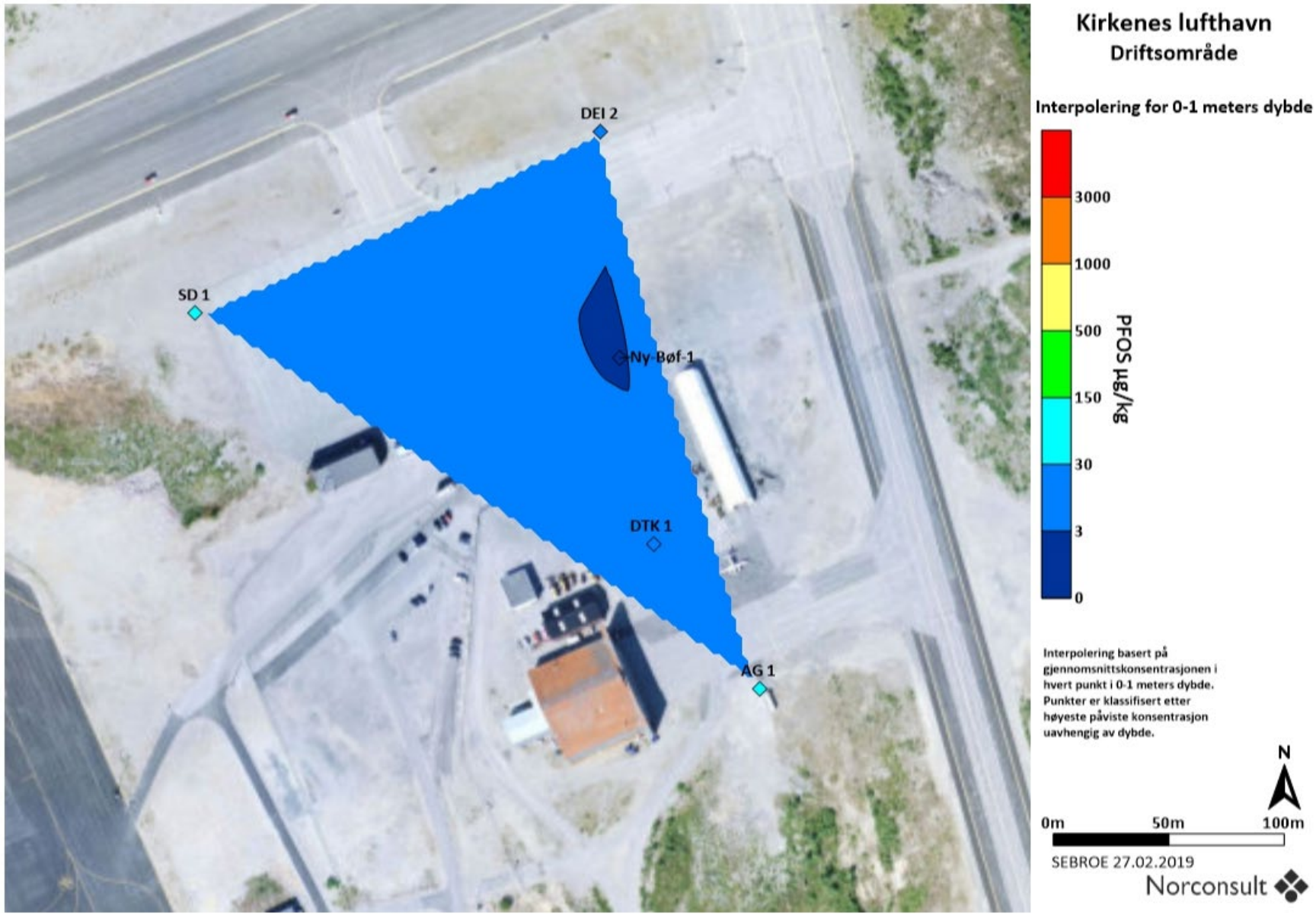
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.

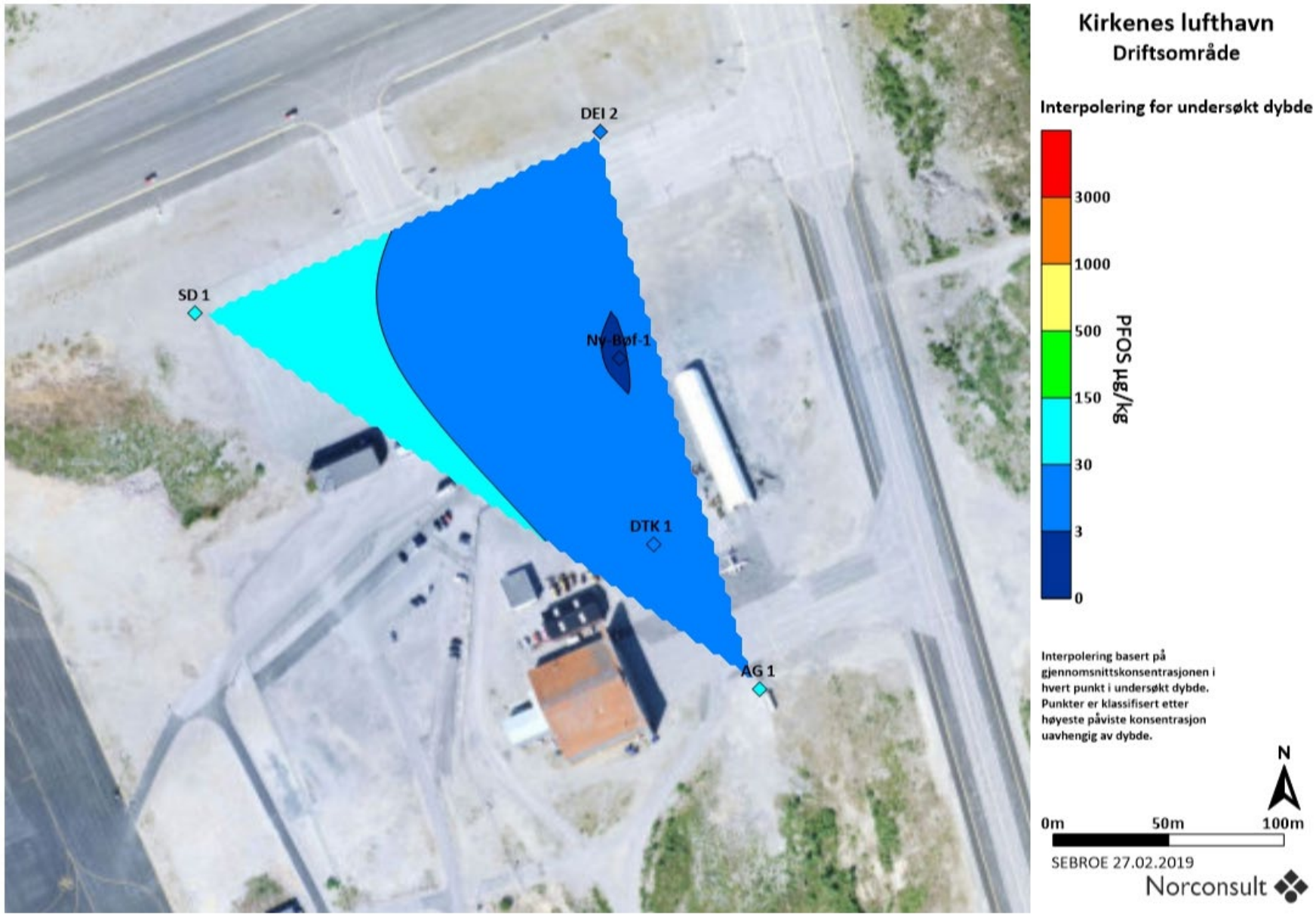
N

0m 50m 100m

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DEI 2
SD 1
Ny Bøf-1
DTK 1
AG 1
Kirkenes lufthavn
Driftsområde
Interpolering for 0-1 meters dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i 0-1 meters dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m
50m
100m
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Kirkenes lufthavn
Driftsområde

Interpolering for undersøkt dybde

PFOS µg/kg
3000
1000
500
150
30
3
0

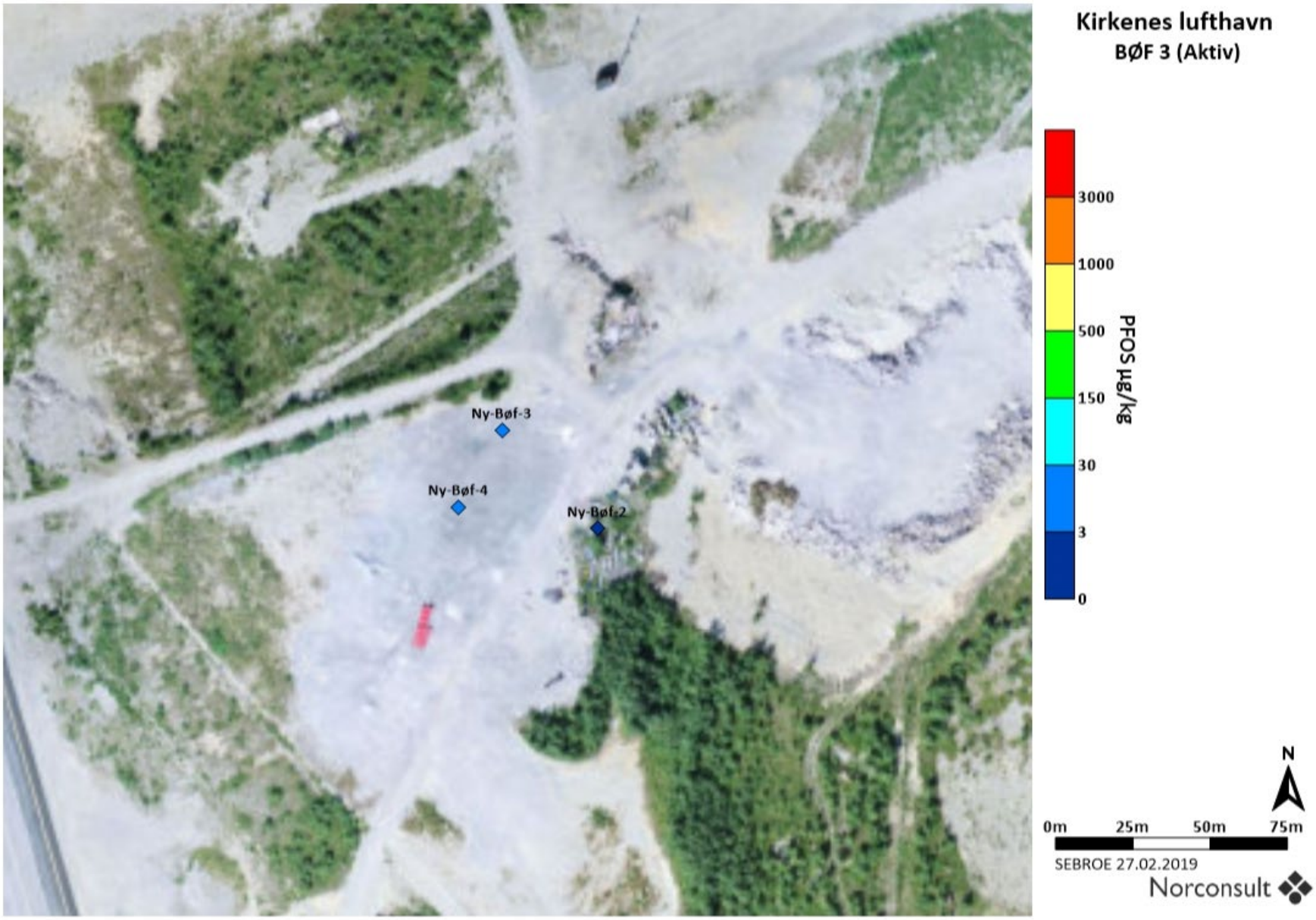
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.

N

0m 50m 100m

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Kirkenes lufthavn
BØF 3 (Aktiv)
3000
1000
500
150
30
3
0
PFOS µg/kg
Ny-Bøf-3
Ny-Bøf-4
Ny-Bøf-2
N
0m
25m
50m
75m
SEBROE 27.02.2019
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13.1 Fire training site (BØF)/contaminated site

Fire training site (BØF)/contaminated site	BØF 1 (old)	BØF 3 (active)	The operating area
	There are two disused fire training sites at Høybuktmoen. In the 1990s, the oldest fire training site (BØF 2) was relocated approx. 100 metres to the east. The new location is what is today known as the old fire training site (BØF 1). All material from BØF 2 has apparently been replaced, and there is visible filler in the area of BØF 2. BØF 1 was taken out of use around 2006.	No operating period is specified, but the site was probably taken into use around 2006 when the old site was closed down. The site has been constructed with an impermeable slab and sump, and surface water is directed to an oil separator and on to discharge into the sea.	

13.2 Use of PFOS and other PFAS

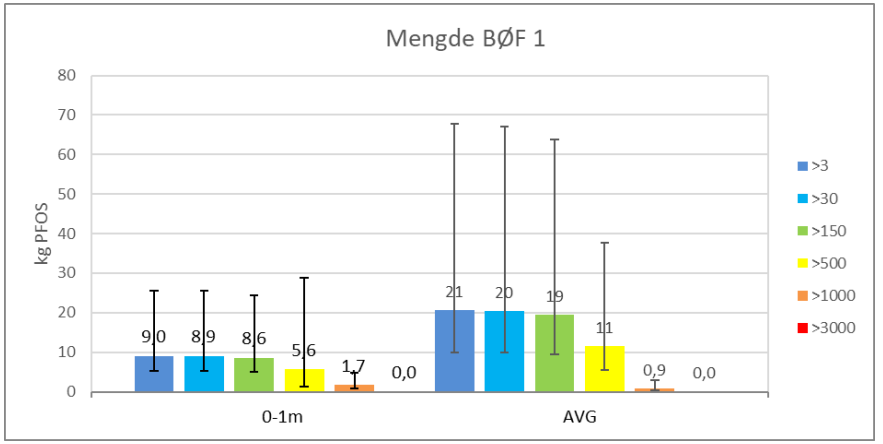
Volume of PFOS used at the site (kg)	Not stated/calculated	Not stated/calculated	Not stated/calculated
Comments/uncertainty			
Volume of PFAS used at the site (kg)	Not stated/calculated	Not stated/calculated	Not stated/calculated
Comments/uncertainty		Avinor completely phased out firefighting foam containing PFAS in 2012 and now uses only PFAS-free firefighting foam.	

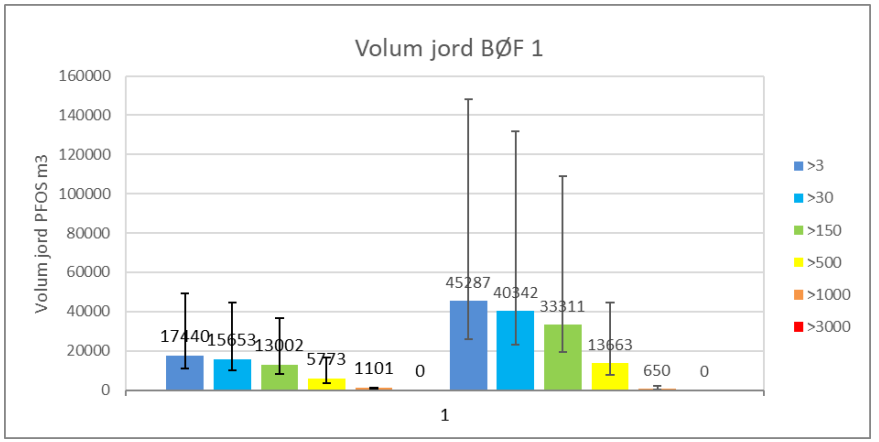
13.3 Soil sampling

Fire training site (BØF)/contaminated site	BØF 1 (old)	BØF 3 (active)	The operating area
Total number of soil samples	31	3	12
Comments/uncertainty (e.g. 95% of the samples were taken from 0-0.1 m)	Good distribution of samples at various depths. Four sampling points located relatively close to BØF 1 (approx. 100 metres north and northeast and west of the centre) are included (2009/3, PFOS 4, PFOS 3 and PFOS 5).	All of the samples were taken from depths of 0-10 cm.	The samples are split between five sampling points
Number of soil samples 0-1 m below ground level	21	3	8
Number of soil samples under 1 m	17	0	7
Comments/uncertainty	Total of 38 soil samples when splitting up samples in the intervals of 0-1 m and > 1 m. There are 13 samples from 1-2 metres and four samples from 2-3 metres.	There is one sample called Ny-BØF-1, which is located by the operating area west of the active BØF. This sample has not been included for BØF 3, and is considered to originate from part of the operating area where there are other samples in which PFAS has been detected.	Total of 15 soil samples when splitting up samples in the intervals of 0-1 m and > 1 m.
Highest measured soil concentration of PFOS µg/kg	2,520	20.7	99.6
Where	Sample BØF 1-14-2 taken from material consisting of a layer of crushed rock, sand and stone from a depth of 20-200 cm.	New BØF 3, gravel from a depth of 0-10 cm.	SD1-3 taken from coarse sand at a depth of 230-250 metres in the runway de-icing area.
Highest measured soil concentration of PFAS µg/kg	2,520	91.3	99.6
Where	Sample BØF 1-14-2 taken from material consisting of a layer of crushed rock, sand and stone from a depth of 20-200 cm.	New BØF 3, gravel from a depth of 0-10 cm.	SD1-3 taken from coarse sand at a depth of 230-250 metres in the runway de-icing area.
Comments/uncertainty	All the samples from BØF 1 were only analysed for PFOS and PFOA.	The three samples from BØF 3 were analysed for 11 different PFAS compounds.	Sample SD1-3 and the other samples from the operating area have only been analysed for PFOS and PFOA.

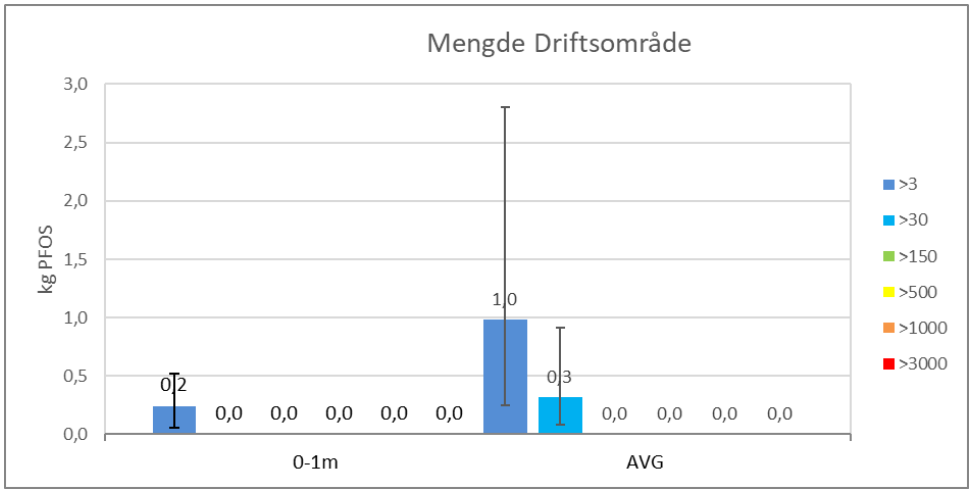
13.4 Quantity calculation

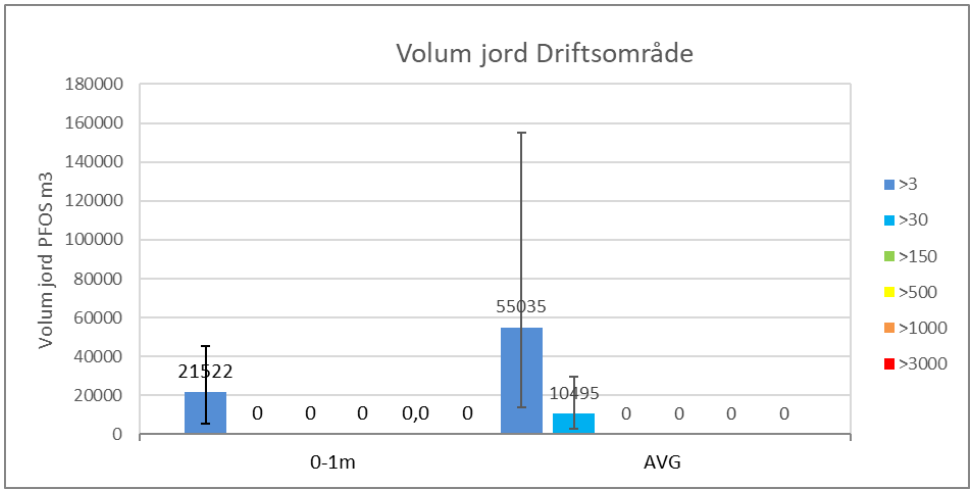
PFOS average for all depths and points > 3 µg/kg		No quantities were calculated for BØF 3.	
Concentration (µg/kg)	382		21
Area (m2)	17,418		22,014
Quantity of soil (tonnes)	76,988		93,560
Quantity of PFOS (kg)	21		1.0
Uncertainty -	11		0.7
Uncertainty +	47		1.8
PFOS average for all depths and points > 30 µg/kg			
Concentration (µg/kg)	425		36
Area (m2)	15,516		4,198
Quantity of soil (tonnes)	68,581		17,842
Quantity of PFOS (kg)	20		0.3
Uncertainty -	10		0.2
Uncertainty +	47		0.6
PFOS average for all depths and points > 150 µg/kg			
Concentration (µg/kg)	489		
Area (m2)	12,812		
Quantity of soil (tonnes)	56,629		
Quantity of PFOS (kg)	19		
Uncertainty -	10		
Uncertainty +	44		
PFOS average for all depths and points > 500 µg/kg			
Concentration (µg/kg)	705		
Area (m2)	5,255		
Quantity of soil (tonnes)	23,227		
Quantity of PFOS (kg)	11		
Uncertainty -	6		
Uncertainty +	26		





PFOS average for all depths and points > 1000 µg/kg			
Concentration (µg/kg)	1,137		
Area (m2)	250		
Quantity of soil (tonnes)	1,105		
Quantity of PFOS (kg)	0.9		
Uncertainty -	0.5		
Uncertainty +	2.0		
PFOS average for all depths and points > 3000 µg/kg			
Concentration (µg/kg)			
Area (m2)			
Volume of soil (tonnes)			
Volume of PFOS (kg)			
Uncertainty -			
Uncertainty +			





13.5 Water sampling and quantity dispersed annually

Fire training site (BØF)/contaminated site	BØF 1 (old)	BØF 3 (active)	The operating area
Have water samples been taken?	Yes	No	No
Where	In two streams northwest of BØF 1, as well as five groundwater wells northwest of the BØF (downstream).		
Highest measured concentration in groundwater PFOS (ng/l)	3,200		
Where	GWB2 (09/2011)		
Highest measured concentration in groundwater PFAS (ng/l)	5,550		
Where	GWB1 (06/2012)		
Comments/uncertainty	The figure is only stated in the table in the DP2 report. There is no analysis attached to the report on PFAS in the groundwater samples labelled 'GWB', so it is uncertain which compounds have been analysed for.		
Highest measured concentration in surface water PFOS (ng/l)	434	approx. 35	
Where	Stream 3 (09/2011)	GSV south of the airport	
Highest measured concentration in surface water PFAS (ng/l)	1,690	180	
Where	Stream 5 (06/2012)	GSV south of the airport	

Comments/uncertainty	The sample was analysed for 11 PFAS compounds.	The Norwegian Armed Forces' Sør-Varanger garrison camp is located south of the airport area. Wastewater from this area and from Vestleiren west of the airport drains to Avinor's discharge pipe before sampling point GSV, which thus documents the quality of the water which drains to the airport area. Several PFAS compounds have been detected in samples of the wastewater from GSV. Surface water from the fire training site drains via an oil separator to the discharge pipe and on to discharge into the sea. Water samples have been taken from the oil separator at the active BØF, and these concentrations vary from year to year and between samplings. The total PFAS in water sample taken in 2016 was approximately 4,000 ng/l, and in 2017 approximately 6,500 ng/l. In two samples from May 2018, total PFAS lies between 3,000 and 5,000 ng/l. This water primarily contains 6:2 FTS. Avinor has not used foam containing PFAS at its airports after 2012. At the discharge point from the airport into the sea, total PFAS concentrations are also very variable. In six samples taken between 2016 and 2018, they vary between < 20 and 160 ng/l. In May 2018, concentrations at the airport at point GSV were higher than at the discharge point. Information is taken from Avinor's environmental monitoring report to the County Governor of Finnmark dated 31.07.18:	
Total quantity dispersed annually from the site (g/year)	0.75	Not calculated	Not calculated
Total quantity dispersed annually from the site PFAS (g/year)	4	Not calculated	Not calculated

To which recipient	Korsfjorden is located about 800 metres to the west/northwest	Korsfjorden is located about 900 metres to the northwest	Korsfjorden is located about 800 metres to the north
Calculated from water or soil concentration.	Water concentration		

13.6 Biota sampling

Have biota samples being taken at the airport?	No	No	No
What kind of biota?			
How many samples?			
Highest measured concentration of PFOS in biota (µg/kg wet weight)			
Where			
Highest measured concentration of PFAS in biota (µg/kg wet weight)			
Where			
Median concentration in comparable populations (e.g. in a lake)			
Comments/references			
References and concentrations in other reports.			

13.7 Uncertainty and other factors

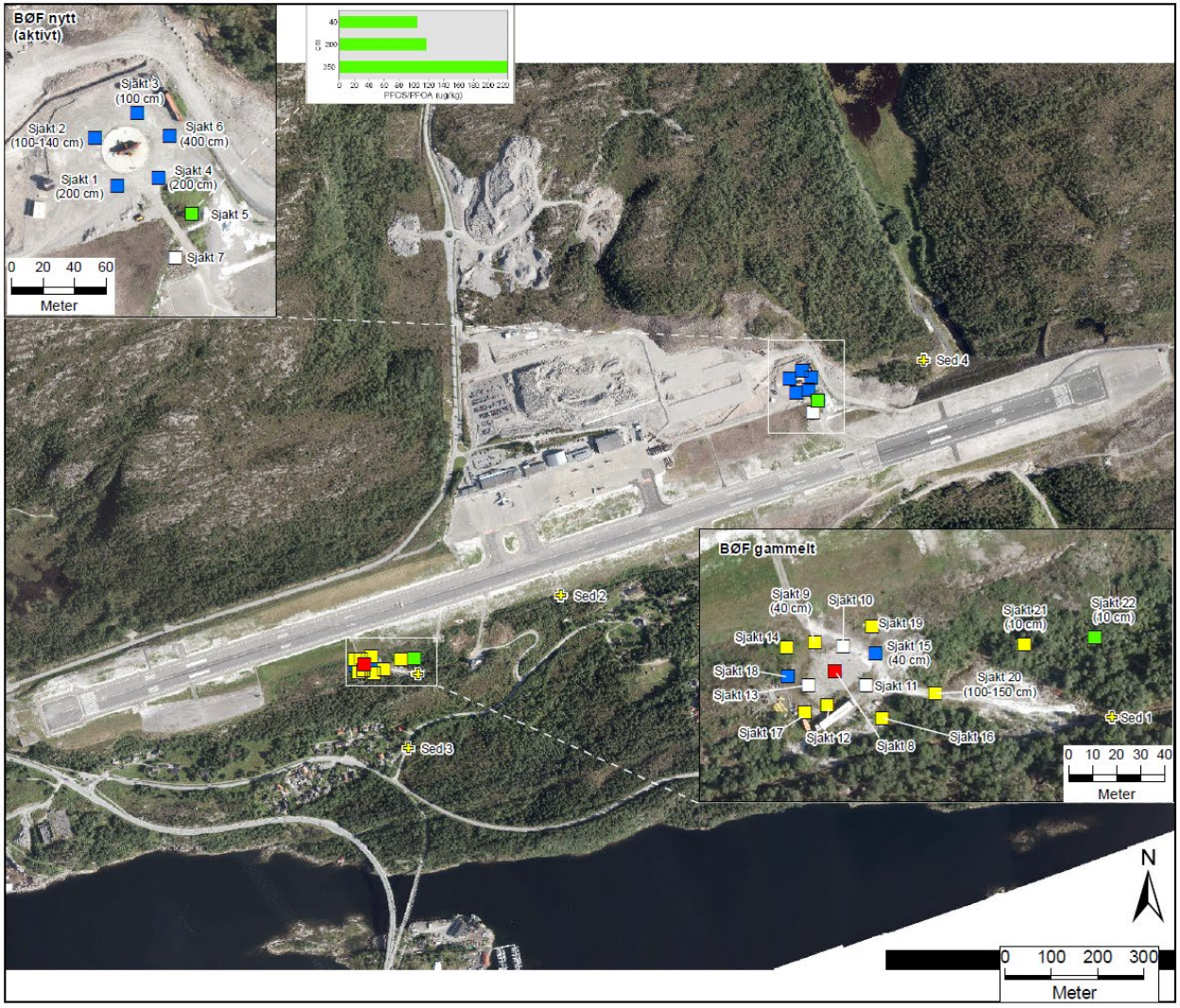
Fire training site (BØF)/contaminated site	BØF 1 (old)	BØF 3 (active)	The operating area
Does the estimate of the quantity of PFOS in the ground correspond with the measured concentrations in water and biota?	Cannot be evaluated for biota, as no biota samples have been taken. There is a closed landfill site owned by the Norwegian Armed Forces situated between the groundwater wells and the BØF, which results in considerable uncertainty as regards concentrations in groundwater and surface water downstream of the BØF.	Cannot be evaluated, as no water or biota samples have been taken.	Cannot be evaluated, as no water or biota samples have been taken.
Evaluations	Relatively high concentrations have been detected at all sampling points taken centrally within the BØF (the mean PFOS concentration in all soil samples near the centre of the site is 540 µg/kg), and relatively high concentrations have been detected in groundwater wells (the mean of ten samples is approx. 1400 ng/l) located approx. 200 metres northwest of the centre of the BØF. In two streams which flow approx. 500 metres northwest of the BØF, towards Korsfjorden, the mean concentration in eight samples was 173 ng/l.		
Comments/uncertainty (Could there be any additional unknown sources of PFOS at the site with runoff to the recipient?)	There is an old armed forces dump downstream of the fire training site, which could be a(n additional) source of PFOS in groundwater. Groundwater wells are situated downstream of the dump. No groundwater samples have been taken between the dump and the BØF, so it is not possible to evaluate whether the concentrations in groundwater are linked to one or both sources of contamination. The soil sample from the armed forces dump was taken from top soil only (0-20 cm). PFOS detected in soil samples from the operating area indicates that dispersal may also be taking place in the direction of Korsfjorden from this part of the airport. In 2017, an environmental survey was carried out and an action plan was drawn up in connection with the establishment of a new runway lighting system at the airport. Samples were taken from 14 points, seven of which were located in areas with possible PFAS contamination (two sampling points at each end of the runway and three points in the fire training site). PFAS contamination was detected at all seven sampling points. The dominant compound was PFOS, which was detected at concentrations of between 0.35 and 160 µg/kg. Four of the samples had concentrations of between 20 and 160 ug/kg. The highest concentrations were detected at the southwestern end of the runway, and at the point located closest to the fire training site. The		

	PFAS-contaminated material is being temporarily stored at the fire training site.		

Has the site been sufficiently mapped with a view to assessing the order of priority?	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the quantity of PFOS in the soil with the stipulated level of uncertainty.	No, the site is insufficiently mapped (see this report for parts 1 and 2, section 2.1.1.6 and section 2.1.3.1).	Yes, in accordance with the criteria (in this report for part 1 and part 2, section 2.1.3.1), sampling points and soil samples are sufficient to calculate the volume of PFOS in the soil with the stipulated level of uncertainty.
Comments/uncertainty	The area in and around the centre of the BØF has been thoroughly investigated with regard to sample numbers and depth distribution. However, there are no samples between the four extreme sampling points in the investigation formation which form a "cross" (BØF 1-6, BØF 1-9, BØF 1-15 and BØF 1-3), and the surface samples (2009/3, PFOS 4 and PFOS 3 as well as PFOS 5) taken approximately 50-100 metres further to the north, northeast and east, increasing the uncertainty in the quantity calculation.		These are four sampling points and a total of 12 soil samples. Ten of the samples contained PFOS concentrations above the detection limit, and five of them had PFOS concentrations of between 20-100 µg/kg. The operating area is therefore considered to be a separate site and quantities have been calculated.

General information about the airport	
Other factors of significance to possible clean-up/implementation of measures (e.g. planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	Water in a stream downstream of the old fire training site was used as a drinking water source by two households north of the airport. This drinking water turned out to contain PFAS. Avinor installed a new drinking water well in 2012. This well was recommended in the DP2 report for inclusion in the monitoring programme. Four analyses from 2012 and 2013 showed that PFAS was present in the water, at ∑PFAS concentrations of between 9 and 11 ng/l. The Kirkenes Peninsula, located about 3 km east of the airport, is a protected area for wildlife. There are several species of animals and plants of particularly high management interest both in the airport area and in Høybukta, which is situated just north of the airport. Various types of habitat (such as oxbow lakes, flood plain ponds, meandering river sections and soft-bottomed areas in the coastal zone) and plains have been recorded just northwest of the airport and in Høybukta. Makkskjær is an important outdoor recreation area situated immediately northwest of the airport. An undisturbed natural area has been registered approx. 2.5 km east/northeast of the airport. Høybukta , which is situated north of the airport, also has recordings of several red-listed plant species in the coastal zone. A number of bird species have also been observed in the area, including several red-listed species. At BØF 1, material contaminated with PFAS is being stored temporarily following works relating to the installation of the new runway lighting at the closed fire training site. The action plan for the new runway lighting recommended that PFAS-contaminated material (approx. 765 m^3) be stored on the paved area and on the impermeable slab at the fire training site. This is because the ground at the fire training site is contaminated with PFOS and the risk of spreading to uncontaminated areas would therefore be avoided. It is planned to temporarily store the PFAS-contaminated material here until a landfill solution has been established. The action plan has been considered and approved by Sør-Varanger municipality. A copy of the approval was sent to the County Governor of Finnmark. At BØF 3, THC has been detected in environmental condition class 4 in one soil sample, and only one sample has been analysed for THC.

14 Kristiansund Airport Kvernberget



Kristiansund lufthavn
Kvernberget (ENKB)

Oversiktskart

Jord og sediment

PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

PFOS sediment ferskvann (ug/kg)
- 0
- <LOQ
- LOQ-63
- 63-6300
- >6300
- Ikke analysert

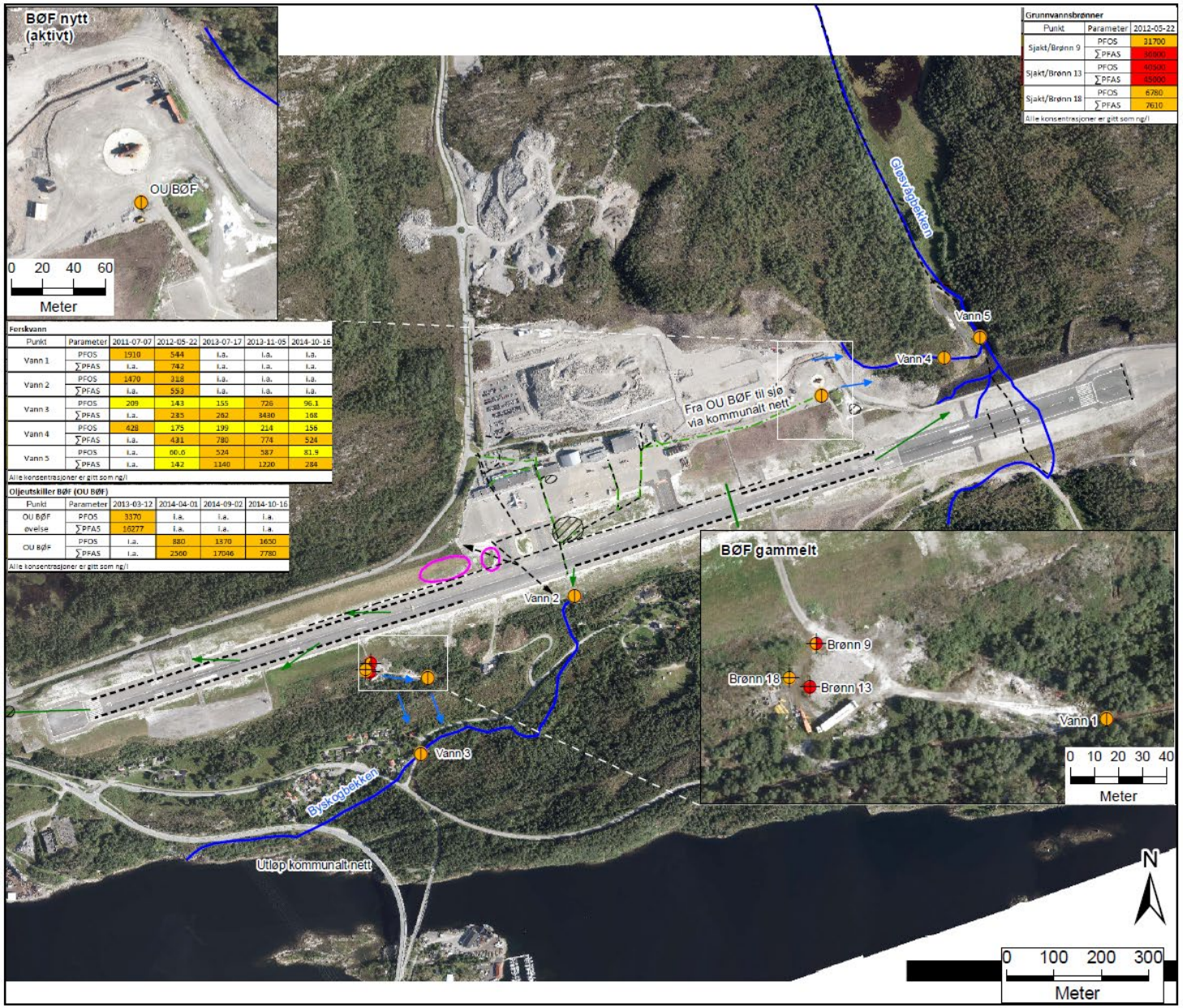
* PFOS er dominerende parameter

LOQ = rapporteringsgrense
i.a. = ikke analysert

AVINOR Norconsult COWI SWECO

Norconsult

APPENDIX A



Kristiansund lufthavn Kvernberget (ENKB)

Oversiktskart inkl. brannøvingsfelt

Vann

PFOS / ∑ PFAS grunnvannsbrønn (ng/l) *
- Ikke analysert
- 0
- <LOQ
- LOQ-230
- 230-36 000
- >36 000

PFOS / ∑ PFAS ferskvann (ng/l) *
- Ikke analysert
- 0
- <LOQ
- LOQ-230
- 230-36 000
- >36 000

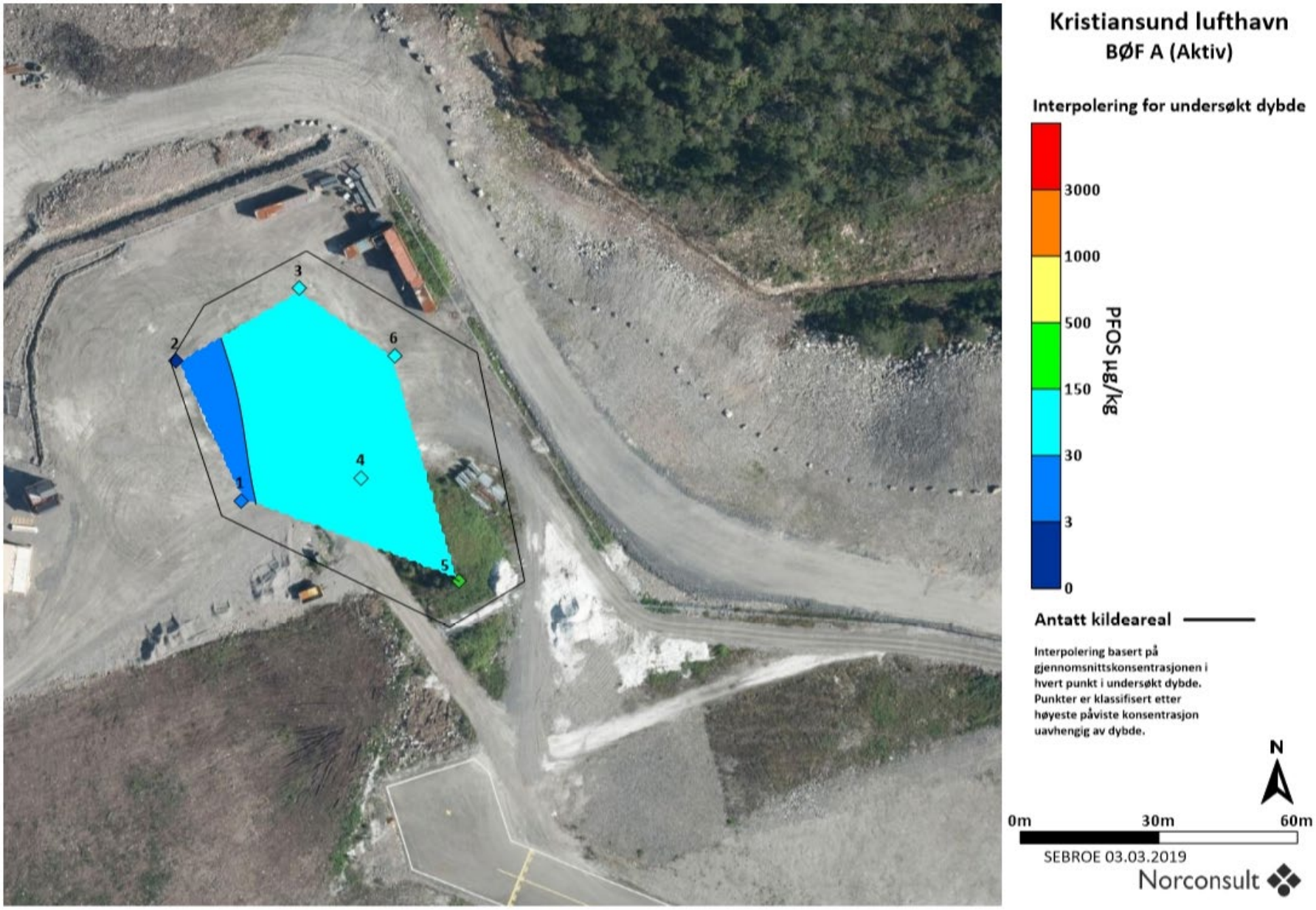
Avlopsledning
- Avløp annet
- Avløp Felles
- Drensvann
- Glykolholdig overvann
- Glykolholdig spillvann
- Overvann
- Pumpespillvannsledning
- Spillvann

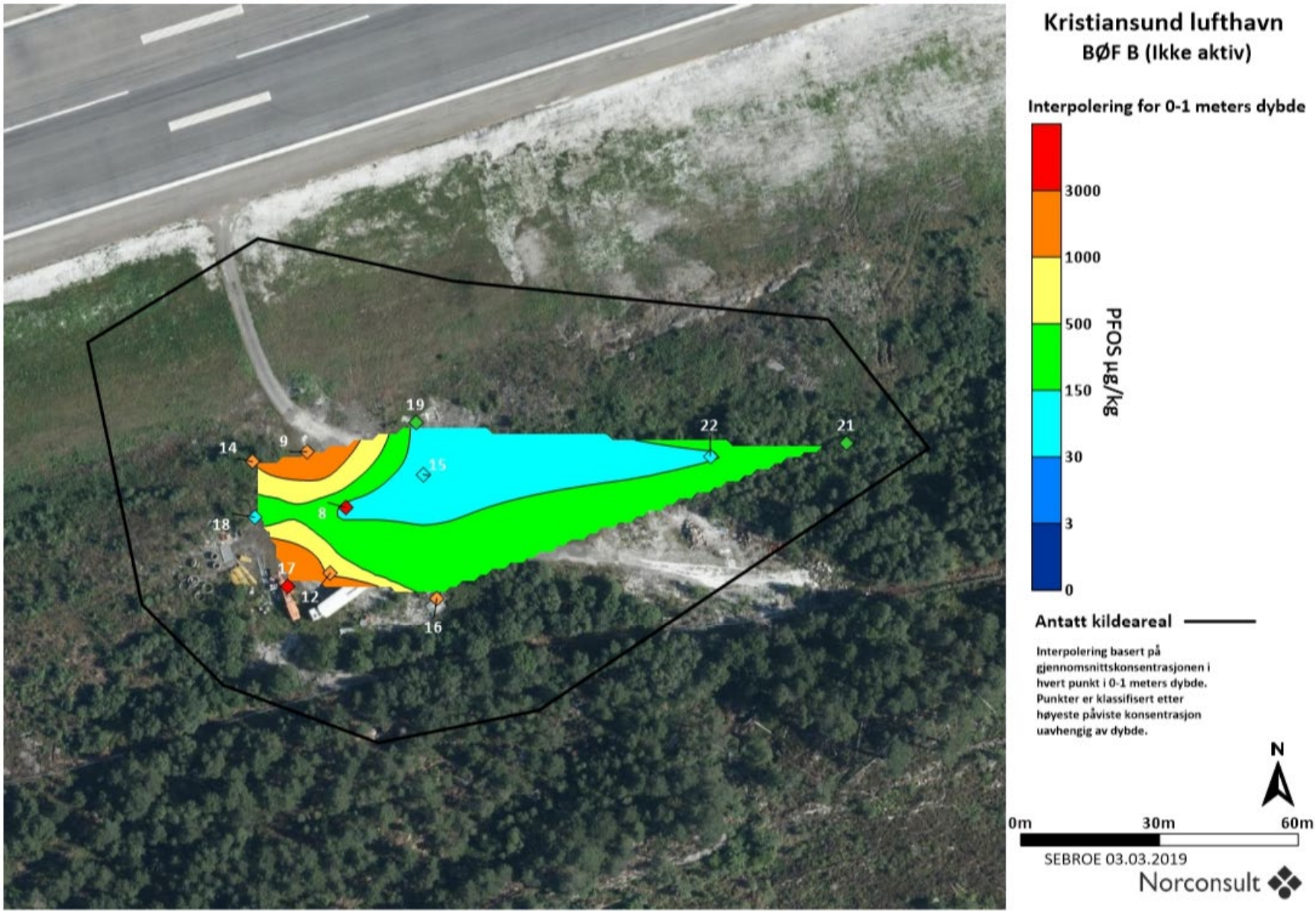
Avrenning
- Deponi glykolforurenset snø
- Overvannsledning
- Avrenningsveg glykol
- Bekkeresipient
- Overvannsystem
- Vannskille rullebane
- Antatt avrenningsveg baneavising
- PFOS-lokalitet
- Antatt dreneringsretning fra BØF

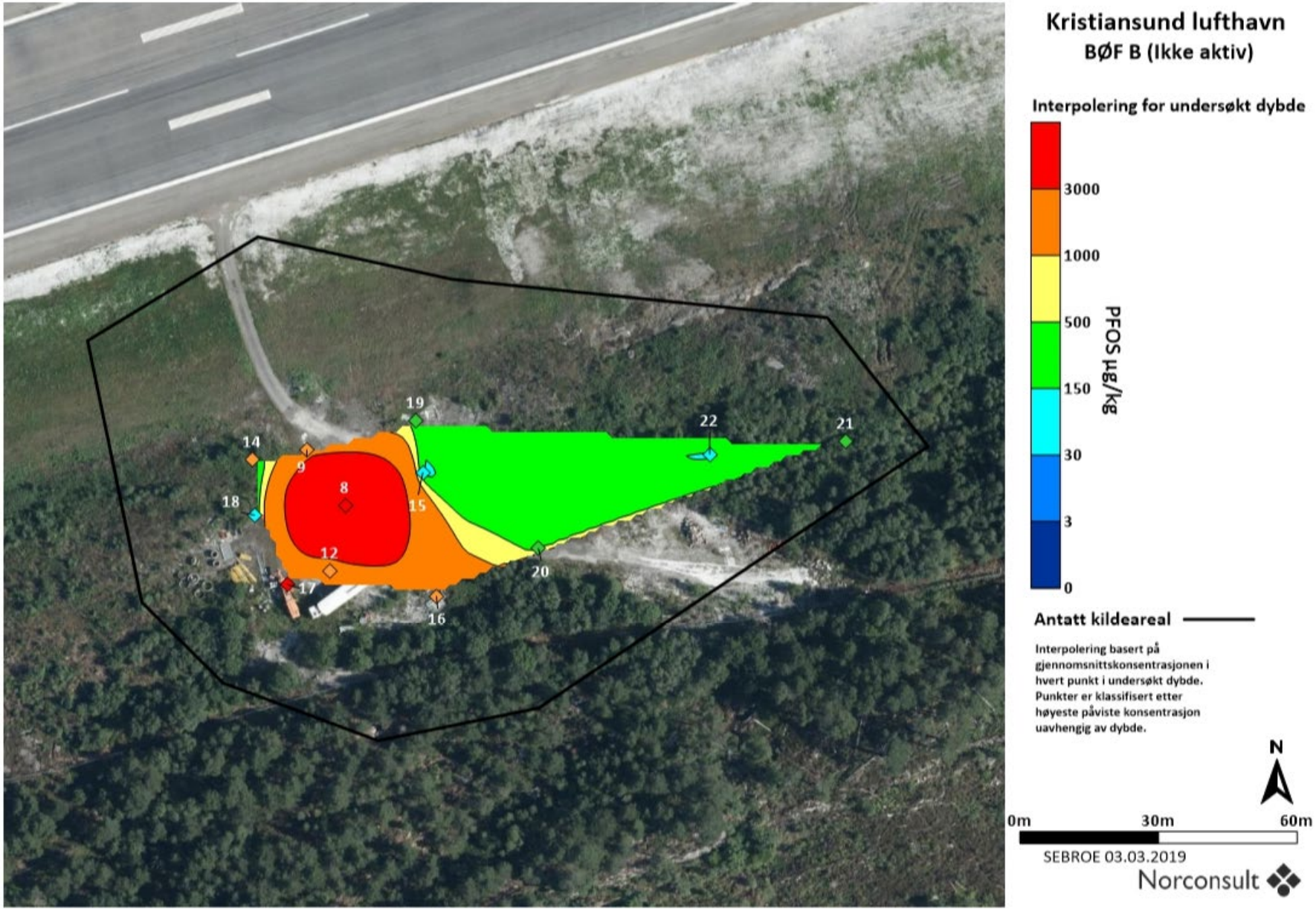
* Venstre halvdel = PFOS
Høyre halvdel = ∑PFAS

LOQ = rapporteringsgrense
i.a. = ikke analysert

AVINOR Norconsult COWI SWECO


Kristiansund lufthavn
BØF A (Aktiv)
Interpolering for undersøkt dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m
30m
60m
SEBROE 03.03.2019
Norconsult
1
2
3
4
5
6


Kristiansund lufthavn
BØF B (Ikke aktiv)
Interpolering for 0-1 meters dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i 0-1 meters dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m
30m
60m
SEBROE 03.03.2019
Norconsult
19
22
21
14
9
15
8
18
17
12
16


Kristiansund lufthavn
BØF B (Ikke aktiv)
Interpolering for undersøkt dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m
30m
60m
SEBROE 03.03.2019
Norconsult
14
9
8
18
19
15
22
21
12
20
17
16

14.1 Fire training site (BØF)/contaminated site

Fire training site (BØF)/contaminated site	BØF A (active)	BØF B (old)
	Active fire training site, taken into use in 2004.	Old fire training site which was taken into use in 1978 and closed in 2004.

14.2 Use of PFOS and other PFAS

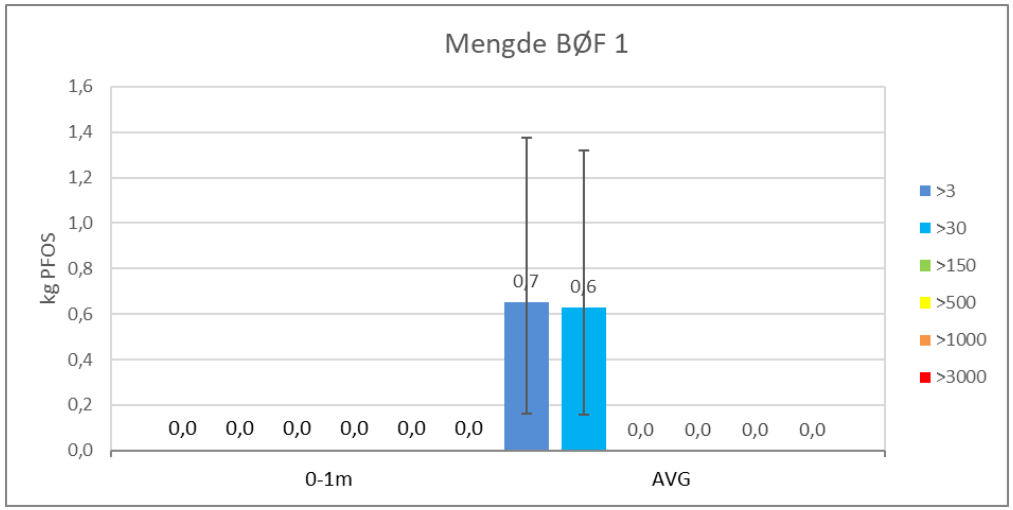
Quantity of PFOS used at the site (kg)		800
Comments/uncertainty	It is unlikely that foam containing PFOS as its main PFAS component has been used, as this was phased out in 2001.	It is not known when the fire training site was taken into use, but it was active through until around 2004. The quantity calculation is based on the period from 1978 to 2002.
Quantity of PFAS used at the site (kg)	105	25
Comments/uncertainty	Estimated use during the period from 2004 to 2012. Avinor completely phased out firefighting foam containing PFAS in 2012 and now uses only PFAS-free firefighting foam.	The quantity calculation is based on the period from 2002 to 2004.

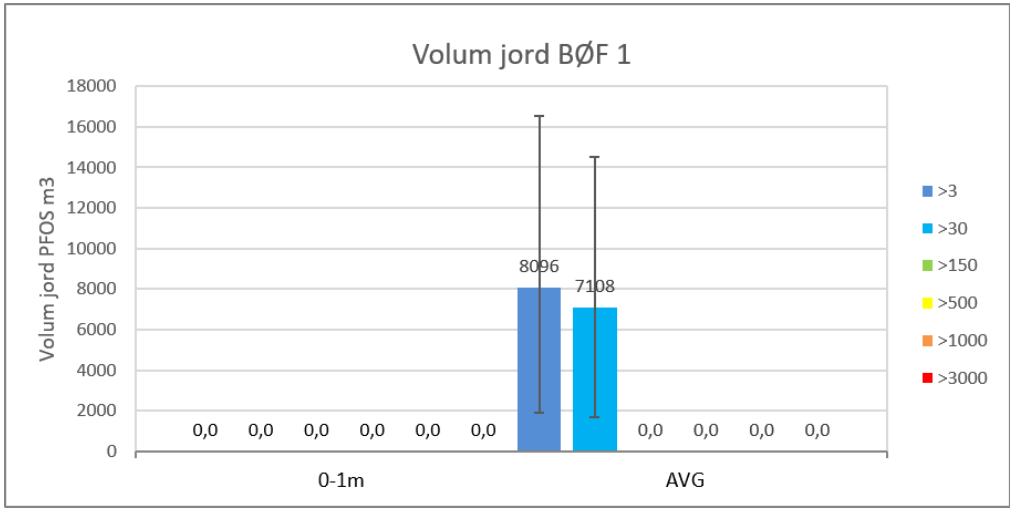
14.3 Soil sampling

Fire training site (BØF)/contaminated site	BØF A (active)	BØF B (old)
Total number of soil samples	8	20
Comments/uncertainty (e.g. 95% of the samples were taken from 0-0.1 m)	All the samples were taken from deeper-lying material (100-400 cm), except for one sample which was taken from a depth of 40 cm.	Two samples from a depth of 10 cm, nine samples from a depth of 40 cm, and eight samples from a depth of between 100-200 cm.
Number of soil samples 0-1 m below ground level	1	11
Number of soil samples under 1 m	7	9
Comments/uncertainty	Stone, gravel, sand, boulders, and one sampling point SJ5 in marsh just outside BØF.	Stone, gravel, sand, marsh, boulders.
Highest measured soil concentration of PFOS µg/kg	222	12,100
Where	Sample of marsh from a depth of 350 cm. Shaft 5-3, located just outside the active BØF to the southeast.	Sample of gravel and sand at a depth of 150 cm. Shaft 8-2, located centrally at the BØF.
Highest measured soil concentration of PFAS µg/kg	222	12,100
Where	Sample of marsh from a depth of 350 cm. Shaft 5-3, located just outside the active BØF to the southeast.	Sample of gravel and sand at a depth of 150 cm. Shaft 8-2, located centrally at the BØF.
Comments/uncertainty	Sample "BØF 5-3" was only analysed for PFOS and PFOA. Only two samples were analysed for more PFAS compounds (12 pcs.). The two samples were also taken from marshland, but do not show any significant concentrations of PFAS compounds other than PFOS.	Sample "BØF 8-2" was only analysed for PFOS and PFOA. However, 12 of the samples were analysed for more PFAS compounds (12 pcs), but none has a higher total than sample Shaft 8-2.

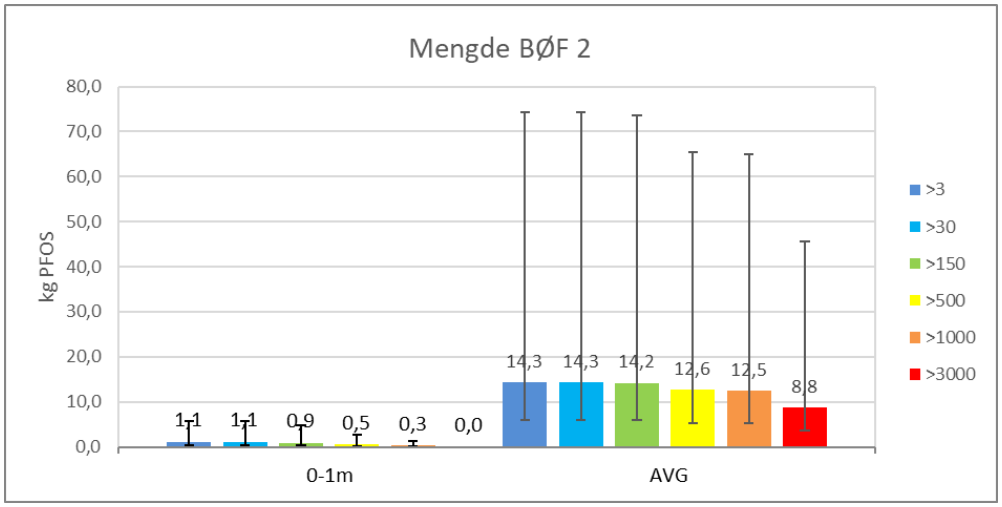
14.4 Quantity calculation

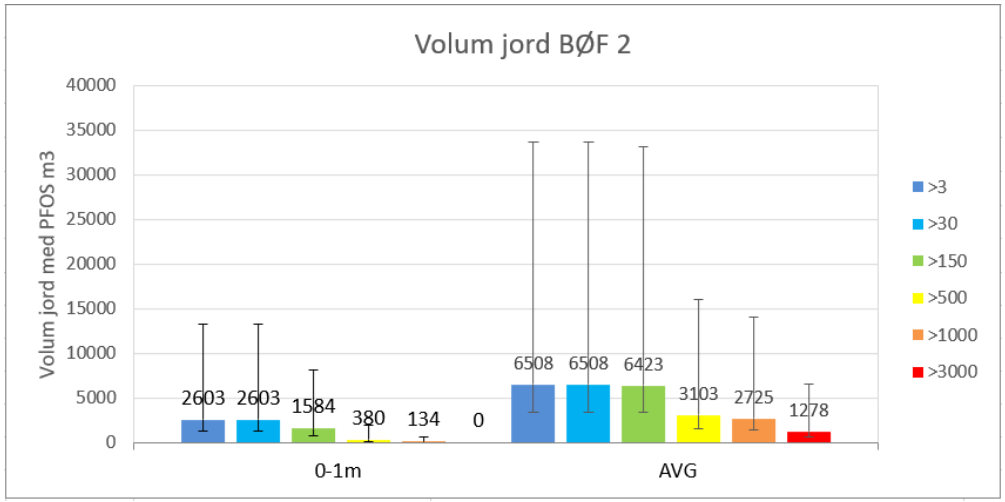
PFOS average for all depths and points > 3 µg/kg		
Concentration (µg/kg)	64	1,748
Area (m2)	2,024	2,603
Quantity of soil (tonnes)	14,573	11,714
Quantity of PFOS (kg)	0.7	14
Uncertainty -	0.5	8.4
Uncertainty +	0.7	60
PFOS average for all depths and points > 30 µg/kg		
Concentration (µg/kg)	70	1,748
Area (m2)	1,777	2,603
Quantity of soil (tonnes)	12,794	11,714
Quantity of PFOS (kg)	0.6	14
Uncertainty -	0.5	8.4
Uncertainty +	0.7	60
PFOS average for all depths and points > 150 µg/kg		
Concentration (µg/kg)		1,757
Area (m2)		2,569
Quantity of soil (tonnes)		11,561
Quantity of PFOS (kg)		14
Uncertainty -		8.4
Uncertainty +		59
PFOS average for all depths and points > 500 µg/kg		
Concentration (µg/kg)		3,227
Area (m2)		1,241
Quantity of soil (tonnes)		5,585
Quantity of PFOS (kg)		13
Uncertainty -		7.4
Uncertainty +		53





PFOS average for all depths and points > 1000 µg/kg		
Concentration (µg/kg)		3,647
Area (m2)		1,090
Quantity of soil (tonnes)		4,905
Quantity of PFOS (kg)		13
Uncertainty -		7.4
Uncertainty +		52
PFOS average for all depths and points > 3000 µg/kg		
Concentration (µg/kg)		5,475
Area (m2)		511
Quantity of soil (tonnes)		2,300
Quantity of PFOS (kg)		8.8
Uncertainty -		5.2
Uncertainty +		37





Fire training site (BØF)/contaminated site	BØF A (active)	BØF B (old)
Comments regarding calculations	In the risk assessment for BØF A carried out in 2016, it was calculated that there is a residual quantity of 2.5 kg ± 1 kg of PFOS in situ in the ground spread across an area of 8,000 ± 2,000 m^2 to a depth 4 ± 0.4 metres.	In the risk assessment for BØF B carried out in 2016, it was calculated that there is a residual quantity of 15 kg ± 7 kg of PFOS in situ in the ground spread across an area of 6,000 ± 2,000 m^2 to a depth 2 ± 0.4 metres.
Is the extent of the contaminated area limited horizontally?	No, for this site, the highest concentrations of PFOS were detected in marshland just outside the fire drill platform, at extreme point shaft 5 to the southeast. Extreme points from the area around the platform have the lowest concentrations in the west (shaft 1 and shaft 2 with 21.4 and 2.9 µg PFOS/kg respectively). To the northeast and east, shaft 3 has a concentration of about 80 µg/kg and shaft 6 approx. 50 µg/kg.	No. The extreme points all have concentrations > 300 µg/kg, except for shaft 18 in the west which has a concentration of approx. 50 µg/kg. Samples must therefore be taken across a larger area in order to delimit contamination down to low concentrations.
Is the extent of the contaminated area limited vertically?	No, the deepest samples do not show concentrations below the detection limit. However, there are relatively low PFOS concentrations in the samples from > 1 metre, with the exceptions of shaft 4 and shaft 5, which have concentrations of between 90 and 225 µg/kg. The highest concentration occurs in the deepest sample from shaft 5 (depth of 350 cm).	No, the deepest samples do not show concentrations below the detection limit. There is no consistent trend of decreasing PFOS concentrations in deeper layers.
Comments/uncertainty	No more than one sample has been taken from the top soil (0-1 m). Only two samples were analysed for PFAS compounds other than PFOS and PFOA.	Groundwater is stated as occurring at a depth of approx. 1 metre.

14.5 Water sampling and annual dispersion

Fire training site (BØF)/contaminated site	BØF A (active)	BØF B (old)
Have water samples been taken?	Yes	Yes
Where	Stream/ditch which carries water via a coffer dam to Gløsvågbekken and Gløsvågen (nature conservation area). Liquid collected from the fire drill platform is drained to an oil separator and on to a pump sump, from where it is pumped to the airport's wastewater system, which discharges into the sea. Runoff from the airport is drained either via Byskogbekken and the municipal network to Omsundet in the south or via Gløsvågbekken to Gløsvågen in the north.	Groundwater wells constructed in excavated shafts at the BØF. Kulp and Byskogbekken
Highest measured concentration in groundwater PFOS (ng/l)		40,500
Where	Not measured	Well 13 (22.05.2012)*
Highest measured concentration in groundwater PFAS (ng/l)		45,000*
Where	Not measured	Well 13 (22.05.2012)*
Comments/uncertainty	In the platform area, the groundwater flows in a small stream to the east, where it is collected in a new coffer dam. The water in the coffer dams drains to Vågen, before discharging into Gløsvågen.	*Probably not representative values because the sample was taken shortly after shaft excavation with well establishment in the shaft. The sample was analysed for 12 PFAS compounds.
Highest measured concentration in surface water PFOS (ng/l)	587	1,910
Where	Water 5 uppermost in the coffer dam which is situated 280 metres east of the active BØF.	Water 1 (07.07.2011). A small knoll which is located about 90 metres east of the old BØF.
Highest measured concentration in surface water PFAS (ng/l)	1,220	3,430

Where	Water 5 uppermost in the coffer dam which is situated 280 metres east of the active BØF.	Water 3 (05.11.2013). Byskogbekken.

Comments/uncertainty	Samples have also been taken from the ditch/stream at sampling point Water 4 located 170 metres from the active BØF. The concentrations are slightly lower in the stream (PFOS 150-430 ng/l and PFAS 430-800 ng/l) than in the coffer dam (Water 5). Water samples from the oil separator are not considered to be representative of the surface water in the area. Water from the oil separator was sampled on four occasions between 2013 and 2014, and has concentrations of PFOS of between 850-3400 ng/l and concentrations of PFAS of between 2,500-16,300 ng/l. The dominant compounds are 6:2 FTS, PFOS and 8:2 FTS. Avinor has not used PFAS foam at its airports since 2012 and the oil separators are emptied and cleaned once a year (unless they produce < 1kg oil during the course of a year), or more often if necessary.	Byskogbekken is a stream located about 180 metres south of the BØF. According to the 2016 report, it is uncertain whether the sample from May 2013 is representative, as the sample was taken so much higher than during four other samplings from 2011-2014 (total PFAS approx. 200 ng/l). The report also states that it is uncertain whether the stream at the sampling point actually captures runoff/groundwater from the BØF.
Total quantity dispersed annually from the site (g/year)	Not calculated (1)*	200
Total quantity dispersed annually from the site PFAS (g/year)	Not calculated (7)*	Not calculated

To which recipient	Gløsvågbekken/Gløsvågen, and *water from the oil separator is directed to the airport's wastewater system, which discharges into the sea (to Ormsundet?)	Byskogbekken and sea, Ormsundet
Calculated from water or soil concentration.	*Water concentration oil separator, but it is uncertain whether the leaching is representative of the current situation, as the use of foam containing PFAS ceased in 2012.	Groundwater and surface water
	The estimated outward transport of PFOS to Gløsvågen is approx. 143 g/year. It was not possible to estimate the transport from BØF A or sources around/below BØF A in isolation. The total quantity dispersed from the airport is estimated to be in the range of 300-400 g per year.	The total quantity dispersed from the airport is estimated to be in the range of 300-400 g per year.

14.6 Biota sampling

Fire training site (BØF)/contaminated site	BØF A (active)	BØF B (old)
Have biota samples been taken at the airport?	Yes	Yes
What kind of biota?	Polychaete, common shore crab, periwinkle, mussel, sea lettuce and common seaweed flea	Common seaweed flea, murex, rough periwinkle, limpet
How many samples?	6	4
Highest measured concentration in biota PFOS (µg/kg wet weight)	17	12
Where	Common seaweed flea, composite sample of n>30, Outlet Vågen	Common seaweed flea, composite sample of n>20, Byskogbekken
Highest measured concentration in biota PFAS (µg/kg wet weight)	22.6	20.4
Where	Common seaweed flea, n>30, Outlet Vågen	Common seaweed flea, n>20, Byskogbekken
Median concentration (µg/kg wet weight) in comparable populations (e.g. in a lake)	The median PFOS concentration in samples of common seaweed fleas collected outside Tromsø Airport was 11.7 µg/kg; see comment/reference.	The median PFOS concentration in samples of common seaweed fleas collected outside Tromsø Airport was 11.7 µg/kg; see comment/reference.

Comments/references	In a composite sample of common seaweed fleas (n=31) at Giæverneset outside Tromsø Airport, concentrations of 9.4 µg/kg PFOS and 9.4 µg/kg PFAS were detected. A composite sample of common seaweed fleas (n=13) was also taken from the sea just offshore of the active BØF located to the north of the same airport. The sample contained 14 µg/kg PFOS and 34.4 µg/kg PFAS. Taken from an Avinor report in 2016, Tromsø Airport Langnes: Investigations of PFAS in soil, water and biota with risk assessment.	In a composite sample of common seaweed fleas (n=31) at Giæverneset outside Tromsø Airport, concentrations of 9.4 µg/kg PFOS and 9.4 µg/kg PFAS were detected. A composite sample of common seaweed fleas (n=13) was also taken from the sea just offshore of the active BØF located to the north of the same airport. The sample contained 14 µg/kg PFOS and 34.4 µg/kg PFAS. Taken from an Avinor report in 2016, Tromsø Airport Langnes: Investigations of PFAS in soil, water and biota with risk assessment.
References and concentrations in other reports.	Avinor 2018, Action plan for PFAS-contaminated land as a result of fire training, Longyearbyen, Svalbard. Two samples of common seaweed fleas in the coastal zone downstream of the closed BØF contained PFOS concentrations of between 1.2-2.5 µg/kg; no other PFAS compounds were detected. Avinor 2016, Leknes Airport. Investigations of PFAS in soil, water and biota. No PFAS was detected in a composite sample of n=50 common seaweed fleas collected from the sea off Leknes Airport in 2013.	Avinor 2018, Action plan for PFAS-contaminated land as a result of fire training, Longyearbyen, Svalbard. Two samples of common seaweed fleas in the coastal zone downstream of the closed BØF contained PFOS concentrations of between 1.2-2.5 µg/kg; no other PFAS compounds were detected. Avinor 2016, Leknes Airport. Investigations of PFAS in soil, water and biota. No PFAS was detected in a composite sample of n=50 common seaweed fleas collected from the sea off Leknes Airport in 2013.

14.7 Uncertainty and other factors

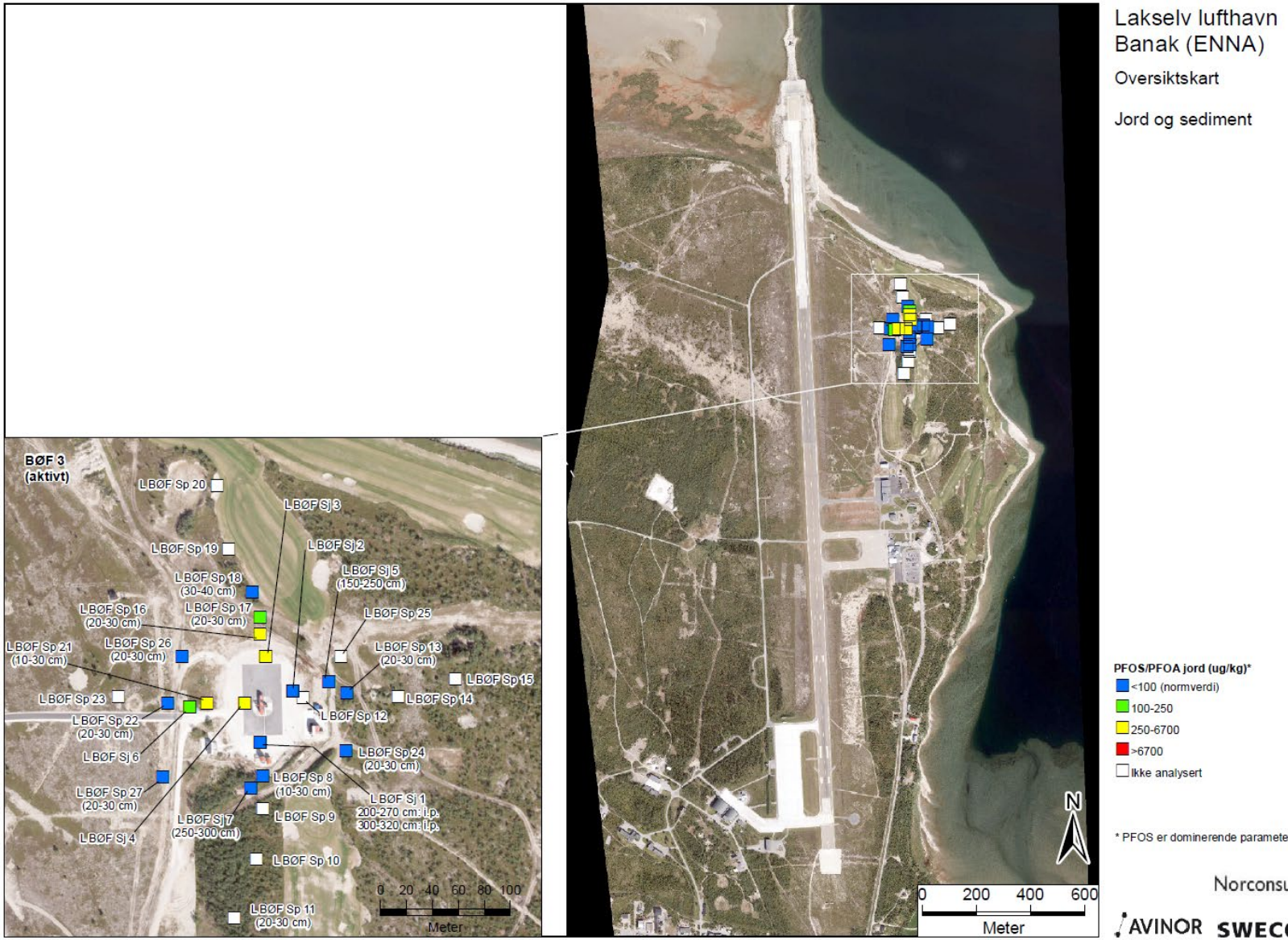
Fire training site (BØF)/contaminated site	BØF A (active)	BØF B (old)
Does the estimate of the quantity of PFOS in the ground correspond with the concentrations measured in water and biota?	Cannot be reliably evaluated.	Cannot be reliably evaluated.
Evaluations	The platform itself at BØF A is constructed from concrete with a double-reinforced slab to prevent cracking, but it has no membrane, so that any leaks will infiltrate into the stone fill beneath the fire drill platform. The concrete slab has some cracks, which could lead to liquid seeping down through the slab. There are relatively low concentrations of PFOS in the soil samples taken from the ground around the platform at the BØF. The material consists of stone, gravel and sand, and a relatively high degree of leaching is anticipated. The soil samples have not been analysed for other PFAS compounds, with the exception of two samples taken from marsh from shaft 5, which contained low concentrations of PFAS compounds other than PFOS. These soil samples did not contain any 6.2 FTS or 8.2 FTS, which are the main components of the foam that was used from 2001.	The soil samples generally have relatively high concentrations, and nine out of 12 sampling points have PFOS concentrations of between 300 and 12100 µg/kg. Only at three of the sampling points was the highest concentration detected at the sampling point below 150 µg/kg. The soil samples have PFOS as the dominant component, followed by PFHxS. In some samples, PFNA and a number of other components have been detected. 6:2 FTS has been detected in a sample from a depth of 100 metres in shaft 19. Samples of groundwater have been taken from wells established in shafts, immediately after construction. The concentration levels in the

	No samples of groundwater have been taken beneath the BØF. Groundwater from the BØF is stated in the risk assessment report as flowing into a small stream to the east, where it is collected in a coffer dam. The concentrations in the stream (sampling point Water 4) and coffer dam (sampling point Water 5) downstream of the BØF indicate an impact with occasionally moderate concentrations of both PFOS (between 60-590 ng/l) and PFAS (between 140-1220 ng/l). PFOS is the dominant component in the water, followed by 6:2 FTS, PFHxA, PFHxS and PFPeA. In the stream, concentrations of total PFAS in samples taken on 22 May 2012 and 16 October 2014 (431 and 524 ng/l) were higher than those in the coffer dam on the same dates (142 and 284 ng/l). If the contamination is caused by runoff from the BØF alone, this would be reasonable, as the stream is closer to the BØF, and the coffer dam is a larger recipient than the stream. However, in the samples taken on 17 July 2013 and 5 November 2013, the concentrations in the stream (approx. 780 ng/l in both samples) are lower than those in the coffer dam (approx. 1220 ng/l in both samples). It is unclear why concentrations in the stream are lower than in the coffer dam as regards these samples. It may be linked to the quantity of water in the dam in connection with precipitation, an increase in concentration as a result of evaporation or emptying of the dam, but it may also be associated with inflow into the coffer dam from an unknown source in the eastern part of the airport, or from runoff from the airport generally. The water from the coffer dam flows to Vågen, before flowing on to Gløsvågen. Concentrations of PFOS and PFUnDA (17 and 5.6 µg/kg respectively) have been detected in a composite sample of common seaweed fleas and of PFOS in sea lettuce (1.2 µg/kg) from the sampling point located at the outflow of Vågen into the stream which discharges into Gløsvågen. PFOS (of between 1-4.7 µg/kg) has also been detected in beach biota at the sampling point located by the outlet of this stream into the sea (Gløsvågen).	samples are therefore not considered to be representative due to the mobilisation of PFAS in connection with excavation. However, no 6:2 FTS was detected in water samples from the groundwater wells. 6:2 FTS was detected in water samples from Byskogbekken, approx. 200 metres downstream of the BØF (Water 3). The water samples from the stream show relatively consistent levels of PFOS (between 95-210 ng/kg) and PFAS (between 160-260 ng/l), with the exception of one sample from November 2013, which contains concentrations of PFOS of 726 ng/l and PFAS of 3430 ng/l. Water sample Water 2, which was taken immediately downstream of the runway, south of the terminal area and east of the old BØRF, also contains high concentrations of PFOS (318 and 1470 ng/l) and PFAS (553 ng/l). There may be sources of PFAS that have not been mapped at the airport.

Comments/uncertainty (Could there be any additional unknown sources of PFOS at the site with runoff to the recipient?)	As described above, there may be additional sources of PFAS in the coffer dam to the east, as runoff from the airport drains either via Byskogbekken and the municipal network to Omsundet in the south or via Gløsvågbekken to Gløsvågen in the north. There are several water flows around the eastern part of the runways which lead to the coffer dam (Figure 7-2 of the risk assessment report). Fire drills have also been carried out using foam at the western end of the airport and southeast of the active fire training site. The years in which these drills were conducted are unknown. In connection with the Avinor project "Safety area and lighting systems", surface samples were collected	The fire engine is cleaned and checked in the vegetated area adjacent to the terminal building and in front of the operations building. Runoff from here will drain south towards Byskogbekken. Fire drills have also been carried out using foam at the western end of the airport and southeast of the active fire training site. The years in which these drills were conducted are unknown.

	from near the active BØF in March 2011. Bedrock material beneath the soil samples was used as fill during the runway extension. Surface samples showed low PFOS concentrations of between 5.8 and 43 µg/kg. These samples are not shown on any maps from any of the reports. The risk assessment report states that these are not representative of the current situation.	
Has the site been sufficiently mapped with a view to assessing the order of priority?	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the quantity of PFOS in the soil with the stipulated level of uncertainty.	Yes, in accordance with the criteria (in this report for part 1 and part 2, section 2.1.3.1), sampling points and soil samples are sufficient to calculate the volume of PFOS in the soil with the stipulated level of uncertainty.
Comments/uncertainty		
General information about the airport		
Other factors of significance to possible clean-up/implementation of measures (e.g. planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	Gløsvågen is a nature reserve located about 500 metres northeast of the airport. It was protected in 1988, with the aim of safeguarding an important wetland and its associated plant communities, bird life and other wildlife. The protected area is a nesting and migratory site for wetland birds. The site has been mapped as a habitat type "brackish water pools (Very important)". The area is of particular interest not only as a resting site during the migration of wetland birds, but also as a breeding ground for certain to some extent more demanding species. Species such as grey heron, mallard, lapwing, common teal, Eurasian curlew and common redshank have been recorded. In mild winters, some birds can also overwinter here. It is the most important wetland in Kristiansund. (www.naturbase.no). Gløsvågen is also of botanical value. In Omsundet south of the airport is Rensvikholmen, where various species have been recorded, including common gull, common tern and common eider. The area around the nature reserve and the airport is a grazing area for roe deer (all year round). On the western side of Gløsvågen, an ancient boreal coniferous forest of local value (Kvernberget East) has been registered. There are no red-listed species linked to fauna in this area. The area consists of a steep hillside with a forest dating from the Middle Ages.	

15 Lakselv lufthavn Banak



Lakselv lufthavn Banak (ENNA)

Oversiktskart

Jord og sediment

PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

* PFOS er dominerende parameter

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Grunnvannsbrønner

Punkt	Parameter	2011-10-11	2012-05-29	2012-05-31	2013-06-05	2013-09-04
L BØF Sj 5	PFOS	i.a.	i.a.	355	294	337
	∑PFAS	i.a.	i.a.	4360	4050	3940
L BØF Sj 6	PFOS	i.a.	i.a.	19000	55900	37700
	∑PFAS	i.a.	i.a.	30000	67500	41900
L BØF Sj 7	PFOS	i.a.	i.a.	167	145	325
	∑PFAS	i.a.	i.a.	986	840	708
LT1	PFOS	i.a.	i.a.	<LOQ	i.a.	i.a.
	∑PFAS	i.a.	i.a.	111	i.a.	i.a.
LT2	PFOS	i.a.	i.a.	<LOQ	i.a.	i.a.
	∑PFAS	i.a.	i.a.	<LOQ	i.a.	i.a.

Alle konsentrasjoner er gitt som ng/l

Ferskvann

Punkt	Parameter	2011-10-11	2012-05-31	2013-05-29	2013-06-05	2013-09-04	2014-05-16	2014-09-18	2015-07-15
L BØF UTLØP	PFOS	383	112	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
	∑PFAS	i.a.	253	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
L BØF Sj3	PFOS	58980	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
	∑PFAS	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.	i.a.
Komm. RA	PFOS	i.a.	i.a.	i.a.	<LOQ	<LOQ	i.a.	i.a.	i.a.
	∑PFAS	i.a.	i.a.	i.a.	<LOQ	<LOQ	i.a.	i.a.	i.a.
Avløpsvann BØF oljeutskiller, normal	PFOS	i.a.	i.a.	i.a.	2230	i.a.	764	29.5	162
	∑PFAS	i.a.	i.a.	i.a.	14700	i.a.	20700	2120	2060
Avløpsvann BØF oljeutskiller v/øvelse	PFOS	i.a.	i.a.	8940	i.a.	i.a.	i.a.	i.a.	i.a.
	∑PFAS	i.a.	i.a.	45600	i.a.	i.a.	i.a.	i.a.	i.a.

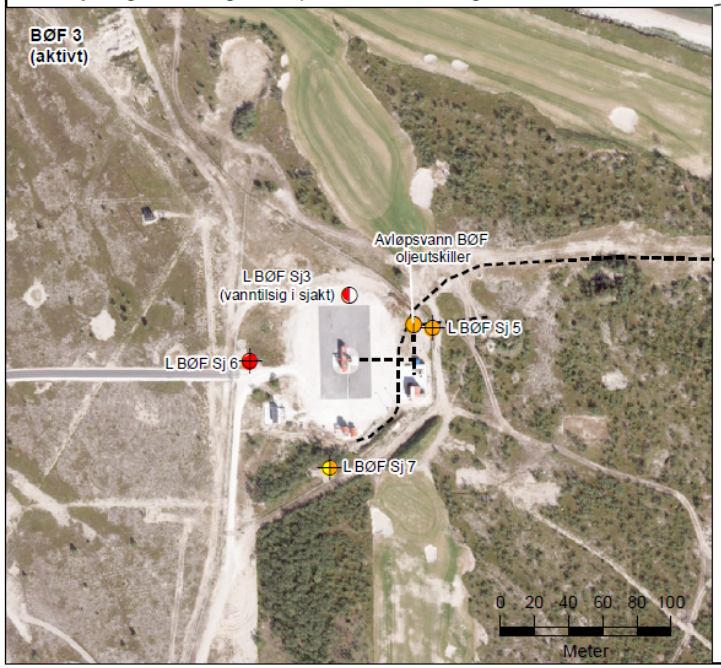
Alle konsentrasjoner er gitt som ng/l

Sjøvann

Punkt	Parameter	2012-05-31
Strand 1	PFOS	25.7
	∑PFAS	95.4

Alle konsentrasjoner er gitt som ng/l

Fargekode for Avløpsvann BØF i kartutsnitt representerer konsentrasjoner i prøve tatt under normale forhold. Konsentrasjoner og tilhørende fargekode for prøve tatt under øvelse er gitt i tabell for ferskvann over.





Lakselv lufthavn Banak (ENNA)

Oversiktskart inkl. brannøvingsfelt 3 (aktivt)

Vann

PFOS / ∑ PFAS grunnvannsbrønn (ng/l) *
- Ikke analysert
- 0
- <LOQ
- LOQ-230
- 230-36 000
- >36 000

* Venstre halvdel = PFOS
Høyre halvdel = PFAS

PFOS / ∑ PFAS ferskvann (ng/l) *
- Ikke analysert
- 0
- <LOQ
- LOQ-230
- 230-36 000
- >36 000

* Venstre halvdel = PFOS
Høyre halvdel = PFAS

PFOS / ∑ PFAS sjøvann (ng/l) **
- Ikke analysert
- 0
- <LOQ
- LOQ-23
- 23-7 200
- >7 200

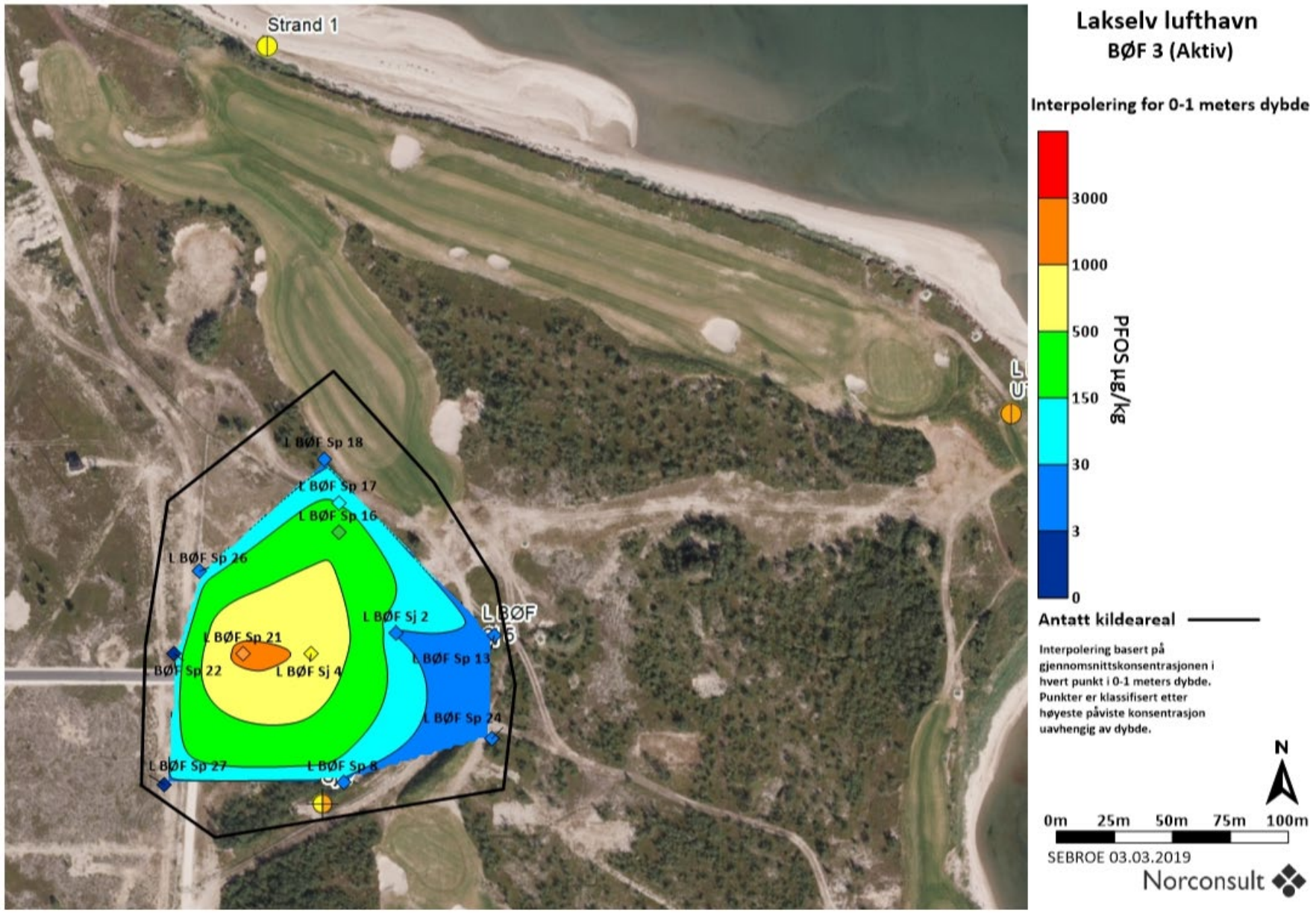
** Senter = PFOS
Ytre ramme = PFAS

Avlopsledning
- Avløp annet
- Avløp Felles
- Drensvann
- Glykolholdig overvann
- Glykolholdig spillvann
- Overvann
- Pumpespillvannsledning
- Spillvann

Avrenning
- Deponi glykolforurenset snø
- Overvannsledning
- Avrenningsveg glykol
- Bekkeresipient
- Overvannsystem
- Vannskille rullebane
- Antatt avrenningsveg baneavising

i.a. = ikke analysert
LOQ = rapporteringsgrense

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Lakselv lufthavn
BØF 3 (Aktiv)

Interpolering for 0-1 meters dybde

PFOS µg/kg
3000
1000
500
150
30
3
0

Antatt kildeareal

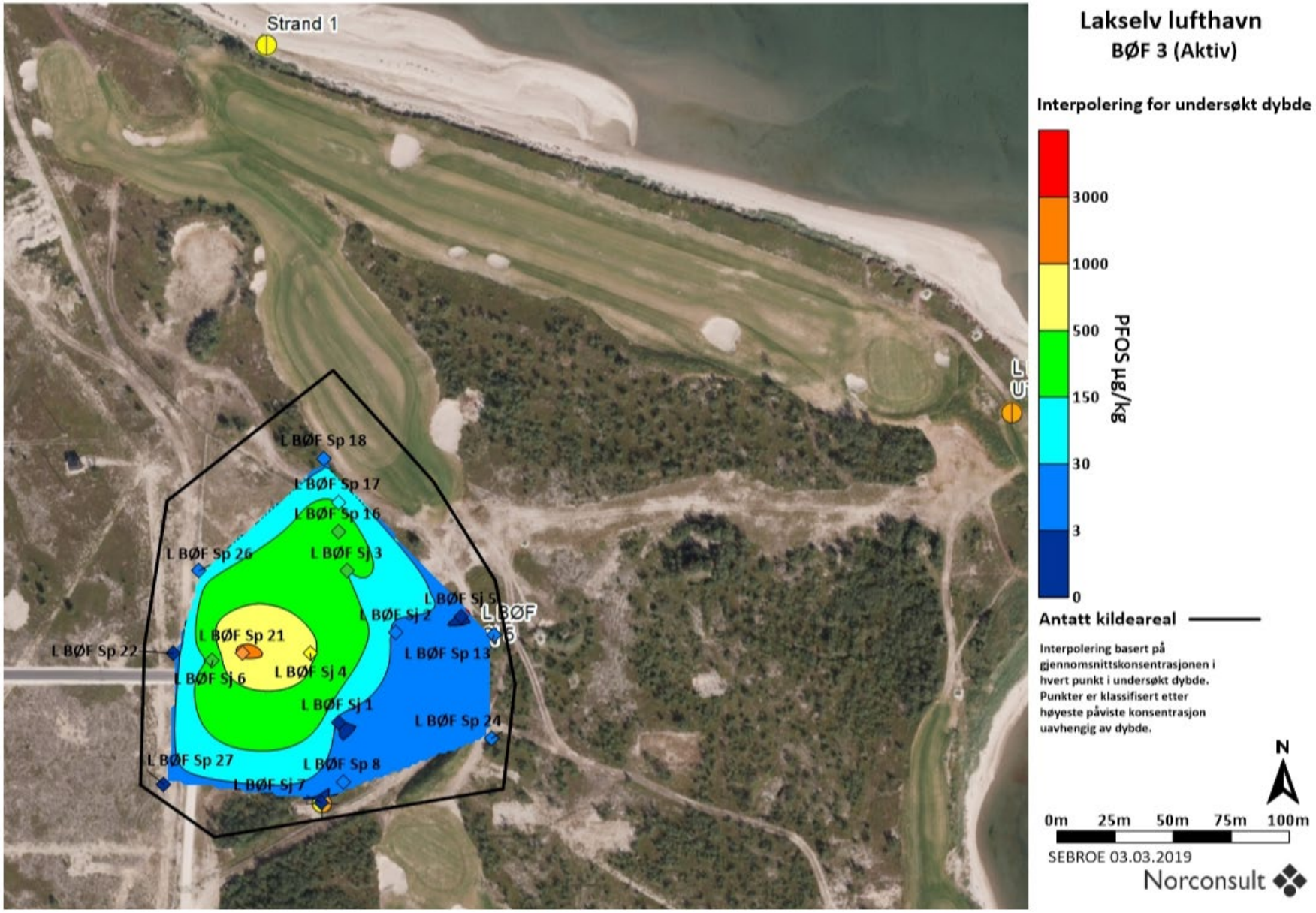
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i 0-1 meters dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.

N

0m 25m 50m 75m 100m

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Strand 1
L BØF Sp 18
L BØF Sp 17
L BØF Sp 16
L BØF Sp 26
L BØF Sj 3
L BØF Sj 5
L BØF Sj 2
L BØF Sp 21
L BØF Sp 22
L BØF Sp 13
L BØF Sj 6
L BØF Sj 4
L BØF Sj 1
L BØF Sp 24
L BØF Sp 27
L BØF Sp 8
L BØF Sj 7
Lakselv lufthavn
BØF 3 (Aktiv)
Interpolering for undersøkt dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m 25m 50m 75m 100m
SEBROE 03.03.2019
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15.1 Fire training site (BØF)/contaminated site

Fire training site (BØF)/contaminated site	BØF 3 (active)
	Used from 1978

15.2 Use of PFOS and other PFAS

Quantity of PFOS used at the site (kg)	810
Comments/uncertainty	Estimated consumption from 1978 up to and including 2001.
Quantity of PFAS used at the site (kg)	140
Comments/uncertainty	Estimated consumption from 2002 to 2012. Avinor completely phased out firefighting foam containing PFAS in 2012 and now uses only PFAS-free firefighting foam.

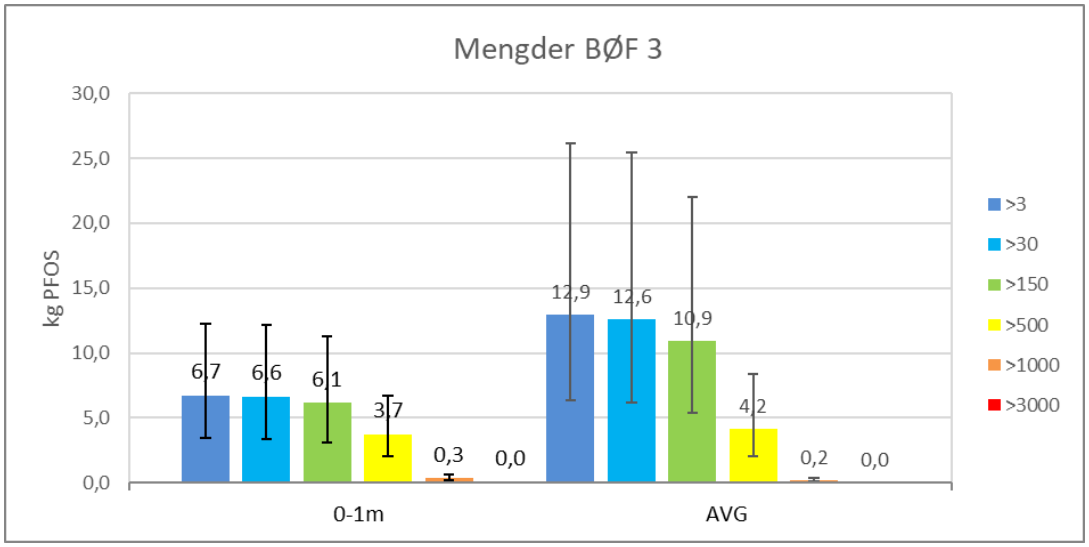
15.3 Soil sampling

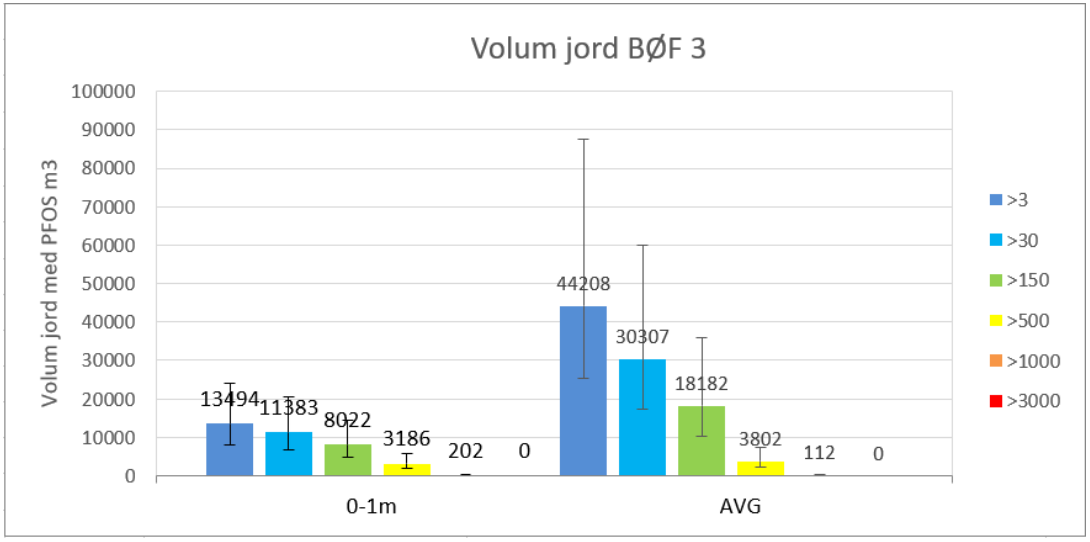
Total number of soil samples	25
Comments/uncertainty (e.g. 95% of the samples were taken from 0–0.1 m)	All samples were taken at depths of between 10-40 cm, except for seven sampling points where deeper samples have been taken
Number of soil samples 0-1 m below ground level	12
Number of soil samples under 1 m	15
Comments/uncertainty	A total of 27 soil samples when splitting up samples in the intervals of 0-1 m and > 1 m.
Highest measured soil concentration of PFOS µg/kg	1,220
Where	L BØF Sp 21 (10-30 cm)
Highest measured soil concentration of PFAS µg/kg	1,220
Where	L BØF Sp 21 (10-30 cm)
Comments/uncertainty	12 compounds were analysed for in nine samples. The other samples were only analysed for PFOS/PFOA. Sample L BØF Sp 21 was only analysed for PFOS and PFOA. The concentration in this sample was the highest.

APPENDIX A

15.4 Quantity calculation

PFOS average for all depths and points > 3 µg/kg	
Concentration (µg/kg)	183
Area (m2)	13,815
Quantity of soil (tonnes)	70,733
Quantity of PFOS (kg)	13
Uncertainty -	6.6
Uncertainty +	13
PFOS average for all depths and points > 30 µg/kg	
Concentration (µg/kg)	260
Area (m2)	9,471
Quantity of soil (tonnes)	48,492
Quantity of PFOS (kg)	13
Uncertainty -	6.4
Uncertainty +	13
PFOS average for all depths and points > 150 µg/kg	
Concentration (µg/kg)	375
Area (m2)	5,682
Quantity of soil (tonnes)	29,092
Quantity of PFOS (kg)	11
Uncertainty -	5.5
Uncertainty +	11
PFOS average for all depths and points > 500 µg/kg	
Concentration (µg/kg)	685
Area (m2)	1,188
Quantity of soil (tonnes)	6,083
Quantity of PFOS (kg)	4.2
Uncertainty -	2.1
Uncertainty +	4.2





PFOS average for all depths and points > 1000 µg/kg	
Concentration (µg/kg)	1,067
Area (m2)	35
Quantity of soil (tonnes)	179
Quantity of PFOS (kg)	0.2
Uncertainty -	0.1
Uncertainty +	0.2
PFOS average for all depths and points > 3000 µg/kg	
Concentration (µg/kg)	
Area (m2)	
Volume of soil (tonnes)	
Volume of PFOS (kg)	
Uncertainty -	
Uncertainty +	

Comments regarding the calculations	In the risk assessment for BØF 3 carried out in 2016, it was calculated that there is a residual quantity of 13 kg ±6 kg of PFOS left in situ in the ground distributed across an area of 14,000 ± 3000 m^2 to a depth 3 ± 1 metres.
Is the extent of the contaminated area limited horizontally?	The contamination appears to be delimited to the south and west, as points Sj7 (250-300 cm), Sp22 (20-30 cm) and Sp27 (20-30 cm) are below the detection limit for the analysed compounds (PFOS/PFOA). Not delimited in other directions.
Is the extent of the contaminated area limited vertically?	No, PFAS may be present in deeper layers. Detected in four samples > 250 cm.
Comments/uncertainty	The contamination appears to be delimited to the top soil to the southeast in concentrations of < 20 µg/kg (Sp13 20-30 cm and Sp24 10-30 cm).

15.5 Water sampling and annual dispersal

Have water samples been taken?	Yes
Where	Three groundwater wells at BØF, and two southeast of the terminal area, a shaft at the BØF, oil separator, sumps, and in seawater in a shaft on the beach approx. 220 m north of the BØF.
Highest measured concentration of PFOS in groundwater (ng/l)	58,900
Where	Groundwater in shaft, L BØF Sj3 (2011-10-11)
Highest measured concentration of PFAS in groundwater (ng/l)	67,500
Where	Groundwater in well, L BØF Shaft 6 (05.06.2013)
Comments/uncertainty	The very highest total concentrations in water were detected in groundwater from well Sj 6, which is located in the source area, west of the platform. Fire drills are believed to have been carried out there.
Highest measured concentration of PFOS in surface water (ng/l)	25.7
Where	Seawater in shaft to the north, Beach 1
Highest measured concentration of PFAS in surface water (ng/l)	95.4
Where	Seawater in shaft to the north, Beach 1
Comments/uncertainty	Water in the shaft has a high content of particles to which PFOS may be bound, and PFOS may be mobilised as a result of excavation below the water level, leading to uncertainty regarding whether the seawater sample is representative. Water samples have also been taken from the municipal treatment plant (no PFAS detected) in order to determine whether PFAS in fish in the sea offshore of the airport could originate from sources other than the airport. Water samples from the oil separator are not considered to be representative of the surface water in the area. Four samples of wastewater were taken from the oil separator during the period 2013 to 2015, which contain PFOS concentrations of between 25 and 2230 ng/l and PFAS between 2000 and 20700 ng/l (when no fire drills are carried out). Water from the oil separator is transported to Brennelvfjorden via a submerged drain. The oil separator plant was rebuilt in 2014, and according to the annual report for 2017, the oil separator was emptied and cleaned, and the plant was described as operating correctly. Avinor has not used PFAS foam at its airports since 2012 and the oil separators are emptied and normally cleaned once a year (unless they produce < 1kg oil during the course of a year), or more often if necessary.

Total quantity dispersed annually from the site PFOS (g/year)	500 (4)*
Total quantity dispersed annually from the site PFAS (g/year)	Not calculated (42)*
To which recipient	Brennelvfjorden. *Water from the oil separator is also transported to Brennelvfjorden via a submerged drain
Calculated from water or soil concentration.	Groundwater. * The figures in parentheses are estimated quantities of PFOS and PFAS which are dispersed to the sea via the oil separator, based on measured concentrations in water samples from the oil separator. The calculation dates from 2016, and it is uncertain whether it is representative of the current situation.

15.6 Biota sampling

Have biota samples being taken at the airport?	Yes
What kind of biota?	Sea trout, flounder, sand gaper and spiral wrack
How many samples?	16
Highest measured concentration in biota PFOS (µg/kg wet weight)	39
Where	Liver, sea trout, n=1
Highest measured concentration in biota PFAS (µg/kg wet weight)	48.4
Where	Liver, sea trout, n=1
Median concentration in comparable populations (e.g. in a lake)	
Comments/references	It was not possible to find any reports of PFAS concentrations in the liver of sea trout from any other investigations. It was mainly muscle samples, or samples of freshwater trout. Higher values of PFAS are generally found in the liver compared with muscle, because PFAS accumulates in blood-filled organs such as the liver and kidneys and in bile. In eight individual muscle samples taken from trout from Langvatnet adjacent to Evenes Airport Harstad, the mean concentration of PFOS was 38.58 ug/kg wet weight (median 14.44) and the concentration of PFAS was 42.10 ug/kg wet weight (median 17.15). In 11 liver samples from trout caught in Kjerkvatnet adjacent to Evenes Airport, the mean concentration of PFOS was 753.6 µg/kg wet weight (median 880), while that of PFAS was 759.5 µg/kg wet weight (median 880). Taken from Avinor's report from 2015; Harstad/Narvik Airport, Evenes, Investigations of soil, water and biota with risk assessment.
References and concentrations in other reports.	**Sea:** Report M 618 refers to studies which show that median concentrations in cod liver from stations in Lofoten, Kvænangen and Varangerfjord indicate that high background concentrations in areas affected by diffuse pollution only may be around 10 µg/kg wet weight. At Evenes, Avinor (2015) reported mean concentrations of PFOS in cod liver of

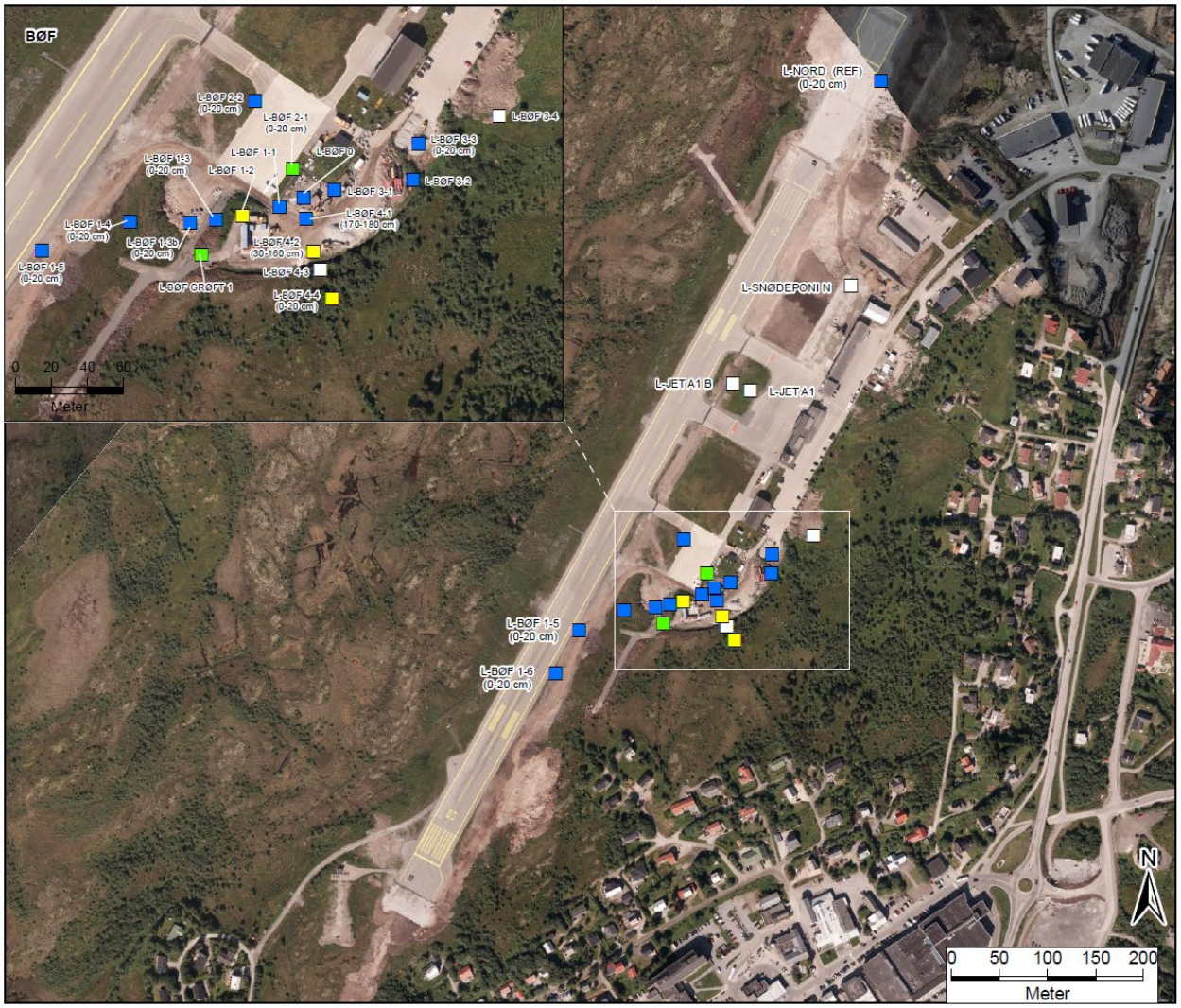
	41.88 µg/kg (median 18 µg/kg) and halibut liver of 10.9 µg/kg (median 11.5 µg/kg). According to the Norwegian Environment Agency's report M 618, 2015, the median concentration of PFOS in cod liver from Inner Oslofjord was 6.5 µg/kg wet weight.

15.7 Uncertainty and other factors

Does the estimate of the quantity of PFOS in the ground correspond with the concentrations measured in water and biota?	Cannot be reliably evaluated, but is considered to be likely.
Evaluations	At Lakselv Airport, there is sandy material, and the groundwater level is approx. 2.5 metres below ground level at the BØF. Very high concentrations of PFAS in groundwater have been detected in the west (Sj6), approximately the same area where the "hotspot" in the soil was located. A relatively high degree of leaching from sand is anticipated, which is reflected in the fact that PFOS/PFAS has been detected in seawater (25.7/95.4 ng/l) in a shaft on the beach approx. 220 m to the north. This may be due to the mobilisation of PFAS in the material as a result of excavation, but it does mean that the contamination has spread to this area and that leaching into the sea is taking place. Significant quantities of contaminated wastewater from the oil separator at the BØF have also been directed to sea. Even though PFAS has not been used at Avinor's airports since 2012, it is not certain whether dispersal is currently taking place from the remaining old contamination in the oil separators and pipes. It is likely that biota may be affected by the leaching that has been taking place from the BØF, as reflected in the PFOS detected in shell sand. However, the other species investigated are not stationary and may also be influenced by other sources.
Calculation	The total quantity of PFOS of > 3 µg/kg is based on the area studied being estimated at approx. 13 kg (+13 -6.5). The mean concentration is calculated at 183 µg/kg. The concentration of PFOS in the groundwater wells at the BØF is between 150 and 55,900 ng/l. Using the mean concentration, ((167+145+325+19000+55900+37700+355+294+337)/9) 12,700 ng/l, produces a mean K_d for the sand at BØF 3 of 14.4 (l/kg). This is considered to be a realistic K_d for sand when compared with K_d values from laboratory tests on sand (Master's theses: Nygård, 2017 and Nordskog, 2013). However, K_d will vary with, amongst other things, the level of contamination relative to the groundwater level (Nygård, 2017).
Comments/uncertainty (Could there be any additional unknown sources of PFOS at the site with runoff to the recipient?)	It cannot be excluded that there are other sites with PFOS or PFAS contamination at the airport, e.g. from the use of firefighting foam for the testing of equipment, which has often been carried out at various arbitrary locations. PFAS compounds (111 ng/l) have been detected in groundwater southeast of the terminal building, which is a relatively long way from BØF 3. Fire training site 1 is located on the Norwegian Armed Forces' land (on the southwestern side of the runway) and was in use from about 1968 until 1978. There is probably no PFOS on this site, as firefighting foam containing PFOS started to be used around 1978. Fire training site 2 is also located on the Norwegian Armed Forces' land (west of the runway) and was in use from about 1978. During the period 1978 to 2005, both fire training sites 2 and 3 were in use. It is likely that there is PFOS and other PFAs in the ground around fire training site 2.
Has the site been sufficiently mapped with a view to assessing the order of priority?	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the quantity of PFOS in the soil with the stipulated level of uncertainty.

Other factors of significance to possible clean-up/implementation of measures (for example, planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	No protected areas have been recorded near the airport. Of natural assets, habitat types have been recorded, along with a number of vulnerable and threatened bird species adjacent to the beach zones and the delta areas (very important habitat type). Lakselva is a popular river for salmon fishing.

16 Leknes Airport



Leknes lufthavn (ENLK)

Oversiktskart

Jord

PFOS/PFOA jord (ug/kg)*

- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

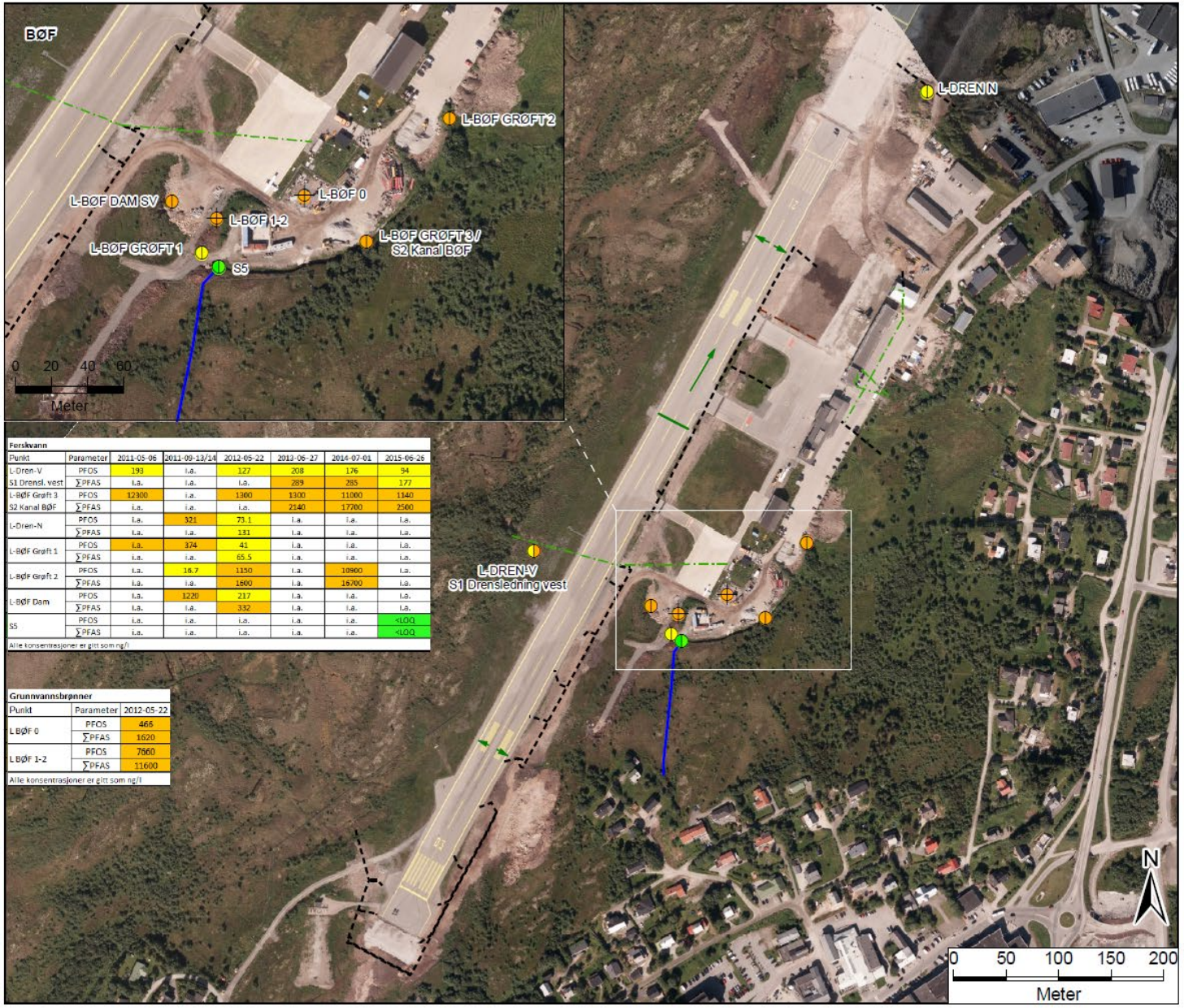
* PFOS er dominerende parameter

LOQ = rapporteringsgrense
i.p. = ikke påvist

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APPENDIX A



Forskvann

Punkt	Parameter	2011-05-06	2011-09-13/14	2012-05-22	2013-06-27	2014-07-01	2015-06-26
L-Dren-V	PFOS	193	i.a.	127	208	176	94
S1 Drensl. vest	∑PFAS	i.a.	i.a.	i.a.	289	285	177
L-BØF Grøft 3	PFOS	12300	i.a.	1300	1300	11000	1340
S2 Kanal BØF	∑PFAS	i.a.	i.a.	i.a.	2140	17700	2500
L-Dren-N	PFOS	i.a.	i.a.	321	73.1	i.a.	i.a.
	∑PFAS	i.a.	i.a.	131	i.a.	i.a.	i.a.
L-BØF Grøft 1	PFOS	i.a.	i.a.	374	41	i.a.	i.a.
	∑PFAS	i.a.	i.a.	65.5	i.a.	i.a.	i.a.
L-BØF Grøft 2	PFOS	i.a.	i.a.	16.7	1150	i.a.	i.a.
	∑PFAS	i.a.	i.a.	i.a.	1800	i.a.	i.a.
L-BØF Dam	PFOS	i.a.	i.a.	1220	217	i.a.	i.a.
	∑PFAS	i.a.	i.a.	i.a.	332	i.a.	i.a.
S5	PFOS	i.a.	i.a.	i.a.	i.a.	i.a.	<LOQ
	∑PFAS	i.a.	i.a.	i.a.	i.a.	i.a.	<LOQ

Alle konsentrasjoner er gitt som ng/l

Grunnvannsbrønner

Punkt	Parameter	2012-05-22
L BØF 0	PFOS	466
	∑PFAS	1620
L BØF 1-2	PFOS	7660
	∑PFAS	11600

Alle konsentrasjoner er gitt som ng/l

Leknes lufthavn (ENLK)

Oversiktskart

Vann

PFOS / ∑ PFAS grunnvannsbrønn (ng/l) *
- Ikke analysert
- 0
- <LOQ
- LOQ-230
- 230-36 000
- >36 000

* Venstre halvdel = PFOS
Høyre halvdel = PFAS

PFOS / ∑ PFAS ferskvann (ng/l) *
- Ikke analysert
- 0
- <LOQ
- LOQ-230
- 230-36 000
- >36 000

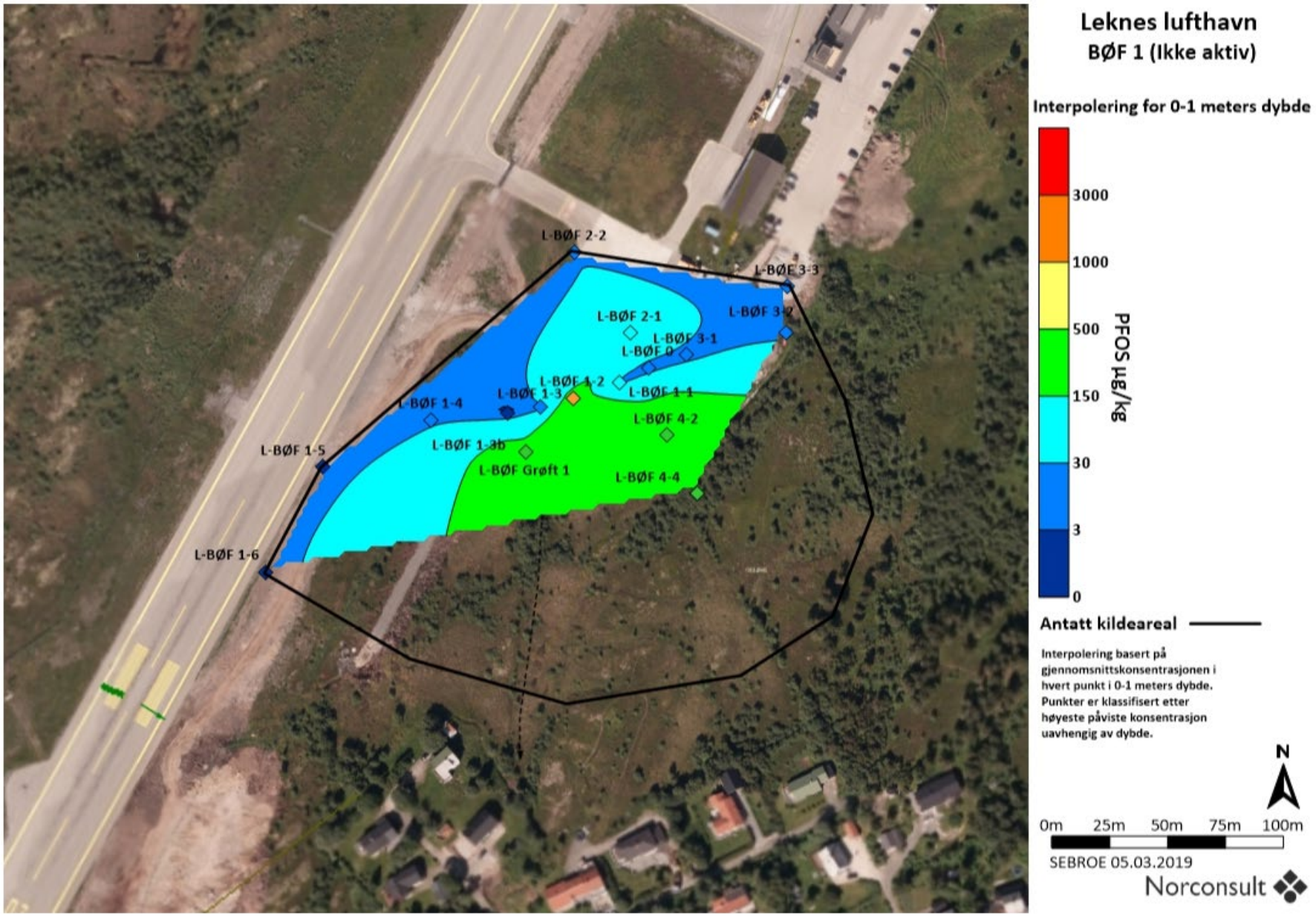
* Venstre halvdel = PFOS
Høyre halvdel = PFAS

Avlopsledning
- Avløp annet
- Avløp Felles
- Drensvann
- Glykolholdig overvann
- Glykolholdig spillvann
- Overvann
- Pumpespillvannsledning
- Spillvann

Avrenning
- Deponi glykolforurenset snø
- Overvannsledning
- Avrenningsveg glykol
- Bekkeresipient
- Overvannsystem
- Vannskille rullebane
- Antatt avrenningsveg baneavising

i.a. = ikke analysert
LOQ = rapporteringsgrense
(tilsv. ikke påvist for ∑PFAS)

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Leknes lufthavn
BØF 1 (Ikke aktiv)

Interpolering for 0-1 meters dybde

PFOS µg/kg
3000
1000
500
150
30
3
0

Antatt kildeareal

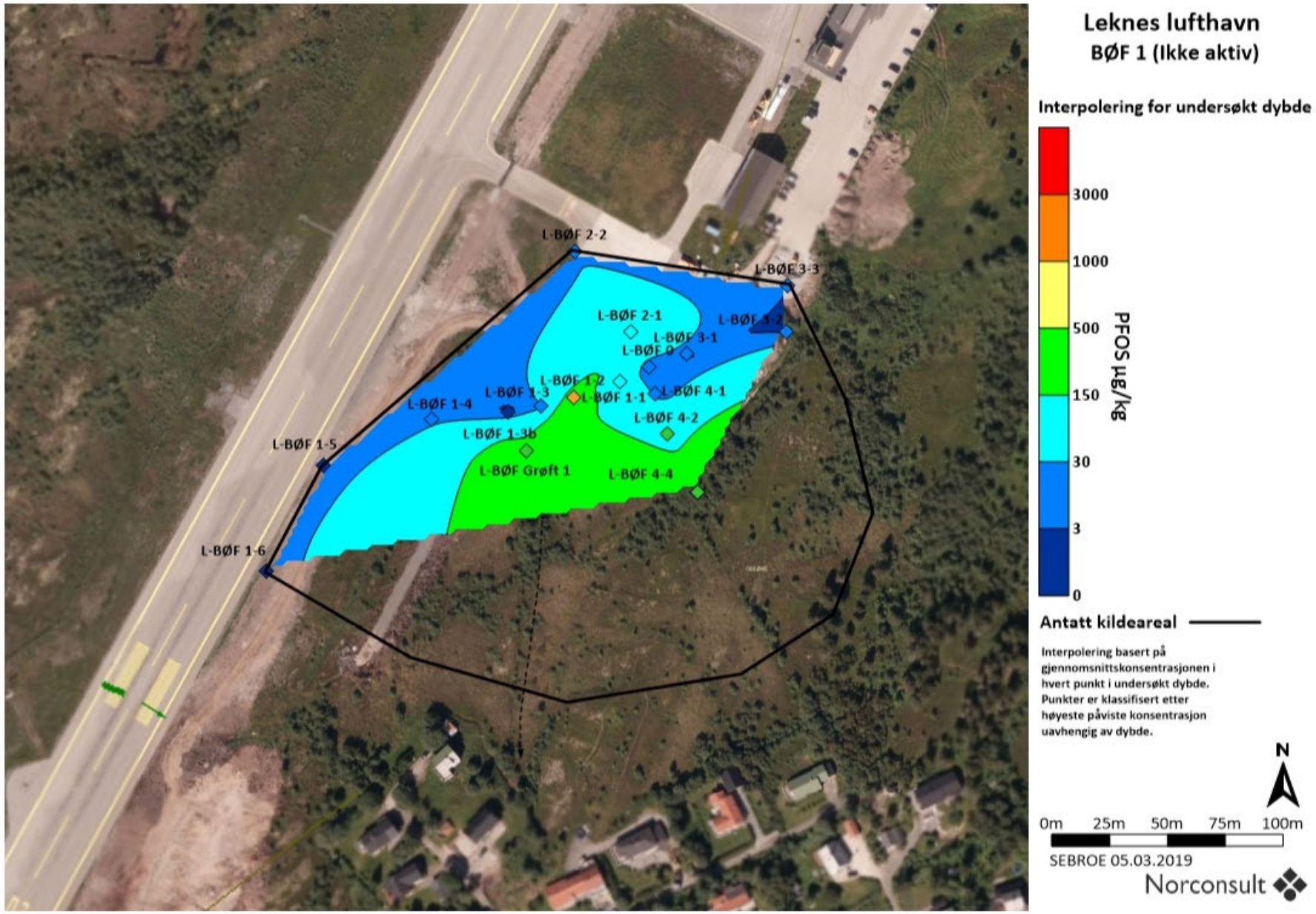
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i 0-1 meters dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.

N

0m 25m 50m 75m 100m

SEBROE 05.03.2019

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Leknes lufthavn
BØF 1 (Ikke aktiv)

Interpolering for undersøkt dybde

PFOS µg/kg
- 3000
- 1000
- 500
- 150
- 30
- 3
- 0

Antatt kildeareal

Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.

N

0m 25m 50m 75m 100m

SEBROE 05.03.2019

Norconsult

16.1 Fire training site (BØF) / contaminated site

Fire training site (BØF) / contaminated site	BØF 1 (not active)
	The site was established in 1991 and was in active use with the use of fuel and firefighting foam until 2008. The site was still in use in 2011, mostly by Fiskerifagskolen, but only smoke was created for the exercises when burning wood and only water was used to extinguish it. Due to the topography of the site it was most common to spray foam to the southwest during exercises; there has previously been a mound outside the BØF in this direction.

16.2 The use of PFOS and other PFAS

Volume of PFOS used at the site (kg)	18
Comments/uncertainty	Estimated consumption of PFOS from 1991 to 2002.
Volume of PFAS used at the site (kg)	4
Comments/uncertainty	Estimated consumption of PFAS from 2002 to 2008. Avinor has not used PFAS-containing foam at its airports after 2012.

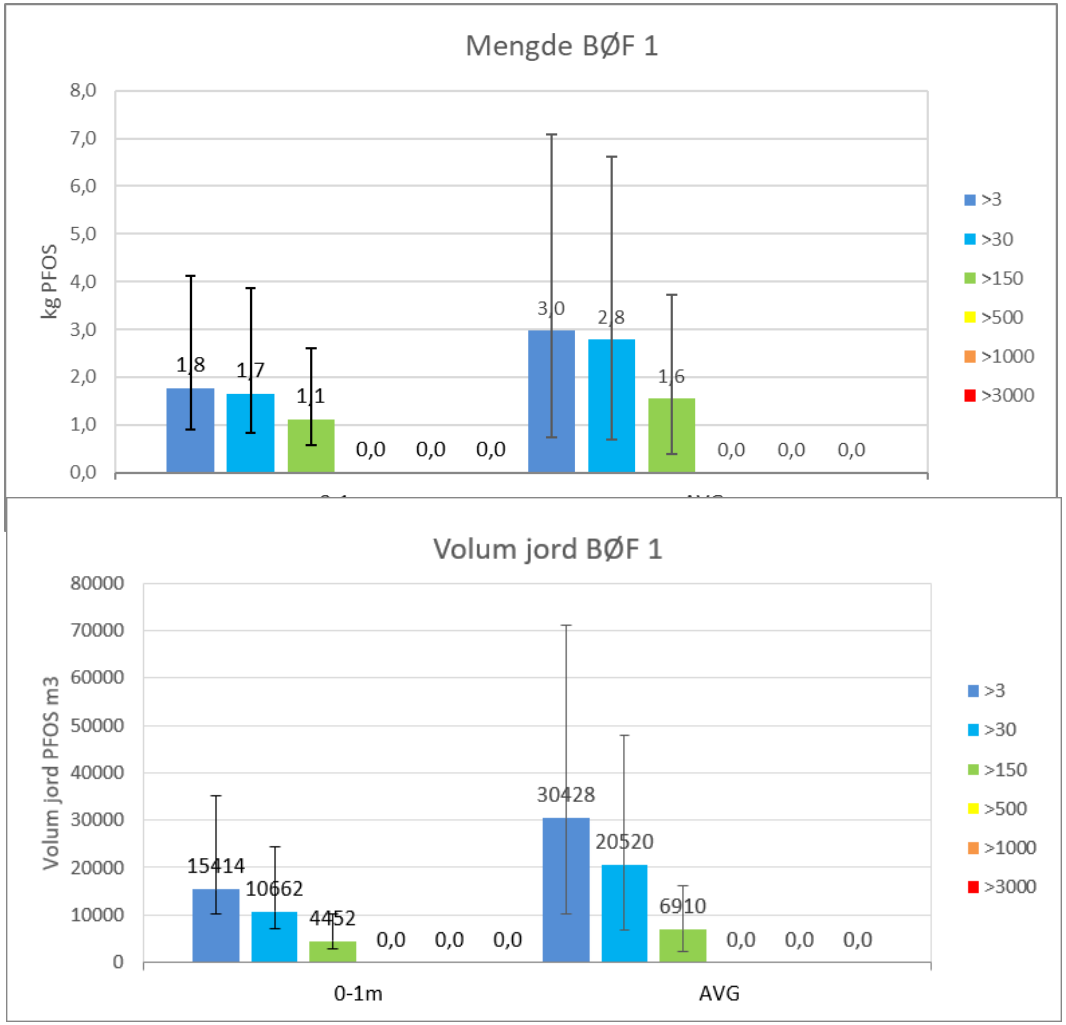
16.3 Soil sampling

Total number of soil samples	23
Comments/uncertainty (for example, 95% of the samples were taken from 0–0.1 m)	11 of the samples are from a depth of 0-0.2 metres, one is from 0.5-0.9 metres, and the remainder are from varying depths between 0.8 and 2.8 metres deep. The materials are stated to consist of sand, rock, gravel, filler, peat and sandy soil/silt.
Number of soil samples 0-1 m beneath the ground	16
Number of soil samples under 1 m	11
Comments/uncertainty	A total of 27 soil samples when splitting up samples in the intervals of 0-1 m and > 1 m.
Highest measured soil concentration of PFOS µg/kg	1,600
Where	L-BØF 1-2 (50-90), materials consisting of peat.
Highest measured soil concentration of PFAS µg/kg	1,606
Where	L-BØF 1-2 (50-90), materials consisting of peat.

Comments/uncertainty	The sample L-BØF 1-2 has only been analysed for PFOS and PFOA, but is still higher than all other samples. Only three of the samples have been analysed for multiple (11) PFAS compounds, of which only a low concentration of PFHxA has been detected in one sample.

16.4 Volume calculation

PFOS average for all depths and points > 3 µg/kg	
Concentration (µg/kg)	93
Area (m2)	15,214
Volume of soil (tonnes)	42,599
Volume of PFOS (kg)	3.0
Uncertainty -	2.2
Uncertainty +	4.1
PFOS average for all depths and points > 30 µg/kg	
Concentration (µg/kg)	129
Area (m2)	10,260
Volume of soil (tonnes)	28,728
Volume of PFOS (kg)	2.8
Uncertainty -	2.1
Uncertainty +	3.8
PFOS average for all depths and points > 150 µg/kg	
Concentration (µg/kg)	215
Area (m2)	3,455
Volume of soil (tonnes)	9,674
Volume of PFOS (kg)	1.6
Uncertainty -	1.2
Uncertainty +	2.2
PFOS average for all depths and points > 500 µg/kg	
Concentration (µg/kg)	
Area (m2)	



Volume of soil (tonnes)	
Volume of PFOS (kg)	
Uncertainty -	
Uncertainty +	
PFOS average for all depths and points > 1000 µg/kg	
Concentration (µg/kg)	
Area (m2)	
Volume of soil (tonnes)	
Volume of PFOS (kg)	
Uncertainty -	
Uncertainty +	
PFOS average for all depths and points > 3,000 µg/kg	
Concentration (µg/kg)	
Area (m2)	
Volume of soil (tonnes)	
Volume of PFOS (kg)	
Uncertainty -	
Uncertainty +	

Comments regarding calculations of volume	In the risk assessment carried out in 2016, a residual volume of PFOS at the BØF of 4 ± 2 kg was calculated. The calculation is based on an area of 13,000 ± 3,000 m2, a depth of 2 ± 0.5 metres, and an average concentration of 114 µg/kg. As contamination is not very delimitated towards the south/southeast, greater uncertainty regarding extent was used in the calculation now carried out in 2019 than in 2016. In 2016, the area was delimitated with respect to concentrations down to 100 µg/kg, and now in 2019 for concentrations down to 3 µg/kg.
Is the extent of the contaminated area limited horizontally?	No, only the extreme point (surface sample) L-BØF 1-6 to the southwest has shown no evidence of PFOS. At the extreme point to the west (surface sample L-BØF 1-5) and north (surface samples L-BØF 2-2 and L-BØF 3-3, and in samples from a depth of 20-160 cm in L-BØF 3-2) < 14 µg/kg was detected. Contamination is least delimitated to the south, southeast and east.
Is the extent of the contaminated area limited vertically?	No. In three of the samples taken from a depth of 170-200 cm, concentrations of PFOS between 25-70 µg/kg were detected. In the deepest sample that is from a depth of 280 cm, and in the groundwater zone, no PFOS was detected. Groundwater levels at the BØF are at about 1.7 metres deep, which is thought to limit extent in materials at depth.

Comments/uncertainty	The highest concentrations (150-1600 µg/kg) have been detected in top soil (< 1 m) at four sampling points (L-BØF grøft 1, 1-2, 2-1, and 4-4), in addition, at one sampling point (L-BØF 4-2) a high concentration was detected in a sample taken from a depth of 30-160 cm. It is unclear how the concentration is distributed at a depth in this depth interval at the sampling point, but in materials from 180-200 cm the concentration is about 55 µg/kg. This is also the only one of the sampling points with a high concentration in surface materials that has samples from deeper materials. There are generally lower concentrations in samples of deeper materials.

16.5 Water sampling and annual dispersion

Have water samples been taken?	Yes
Where	Groundwater at the BØF, surface water at BØF and in run-off channels east, west and north of runway
Highest measured concentration of PFOS in groundwater (ng/l)	7,660
Where	L BØF 1-2 (22.05.2012)
Highest measured concentration of PFAS in groundwater (ng/l)	11,600
Where	L BØF 1-2 (22.05.2012)
Comments/uncertainty	It is not specified when or how the wells were established, but they are registered in the Leknes Airport Locality Report from 2011, which is an appendix to the DP2 report, and it is then likely that they were established in 2011. The well at the snow depot was bored with an excavator in 2011, so the same method may have been used for wells at the BØF. The sampling of the wells is from 2012. Analysis was carried out for 11 PFAS compounds, and the compound that had the highest concentration in the water sample from well 1-2 is PFOS, followed by PFHxS, and then PFPeA (6:2 FTS was also detected).
Highest measured concentration of PFOS in surface water (ng/l)	12,300
Where	S2 L-BØF Grøft 3 (2011-05-06)
Highest measured concentration of PFAS in surface water (ng/l)	17,700
Where	S2 L-BØF Grøft 3 (2014-07-01)
Comments/uncertainty	Samples from 2011-05-06 were only analysed for PFOA and PFOS.
Total annual dispersion of PFOS from the site (g/year)	70
Total annual dispersion of PFAS from the site (g/year)	Not calculated

To which recipient	From the 2016 report: There are three main recipients of drainage water from the fire training site: Either the marshlands to the west or Fyglsjøen via Borgvatnet to the east.
Calculated from water or soil concentration.	Water concentration

16.6 Biota sampling

Have biota samples being taken at the airport?	Yes
What kind of biota?	Mussels, periwinkle, common seaweed flea, common shore crab, lugworm. All biota samples are composite samples.
How many samples?	5
Highest measured concentration of PFOS in biota (µg/kg wet weight)	Not detected above the detection limit
Where	All samples were below the detection limit (< 1ug/kg ww).
Highest measured concentration of PFAS in biota (µg/kg wet weight)	12
Where	Mussels, composite sample (n=10). The samples of biota were analysed for 14 compounds. Only 6:2 FTS was detected.
Median concentration (µg/kg ww) in comparable populations (for example, in a lake)	The average concentration of PFAS in three composite samples of mussels in the inner Oslo fjord was 0.58 µg/kg ww. The average concentration of PFOS was 0.07 µg/kg. Analysis was carried out for 13 compounds, and three compounds were detected. The highest concentration was for PFOSA of 0.46 µg/kg, and 0.05 µg/kg of PFHxS was also detected. Obtained from the Norwegian Environment Agency's report; Environmental Contaminants in an Urban Fjord from 2016 (M-812).
Comments/references	
References and concentrations in other reports.	The EQS value in the Water Regulations for PFOS in biota is 9.1 µg/kg wet weight. In a risk assessment from 13 December 2018, EFSA changed the tolerability limit (TDI - tolerable daily intake) for PFOS and PFOA, so these are now far lower than

	the TDI values set in 2008. This may cause EQS for biota to also be lower in the future.

16.7 Uncertainty and other factors

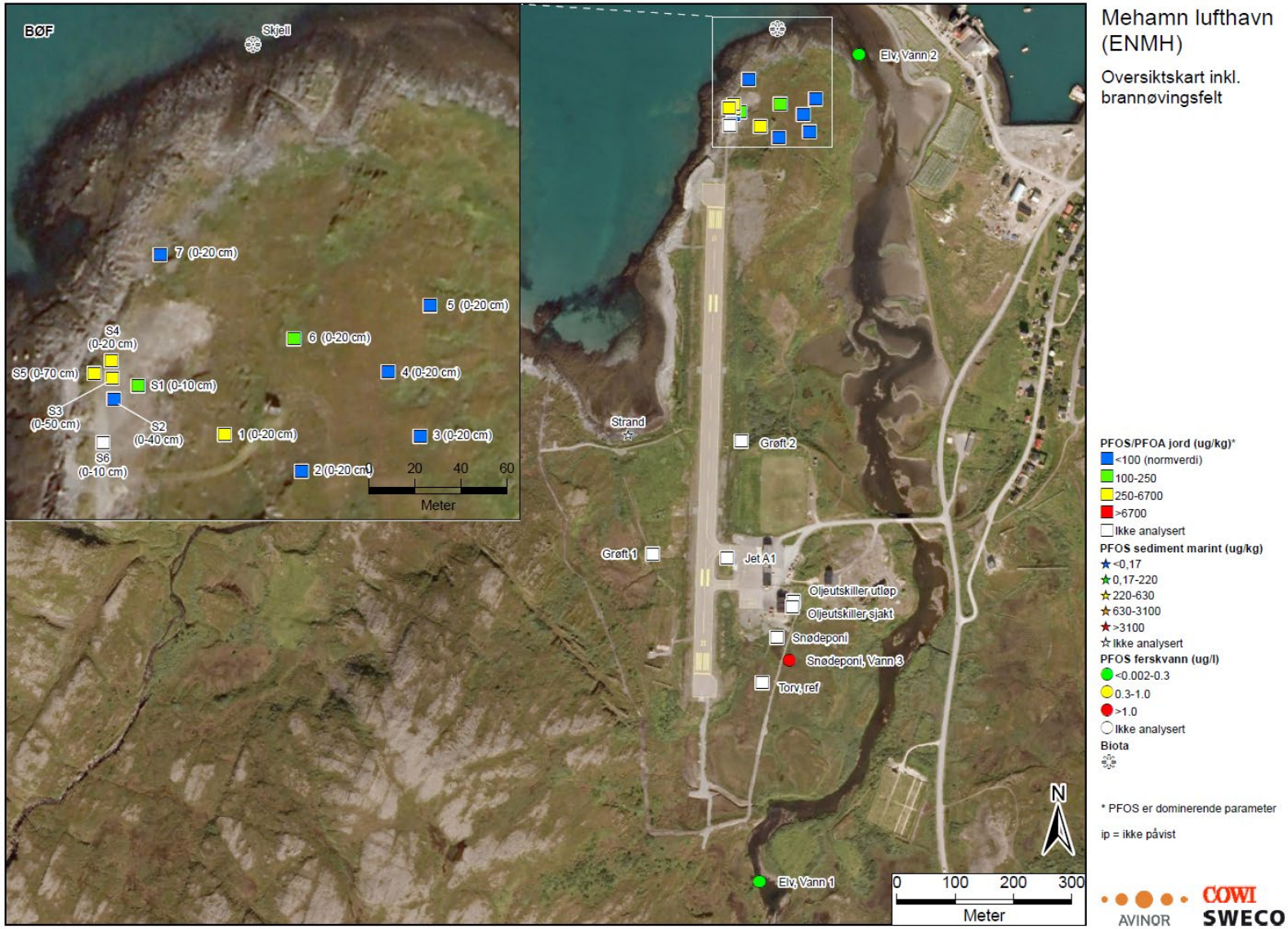
Does the estimate of the volume of PFOS in the ground correspond with the measured concentrations in water and biota?	Cannot be reliably evaluated. Groundwater samples under the BØF show high concentrations of PFOS and PFAS, these were only sampled once (2012), and there are much higher concentrations in well 1-2 than in well 0. No information has been given on the establishment of these wells (e.g. whether sealing materials was used to prevent surface infiltration), but both wells are in areas where training objects are said to have been located. Soil samples from shafts 1-2, which is the same place as well 1-2, also have the highest detected soil concentrations (1600 µg/kg) in peat soil at a depth of between 50-90 cm. No samples were taken deeper in the shaft. In shaft 0, which is the same place as well 0, there are low concentrations (<8 µg/kg) in the two soil samples taken. The samples are from a depth of 90-180 cm and from a depth of 180-200 cm. The soil samples were not analysed for compounds other than PFOS, but in the water samples the compounds PFOS, PFPeA, PFHxS, PFHpA and 6:2 FTS have the highest concentrations. There is also a high concentration of PFAS in surface water taken from trenches around the BØF, especially to the east (grøft 3) and northeast (grøft 2), which seems to be linked, among other things, to run-off from the concrete slab during exercises. These samples have the highest PFOS concentrations, but also a significant content of, among other things, 6:2 FTS and PFHxS.

Evaluations	Aerial photos from 2004 show that there have been mounds around the BØF on the north, west and south sides. In the DP2 and 2016 reports it is stated that a material replacement has taken place at the BØF, including in 2008; "The BØF is located in an area where the ground originally consisted of large amounts of peat materials, but where some material replacement must have been carried out when the training site was out into use. The upper 1-2 m of the materials in the central area of the fire training site have also been replaced with new filler a few years ago. It is not known where the replaced materials were disposed of." Aerial photos from 2009 show that the mound in the south has been removed, and the site has been expanded to the south. However, there are high concentrations in groundwater and trench water at the BØF. The concentrations in surface water were tested several times during the period between 2011 and 2014, and for the sampling points grøft 2 and 3, concentrations vary significantly. For both sampling points, concentrations are far higher in 2014 compared to samples from 2012. The highest PFOS concentration in surface water is from grøft 3 in 2011. Sampling point "grøft 3" is directly after water from surface water pipes from the concrete slab on the fire training site flows into the trench. The water in the trench flows further north before it ends in a marshland area. Sampling point "grøft 2" is located in a trench before the water flows into the marshland. PFOS and PFAS are registered on the west side of the runway in water samples (L-DREN-V, for PFOS between 94 and 208 ng/l and PFAS between 177 and 289 ng/l). It is likely that the pond located just west of the BØF is draining here. The biota samples are taken in Fyglsjøen, which is part of the Buksnesfjord. The sampling station is about 1.4 km from the BØF, and Leknes city centre lies between the sampling station and BØF. There are therefore many other possible sources of contamination in biota at the sampling station, and it is therefore uncertain whether the content of PFAS in mussels is due to the spread of contamination from the BØF. Upon examination, signs were found of untreated sewage being released near the sampling area.

Comments/uncertainty (Could there be additional unknown sources of PFOS at the site with run-off to the recipient?)	From the 2016 report: PFOS and PFAS were recorded in water samples from point L-Dren-N located at the north end of the airport (200 ng/l, average of two samplings). It is not known where this originates from, but the northern part of the runway drains to the point. The BØF probably does not drain here. As this point is north of the watershed at the airport, the PFAS detected here will originate from sources other than the fire training site. As at other airports, the setting of target images and foam cannon sight adjustment was probably carried out in the longitudinal direction of the runway. It is possible that this may be the source of PFOS/PFAS in the sample from L-Dren N.
Has the site been sufficiently mapped with a view to assessing	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the volume of PFOS in the soil with the stipulated level of uncertainty.

the order of priority?	
Comments/uncertainty	Only three soil samples were analysed for more PFAS compounds than PFOS and PFOA. In water samples, only the long-chain compounds PFDA and PFNA were not detected.
Other factors of significance for any clean-up/initiation of measures (for example, planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	There are no protected areas directly connected to the airport. The airport is located within an area with registered nature types and selected habitats such as hayfields alongside the runway, and coastal marshes to the west. The coastal marshes have qualities of national value. South of the marshes is Storeidvatnet which is a nature reserve (about 2 km away from the airport). The lush growth in Storeidvatnet is the basis for a very rich and interesting bird life. Several species of birds have been registered, which are very rare for the region. Within the airport area, the following species have been registered of particularly high management interest: eriophorum, common gull, sand martin, several types of entoloma and northern bur-reed. Species are also registered in Haldsvågen to the south, Kretjønna to the north and in Gunnarvatnet to the southeast. Cultural monuments have been registered just east of the airport, as well as the outdoor recreation area Buggeskogen. From the DP2 report: A strong smell of oil from the groundwater was recorded during the surveys. In item 1-2, where the materials have not shifted, and which is in reality is a landfill for various scrap, the content of both PFOS and oil is high. The THC concentration is in environmental condition class 5. In item 1-1 THC is in environmental condition class 4.

17 Mehamn Airport



Mehamn lufthavn (ENMH)

Oversiktskart inkl. brannøvingsfelt

PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

PFOS sediment marint (ug/kg)
- ★ <0,17
- ★ 0,17-220
- ★ 220-630
- ★ 630-3100
- ★ >3100
- ☆ Ikke analysert

PFOS ferskvann (ug/l)
- <0.002-0.3
- 0.3-1.0
- >1.0
- Ikke analysert

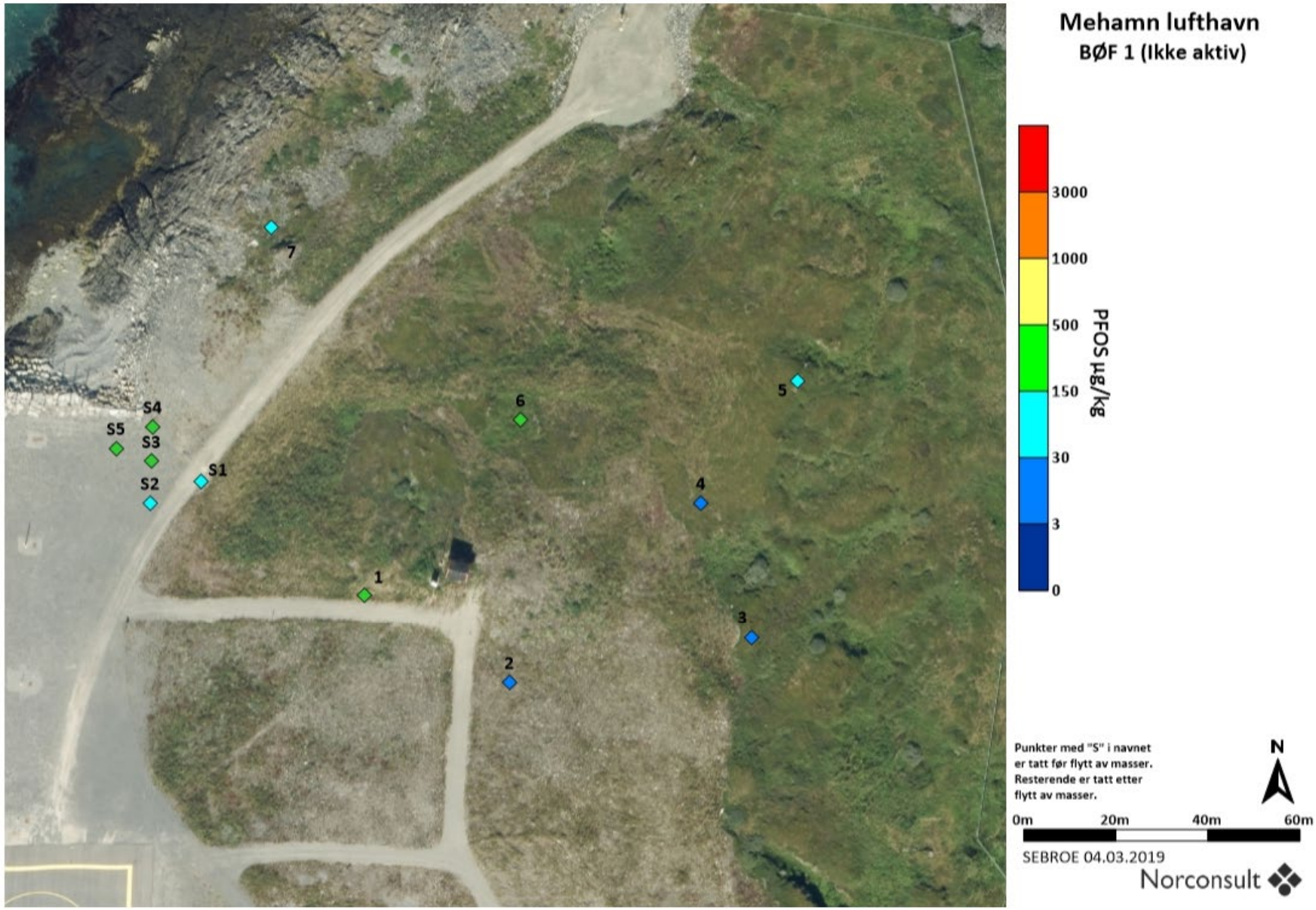
Biota

* PFOS er dominerende parameter

ip = ikke påvist

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APPENDIX A



17.1 Fire training site (BØF) / contaminated site

Fire training site (BØF) / contaminated site	BØF 1 and 2 (not active)
	BØF 1 was used in the period 1974 –1986. BØF 2 was put into use after 1986. BØF 2 was only used once after 2005 and then without the use of chemicals. BØF 1 and BØF 2 are very close to each other, and are therefore considered one BØF in the DP2 report. From the DP2 report: In connection with the S&L project, the runway was expanded northwards, and now covers the fire training site, both the new (BØF 2) and old part (BØF 1). The two former fire training sites are now covered in up to 3m of rock materials. During construction, vegetation was removed and set aside. A rocky knoll that was located south of the BØF was blasted and used as filler for the extension of the runway in the north. Erosion blocks were placed under the filled materials to prevent eluviation to the sea. Vegetation and peat were replaced after the blasting work was completed. The original materials at the fire training site were not removed before the blasted rock was laid. Surveys of the materials at the BØF were carried out in two stages. Ramboll conducted sampling of the materials at one BØF (it is uncertain which) in the spring of 2011, before the rock materials was laid. In this connection, samples were taken from five points. Later in 2011, Sweco conducted a survey of the materials. The BØF was then covered with up to 3 metres of rock materials, and thus 7 samples of original materials were taken north and east of the fire training sites. The samples were taken approximately 60-120 metres from the BØF. Due to the fact that only 5 samples of one of the BØFs were taken, it was decided not to calculate amounts for this site. Since the two BØFs were described as being close to each other (probably less than 50 metres distance between them), it was also decided to treat them as one site in this reporting form.

17.2 The use of PFOS and other PFAS

Volume of PFOS used at the site (kg)	Not calculated
Comments/uncertainty	
Volume of PFAS used at the site (kg)	Not calculated
Comments/uncertainty	

17.3 Soil sampling

Total number of soil samples	12
Comments/uncertainty (for example, 95% of the samples were taken from 0–0.1 m)	7 of the samples were taken of surface materials (0-0.2 m) north and east of the BØF (about 60-120 metres from the BØF). 5 of the samples were taken of the BØF before the area was filled with rubble.
Number of soil samples 0-1 m beneath the ground	12
Number of soil samples under 1 m	0
Comments/uncertainty	The deepest sample (S5) was taken from a depth of 0.7 m.
Highest measured soil concentration of PFOS µg/kg	460
Where	S3 (0-0.4 m). The materials consists of gravel, sand and stone. The sample was taken of the materials at the BØF before the area was filled with rubble.
Highest measured soil concentration of PFAS µg/kg	460
Where	S3 (0-0.4 m). The materials consists of gravel, sand and stone.
Comments/uncertainty	Sample "S3" was only analysed for PFOS. The samples taken at the BØF before the area was filled with rubble were only analysed for PFOS. The samples taken north and east of the BØF were analysed for PFOS and PFOA.

17.4 Volume calculation

Volume was not calculated.	Volume was not calculated at this site located under the runway. The site consists of two old fire training sites next to one another, and the distance between them is uncertain, but they are stated to be close (assumed to be less than 50 metres). Five sampling points at one of the sites were surveyed prior to the extension of the runway, but the extent of the training site(s) is very uncertain based on these samples. Sampling after the expansion provides little delimitation for the area.
Comments	The DP2 report assumes that the most contaminated area is within an area of 30x20 metres, and that the thickness of the contaminated materials is 0.4 metres. It is calculated that the average concentration of the contaminated materials is 238 µg/kg. Based on these figures, it is calculated that 90 g of PFOS remains at BØF. There is probably some uncertainty associated with this figure. Samples were only taken of one of the previous BØFs (it is uncertain whether samples were taken of the newest or oldest BØF). There is no information on the degree of contamination of the materials at the second BØF.
Is the extent of the contaminated area limited horizontally?	No, the contamination is not delimitated horizontally. Concentrations above the detection limit were detected in all samples, both in those taken at the BØF and those taken of the original materials north and east of the BØF. Roughly speaking, the highest concentrations were detected in the materials at the BØF, but a concentration of 235-255 µg/kg was also detected in two of the samples taken from the original materials north and east of the BØF.
Is the extent of the contaminated area limited vertically?	No. Contamination above the detection limit was detected down to 0.7 m. It is uncertain how much deeper this contamination extends. However, the area has shallow bedrock so it is assumed to be a limited extent.
Comments/uncertainty	

17.5 Water sampling and annual dispersion

Have water samples been taken?	Yes
Where	Samples were taken in the Mehamnelva, both upstream and downstream. Samples of a downstream lake and snow depot were also taken south of the terminal.
Highest measured concentration of PFOS in groundwater (ng/l)	No groundwater samples were taken
Where	
Highest measured concentration of PFAS in groundwater (ng/l)	No groundwater samples were taken
Where	
Comments/uncertainty	No groundwater was detected in the area.
Highest measured concentration of PFOS in surface water (ng/l)	2,280
Where	Snødeponi, vann3 (sample taken of a lake downstream snow from snow depot)
Highest measured concentration of PFAS in surface water (ng/l)	3,970
Where	Snødeponi, vann3 (sample taken of a lake downstream snow from snow depot)
Comments/uncertainty	The sample "Snødeponi, vann 3" was analysed for 12 PFAS compounds. 6:2 FTS, PFBS, PFBA, PFHxS, PFHxA, PFHpA, PFOA, PFOS and PFPeA were detected in the sample. PFOS is the predominant compound, but high concentrations of PFHxS, PFHxA, and PFPeA were also detected in the sample (concentrations between 200-823 ng/l). The deep hole where the water sample was taken is a long way from the BØF. It is therefore likely that the contamination in this water sample comes from a different source than the BØF.
Total annual dispersion of PFOS from the airport	This was not calculated. The DP2 report describes the materials at the BØF as located under several metres of rock/gravel with a paved cover. The probability of the contaminated materials coming into contact with water is small, which is why the potential for dispersion from here is small. There is evidence of contamination in surrounding terrain, where there is about 20 cm of peat over the bedrock. This contamination can be spread to the Mehamnelva by water. Experience from the DP2 project suggests that peat has a good retention capability for PFOS. The DP2 report concluded that any run-off of PFOS is unlikely to have an environmental impact on the Mehamnfjord, as it is assumed that water replacement in Mehamnfjorden is at least 100 million m3/year.
Total annual dispersion of PFAS from the airport	Not calculated
To which recipient	Run-off from the BØF will go to the Sørfjorden/Mehavnfjorden

Calculated from water or soil concentration.	

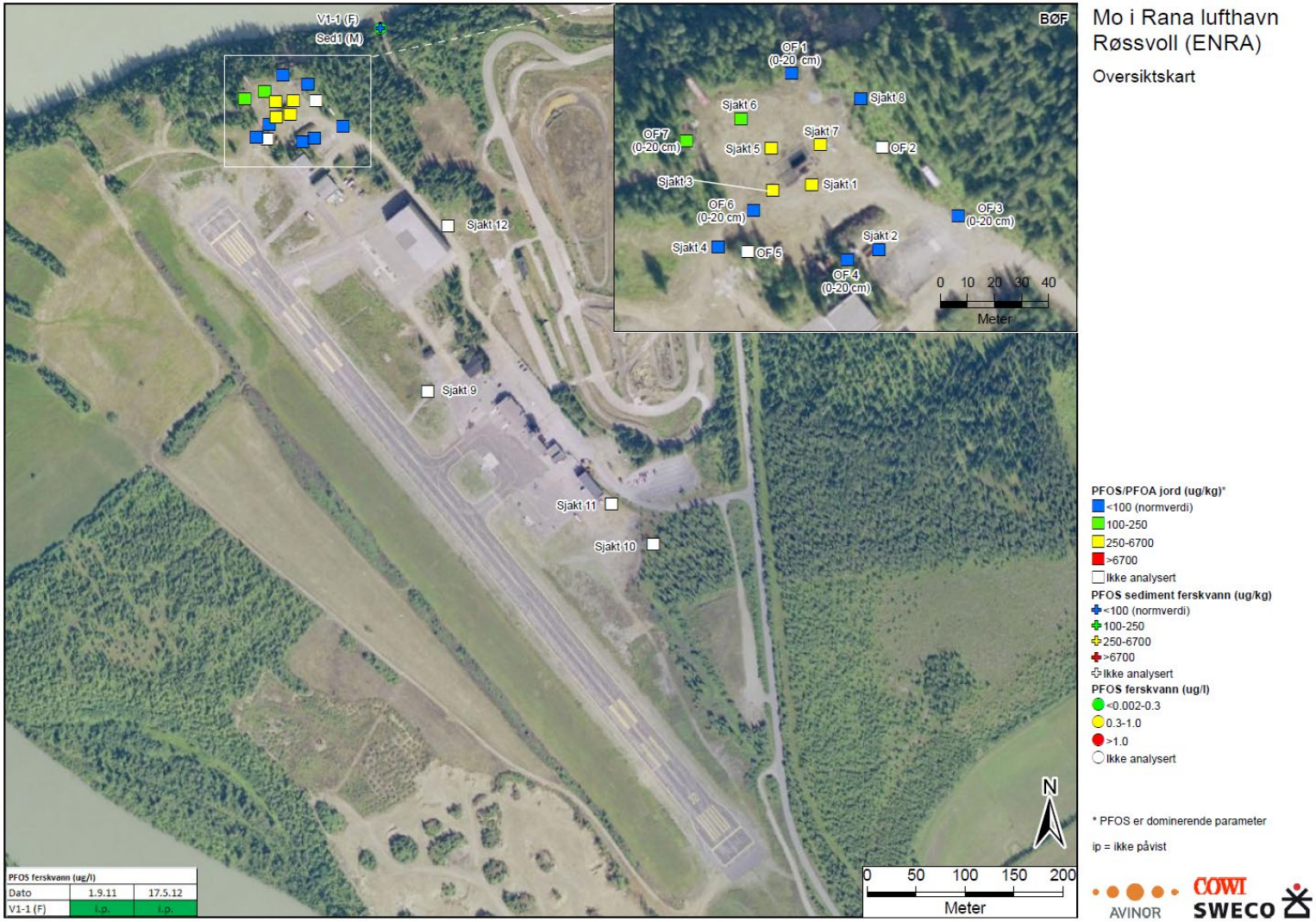
17.6 Biota sampling

Have biota samples being taken at the airport?	Yes
What kind of biota?	Mussels
How many samples?	1
Highest measured concentration of PFOS in biota (µg/kg wet weight)	Not detected
Where	Only specimen in water outside the BØF
Highest measured concentration of PFAS in biota (µg/kg wet weight)	Not detected
Where	Only specimen in water outside the BØF
Median concentration in comparable populations (e.g. in a lake)	The average concentration of PFOS in mussel samples from the inner Oslofjord was 0.07 µg/kg vv. Analysis was carried out for 13 compounds, and three compounds were detected. The highest concentration was for PFOSA of 0.46 µg/kg, and 0.05 µg/kg of PFHxS was also detected. Norwegian Environment Agency: "Environmental Contaminants in an Urban Fjord, 2016", report M-812 from 2017
Comments/references	The mussel sample was analysed for PFOS and PFOA.
References and concentrations in other reports.	

17.7 Uncertainty and other factors

Does the estimate of the volume of PFOS in the ground correspond with the measured concentrations in water and biota?	No volume calculations have been carried out, due to the fact that few samples have been taken from the actual BØF. However, the soil samples taken show concentrations up to 460 µg/kg. Some PFOS has been found in the water sample taken in Mehamnelva, downstream from the airport. This suggests that there is some leaching of PFOS from the BØF or from the surrounding areas. No PFOS has been detected in the biota sample taken at the outlet of the Mehamnelva. The DP2 report states that "The mussel tested was about 3-5 cm long, suggesting that it was too "young" to have lived while there was activity using foam at the fire training site". The mussel was taken on the northwest side of Sørfjordneset on which the BØF is located, and was therefore taken closer to the fjord than the Mehamnelva, which runs along the east side of the headland with an outlet north of the headland. It is believed that water replacement in Mehamnfjorden is extensive, so ongoing leaching will be diluted quickly. The highest concentrations in water were detected in the sample taken from a deep hole downstream of the snow depot. High concentrations of PFOS were detected in this water sample. In addition, a number of other PFAS compounds were detected. It is likely that the contamination in this sample has a source other than the BØF, due to the fact that the deep hole is far away from the BØF (800-900 metres south of the BØF), and not downstream of the BØF.
Evaluations	
Comments/uncertainty: (Could there be additional unknown sources of PFOS at the site with run-off to the recipient?)	The high concentration of PFAS in water from the deep hole downstream of the snow depot indicates that there is another source of PFAS contamination at the airport in addition to the BØF. It cannot be ruled out that testing/training has taken place using foam cannons or washing of the foam cannons was conducted in the area around the snow depot.
Has the site been sufficiently mapped with a view to assessing the order of prioritisation?	No, the site is inadequately mapped (ref. this report for sections 1 and 2, chapter 2.1.1.6 and chap. 2.1.3.1. Few samples have been taken of the area itself for the two fire training sites, as the runway has been extended over this area. In addition, samples were not taken from of one of the fire training sites.
Comments/uncertainty	
Other factors of significance for any clean-up/initiation of measures (for example, planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	Mehamnelva and Sørfjorden are registered as areas with a high management interest due to common eiders. Other species with a high and especially high management interest have also been registered in the area around the airport. An area of "sea meadow and mudflats" habitat has been registered east of the airport, along the Mehamnelva. A cultural heritage site has been registered west of the airport. Mehamn Airport is assessed as Avinor's vulnerability class 2, which is somewhat less vulnerable recipients, moderate priority and level of facility. Mehamnelva is used for fishing (sea trout and sea char).

18 Mo i Rana Airport, Røssvoll



Mo i Rana lufthavn
Røssvoll (ENRA)

Oversiktskart

PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

PFOS sediment ferskvann (ug/kg)
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

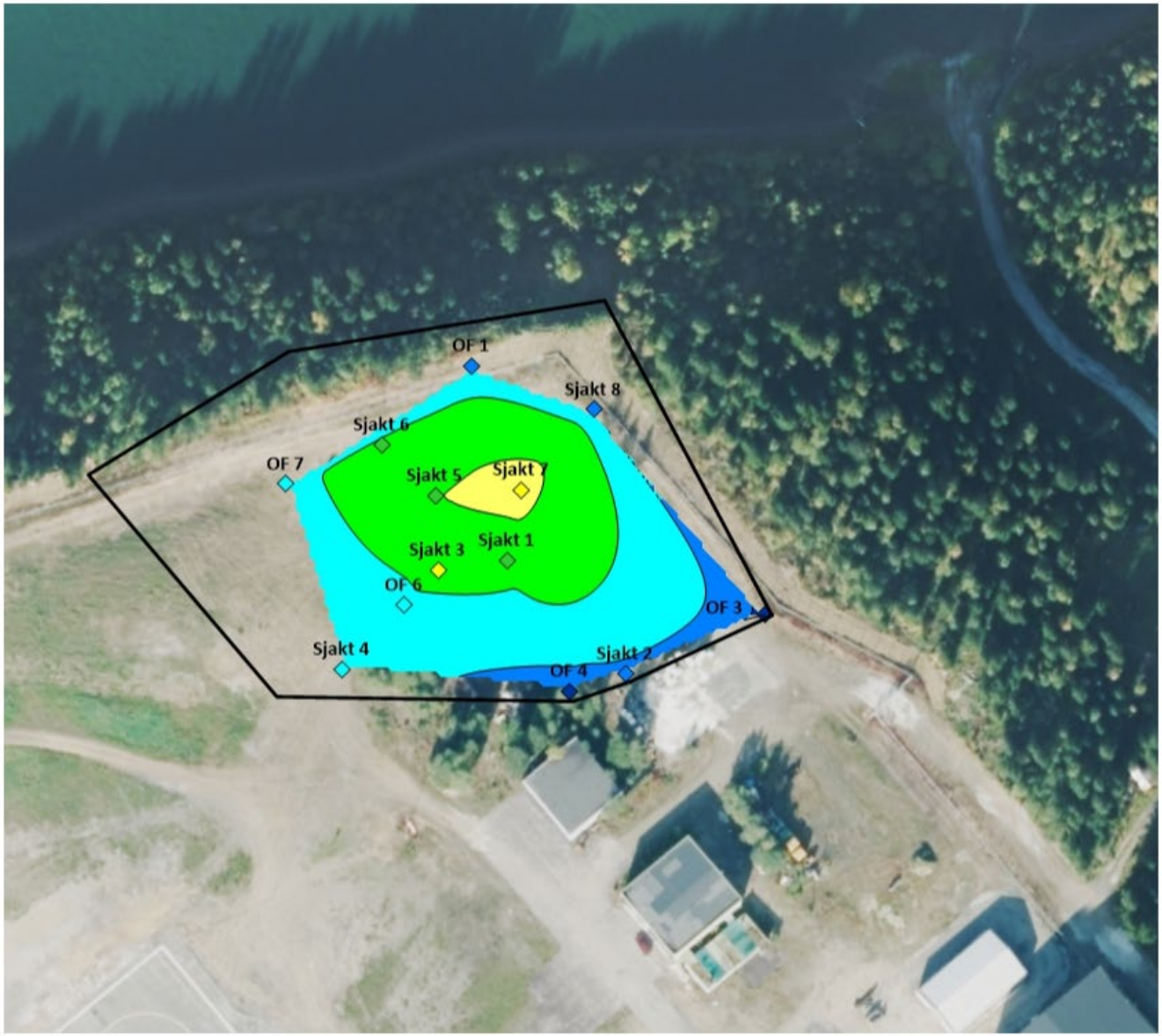
PFOS ferskvann (ug/l)
- <0.002-0.3
- 0.3-1.0
- >1.0
- Ikke analysert

* PFOS er dominerende parameter

ip = ikke påvist

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APPENDIX A



Mo i Rana lufthavn
BØF 1 (Ikke aktiv)

Interpolering for 0-1 meters dybde

PFOS µg/kg
3000
1000
500
150
30
3
0

Antatt kildeareal

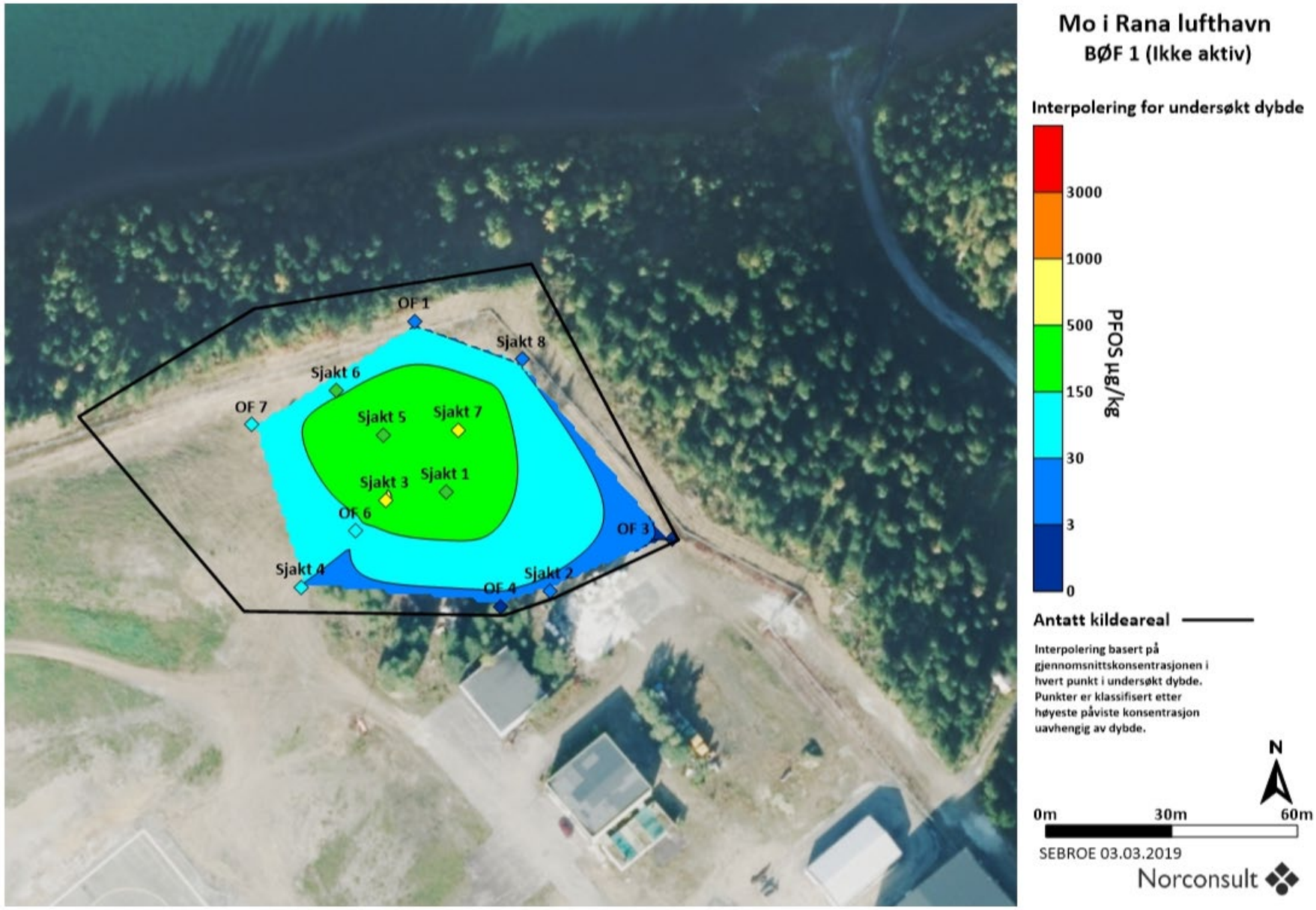
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i 0-1 meters dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.

N

0m 30m 60m

SEBROE 03.03.2019

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Mo i Rana lufthavn
BØF 1 (Ikke aktiv)

Interpolering for undersøkt dybde

PFOS µg/kg
3000
1000
500
150
30
3
0

Antatt kildeareal

Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.

N

0m 30m 60m

SEBROE 03.03.2019

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18.1 Fire training site (BØF) / contaminated site

Fire training site (BØF) / contaminated site	BØF 1 (old)
	The fire training site's exemption for operations expired on 31.12.06. In connection with the fire training site, some old chemical tanks (oil/diesel tanks) and various other debris were observed that were not in use.

18.2 The use of PFOS and other PFAS

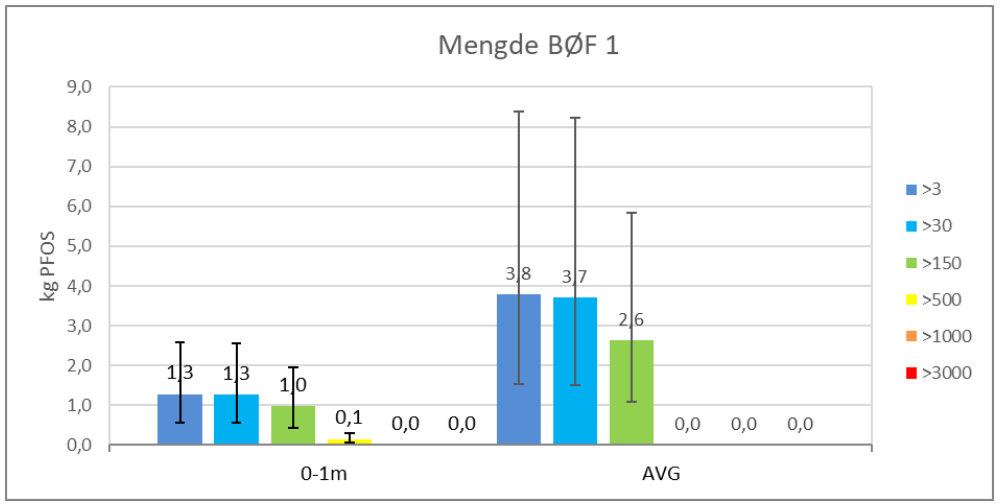
Volume of PFOS used at the site (kg)	Not stated/calculated
Comments/uncertainty	
Volume of PFAS used at the site (kg)	Not stated/calculated
Comments/uncertainty	

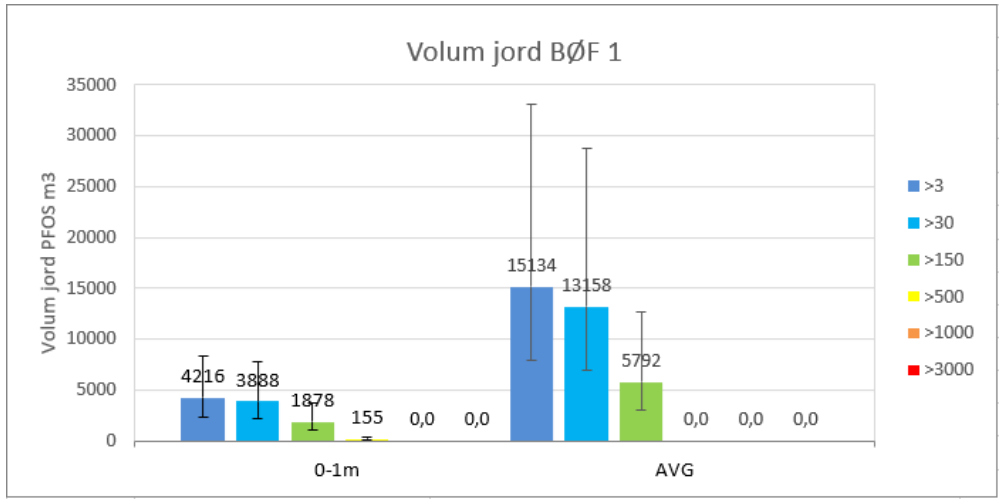
18.3 Soil sampling

Total number of soil samples	21
Comments/uncertainty (for example, 95% of the samples were taken from 0–0.1 m)	13 of the samples were taken from 0-10 or 0-20 cm.
Number of soil samples 0-1 m beneath the ground	13
Number of soil samples under 1 m	8
Comments/uncertainty	There were no samples between 0.2-2 m.
Highest measured soil concentration of PFOS µg/kg	727
Where	Shaft 7-1 (0-0.1 m). The materials consists of gravelly sand.
Highest measured soil concentration of PFAS µg/kg	755
Where	Shaft 3-3 (3.6 m). The materials consists of gravelly sand.
Comments/uncertainty	All samples were analysed for PFOS and PFOA. Only three of the samples have been analysed for a total of 11 PFAS compounds. In two of these samples, PFOS, but also 6:2 FTS and PFOA, have been detected. In the third sample, PFOS, as well as low concentrations of PFBA, PFHxS, PFOA were detected.

18.4 Volume calculation

PFOS average for all depths and points > 3 µg/kg	
Concentration (µg/kg)	147
Area (m2)	4,204
Volume of soil (tonnes)	25,728
Volume of PFOS (kg)	3.8
Uncertainty -	2.2
Uncertainty +	4.6
PFOS average for all depths and points > 30 µg/kg	
Concentration (µg/kg)	166
Area (m2)	3,655
Volume of soil (tonnes)	22,369
Volume of PFOS (kg)	3.7
Uncertainty -	2.2
Uncertainty +	4.5
PFOS average for all depths and points > 150 µg/kg	
Concentration (µg/kg)	268
Area (m2)	1,609
Volume of soil (tonnes)	9,847
Volume of PFOS (kg)	2.6
Uncertainty -	1.6
Uncertainty +	3.2
PFOS average for all depths and points > 500 µg/kg	
Concentration (µg/kg)	
Area (m2)	
Volume of soil (tonnes)	
Volume of PFOS (kg)	
Uncertainty -	
Uncertainty +	





PFOS average for all depths and points > 1000 µg/kg	
Concentration (µg/kg)	
Area (m2)	
Volume of soil (tonnes)	
Volume of PFOS (kg)	
Uncertainty -	
Uncertainty +	
PFOS average for all depths and points > 3,000 µg/kg	
Concentration (µg/kg)	
Area (m2)	
Volume of soil (tonnes)	
Volume of PFOS (kg)	
Uncertainty -	
Uncertainty +	

Comments regarding calculations of volume	In the DP2 report, it is calculated that 1,732 g of PFOS and 23.4 g of PFOA remain at the BØF. It is thus assumed that the contaminated area is within an area of 707 m2, and that the thickness of the contaminated materials is 4 m. The basis for the calculation then conducted in 2019 is a much larger area to delimitate contamination to < 3 µg/kg.
Is the extent of the contaminated area limited horizontally?	The only extreme points where there are concentrations below the detection limit are OF 3 and OF 4 to the south and east. Shaft 8 and OF 1 to the northeast have concentrations < 20 µg/kg. The contamination is least delimitated in the northwestern and western directions (in the direction of Langvassåga) - a concentration of 119 µg/kg has been detected at the extreme OF7.
Is the extent of the contaminated area limited vertically?	No, in several of the shafts, relatively high concentrations (300-750 µg/ kg) of PFOS have been detected in deep materials (3.5 metres deep). It is not known how much deeper the contamination extends, and the depth to groundwater in the materials is stated to be > 5 metres in the DP2 report (a survey was conducted to 4 metres deep and no water was found). The deepest sample was taken at 4.3 metres in shaft 4 furthest to the southwest, and PFOS was not detected.
Comments/uncertainty	No samples have been analysed in the layer 0.2-2 metres. There is therefore a great deal of uncertainty as to the degree of contamination of these materials. In some of the shafts, it was observed that the concentration of PFOS increases with increasing depth. In other shafts, the opposite was observed as the concentration of PFOS decreases with increasing depth. It was mainly in the shafts found in the central part of the BØF that an increasing concentration of PFOS with depth as observed, while in the shafts that are more on the outskirts it was observed that the concentration decreases with increasing depth.

18.5 Water sampling and annual dispersion

Have water samples been taken?	Yes
Where	Sample of assumed leaching water to Langvassåga taken 120 metres east of the BØF.
Highest measured concentration of PFOS in groundwater (ng/l)	No groundwater samples have been taken. No environmental wells were sunk due to the fact that groundwater is deep in the area.
Where	
Highest measured concentration of PFAS in groundwater (ng/l)	
Where	
Comments/uncertainty	
Highest measured concentration of PFOS in surface water (ng/l)	Not detected above the detection limit.
Where	
Highest measured concentration of PFAS in surface water (ng/l)	5.5
Where	Vann 1 - sampled 17.5.12 (point marked V1-1 on overview map)
Comments/uncertainty	Only the compound PFPeA was detected in water sample Vann 1. The sample point in the DP2 report is described as "assumed leaching water from the area at the recipient in the north". Samples were taken at the point twice (1.9.11 and 17.5.12).
Total annual dispersion of PFOS from the site (g/year)	5.3
Total annual dispersion of PFAS from the site (g/year)	Not calculated
To which recipient	Langvassåga (river)
Calculated from water or soil concentration.	Soil concentration

18.6 Biota sampling

Have biota samples being taken at the airport?	No
What kind of biota?	
How many samples?	
Highest measured concentration of PFOS in biota (µg/kg wet weight)	
Where	
Highest measured concentration of PFAS in biota (µg/kg wet weight)	
Where	
Median concentration in comparable populations (e.g. in a lake)	

Comments/references	
References and concentrations in other reports.	

18.7 Uncertainty and other factors

Does the estimate of the volume of PFOS in the ground correspond with the measured concentrations in water and biota?	Cannot be evaluated. It is uncertain whether the low concentration of PFPeA detected in one leaching water sample, and PFOA in the other leaching water sample can be related to the contamination at the BØF. No biota samples were taken.
Evaluations	The water samples were taken about 120 metres east of the BØF, and it is uncertain whether leaching water from the BØF will reach this sampling point. Groundwater was expected to flow north. In the water sample taken on 17.5.12, a concentration of 5.5 ng/l of the PFPeA compound was detected. This compound was not detected in any of the three soil samples analysed for this compound. Some PFOA was detected in the sample taken on 17.5.11 (2.5 ng/l). PFOA was also detected in the soils at the BØF. No PFOS was detected in the water samples, even though there were by far the highest concentrations of this PFAS compound in the soil samples.
Comments/uncertainty: (Could there be additional unknown sources of PFOS at the site with run-off to the recipient?)	No further sources were provided, but this cannot be ruled out. Indeed this is highly possible considering that PFPeA was detected in the water sample, and not in the soil samples from the BØF.
Has the site been sufficiently mapped with a view to assessing the order of priority?	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the volume of PFOS in the soil with the stipulated level of uncertainty.
Comments/uncertainty	No soil samples were taken at a depth of between 0.2-2 metres. There is therefore a great deal of uncertainty as to the degree of contamination in this layer of materials. The contamination in the central area of the BØF is not delimitated by depth. Furthermore, no survey was conducted to establish whether there was dispersion to groundwater. The BØF is located on permeable sand and gravel materials, and it cannot be ruled out that there has been/is transportation of contamination all the way down to the groundwater.

Other factors of significance for any clean-up/initiation of measures (for example, planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	No protected areas have been registered near the airport, but several species (birds and plants) of high and especially high management interest have been registered in and around the airport. To the northeast and east of the airport there are important outdoor areas, Røssvoll and Skonseng. Langvassåga and Ranelva hold sea trout and salmon farms and are used for angling.

19 Molde Airport, Årø



Molde lufthavn
Årø (ENML)

Oversiktskart

Jord og sediment

PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

PFOS sediment marint (ug/kg)
- 0
- <LOQ
- LOQ-63
- 63-6300
- >6300
- Ikke analysert

* PFOS er dominerende parameter

LOQ = rapporteringsgrense
i.a. = ikke analysert

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APPENDIX A



Molde lufthavn
Årø (ENML)

Oversiktskart

Vann

PFOS / ∑ PFAS grunnvannsbrønn (ng/l) *
- Ikke analysert
- 0
- <LOQ
- LOQ-230
- 230-36 000
- >36 000

PFOS / ∑ PFAS ferskvann (ng/l) *
- Ikke analysert
- 0
- <LOQ
- LOQ-230
- 230-36 000
- >36 000

Avlopsledning
- Avløp annet
- Avløp Felles
- Drensvann
- Glykolholdig overvann
- Glykolholdig spillvann
- Overvann
- Pumpespillvannsledning
- Spillvann

Avrenning
- Deponi glykolforurenset snø
- Overvannsledning
- Avrenningsveg glykol
- Bekkeresipient
- Overvannsystem
- Vannskille rullebane
- Antatt avrenningsveg baneavising

i.a. = ikke analysert
LOQ = rapporteringsgrense
(tilsv. ikke påvist for ∑PFAS)

Grunnvannsbrønner

Punkt	Parameter	2011-10-03	2012-05-30
BØF 1-4*	PFOS	23900	i.a.
	∑PFAS	i.a.	i.a.
MBR1	PFOS	10.6	<LOQ
	∑PFAS	i.a.	<LOQ
MBR2	PFOS	<LOQ	<LOQ
	∑PFAS	i.a.	<LOQ

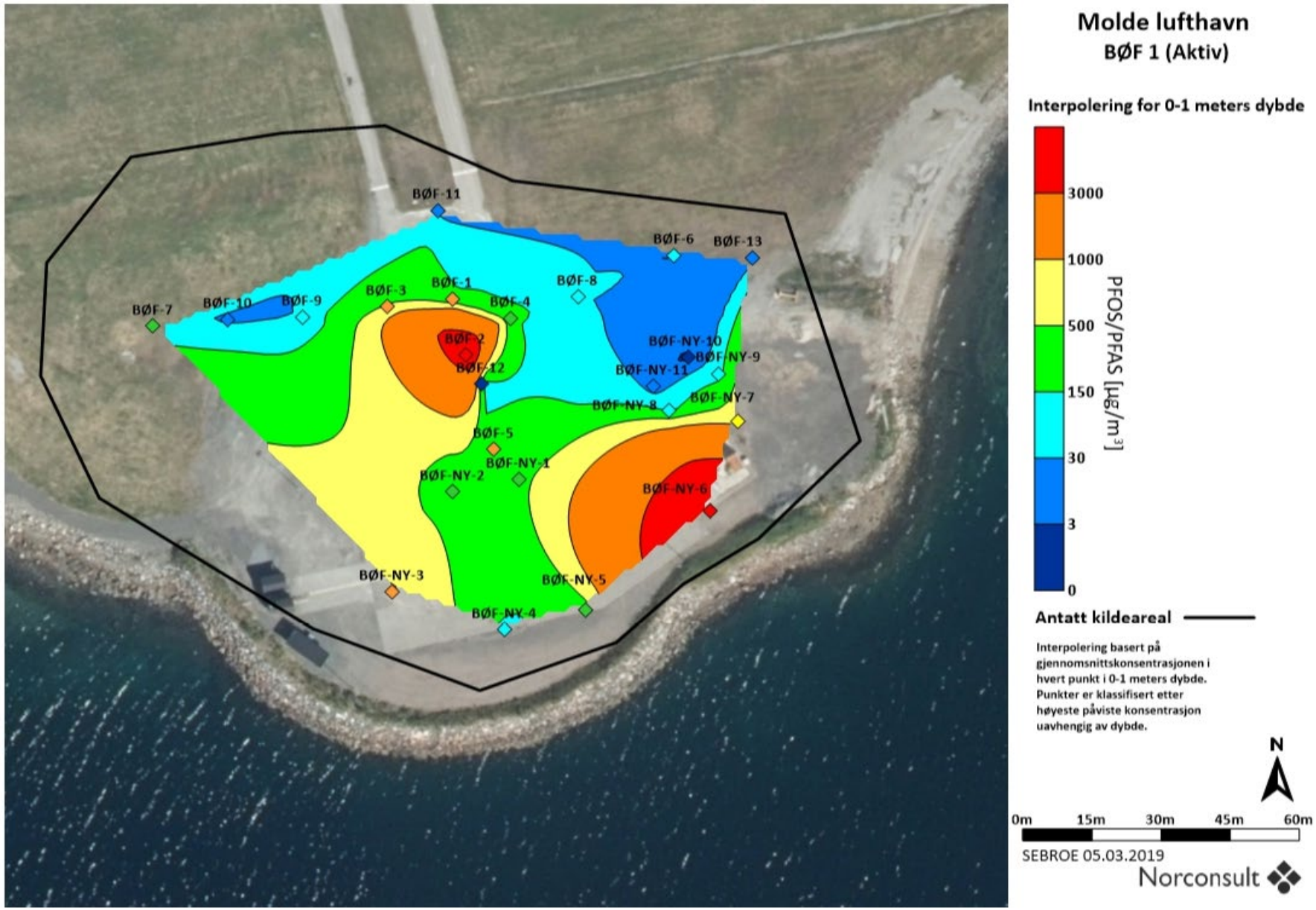
Alle konsentrasjoner er gitt som ng/l
* Vann i sjakt

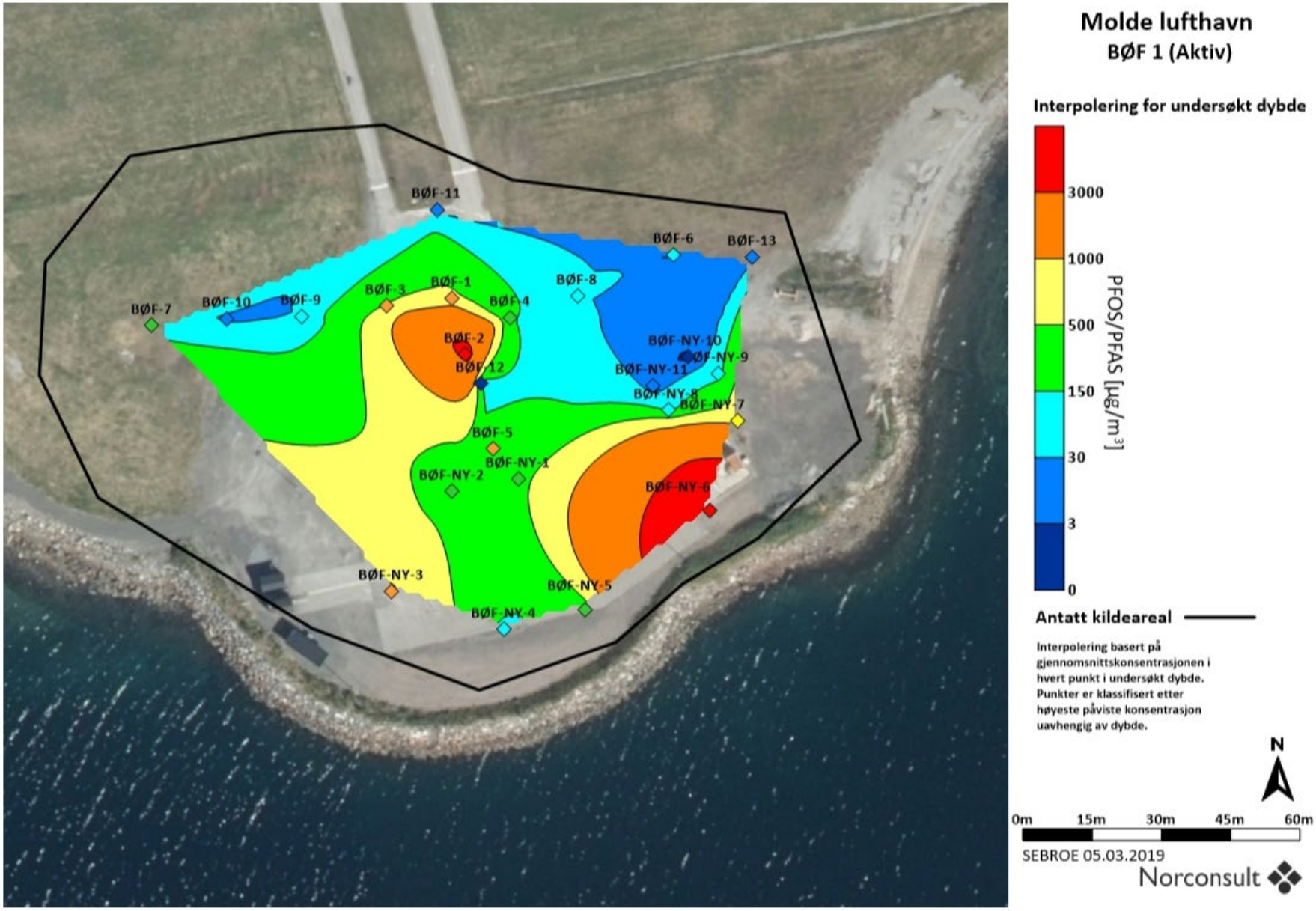
Oljeutskiller

Punkt	Parameter	2012-10-31	2013-03-13	2014-04-02	2014-09-04	2015-04-23
OU-BØF	PFOS	366	106	272	835	147
	∑PFAS	57447	44500	58600	75100	6911.7

Alle konsentrasjoner er gitt som ng/l

AVINOR Norconsult COWI SWECO


Molde lufthavn
BØF 1 (Aktiv)
Interpolering for 0-1 meters dybde
3000
1000
500
150
30
3
0
PFOS/PFAS [µg/m³]
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i 0-1 meters dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m 15m 30m 45m 60m
SEBROE 05.03.2019
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BØF-11
BØF-6
BØF-13
BØF-7
BØF-10
BØF-9
BØF-3
BØF-1
BØF-8
BØF-4
BØF-2
BØF-12
BØF-NY-10
BØF-NY-9
BØF-NY-11
BØF-NY-8
BØF-NY-7
BØF-5
BØF-NY-1
BØF-NY-2
BØF-NY-6
BØF-NY-3
BØF-NY-5
BØF-NY-4



Molde lufthavn

BØF 1 (Aktiv)

Interpolering for undersøkt dybde

PFOS/PFAS [µg/m³]

- 3000
- 1000
- 500
- 150
- 30
- 3
- 0

Antatt kildeareal

Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.

N

0m 15m 30m 45m 60m

SEBROE 05.03.2019

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19.1 Fire training site (BØF) / contaminated site

Fire training site (BØF) / contaminated site	BØF 1 (active and old)
	Molde Airport has several old fire training sites located in roughly the same area. The last one was taken out of service around 2006 and a new active fire training site that was re-established in the same place is now in use. Old aerial photos from 2006 show that the part of the BØF where the new platform was built was filled out to the sea in 2006. BØF 1 is located at about 4 m above sea level, right by the sea. There is no written documentation on the use of the fire training site. According to information provided by the airport, the area under the active site was dug up some years ago to lay down an impermeable membrane. Surface water from the impermeable membrane flows to an oil separator. The oil separator has a drainage pipe that discharges to the sea at a depth of 2 metres, about 50 metres from shore.

19.2 The use of PFOS and other PFAS

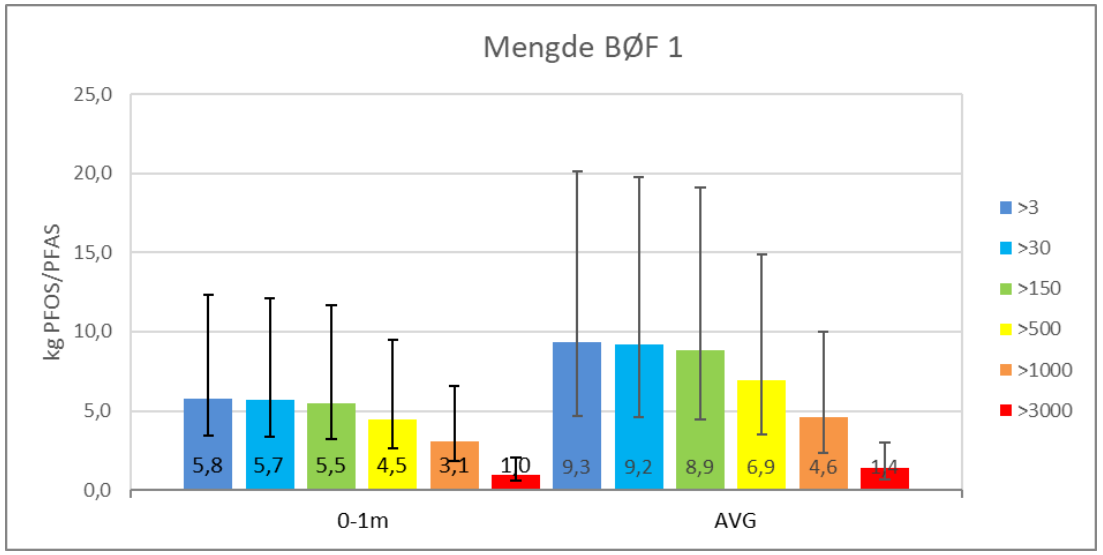
Volume of PFOS used at the site (kg)	1480
Comments/uncertainty	Estimated consumption from 1978 to 2001.
Volume of PFAS used at the site (kg)	250
Comments/uncertainty	Estimated consumption from 2001 to 2012. Extinguishing foam containing PFAS compounds was phased out at Avinor airports in 2012.

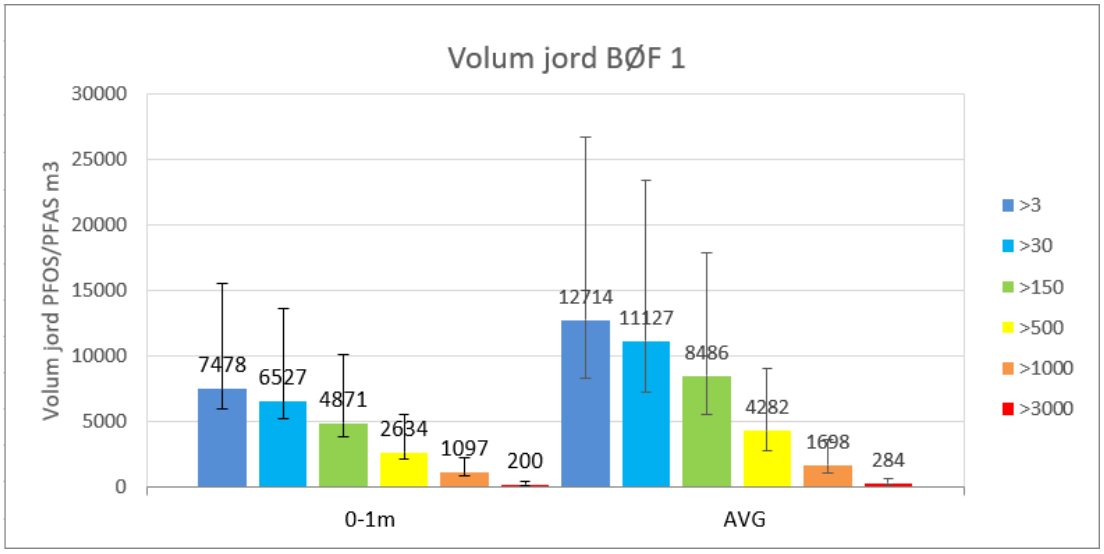
19.3 Soil sampling

Total number of soil samples	38
Comments/uncertainty (for example, 95% of the samples were taken from 0–0.1 m)	There are a total of 41 samples if the samples that cover the different intervals (0-1 metres and > 1 metre) are divided up. 23 of the samples (about 55%) are surface samples, taken from 0-0.1 or 0-0.2 metres. No samples have been taken at depth exceeding 1.7 metres at any points. The materials at the old part are stated to consist of crushed stone, rock, gravel, sand, clay, organic sand. The materials in the top soil in the new part are stated to consist of crushed stone, sand and gravel.
Number of soil samples 0-1 m beneath the ground	34
Number of soil samples under 1 m	9
Comments/uncertainty	Several of the samples below a depth of 1 metre are taken from intervals that also include soil from depths exceeding 1 metre.
Highest measured soil concentration of PFOS µg/kg	10,700
Where	BØF 2-2 (0.2-1.5 m). The materials consist of sand, gravel and rock.
Highest measured soil concentration of PFAS µg/kg	10,700
Where	BØF 2-2 (0.2-1.5 m). The materials consist of sand, gravel and rock.
Comments/uncertainty	The sample BØF 2-2 was only analysed for PFOS and PFOA. All 27 samples from the old part of the BØF (those tested in October 2011) were only analysed for PFOS and PFOA. The 11 soil samples taken from the new part of the BØF (those tested in June 2012) were analysed for 12 PFAS compounds. At the new part of the BØF, low concentrations (or not detected) of PFOS and high concentrations (> 100 ug/kg) of total PFAS were detected in six of 11 samples.

19.4 Volume calculation

PFOS average for all depths and points > 3 µg/kg	
Concentration (µg/kg)	583
Area (m2)	7,479
Volume of soil (tonnes)	22,886
Volume of PFOS/∑PFAS (kg)	9.3
Uncertainty -	4.6
Uncertainty +	11
PFOS average for all depths and points > 30 µg/kg	
Concentration (µg/kg)	654
Area (m2)	6,545
Volume of soil (tonnes)	20,028
Volume of PFOS/∑PFAS (kg)	9.2
Uncertainty -	4.6
Uncertainty +	11
PFOS average for all depths and points > 150 µg/kg	
Concentration (µg/kg)	828
Area (m2)	4,992
Volume of soil (tonnes)	15,276
Volume of PFOS/∑PFAS (kg)	8.9
Uncertainty -	4.4
Uncertainty +	10
PFOS average for all depths and points > 500 µg/kg	
Concentration (µg/kg)	1,283
Area (m2)	2,519
Volume of soil (tonnes)	7,708
Volume of PFOS/∑PFAS (kg)	6.9
Uncertainty -	3.4
Uncertainty +	8.0





PFOS average for all depths and points > 1000 µg/kg	
Concentration (µg/kg)	2,164
Area (m2)	999
Volume of soil (tonnes)	3,057
Volume of PFOS/∑PFAS (kg)	4.6
Uncertainty -	2.3
Uncertainty +	5.3
PFOS average for all depths and points > 3,000 µg/kg	
Concentration (µg/kg)	3,874
Area (m2)	167
Volume of soil (tonnes)	511
Volume of PFOS/∑PFAS (kg)	1.4
Uncertainty -	0.7
Uncertainty +	1.6

Comments regarding calculations	In the calculation carried out in the risk assessment in 2016, the amount of PFOS was calculated for this site. In the calculation in 2019, total PFAS concentrations were calculated in the samples from the new part of the BØF. This is because almost no PFOS was detected, and the concentrations of total PFAS were between 7.3 and 6,108.8 µg/kg. Six of the 11 samples have concentrations above 100 µg/kg. Due to the fact that less contamination of PFOS was detected in the top layer (0-0.2 m) was detected In the calculation from 2016, the remaining concentration in top layers and in deeper layers was calculated separately. When the calculation was made in 2016, it was thought that the most contaminated area was within an area of 8,000 ± 1,000 m2. It was calculated that the average concentration in the top layer (0-0.2 m) was 12 µg/kg and that the average concentration in the deeper materials (0.2-1.7 m) was 960 µg/kg. Furthermore, it was calculated that 0.03 ± 0.02 kg PFOS remains in the top materials, and 18 ± 11 kg in the deeper materials. In the calculation from 2019, no differentiation is made between top layers and deeper layers. The basis used was the surveyed area of approximately 7,500 m2, and that the thickness of the contaminated materials is 1.7 m. An average concentration of ∑PFAS of 583 µg/kg within this area was used. It is assumed that part of the volume consists of larger fractions which are subtracted from the volume for the calculation. On this basis, it was calculated that there remains approximately 9 kg ∑PFAS in the surveyed volume at BØF 1. The uncertainty in the calculation indicates that there may be up to twice the amounts.
Is the extent of the contaminated area delimitated horizontally?	No. The lowest concentrations were at the extreme points (surface samples) to the north (BØF 11) and northwest (BØF 13). These have concentrations of PFOS < 20 µg/kg. The extreme to the west (BØF 7 samples from several depths) has a concentration of 164 µg/kg, and at the extreme to the east (surface sample BØF-NY-6) there was a total PFAS of 6,108.8 µg/kg.
Is the extent of the contaminated area delimitated vertically?	No. Concentrations of PFOS above the detection limit were detected in all seven shafts (BØF 1 to BØF 7), six of the shafts had samples with concentrations > 100 µg/kg, and in five of these there were also concentrations of PFOS > 100 µg/kg in the deepest sample. In the southern part of the BØF (in the active part) only surface samples were taken. These show low concentrations of PFOS, but six of 11 samples have concentrations of total PFAS > 100 µg/kg. It cannot be ruled out that there are also high concentrations in the deeper materials in this area.
Comments/uncertainty	

19.5 Water sampling and annual dispersion

Have water samples been taken?	Yes
Where	Samples were taken from two groundwater wells at the terminal site. Samples of groundwater seepage were also taken in one of the shafts (outside the current site, but within the area where there has previously been a fire training site) at BØF 1. In addition, water samples were regularly taken from the wastewater from the oil separator associated with BØF 1.
Highest measured concentration in groundwater of PFOS (ng/l)	23,900
Where	Water in shaft BØF 1-4, sampled 03.10.2011.
Highest measured concentration in groundwater of PFAS (ng/l)	24,284
Where	Water in shaft BØF 1-4, sampled 03.10.2011.
Comments/uncertainty	Analysis was only made for PFOA and PFOS in the water sample from shafts. In the groundwater wells at the terminal area, PFOS was only detected in a water sample (10.6 ng/l PFOS in MBR1).
Highest measured concentration in surface water of PFOS (ng/l)	
Where	No samples of surface water were taken.
Highest measured concentration in surface water of PFAS (ng/l)	
Where	
Comments/uncertainty	Water from the oil separator is stated to flow to sea in Fannefjorden through drain pipes. Water samples from the oil separator are not considered to be representative of the surface water in the area. The oil separator and drain only receive water from the fire training site itself, not surface water from other parts of the airport. Five water samples were taken in the oil separator between 2012 and 2015, and concentrations of PFOS detected were between 106 and 835 ng/l, and PFAS between 6,911.7 and 75,100 ng/l. The sample with the highest concentrations is from September 2014. The predominant compound in the water samples is 6:2 FTS. High concentrations of PFHxA and PFPeA were also detected in the samples. Extinguishing foam containing PFAS compounds was phased out at Avinor airports in 2012. In seven recent measurements from 2016 to 2018, the concentrations of total PFAS in the oil separator vary. In four of the samples it was < 20,000 ng/l, and in three of the samples between 40,000 and 50,000 ng/l. It was predominantly the compound 6:2 FTS that constituted the concentrations detected (the latest information is taken from Avinor's environmental monitoring report from Molde Airport 2017-2018).

Total annual dispersion rate from the site of PFOS (g/year)	636 (1)*
Total annual dispersion rate from the site of PFAS (g/year)	Not calculated (100)*
To which recipient	Fire training site(s) have run-off to sea. Run-off from BØF 1 will mainly infiltrate the ground down to the groundwater and further towards the fjord. When PFOS reaches groundwater, it will be transported quickly into the fjord due to the tide. In the event of heavy rainfall and large amounts of water, water can run off on the surface towards the fjord.
Calculated from water or soil concentration.	The total annual dispersion of PFOS is calculated based on the sample of groundwater in the shaft (BØF 1-4) that was taken during shaft digging. The PFOS concentration in water samples taken during digging may be elevated due to mobilisation of the compounds, and is not necessarily representative of groundwater otherwise in the area. There is therefore a relatively high uncertainty related to total annual dispersion. *Annual dispersion was calculated from the oil separator based on average water samples in the oil separator.

19.6 Biota sampling

Have biota samples being taken at the airport?	Yes
What kind of biota?	Rough periwinkle, limpet, common shore crab, and common seaweed flea.
How many samples?	6
Highest measured concentration of PFOS in biota (µg/kg wet weight)	38
Where	Limpet, composite sample n>15, (BØF west)
Highest measured concentration of PFAS in biota (µg/kg wet weight)	54.5
Where	Seaweed flea, composite sample n>20, (BØF eastern emissions)
Median concentration in comparable populations (e.g. in a lake)	The average concentration of the composite sample of approximately 500 g of limpet at the reference station "Vardetangen" at Fonnesflaket in Northern Hordaland was 0.229 µg/kg of wet weight. Reference: Uni Research Miljø SAM-Marlin: "Undersøkelse av miljøgifter i sediment og albuesnegl ved Fonnesflaket i Lindås 2016" ("Survey of environmental contaminants in sediment and limpet at Fonnesflaket in Lindås 2016")

Comments/references	The median concentration of total PFAS in limpet (n=6) was 33.75 µg/kg ww in a bay just outside BØF at Statoil Mongstad in 2015. The median concentration of PFOS in the same samples was 7.2 µg/kg. Retrieved from Statoil Petroleum report; "Environmental contaminants in biota at Statoil Mongstad 2015, SAM e-report no: 35-2015.
References and concentrations in other reports.	The EQS value in the Water Regulations for PFOS in biota is 9.1 µg/g wet weight. PFOS was detected in all of the biota tests taken at Molde Airport, but only three of the samples show concentrations above the EQS value. For total PFAS, the concentrations in four of the samples were higher than this limit value. In a risk assessment from 13 December 2018, EFSA changed the tolerability limit (TDI - tolerable daily intake) for PFOS and PFOA, so these are now far lower than the TDI values set in 2008. This may cause EQS for biota to also be lower in the future.

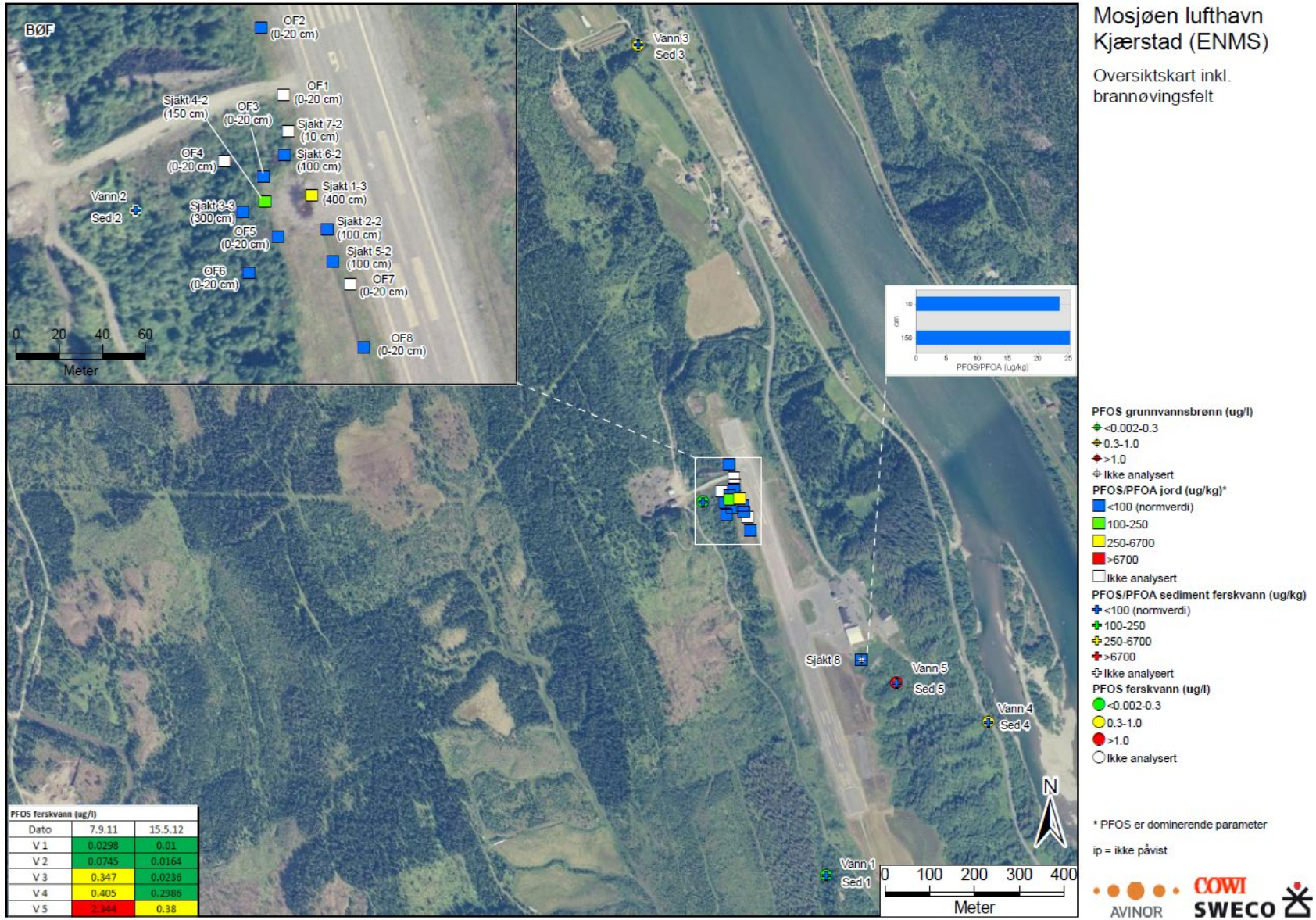
19.7 Uncertainty and other factors

Does the estimate of the volume of PFOS in the ground correspond with the measured concentrations in water and biota?	It is difficult to assess for water, as a groundwater sample was only taken at BØF 1. The groundwater sample was taken during the establishment of shafts. When digging in materials containing PFAS, the compounds will be easily mobilised, so that the water sample receives higher concentrations. It is uncertain how representative this analysis result is for groundwater elsewhere in the area. Cannot be reliably evaluated for biota.
Evaluations	It is calculated that approximately 9 kg (between 5-20 kg) PFOS remains at the surveyed area of BØF 1. It is estimated that 1480 kg of PFOS was used at the site. This shows that most of PFOS has already leaked out to recipient. The soil samples taken from the old part of the fire training site (BØF1-BØF13) show high concentrations of PFOS in some areas. These samples were only analysed for PFOS and PFOA. The soil samples taken from the active part of the fire training area show no/little PFOS contamination, but on the other hand relatively high concentrations of 6:2 FTS and 8:2 FTS. This is consistent with the fact that PFOS-containing foam was previously used, while from 2001 foam with other PFAS compounds was used. Only samples of surface materials were taken at the active BØF, and it is therefore unclear how much PFAS is located in the deeper materials. The surface materials also consist of permeable materials of gravel, crushed stone and sand, so a large amount of PFAS may have been dispersed in water down through the soil profile. In eight of the 11 soil samples taken at the new part of BØF, higher concentrations of 8:2 FTS than 6:2 FTS were detected. Far higher concentrations of 6:2 FTS were detected in water samples from the oil separator than of 8:2 FTS. This reversed situation may be due to the fact that 6:2 FTS is more soluble in water in soil than 8:2 FTS due to its shorter chain length is, and leaks out much faster. In the water samples from the oil separator, high concentrations of a number of other compounds (listed according to concentration, highest first) were also detected: 6:2 FTS, PFHxA, PFPeA, PFHpA, 8:2 FTS, PFOA, PFBA, PFOS), but these were only detected in small or zero amounts in soil samples compared to 8:2 FTS and 6:2 FTS. The sample of groundwater in shafts was only analysed for PFOS and PFOA. PFOS (between 2.2-38 µg/kg) was detected in all six biota tests. The species analysed are native species of clams and beach biota caught a short distance from the BØF. In all samples except of two, it was the compound PFUnDA that was prominent in addition to PFOS. Analysis for this compound was not conducted in soil or water. 8:2 FTS was detected in one of the biota samples, but 6:2 FTS was not detected. The findings of PFAS in stationary species so close to the source suggest that the content of the biota samples is due to the spread from the BØF.

Comments/uncertainty: (Could there be any additional unknown sources of PFOS at the site with run-off to the recipient?)	Before the new operations building was put into use in the autumn of 2006, the fire station was in the middle of today's aircraft parking stand. It cannot be ruled out that fire engines with remains of PFOS/PFAS were cleaned/washed here before 2006, but there is no certain information about this. There are two environmental wells at Molde Airport, these are located at the tank facility (for aviation fuel) just east of the aircraft parking stand. PFOS just above the detection limit was detected in MBR1 in October 2011, but this was not found again when sampling a few months later in May 2012. PFAS was not detected either in 2011 or in 2012 in the second well, MBR2. The source of PFOS detected in MBR1 in 2011 may be the washing of a fire engine or an unfortunate discharge of firefighting foam from the time when the fire station was located in the middle of the current aircraft parking stand. At other airports it has been common practice to test cannons and adjust the foam cannon sight at both ends of the runway. It is assumed that this also applies to Molde Airport. There is a workshop where fire engines have been washed inside. There may have been PFAS in the washing water that was led on to the sewage system from here. Two composite surface soil samples at the largest snow depot show concentrations of PFOS of 4.9 and 37.6 µg/kg. From the snow depot there is a surface water pipeline leading into the Årøelva.
Has the site been sufficiently mapped with a view to assessing the order of prioritisation?	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the volume of PFOS in the soil with the stipulated level of uncertainty.
Comments/uncertainty	There are uncertainties related to the degree of contamination in the deeper materials under the active BØF. There are also uncertainties related to the contamination level of groundwater in the area. This should be surveyed more closely.
Other factors of significance for any clean-up/initiation of measures (for example, planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	Management interest along the beach zone at the airport area. In addition, common eelgrass has been registered at the outlet of the Årøelva on the west side of the airport. Furthermore, on the northeast side of the runway, locally important habitats have been registered (natural pastures and parkland), and there are many red-listed bird and other species in the area around the airport. Molde Airport is registered with Avinor's vulnerability class 1, which means non-vulnerable recipients, standard level at the facility. From Naturbase: Tern, which is a species of especially high management interest, has been registered in the entire coastal zone below the airport. Other species of high and especially high management interest are also registered at and around the airport. Several habitats have been registered around the airport, both on land and in the water; natural pastures, parklands and common eelgrass. Fannefjord is used for angling and professional fishing.

APPENDIX A

20 Mosjøen Airport, Kjærstad



PFOS ferskvann (ug/l)		
Dato	7.9.11	15.5.12
V 1	0.0298	0.01
V 2	0.0745	0.0164
V 3	0.347	0.0236
V 4	0.405	0.2986
V 5	2.344	0.38

Mosjøen lufthavn
Kjærstad (ENMS)

Oversiktskart inkl. brannøvingsfelt

PFOS grunnvannsbrønn (ug/l)
- <0.002-0.3
- 0.3-1.0
- >1.0
- Ikke analysert

PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

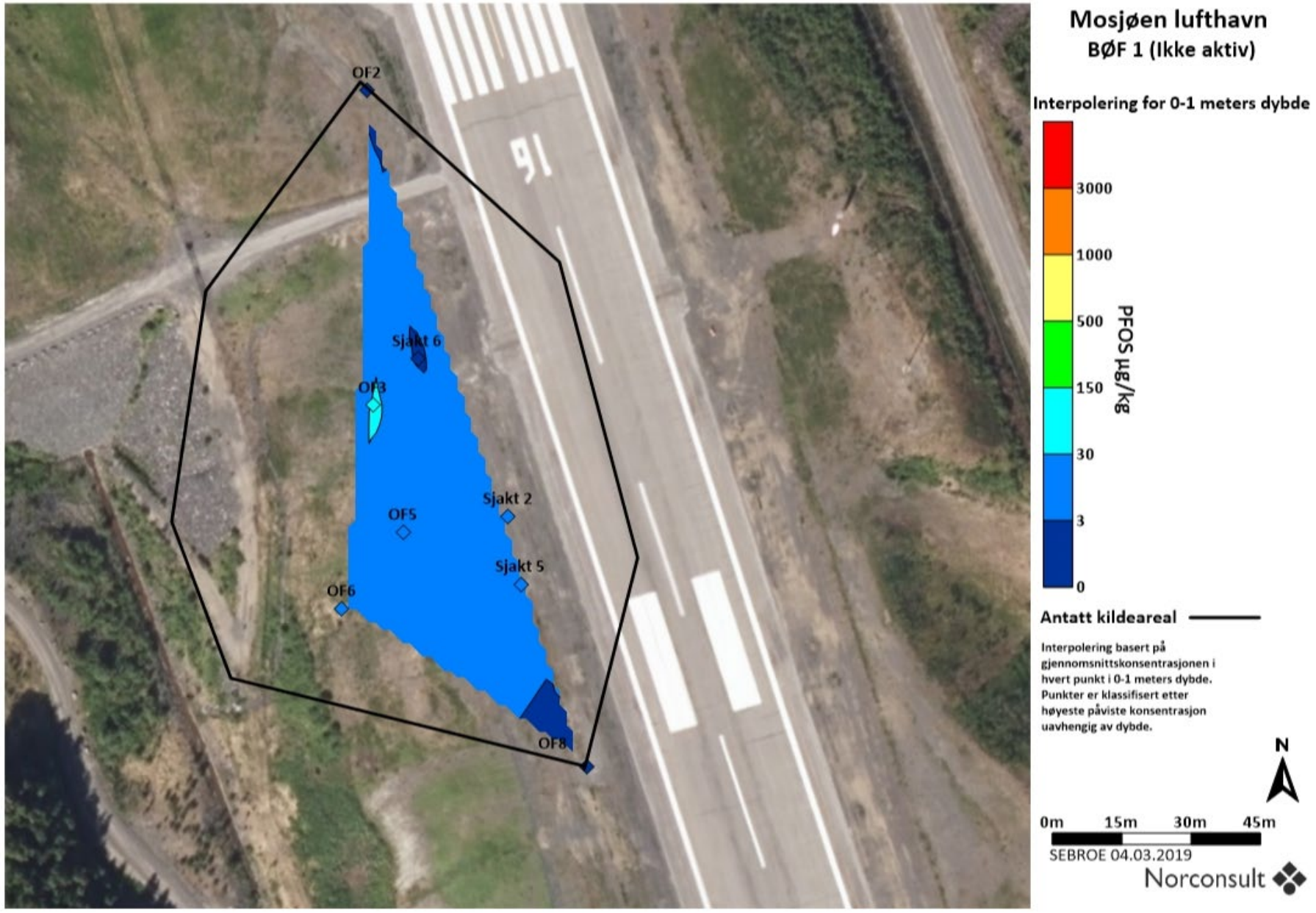
PFOS/PFOA sediment ferskvann (ug/kg)
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

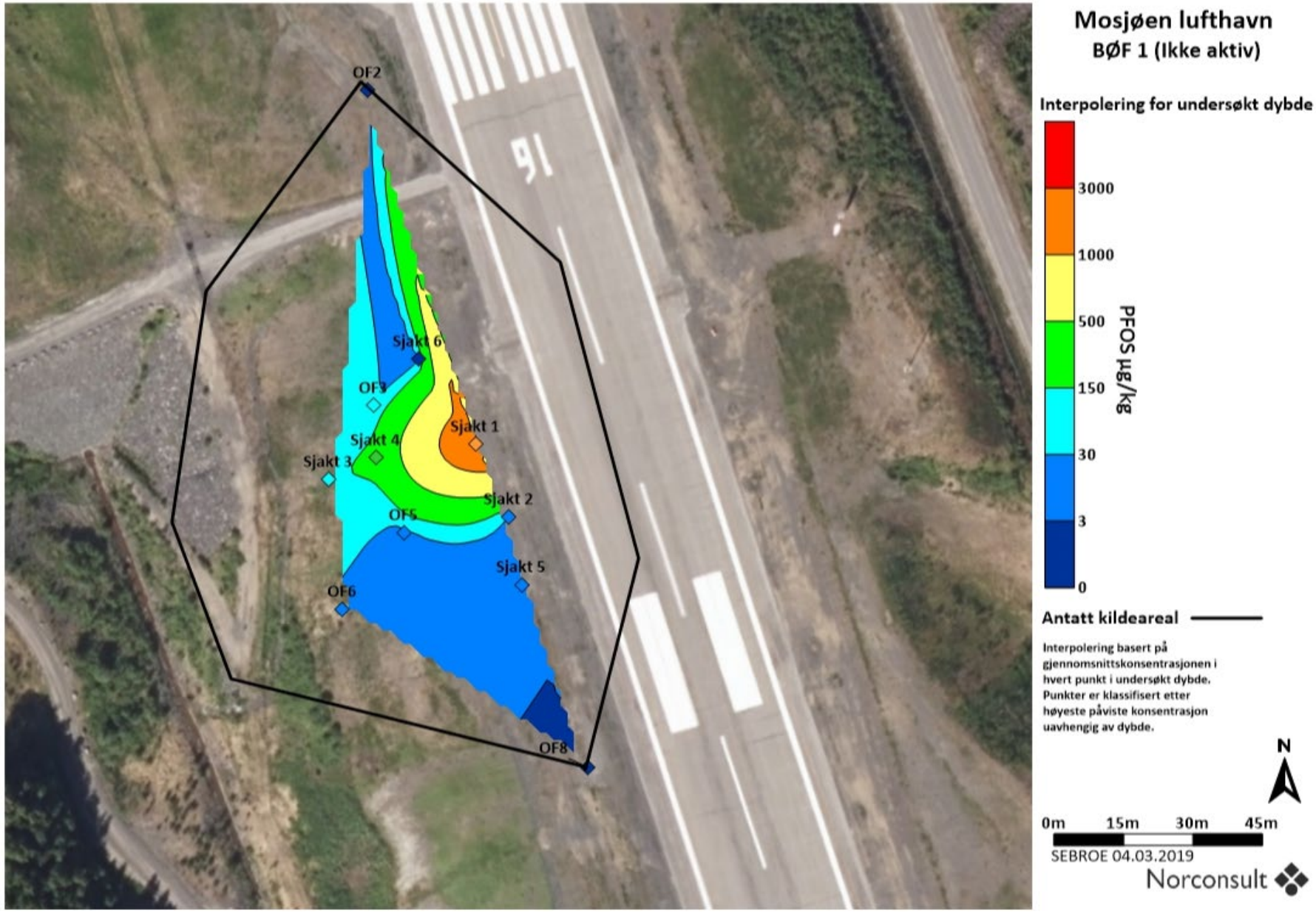
PFOS ferskvann (ug/l)
- <0.002-0.3
- 0.3-1.0
- >1.0
- Ikke analysert

* PFOS er dominerende parameter

ip = ikke påvist

AVINOR COWI SWECO


OF2
Sjakt 6
OF3
Sjakt 2
OF5
Sjakt 5
OF6
OF8
Mosjøen lufthavn
BØF 1 (Ikke aktiv)
Interpolering for 0-1 meters dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i 0-1 meters dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m 15m 30m 45m
SEBROE 04.03.2019
Norconsult


Mosjøen lufthavn
BØF 1 (Ikke aktiv)
Interpolering for undersøkt dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m 15m 30m 45m
SEBROE 04.03.2019
Norconsult
OF2
Sjakt 6
OF3
Sjakt 1
Sjakt 4
Sjakt 3
Sjakt 2
OF5
Sjakt 5
OF6
OF8
91

20.1 Fire training site (BØF) / contaminated site

Fire training site (BØF) / contaminated site	BØF 1 (old)
	The BØF was used up to and including 2005. There is no information on when the site was established. The DP2 report states that the site was removed/cleaned up in accordance with the action plan approved by Vefsn municipality on 18 October 2007. It is uncertain whether materials were removed in connection with this, or whether the BØF was covered by other materials. Sampling was carried out in 2011. In 2012, the monthly function of the fire engine's cannon and semi-annual crash exercises where extinguishing foam is used were still carried out.

20.2 The use of PFOS and other PFAS

Volume of PFOS used at the site (kg)	Not calculated/stated
Comments/uncertainty	
Volume of PFAS used at the site (kg)	Not calculated/stated
Comments/uncertainty	

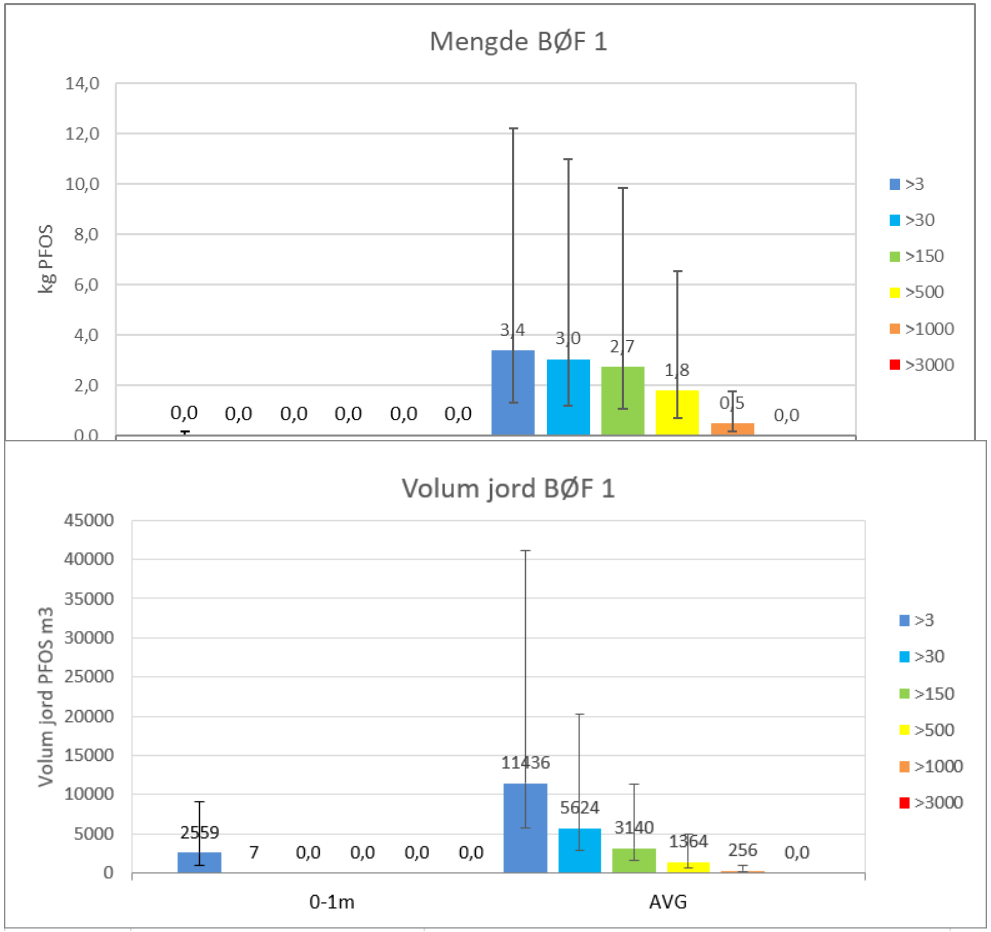
20.3 Soil sampling

Total number of soil samples	11
Comments/uncertainty (for example, 95% of the samples were taken from 0–0.1 m)	5 of the samples were taken from 0-20 cm. 3 samples were taken from a depth of 1 metre. The remaining three samples were taken at different depths between 1.5 and 4 metres
Number of soil samples 0-1 m beneath the ground	8
Number of soil samples under 1 m	3
Comments/uncertainty	There are no samples from the 0.2-1 m layer. 3 of the samples were taken from 100 cm. These are included in the "number of soil samples 0-1 m beneath the ground" and not in the "number of soil samples below 1 m".
Highest measured soil concentration of PFOS µg/kg	1,590
Where	Shaft 1-3 (4 m). The materials consist of soil with a very high clay content. The odour of oil from the materials was also noted.
Highest measured soil concentration of PFAS µg/kg	1,593
Where	Shaft 1-3 (4 m). Total of PFOS and PFOA. The materials consist of soil with a very high clay content. The odour of oil from the materials was also noted.

Comments/uncertainty	Sample "sjakt 1-3" was analysed for PFOS and PFOA. All 11 samples were analysed for PFOS and PFOA; in addition, 2 of the samples (overflate 3 and overflate 5) were analysed for 6:2 FTS and total PFC. These two samples were probably analysed for several PFAS compounds, but the analysis appendix for the samples in question was not attached to the report.

20.4 Volume calculation

PFOS average for all depths and points > 3 µg/kg	
Concentration (µg/kg)	185
Area (m2)	2,859
Volume of soil (tonnes)	18,298
Volume of PFOS (kg)	3.4
Uncertainty -	2.1
Uncertainty +	8.8
PFOS average for all depths and points > 30 µg/kg	
Concentration (µg/kg)	338
Area (m2)	1,406
Volume of soil (tonnes)	8,998
Volume of PFOS (kg)	3.0
Uncertainty -	1.9
Uncertainty +	7.9
PFOS average for all depths and points > 150 µg/kg	
Concentration (µg/kg)	543
Area (m2)	785
Volume of soil (tonnes)	5,024
Volume of PFOS (kg)	2.7
Uncertainty -	1.7
Uncertainty +	7.1
PFOS average for all depths and points > 500 µg/kg	



Concentration (µg/kg)	827
Area (m2)	341
Volume of soil (tonnes)	2,182
Volume of PFOS (kg)	1.8
Uncertainty -	1.1
Uncertainty +	4.7

PFOS average for all depths and points > 1,000 µg/kg	
Concentration (µg/kg)	1,196
Area (m2)	64
Volume of soil (tonnes)	410
Volume of PFOS (kg)	0.5
Uncertainty -	0.3
Uncertainty +	1.3
PFOS average for all depths and points > 3,000 µg/kg	
Concentration (µg/kg)	
Area (m2)	
Volume of soil (tonnes)	
Volume of PFOS (kg)	
Uncertainty -	
Uncertainty +	

Comments regarding calculations of volume	In the DP2 report, it is calculated that 2,632 g of PFOS and 8.8 g of PFOA remain in the materials. This assumes that the most contaminated area is within an area of 30x20 metres, and that the thickness of the contaminated materials is 3 metres.
Is the extent of the contaminated area delimitated horizontally?	No. The only extreme points where there are concentrations below the detection limit are in OF 2 (northernmost point) and OF 8 (southernmost point). However, at both of these points only surface samples (0-0.2 m) were taken. In the northernmost shaft (sjakt 6) a sample was taken from a depth of 100 cm, and here too PFOS was not detected. The contamination is not delimitated to the east or to the west. It can seem that shaft 1 is located in the most contaminated area, and that the strongest contaminated area extends further east towards the runway (where no sampling has been carried out).
Is the extent of the contaminated area delimitated vertically?	No. The highest concentrations were detected in the three samples of deeper materials (> 1 metre). In sjakt 1, a concentration of PFOS of 1,590 µg/kg was detected 4 metres below the ground surface. It is uncertain how much deeper this contamination extends. In the other two deeper samples (sjakt 3 at 3 m and sjakt 4 at 1.5 m), concentrations of 99.5 and 238 µg/kg respectively were detected. The contamination is therefore not delimitated vertically at any of the sampling points. In general, low concentrations of PFOS were found in surface samples taken at the BØF. This may be due to the fact that a clean-up of the BØF was carried out in 2007.
Comments/uncertainty	According to the DP2 report the marsh to the west and the clay materials south of the BØF will act as natural barriers to further horizontal dispersion in these directions. However, PFOS contamination was detected at a depth of 4 metres in sjakt 1, and it is stated that there is clay soil from 1.4 to the surveyed depth of 4 metres in this shaft. Since there is dry crust clay above groundwater level, the contamination can spread in cracks in the clay. No samples of materials between 1-4 metres was analysed in this shaft. In sjakt 3, the contaminated sample was taken in clay right after the transition from marsh to clay, and in sjakt 4 the contaminated sample was taken in clay right after the transition from clay soil to clay.

20.5 Water sampling and annual dispersion

Have water samples been taken?	Yes
Where	In the stream that flows west of the BØF. These were taken upstream (vann 1), at the BØF (vann 2) and downstream of the BØF (vann 3). In addition, two water samples (Vann 5 and Vann 4) were taken on the slope down towards Vefsna, southeast of the terminal area (below the snow depot and Widerøe's hangar).
Highest measured concentration of PFOS in groundwater (ng/l)	No groundwater samples have been taken.
Where	-
Highest measured concentration of PFAS in groundwater (ng/l)	-
Where	-
Comments/uncertainty	-
Highest measured concentration of PFOS in surface water (ng/l)	2,190
Where	Vann 5 (downstream of the snow depot) The sample was taken on 8.9.11
Highest measured concentration of PFAS in surface water (ng/l)	2,344
Where	Vann 5 (downstream of the snow depot) The sample was taken on 8.9.11
Comments/uncertainty	The water sample was only analysed for PFOS and PFOA. Water samples from 2012 were analysed for 11 PFAS, but had no higher concentrations than for PFOS and PFOA in the 2011 sample. The analysis report for water samples from 2012 was not attached to the report, and only PFOS, PFOA and 6:2 FTS are shown in the report, so it is uncertain which other PFAS compounds were detected in these.
Total annual dispersion of PFOS from the site (g/year)	214.7 g 3.7 g from groundwater and 211 g from surface water
Total annual dispersion of PFAS from the site (g/year)	316 g The total annual emissions of PFAS from surface water was calculated
To which recipient	Vefsna. The BØF is located 70 metres east of Litlmyrdalsbekken which flows north, where it meets Tverråga right at its outlet to Vefsna. Litlmyrdalsbekken is about 8-12 metres lower in the terrain than the BØF.

Calculated from water or soil concentration.	Concentrations of PFOS in groundwater are calculated based on mean soil concentrations. Dispersion from surface water was calculated based on water samples of the surface water at sample point "Vann 4" located southeast of the terminal area, so it is unclear whether this can be linked to the BØF.

20.6 Biota sampling

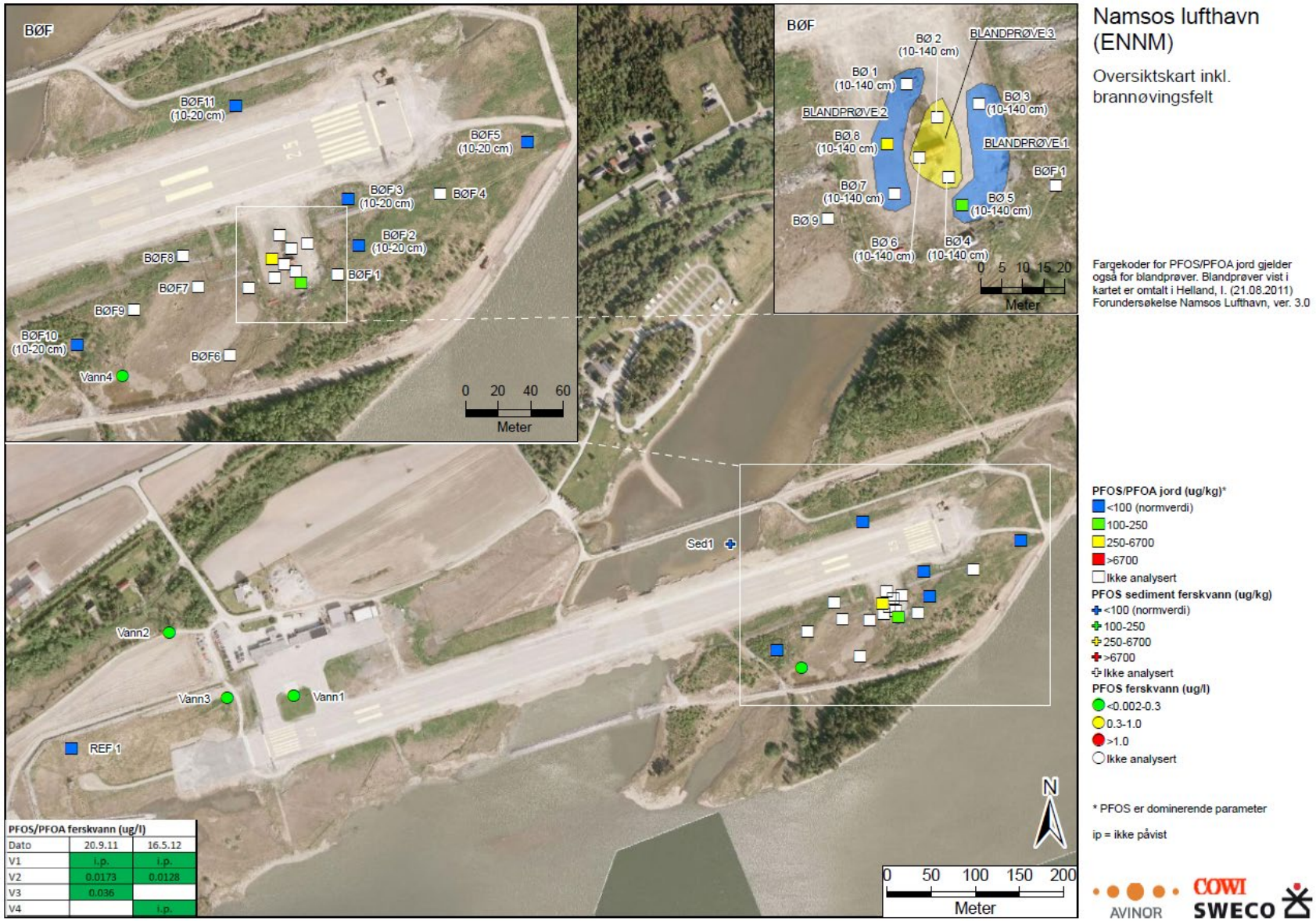
Have biota samples being taken at the airport?	No
What kind of biota?	-
How many samples?	-
Highest measured concentration of PFOS in biota (µg/kg wet weight)	-
Where	-
Highest measured concentration of PFAS in biota (µg/kg wet weight)	-
Where	-
Median concentration in comparable populations (e.g. in a lake)	-
Comments/references	-
References and concentrations in other reports.	-

20.7 Uncertainty and other factors

Does the estimate of the volume of PFOS in the ground correspond with the measured concentrations in water and biota?	Cannot be evaluated for biota, as no biota samples have been taken. Cannot be reliably evaluated for water. No groundwater samples were taken. The surface water samples (Vann 2 and Vann 3) from Litlmyrdalsbekken, which flows directly west of the BØF, have PFOS content, but the sample Vann 2 taken closest to the BØF has lower concentrations than the sample Vann 3 taken about 1 km further north. However, PFOS in somewhat lower concentrations was also detected in the water sample (Vann 1) taken upstream of the BØF, which may indicate influence from several sources. PFOS was also detected in the water samples southeast of the terminal area (Vann 5 and Vann 4) which may be due to other sources.
Evaluations	Water samples were taken at 5 points around and at the airport. For all points, higher concentrations were detected in the samples taken on 7.9.11 than in the samples taken on 15.5.12. The highest concentration was detected in a sample from a stream "Vann 5" taken on 7.8.11. This point is located approximately 550 metres southeast of the BØF, downstream of the terminal area, snow depot and Widerøe's hangar. Since the "Vann 5" sampling point is so far away from the BØF, and in the southeastern direction, the contamination in the water sample is not likely to be due to direct runoff or dispersion from the BØF, although this cannot be completely ruled out. The DP2 report describes that runoff can occur under the runway and towards Vefsna, but the flow direction for groundwater flow at the BØF is assumed to be either towards Litlmyrdalsbekken which runs just west of the BØF, or under the runway to the northeast/east in the terrain slope direction towards Vefsna. It over 4 metres to groundwater at the BØF, and no groundwater samples have been taken under the BØF. It is more likely that there is a source at the snow depot, Widerøe's hangar and/or that something at the terminal area is the source. If snow containing PFOS from the BØF has been deposited at the snow depot, this may have led to local dispersion of PFOS to the ground at the snow depot, which further impacts the water samples taken downstream of the snow depot. In the water sample V4 taken in the same stream, but at the outlet to Vefsna about 350 metres southeast of the terminal area, there are also high concentrations of PFOS, 405 ng/l (2011) and 298.6 ng/l (2012) and PFAS 508 ng/l (only analysed in 2012). In addition to the water samples at point "Vann 2" in Litlmyrdalsbekken just west of the BØF, water samples have been taken at "Vann 3" in Litlmyrdalsbekken approximately 1 km north of the BOF (downstream). In "Vann 2", PFOS concentrations of 69.5 ng/l (2011) and 11.4 ng/l (2012) were detected, and in "Vann 3", PFOS concentrations of 347 ng/l (2011) and 23.6 ng/l (2012) were detected. The water sample (Vann 1) taken in Litlmyrdalsbekken at the southwest end of the runway, upstream of the BØF, also shows some PFOS, at a concentration of 29.8 µg/l. This may indicate that there are one or more other sources of PFOS, without knowing what/where that source is.

Comments/uncertainty: (Could there be any additional unknown sources of PFOS at the site with run-off to the recipient?)	There may be other sources of PFOS at the airport, due to the high PFOS concentrations in the samples "Vann 5" and "Vann 4", as well as the content of PFOS in sample "Vann 1". The DP2 report states that the BØF was "removed" in 2007; if materials were excavated it is uncertain where this was moved. Aerial photos from 2004 and 2009 show that there were terrain changes at the BØF and major terrain changes northwest of the BØF during this period.
Has the site been sufficiently mapped with a view to assessing the order of prioritisation?	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the volume of PFOS in the soil with the stipulated level of uncertainty.
Comments/uncertainty	The uncertainties in the calculation of amounts of PFOS reflect uncertainty about the extent of the contamination/amount of contaminated materials, especially in the eastern direction towards the runway, but also in depth. Furthermore, no survey was conducted to establish whether there was dispersion to groundwater.
Other factors of significance for any clean-up/initiation of measures (for example, planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	Vefsna is a permanently protected river, with a long tradition of widespread angling for salmon and sea trout. Vefsna is also registered as a very important outdoor recreation area. West of the airport is another important outdoor recreation area "Kjærstad Aufles Kvalfors". Rossvollholmen, which is located in Vefsna, is registered as the important "large river bank" habitat. Other species with a high and especially high management interest have also been registered directly east of the airport.

21 Namsos Airport



PFOS/PFOA ferskvann (ug/l)		
Dato	20.9.11	16.5.12
V1	i.p.	i.p.
V2	0.0173	0.0128
V3	0.036	
V4		i.p.

Namsos lufthavn (ENNM)

Oversiktskart inkl. brannøvingsfelt

Fargekoder for PFOS/PFOA jord gjelder også for blandprøver. Blandprøver vist i kartet er omtalt i Helland, I. (21.08.2011) Forundersøkelse Namsos Lufthavn, ver. 3.0

PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

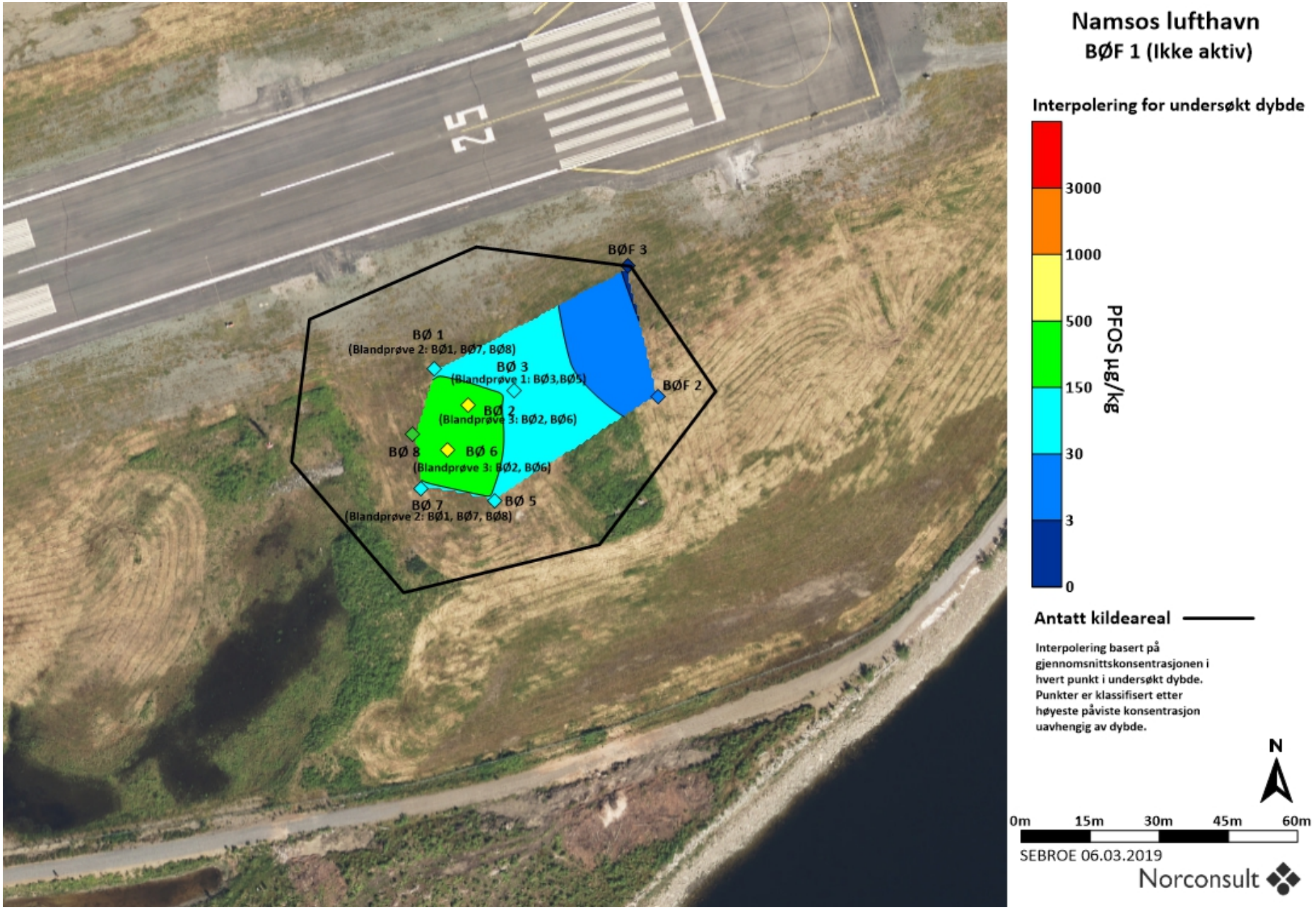
PFOS sediment ferskvann (ug/kg)
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

PFOS ferskvann (ug/l)
- <0.002-0.3
- 0.3-1.0
- >1.0
- Ikke analysert

* PFOS er dominerende parameter

ip = ikke påvist

AVINOR COWI SWECO


Namsos lufthavn
BØF 1 (Ikke aktiv)
Interpolering for undersøkt dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m 15m 30m 45m 60m
SEBROE 06.03.2019
Norconsult
BØF 3
BØ 1
(Blandprøve 2: BØ1, BØ7, BØ8)
BØ 3
(Blandprøve 1: BØ3,BØ5)
BØF 2
BØ 2
(Blandprøve 3: BØ2, BØ6)
BØ 8
BØ 6
(Blandprøve 3: BØ2, BØ6)
BØ 7
(Blandprøve 2: BØ1, BØ7, BØ8)
BØ 5

21.1 Fire training site (BØF) / contaminated site

Fire training site (BØF) / contaminated site	BØF 1 (old)
	It is not specified when the BØF was used/established. The fire training site's exemption for operations expired on 31.12.06. There is no activity at the BØF today. During the survey in 2011, concrete vessels, manholes and pipelines remained in the ground at the site. The BØF is not on Avinor's grounds, but Avinor is the owner of the contamination. Surveys of the BØF were carried out by the County Governor in 2007.

21.2 The use of PFOS and other PFAS

Volume of PFOS used at the site (kg)	Not stated/calculated
Comments/uncertainty	
Volume of PFAS used at the site (kg)	Not stated/calculated
Comments/uncertainty	

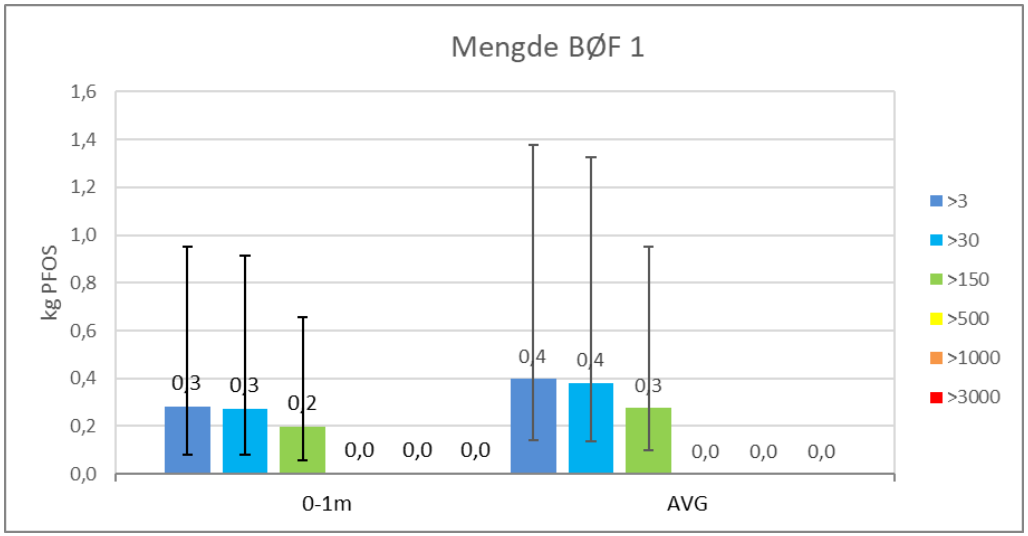
21.3 Soil sampling

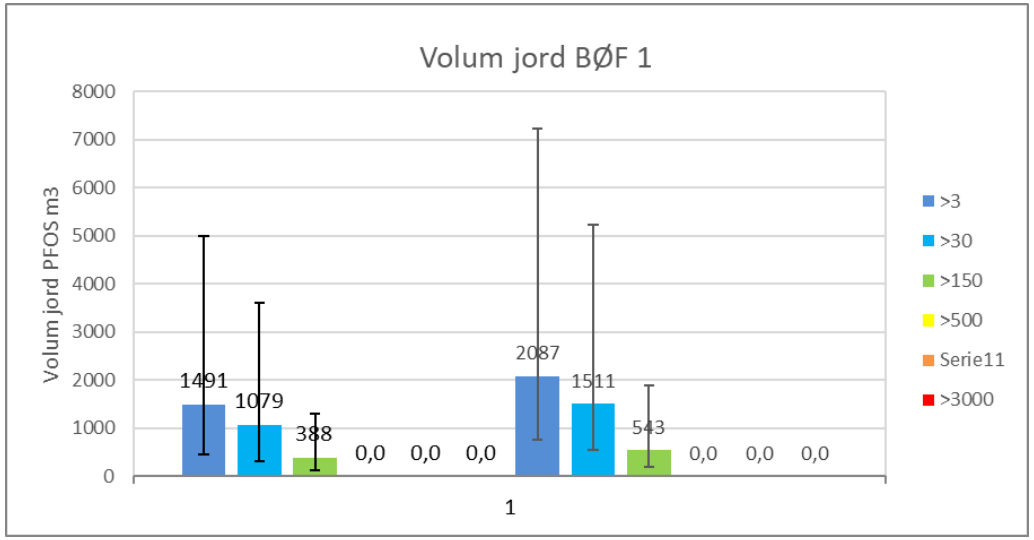
Total number of soil samples	7
Comments/uncertainty (for example, 95% of the samples were taken from 0–0.1 m)	Samples were taken from 10 points, but several of the samples were merged into composite samples. Therefore 7 soil samples (3 samples and 4 individual analyses) were analysed.
Number of soil samples 0-1 m beneath the ground	7
Number of soil samples under 1 m	5
Comments/uncertainty	Two of the samples are surface samples from a depth of 0.1-0.2 metres. Five of the samples were taken in the range 0.1-1.4 metres. A total of 12 soil samples when splitting up samples in the intervals of 0-1 m and > 1 m. The materials are described in the report's text as rough gravel to sand, with elements of large rubble. The type of materials is not described for each shaft.
Highest measured soil concentration of PFOS µg/kg	503
Where	Composite sample 3: BØ2 and BØ6. (0.1-1.4 m)
Highest measured soil concentration of PFAS µg/kg	503
Where	Composite sample 3: BØ2 and BØ6. (0.1-1.4 m)

Comments/uncertainty	All samples were only analysed for PFOS and PFOA. No PFOA has been detected in any of the samples.

21.4 Volume calculation

PFOS average for all depths and points > 3 µg/kg	
Concentration (µg/kg)	119
Area (m2)	1,491
Volume of soil (tonnes)	3,340
Volume of PFOS (kg)	0.4
Uncertainty -	0.3
Uncertainty +	1.0
PFOS average for all depths and points > 30 µg/kg	
Concentration (µg/kg)	158
Area (m2)	1,079
Volume of soil (tonnes)	2,417
Volume of PFOS (kg)	0.4
Uncertainty -	0.2
Uncertainty +	0.9
PFOS average for all depths and points > 150 µg/kg	
Concentration (µg/kg)	316
Area (m2)	388
Volume of soil (tonnes)	869
Volume of PFOS (kg)	0.3
Uncertainty -	0.2
Uncertainty +	0.7
PFOS average for all depths and points > 500 µg/kg	
Concentration (µg/kg)	
Area (m2)	
Volume of soil (tonnes)	





Volume of PFOS (kg)	
Uncertainty -	
Uncertainty +	

PFOS average for all depths and points > 1,000 µg/kg	
Concentration (µg/kg)	
Area (m2)	
Volume of soil (tonnes)	
Volume of PFOS (kg)	
Uncertainty -	
Uncertainty +	
PFOS average for all depths and points > 3,000 µg/kg	
Concentration (µg/kg)	
Area (m2)	
Volume of soil (tonnes)	
Volume of PFOS (kg)	
Uncertainty -	
Uncertainty +	

Comments regarding calculations	The basis for the DP2 report is that the most contaminated area is within an area of 17,670 m2, and that the average concentration of PFOS in this area is 286 µg/kg. It is thought that the contaminated materials have an expanse of 1.5 metres. This gives a residual volume of PFOS of approximately 12 kg, and a remaining volume of PFOA of 80 g. The reason why such a large contamination area with this concentration was assumed is uncertain. In the calculation made in 2019, an average concentration of 292 µg/kg has been used, and it is estimated that there is about 0.4 kg PFOS remaining in the ground within the surveyed area of approximately 1,500 m2 with a depth of 1.4 metres. It is further estimated that it could be approximately 1.4 kg if the contaminated area is approximately 4,800 m2 and the depth is 2.4 metres.

Is the extent of the contaminated area delimitated horizontally?	No. The soil samples at the BØF were taken as three composite samples from seven sampling points, and four individual samples were also analysed. It is therefore not known what the concentrations are for five of the sampling points. At the extreme points (surface samples) to the east, PFOS has not been detected in BØF 3, and in BØF 2, 5.4 µg/kg PFOS has been detected.

Is the extent of the contaminated area delimitated vertically?	No. All soil samples were taken in the interval 10-140 cm deep, and there were composite samples from seven different points. It is thus not known how the concentration distribution is within the depth range, and no samples deeper than 1.4 metres have been taken. It is believed that this is because groundwater was encountered at approx. 1.4 metres. The contamination status of the materials below 1.4 metres is not known.
Comments/uncertainty	In addition to the samples at the BØF, surface samples have also been taken on the north side of the runway (BØF 11), some distance east of the BØF (BØF 5) and some distance west of the BØF (BØF 10). There are concentrations below the detection limit in all of these samples.

21.5 Water sampling and annual dispersion

Have water samples been taken?	Yes
Where	Samples of groundwater were taken from shaft/excavator bucket from three shafts. Samples of surface water were taken from two manholes at the aircraft parking stand, from a manhole at the terminal building and of surface water at the BØF.
Highest measured concentration in groundwater of PFOS (ng/l)	213,000
Where	BØ4 (20.09.11) water from shaft/excavator bucket
Highest measured concentration in groundwater of PFAS (ng/l)	214,860
Where	BØ4 (20.09.11) water from shaft/excavator bucket
Comments/uncertainty	Only the concentrations of PFOS, PFOA and 6:2 FTS are shown in the table in the DP2 report. The analysis reports were not enclosed, so it is uncertain whether the samples have been analysed for further PFAS compounds. Analysis in water from shafts does not provide representative groundwater concentrations, as the analyses will have elevated PFAS concentrations due to the mobilization of the compounds when digging
Highest measured concentration	16.1

in surface water of PFOS (ng/l)	
Where	Vann 3, Infiltration foam at the new aircraft parking stand (20.9.11)
Highest measured concentration in surface water of PFAS (ng/l)	36
Where	Vann 4, surface water at the BØF (16.5.12)
Comments/uncertainty	Only the concentrations of PFOS, PFOA and 6:2 FTS are shown in the table in the DP2 report. The analysis reports were not enclosed, so it is uncertain whether the samples have been analysed for further PFAS compounds.

Total annual dispersion rate from airport PFOS (g/year)	49
Total annual dispersion rate from airport PFAS (g/year)	not calculated
To which recipient	Namsen
Calculated from water or soil concentration.	Water concentration

21.6 Biota sampling

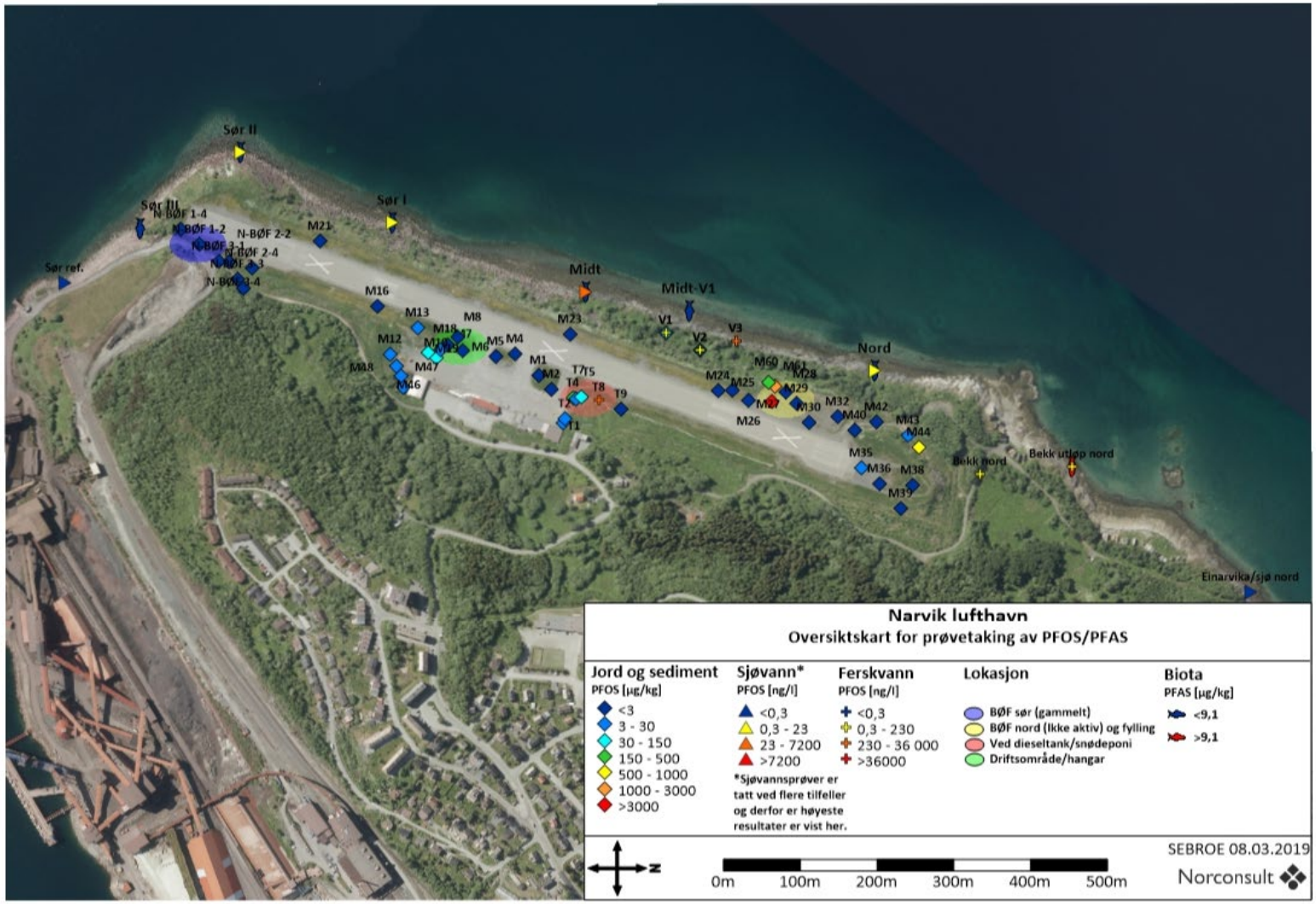
Have biota samples being taken at the airport?	No
What kind of biota?	
How many samples?	
Highest measured concentration of PFOS in biota (µg/kg wet weight)	
Where	
Highest measured concentration of PFAS in biota (µg/kg wet weight)	
Where	
Median concentration in comparable populations (e.g. in a lake)	
Comments/references	
References and concentrations in other reports.	

APPENDIX A

21.7 Uncertainty and other factors

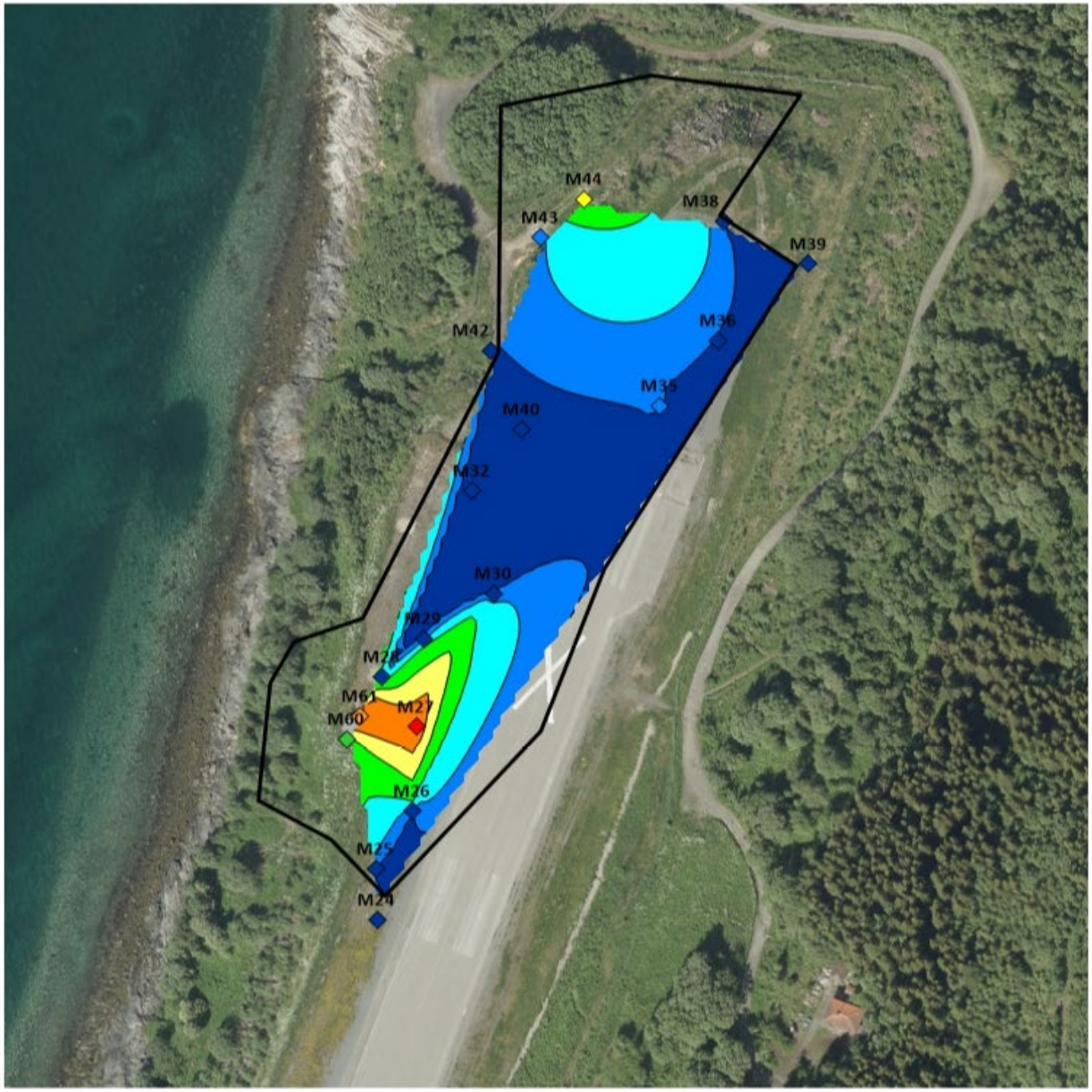
Does the estimate of the volume of PFOS in the ground correspond with the measured concentrations in water and biota?	Cannot be evaluated for biota, as no biota samples have been taken. Cannot be reliably evaluated for water.
Evaluations	There is considerable uncertainty associated with soil sampling; since three composite samples and four individual samples were taken, the concentration distribution in the investigated area is uncertain. However, there are concentrations > 100 µg/kg in three of a total of seven soil samples analysed. The water samples at the BØF were taken in shafts and are not representative of groundwater. In surface water (Vann 4) which was taken about 100 metres southwest of the BØF, no PFOS was detected, but 36 ng/l PFAS was detected. It is uncertain which compounds were present, since the analysis appendix for the sample in question was not included in the report.
Comments/uncertainty: (Could there be additional unknown sources of PFOS at the site with run-off to the recipient?)	Samples of surface water were taken from three different manholes around the terminal area, which is at the other end of the airport in relation to the BØF. Some PFAS has been detected in all water samples, but at low concentrations (maximum total PFAS 36 ng/l). The contamination in these samples is likely to have a different source than the BØF. Dispersion of contamination from the BØF to this area is unlikely, as the BØF is located on an island in Namsen (Storøya) and the terminal area is on the mainland. It is therefore likely that there could be a source of PFOS contamination in the area around the terminal building.
Has the site been sufficiently mapped with a view to assessing the order of priority?	No, the site is too poorly mapped (ref. this report for sections 1 and 2, chapter 2.1.1.6 and chapter 2.1.3.1). This is because there is great uncertainty related to the distribution of concentration in the area surveyed. The area surveyed is relatively small (1,500 m2), and the contaminated area is not very delimitated.
Comments/uncertainty	
Other factors of significance for any clean-up/initiation of measures (for example, planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	From Naturbase: Several species with a high and especially high management interest have been registered around the airport. Just south of the airport, two habitats have been registered: "soft-bottomed areas in the coastal zone" and "sea meadow and mudflats". Høknesøra, which borders the airport in the north is a state-secured outdoor recreation area. The airport is assessed as Avinor's vulnerability class 2, which is somewhat less vulnerable recipients, moderate priority and level of facility. The groundwater level at the airport is high (1-1.5 metres below terrain) and flows into Namsen. Namsenvassdraget is one of Norway's largest and most important salmon rivers. At the BØF, THC was detected in environmental condition class 2 in four soil samples, and environmental condition class 4 in two soil samples.

22 Narvik Airport



Norconsult

APPENDIX A



Narvik lufthavn
Gammel brannøvningsfelt i nordvest, og deponerte masser nord (Ikke aktiv)

Interpolering for 0-1 meters dybde

PFOS µg/kg
3000
1000
500
150
30
3
0

Antatt kildeareal

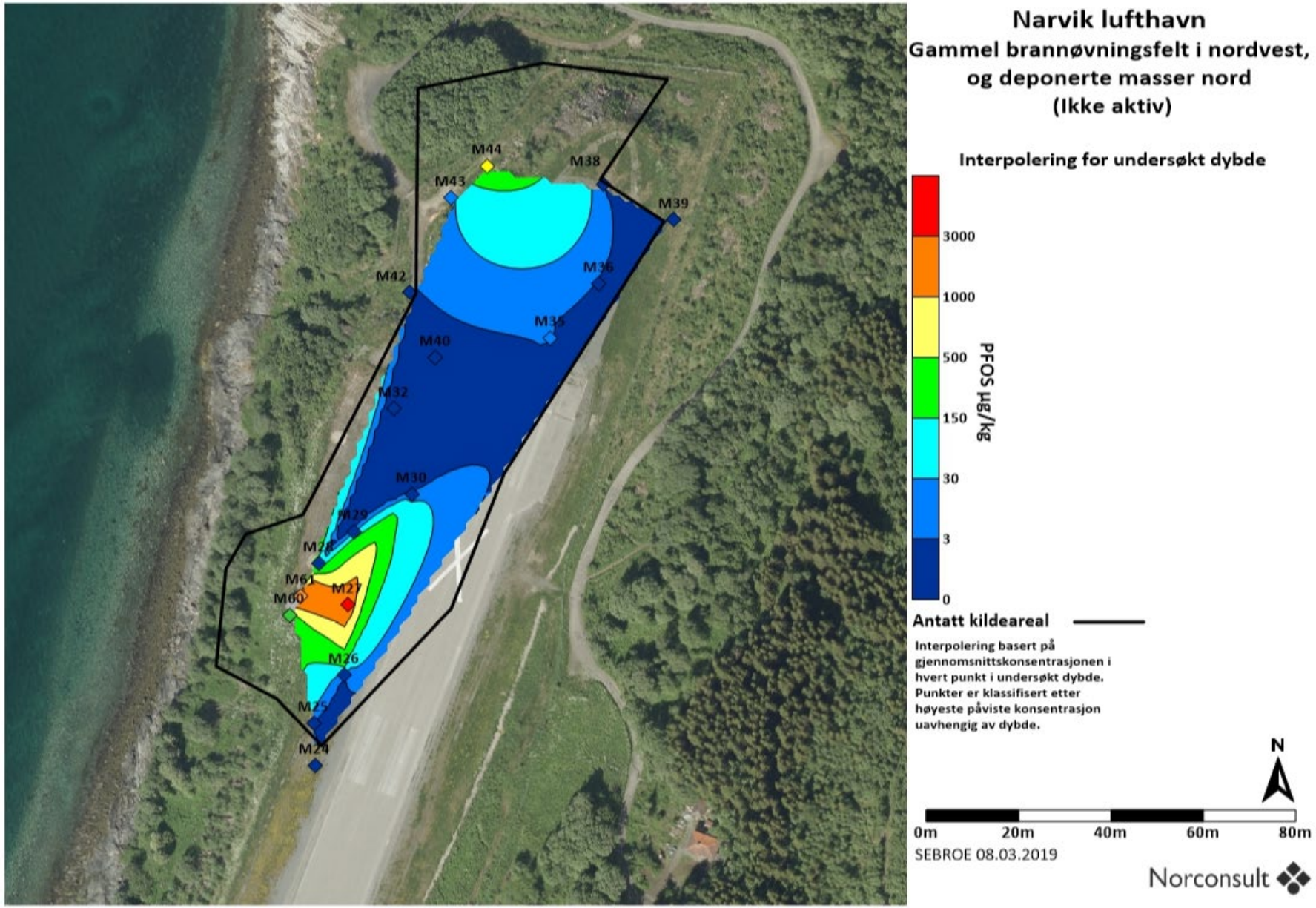
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i 0-1 meters dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.

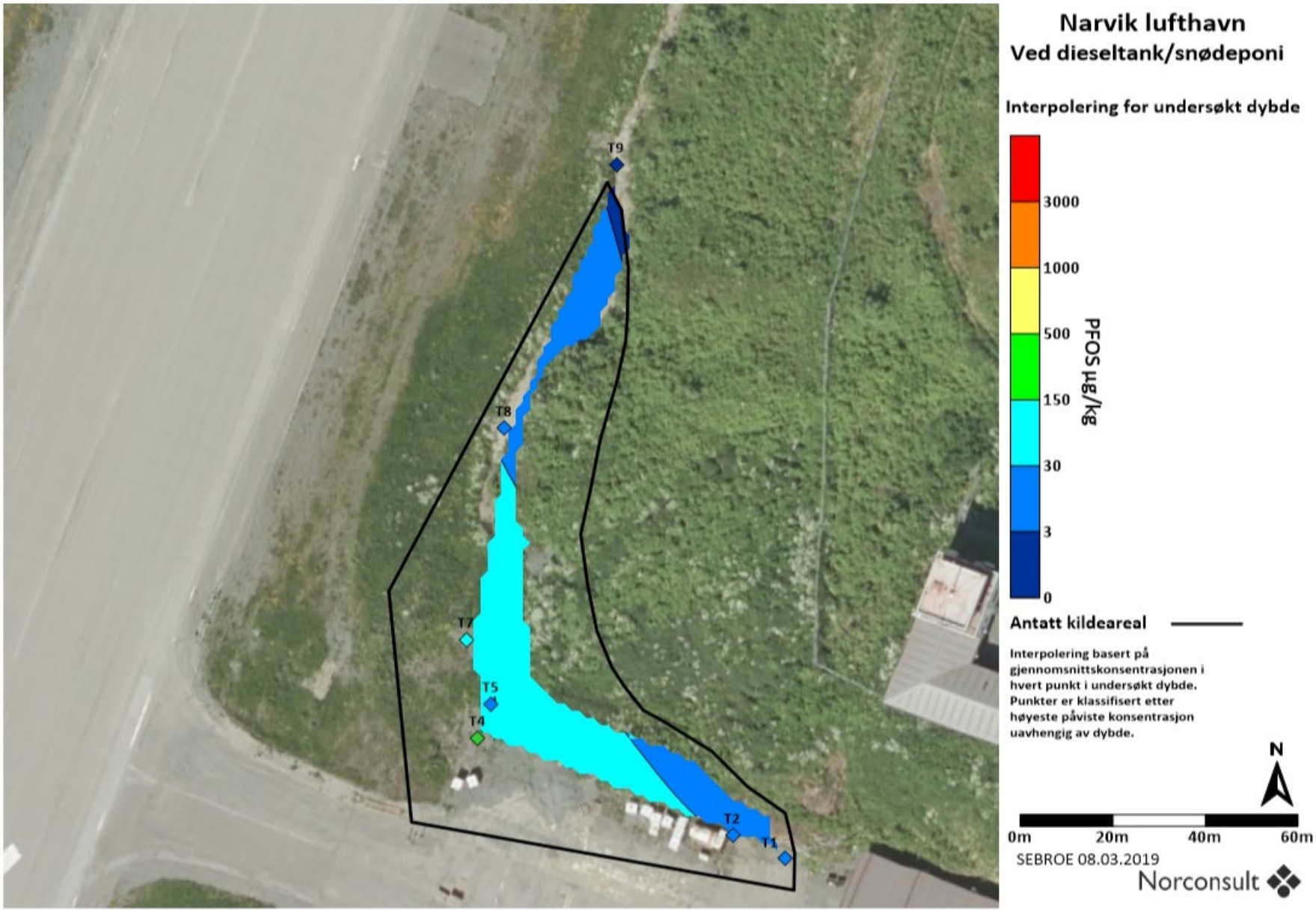
N

0m 20m 40m 60m 80m

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Narvik lufthavn
Gammel brannøvningsfelt i nordvest,
og deponerte masser nord
(Ikke aktiv)
Interpolering for undersøkt dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m 20m 40m 60m 80m
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M44
M38
M43
M39
M42
M36
M35
M40
M32
M30
M29
M28
M61
M27
M60
M26
M25
M24



Narvik lufthavn
Ved dieseltank/snødeponi

Interpolering for undersøkt dybde

PFOS µg/kg
3000
1000
500
150
30
3
0

Antatt kildeareal

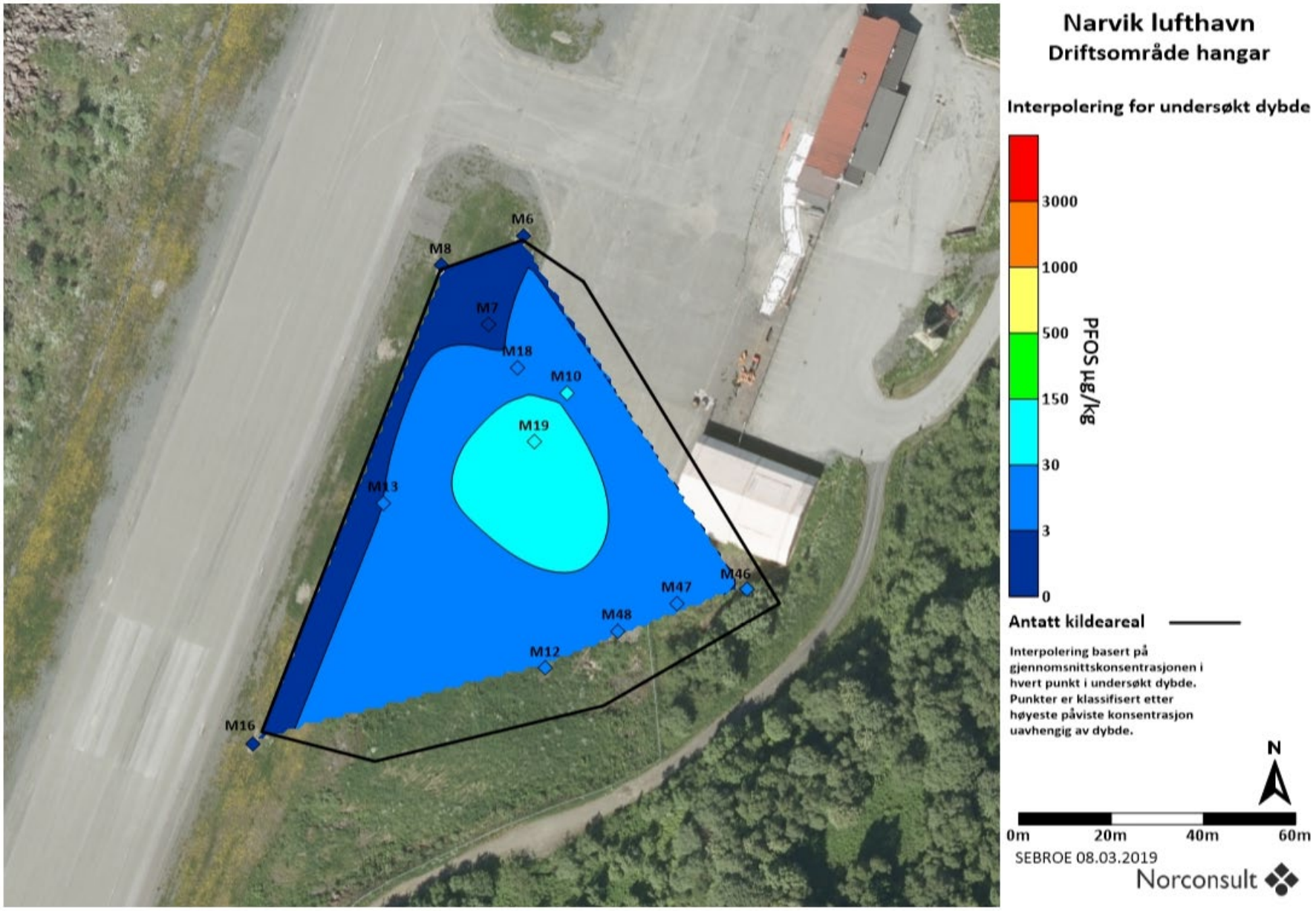
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.

N

0m 20m 40m 60m

SEBROE 08.03.2019

Norconsult



Narvik lufthavn
Driftsområde hangar

Interpolering for undersøkt dybde

PFOS µg/kg
3000
1000
500
150
30
3
0

Antatt kildeareal

Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.

N

0m 20m 40m 60m

SEBROE 08.03.2019

Norconsult

22.1 Fire training site (BØF) / contaminated site

Fire training site (BØF) / contaminated site	BØF south (old)	BØF north (not active) and filling	At diesel tank/snow depot	Operations area/hangar
	A fire training site has been registered on municipal property outside the airport fence to the southeast. The operating period of the fire training site is not specified. The fire training site was used as a training site for both the municipal fire service and for Avinor. It is stated that water was mainly used in connection with the exercises in this fire training site.	This fire training site was used while the airport was under municipal management. The operating period for the fire training site is not stated, but the fire training site has not been used since 1998. This site is located northwest of the airport area, but there is some uncertainty about the exact location of the BØF. The field is 28 metres above sea level. Samples have also been taken at sampling points further north from the BØF, towards an area north of the runway where various types of waste have been deposited of in a filling. Functional testing of foam cannons may have been performed along the emergency route in the north, and at the base of and at the top of the filling. At the base of the filling, waste was occasionally burned, and in some cases foam was used for extinguishing. All of the sampling points in the northern part of the runway are included in the reporting and calculations for BØF north, as these are so close to each other.	At the oil tank northwest of the operating building, materials contaminated by oil have previously been detected. The area west of the tank has been used as a snow depot, and it is suspected that foam tests have been carried out there.	The area has been used as a snow depot, storage area for chemicals and waste fractions, for vehicle and equipment washing and probably for function tests for fire extinguishing equipment.

22.2 The use of PFOS and other PFAS

Volume of PFOS used at the site (kg)	Not stated/calculated	Not stated/calculated	Not stated/calculated	Not stated/calculated
Comments/uncertainty	-			
Volume of PFAS used at the site (kg)	Not stated/calculated	Not stated/calculated	Not stated/calculated	Not stated/calculated
Comments/uncertainty	-	-		

APPENDIX A

22.3 Soil sampling

Fire training site (BØF) / contaminated site	BØF south (old)	BØF north (not active) and filling	At diesel tank/snow depot	Operations area/hangar
Total number of soil samples	7	19	10	19
Comments/uncertainty (e.g. 95% of samples taken from 0–0.1 m)	The samples were taken during the DP2 survey in 2012. It was not possible to take samples in the central parts of the BØF, as there was a busy construction road here. In addition, the BØF was covered with rock and ore. The samples were taken along the runway (firefighting foam was flushed from the runway and over the fence when the range of the canons was tested), and along the old access road to the site.	The samples were taken during the survey in 2017 and supplementary surveys in 2018. There were some uncertainties related to the exact location of the BØF, since it had not been used since 1998.	The samples were taken during the survey in 2017. Samples were taken in eight shafts, and in one or two depth intervals in the upper metre in each shaft.	The samples were taken during the survey in 2017. At three of the test points only three surface samples were taken. The deepest sample was taken at a depth of 2 metres.
Number of soil samples 0-1 m beneath the ground	7	28	10	18
Total number of soil samples under 1 m	0	6	1	3
Comments/uncertainty	All of the samples were taken from 0-20 cm. The materials are described as soil mixed with sand and gravel.	The materials at the BØF are described as sand/gravel/rock over rubble to the south (shafts M24-M26), and more sandy materials over soil and solid bedrock to the north. bedrock/large rocks of 0.7 to 1.3 m were described in several shafts at the BØF. Different types of waste (concrete, plastic, metal, wood, etc.) were observed at the base of the filling north of the runway. Both at the top of the filling and at the base of the filling there are traces of the burning of waste/fire training.	The deepest sample was taken at a depth of 1.1 metres. The materials are described as variations of filler, sand, gravel, rock, crushed stone and soil.	There are a total of 21 samples if the samples that cover both 0-1 m and> 1 m are split up.
Highest measured soil concentration PFOS (µg/kg)	2.2	3,000	180	81
Where	N-BØF 3-1 (0-0.2 m). The materials consist of soil mixed with sand and gravel.	M27-2 (0.8-1.8 m) taken in materials of dark brown soil, sand, gravel and stone. Plant residues.	T4-1 (0-0.5m) taken in materials consisting of soil, sand and rock with elements of plastic and reinforced iron.	M19-1 (0-1 m) taken in materials consisting of sand, gravel and pebbles with the highest at 0.5 m. Coarse rock with fine material occasionally downwards in shaft.
Highest measured soil concentration PFOS µg/kg	2.2	3,014	269	90

Where	N-BØF 3-1 (0-0.2 m). The materials consist of soil mixed with sand and gravel.	M27-2 (0.8-1.8 m) taken in materials of dark brown soil, sand, gravel and stone. Plant residues.	T4-1 (0-0.5m) taken in materials consisting of soil, sand and rock with elements of plastic and reinforced iron.	M19-1 (0-1 m) taken in materials consisting of sand, gravel and pebbles with the highest at 0.5 m. Coarse rock with fine material occasionally downwards in shaft.
Comments/uncertainty	The samples were analysed for PFOS/PFOA. No PFOA has been detected in any of the samples.	All samples have been analysed for 30 PFAS compounds*.	All samples have been analysed for 30 PFAS compounds*.	All samples have been analysed for 30 PFAS compounds*.

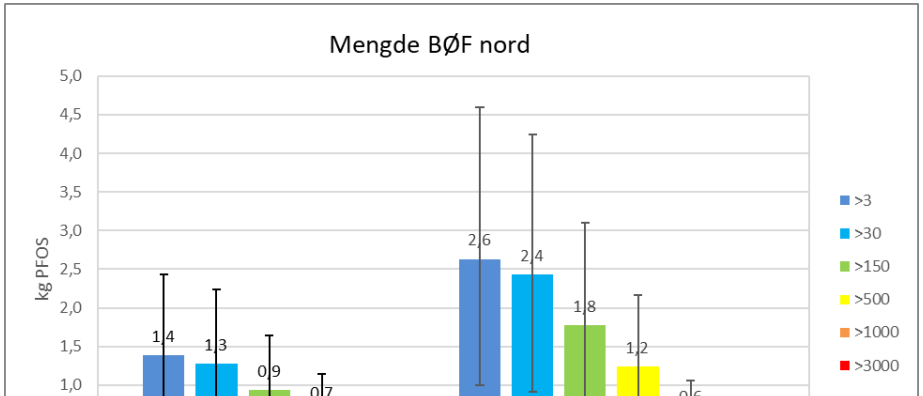
*Other PFAS compounds have been detected in several of the samples, but PFOS is the predominant compound.

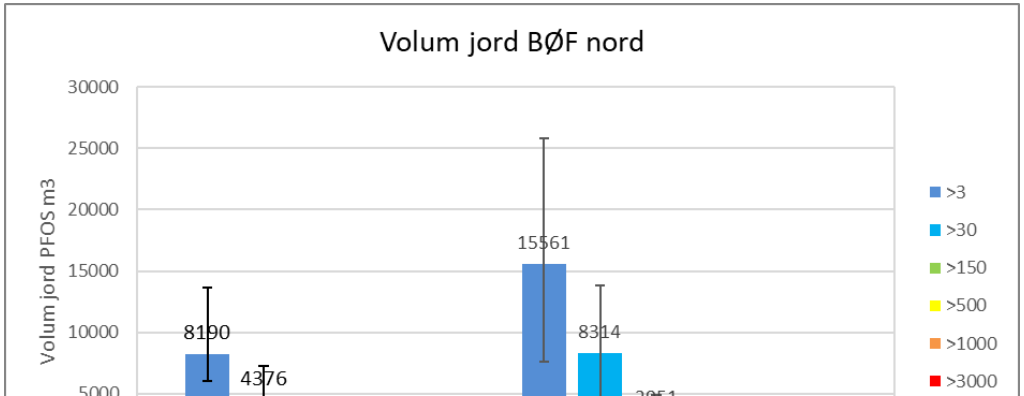
22.4 Volume calculation

PFOS average for all depths and points > 3 µg/kg	Amounts for BØF south were not calculated.	BØF north (not active) and filling	At diesel tank/snow depot	Operations area/hangar
Concentration (µg/kg)		151	151	18
Area (m2)		8,190	348	4,591
Volume of soil (tonnes)		24,898	651	15,609
Volume of PFOS (kg)		2.6	0.01	0.17
Uncertainty -		1.6	0.009	0.13
Uncertainty +		2.0	0.05	0.13
PFOS average for all depths and points > 30 µg/kg				
Concentration (µg/kg)		261	54	44
Area (m2)		4376	217	878
Volume of soil (tonnes)		13,303	406	2,985
Volume of PFOS (kg)		2.4	0.01	0.08
Uncertainty -		1.5	0.008	0.06
Uncertainty +		1.8	0.04	0.06
PFOS average for all depths and points > 150 µg/kg				
Concentration (µg/kg)		537		
Area (m2)		1,553		
Volume of soil (tonnes)		4,721		
Volume of PFOS (kg)		1.8		
Uncertainty -		1.1		

Uncertainty +		1.3		
PFOS average for all depths and points > 500 µg/kg				
Concentration (µg/kg)		870		
Area (m2)		668		
Volume of soil (tonnes)		2,031		
Volume of PFOS (kg)		1.2		
Uncertainty -		0.8		
Uncertainty +		0.9		

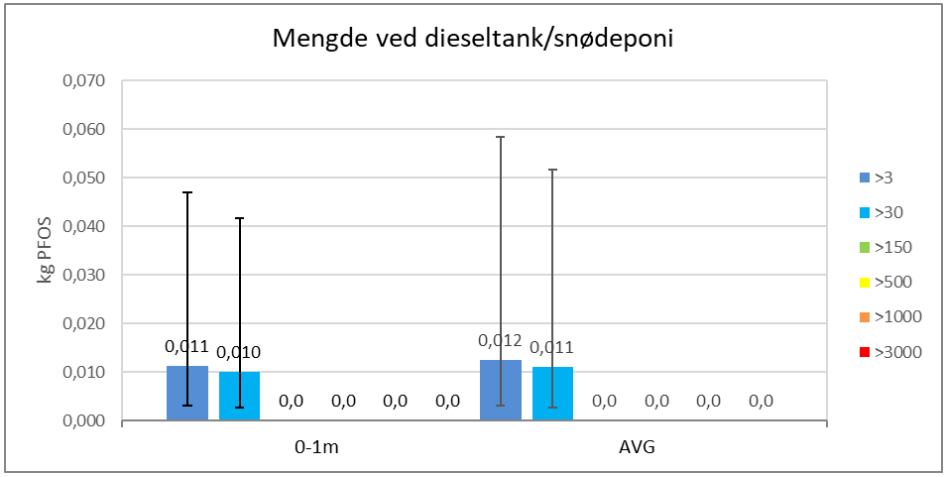
PFOS average for all depths and points > 1,000 µg/kg				
Concentration (µg/kg)		1,198		
Area (m2)		237		
Volume of soil (tonnes)		720		
Volume of PFOS (kg)		0.6		
Uncertainty -		0.4		
Uncertainty +		0.5		
PFOS average for all depths and points > 3,000 µg/kg				
Concentration (µg/kg)				
Area (m2)				
Volume of soil (tonnes)				
Volume of PFOS (kg)				
Uncertainty -				
Uncertainty +				

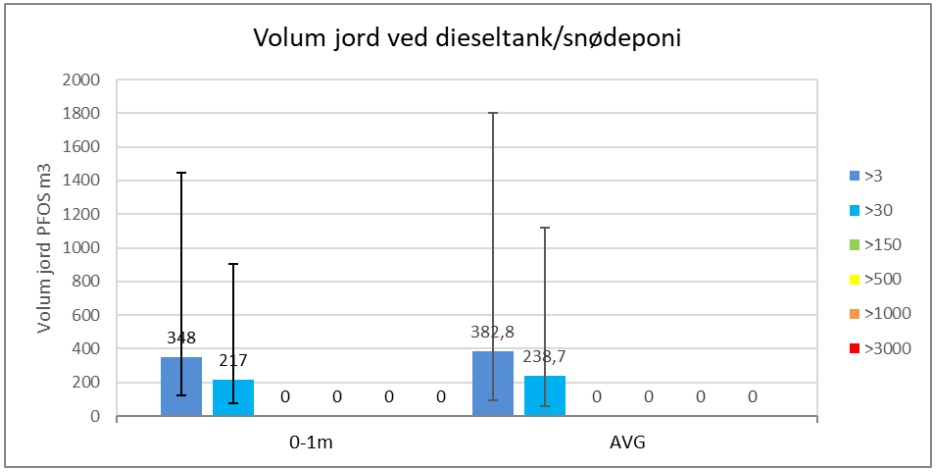


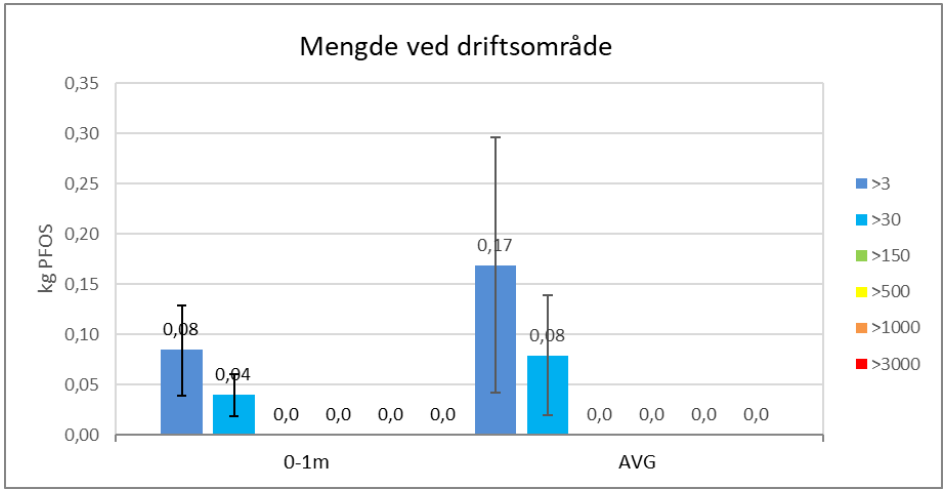


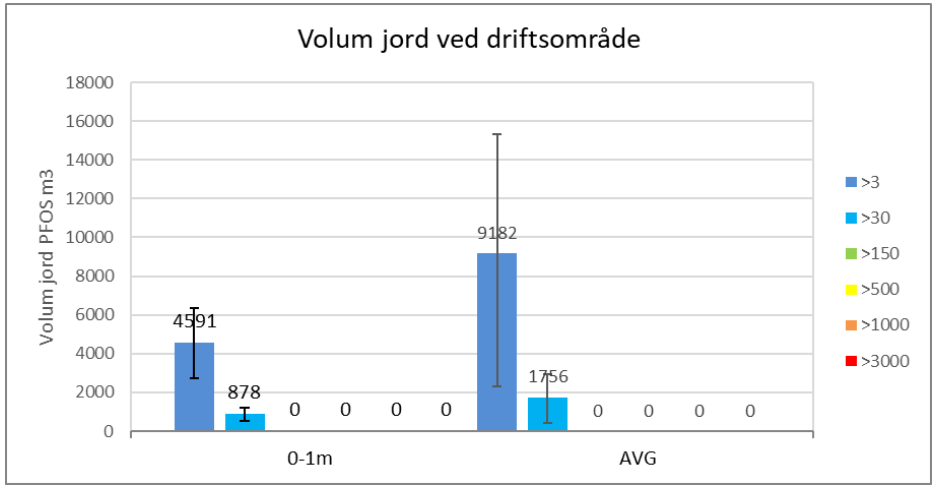
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APPENDIX A









Fire training site (BØF) / contaminated site	BØF south (old)	BØF north (not active) and filling	At diesel tank/snow depot	Operations area/hangar
Comments regarding calculations	No amount calculation has been carried out, as no concentrations above 3 µg/kg have been established in any of the points.	No quantities were calculated have been made for this site before 2019.	No quantities were calculated have been made for this site before 2019.	No quantities were calculated have been made for this site before 2019.
Is the extent of the contaminated area delimitated horizontally?	Since samples have only been taken on the outskirts/next to the old fire training site, and not by the materials in the centre of the fire training site, the contamination has not been delimitated horizontally.	No, the contamination is not delimitated horizontally at the BØF or at the deposited materials in the north. Concentrations above 3 µg/kg have been detected at several extreme points. There is no delimitation to the west or east at the BØF, and there is no delimitation further to the north at the deposited materials.	No, the contamination is not delimitated horizontally, but relatively low concentrations have been detected in the materials with the exception of two sampling points (T4 and T7). The sampling points at this site are located after each other, making it difficult to see if it is a clear centre of contamination. To the east, the terrain rises steeply uphill. It can be assumed that there is little PFOS in the materials up the slope, unless foam has been sprayed upwards in this direction.	Yes, the contamination is apparently quite well delimitated horizontally. Concentrations above 3 µg/kg have been detected at several extreme points, but the concentrations are low. At the extreme west and north <2 µg/kg, and south/southeast <14 g/kg.
Is the extent of the contaminated area delimitated vertically?	Samples have only been taken down to 0.2 metres. The degree of contamination of the deeper materials is therefore uncertain.	No. Four of the five soil samples that have concentrations of PFOS> 100 µg/kg are from materials from 0.6 to 1.8 metres. It is uncertain how much deeper this contamination extends. The depth to groundwater was not described, but bedrock/large rocks were described between 0.7 to 1.3 m in several shafts at the BØF.	No, the contaminants are not delimitated vertically, as concentrations above 3 µg/kg have been detected in several of the deepest samples. One of the high concentrations (120 µg/kg) is also from sampling point T7 that is not delimitated in depth. However, since relatively low concentrations have been detected and the groundwater level is probably at about the same depth as the deepest sample, it is assumed that the vertical extent is limited.	Concentrations are generally low (the two highest concentrations are 33 and 81 µg/kg). The two highest concentrations are in samples from 0-1 metres and 0.15-1 metres, and are not delimitated by deeper sampling.
Comments/uncertainty		According to information from airport personnel, there was natural ground (soil with vegetation) in this area with a rock crust that delimitated the area for fire drills. In connection with the establishment of aviation technology installations, the area was filled and levelled with sandy materials. This may be related to the highest concentrations being detected in materials deeper than 0.6 metres.		

		Plant residue is described in the description of shaft 27-2 (0.8-1.8 m).		

22.5 Water sampling and annual dispersion

Fire training site (BØF) / contaminated site	BØF south (old)	BØF north (not active) and filling	At diesel tank/snow depot	Operations area/hangar
Have water samples been taken?	See BØF north	Yes	See BØF north	See BØF north
Where		Water samples have been taken in several places at the airport. Seawater samples have been taken in the coastal zone at several points along the airport area. Seawater samples have also been taken further out into the sea. Samples have been taken from 3 water flows on the slope west of the runway. Water samples have also been taken from Narvik treatment plant. The northern part of the airport area borders a marsh area. Here, water samples have been taken from a trench/stream downstream of the airport area, at the outlet point of the shoreline, from a stream flowing into the marsh and from a sampling shaft at the edge of the marsh (closest to the airport).		
Highest measured concentration of PFOS in groundwater (ng/l)		300		
Where		Water in sampling shaft M51 (sample was taken in June 2017)		
Highest measured concentration of PFAS in groundwater (ng/l)		910		
Where		Water in sampling shaft M51 (sample was taken in June 2017)		
Comments/uncertainty		Samples of water in shafts often show elevated concentrations of PFAS due to mobilisation of the compounds through digging.		
Highest measured concentration of PFOS in surface water (ng/l)		750		
Where		V3 (June 2017) Water flow in the lower slope west of the runway.		

Highest measured concentration of PFAS in surface water (ng/l)		1,000		
Where		V3 (June 2017) Water flow in the lower slope west of the runway.		
Comments/uncertainty	One of the samples of seawater (Sør ref.) was taken in the coastal zone southeast of the old fire training site. No PFOS or PFAS was detected in this water sample.	Seawater samples have been taken in the coastal zone, along the airport area and at increasing distances to the north and south. The results show several PFAS compounds above the detection limits (between 0.65 and 54 ng/l) at the sampling points at the airport, PFOS being the predominant compound (concentrations between 0.58-46 ng/l). At the MIDT point, the values for sinking sea are significantly higher than for rising sea. At the stations further away from the airport, PFAS was not detected above the detection limits. Seawater samples (of the surface and at depth/bottom) have been taken at distances of 50 and 150 metres from the sampling stations in the coastal zone below the airport. No PFOS was detected in any of these water samples, but 8:2 FTS was detected in 15 of the 20 samples. PFOS and other PFAS were also detected in water discharged from Narvik treatment plant (PFOS 3.7 ng/l and PFAS 18 ng/l). This water is discharged into the sea north of the airport. PFAS was also detected in all samples taken from the marsh area north of the runway.		

Fire training site (BØF) / contaminated site	BØF south (old)	BØF north (not active) and filling	At diesel tank/snow depot	Operations area/hangar
Total annual dispersion from the site of PFOS (g/year)	Not calculated	Not calculated	Not calculated	Not calculated
Total annual dispersion from the site of PFAS (g/year)	Not calculated	Not calculated	Not calculated	Not calculated
To which recipient	Ofotfjorden	Ofotfjorden	Ofotfjorden	Ofotfjorden

22.6 Biota sampling

Have biota samples being taken at the airport?	Yes	See description below BØF south (old)	See description below BØF south (old)	See description below BØF south (old)
What kind of biota?	Cod and limpets.			
How many samples?	10-15 muscle samples and 15 liver samples from cod were analysed at 3 different stations (a total of 85 samples analysed). 11 samples of limpet were also analysed.			

Highest measured concentration of PFOS in biota (µg/kg wet weight)	64.3 (liver sample from cod)			
Where	MIDT 11L (cod from the station "Midt")			
Highest measured concentration of PFAS in biota (µg/kg wet weight)	70.7 (liver sample from cod)			
Where	MIDT 11L (cod from the station "Midt")			
Median concentration in comparable populations (e.g. in a lake)	The concentrations of total PFAS in the other 14 liver samples of cod from the same (midt) station were between 0.6 and 3.42 µg/kg. So there were especially high concentrations in cod at midt 11L. In addition to sampling of cod from two stations outside the airport, samples were also taken from a reference station at Tangvika/Tangodden about 3-4 km from the airport. PFAS was also detected in all liver samples from the reference station. The concentrations of total PFAS in the 15 samples varied between 0.35 and 3.46 µg/kg. The highest concentration of PFOS in liver samples from cod at the reference station was 2.01 µg/kg, and total PFAS was 3,46 µg/kg. The results from the sampling of cod are given in the report prepared by Norconsult "Prøveinnsamling av fisk for analyser av PFAS" (Sampling of fish for analysis of PFAS), dated 4.12.17. In general, for all three sampling stations, the muscle samples had lower concentrations than the liver samples.			

Comments/references	It is the biota samples (limpet) taken at stations Sør I, II, and II, as well as sør ref. (which is relatively close to the old BØF), which are believed to be most representative of the influence of the old BØF south. The concentrations of PFOS and PFAS in limpet at these stations are < 2.5 µg/kg. High concentrations of PFOS have also been detected in biota samples of limpet taken at the outlet of the stream that drains marsh in the north ("bekk nord"). A PFOS concentration of 62.8 ng/g was detected here. The results from sampling of limpet are given in the report prepared by Ramboll "Datarapport miljøtekniske undersøkelser Narvik lufthavn" (Data report of environmental technical studies Narvik Airport), dated 6.7.18.			
References and concentrations in other reports.	The EQS value in the Water Regulations for PFOS in biota is 9.1 µg/kg wet weight. In a risk assessment from 13 December 2018, EFSA changed the tolerability limit (TDI - tolerable daily intake) for PFOS and PFOA, so these are now far lower than the TDI values set in 2008. This may cause EQS for biota to also be lower in the future.			

22.7 Uncertainty and other factors

Fire training site (BØF) / contaminated site	BØF south (old)	BØF north (not active) and filling	At diesel tank/snow depot	Operations area/hangar

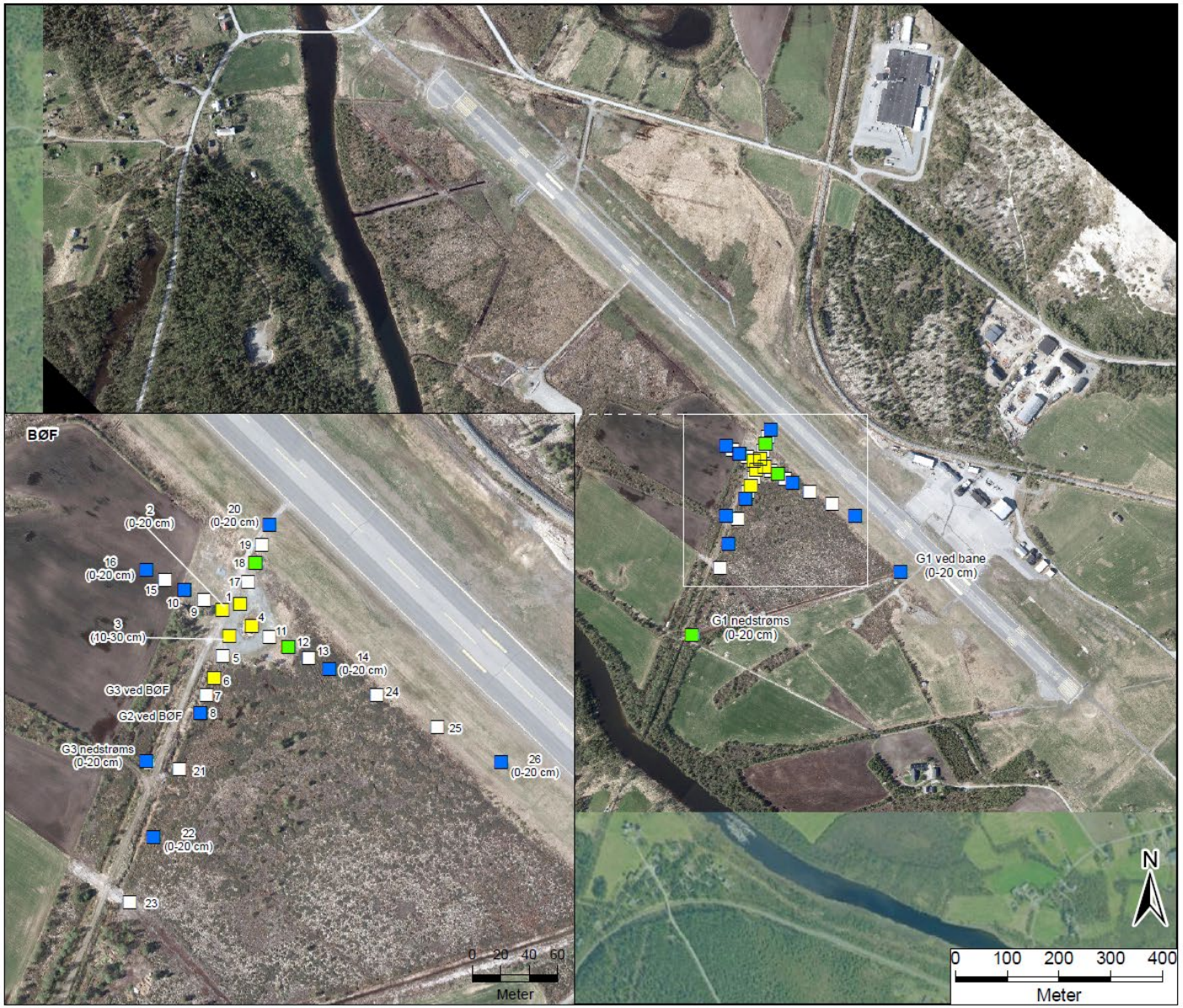
Does the estimate of the volume of PFOS in the ground correspond with the measured concentrations in water and biota?	Cannot be assessed as the actual BØF has not been surveyed.	This is difficult to assess as there are several sites at Narvik Airport that can supply PFOS/PFAS contamination to water and biota. However, at the sites "BØF nord" and the filling north of the runway, the highest volume of PFOS residual contamination in the ground was calculated, and therefore it is likely that within the airport area there is and has been the most dispersion from these sites. The highest concentrations in limpet have been detected at test stations "nord" and "midt".	This is difficult to assess as there are several sites at Narvik Airport that can supply PFOS/PFAS contamination to water and biota. No water or biota samples were taken in the immediate vicinity of the site.	This is difficult to assess as there are several sites at Narvik Airport that can supply PFOS/PFAS contamination to water and biota. No water or biota samples were taken in the immediate vicinity of the site.
Evaluations		There is uncertainty about the exact location of the old fire training site, and soil samples have therefore been taken over a relatively large area. The results show that the highest concentrations in soil at the BØF have been detected in points taken around a small building located here (it is believed that this was set up in connection with the establishment of aviation technology installations). In addition, relatively high concentrations have been detected in a shaft at the base of the filling (point M44), which is further north. PFOS/PFAS have been detected in water samples taken from the water flow below the runway, south/southwest of the BØF (V1, V2 and V3). The concentrations in the samples were higher when sampling in June than in May. Both in May and June, concentrations in V1 and V2 were far lower than in V3. In June, concentrations of total PFAS in V1 and V2 were 220 and 120 ng/l, respectively, and in V3 (total PFAS 1000 ng/l). Given that these water samples are relatively close to "BØF nord" and V3 is closest, it is likely that dispersion from this area may be the source of the contamination in the water. It cannot be ruled out that there are other sources of contamination in the water samples as well. There are also signs of dispersion of PFAS in the direction north of the filling. PFOS contamination in the landfill is not very delimitated further to the north. The Ramboll report of 2017/2018 states that the northern part of the airport area borders a lower-lying marsh area. The airport area drains to the marsh area, which in turn drains via a smaller stream to the sea. Water samples have been taken at four different test points in this marsh area grøft/bekk, bekk nord, in sjakt M51 and bekk nord for myr), and three shafts have been dug (sjakt M49, 50 and 51). Concentrations of PFOS in water samples in "stream north" are between 130 and 210 ng/l, and the sum of PFAS between 370 and 480 ng/l. Water in excavation shafts tends to have elevated values of PFAS due to mobilization, and the concentration of PFOS / PFAS in the sample was 300/910 ng/l. At bekk nord for myra there were very low concentrations of PFOS/PFAS (0.81/1.9 ng/l). In the eight soil samples from shafts in this area there	Relatively low concentrations of PFOS in soil have been detected at this site, with the exception of two points with concentrations of 120 and 180 µg/kg. A water sample from sjakt T8 has been taken. A PFOS concentration of PFOS of 290 ng/l was detected here. A number of other PFAS compounds were also detected, but at lower concentrations; total PFAS was 360 ng/l. A drainage trench passes through the area, and it cannot be ruled out that this can be a dispersion route for contamination from the area. The Ramboll report from 2017/2018 states that no water was detected in sample shaft T9, which may indicate that the water from the snow depot is led under the runway and to the sea somewhere between sampling points T8 and T9.	

		are generally low concentrations, the two highest concentrations of PFOS are 9.8 and 66 µg/kg.		

Comments/uncertainty: (Could there be any additional unknown sources of PFOS at the site with run-off to the recipient?)	It is not known whether there are other sources in the area where the old fire training site is located, but it was stated that it was often flushed from the runway and over the fence when the range of the canon was tested.	It is not known whether there are other sources in the area where "BØF nord" and the filling north of the runway are located.	Soil samples were taken at the former airport control tower, which was located east of the site. Some PFOS was detected in the three soil samples from this area, but at low concentrations (0.17-2.6 µg/kg). PFOS has been detected at concentrations lower than 3 µg/kg in eight soil samples from shafts between the taxiways, in eight samples at the tank facility for aviation fuel, in three samples in shafts west of the runway (south of BØF nord), and in six samples at creosote poles north of the airport area. The concentrations of total PFAS in the samples from these areas are all lower than 7 µg/kg, but they are stated including LOQ, so they may be even lower.	PFOS has been detected at concentrations lower than 3 µg/kg in three soil samples from shafts at the airport control tower, in eight samples at the tank facility for aviation fuel, in three samples in shafts west of the runway (south of BØF nord), and in six samples at creosote poles north of the airport area. The concentrations of total PFAS in the samples from these areas are all lower than 7 µg/kg, but they are stated including LOQ, so they may be even lower.
Has the site been sufficiently mapped with a view to assessing the order of prioritisation?	No. No samples were taken of the materials from the actual fire training site, only of materials on the outer edge. The site is therefore not well enough mapped with a view to assessing the order of prioritisation (see this report for parts 1 and 2, chapter 2.1.1.6 and chapter 2.1.3.1).	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the volume of PFOS in the soil with the stipulated level of uncertainty.	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the volume of PFOS in the soil with the stipulated level of uncertainty. Due to the low calculated volume of PFOS (10-50 g) at the site, it will not be prioritised in a cost/benefit perspective (ref. this report for parts 1 and 2, chapter. 2.1.1.6 and chapter 2.1.3.1).	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the volume of PFOS in the soil with the stipulated level of uncertainty. Due to the low calculated volume of PFOS (170-300 g) at the site, it will not be prioritised in a cost/benefit perspective (ref. this report for parts 1 and 2, chapter. 2.1.1.6 and chapter 2.1.3.1).
Comments/uncertainty	Today, the actual fire training site is covered by a landfill for rocks and ore, and is filled with excess materials from the ore reception. There is a construction road over the central parts of the site. Surveying the materials at the actual fire training site has therefore not been possible. The degree of contamination in the centre of the old fire training site is therefore unknown.	As there are uncertainties related to the exact location of the BØF, and the highest concentrations are not delimitated to the west or east, it cannot be ruled out that there is more contamination in this area than the sampling has revealed. This also applies further to the north of the filling.	As the sampling points at this location are located in a row, it is difficult to assess the extent of contamination in a western direction towards the runway. It is believed that the contamination is delimitated by the steep slope to the east, but this is not documented with sampling.	

General information about the airport	
Other factors of significance for any clean-up/initiation of measures (for example, planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	Species of high and especially high management interest at and around the airport, as well as in the sea areas outside the airport. An area of "common eelgrass" habitat is registered in the sea north of the airport. Important and very important outdoor recreation areas are registered close to the airport. The areas are located east and north of the airport, as well as in the sea area outside the airport. Some cultural monuments have also been registered at the airport.

23 Røros Airport



Røros lufthavn (ENRO)

Oversiktskart

Jord og sediment

PFOS/PFOA jord (ug/kg)
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

* PFOS er dominerende parameter

LOQ = rapporteringsgrense
i.a. = ikke analysert

AVINOR COWI SWECO

Norconsult

APPENDIX A

Grunnvannsbrønner

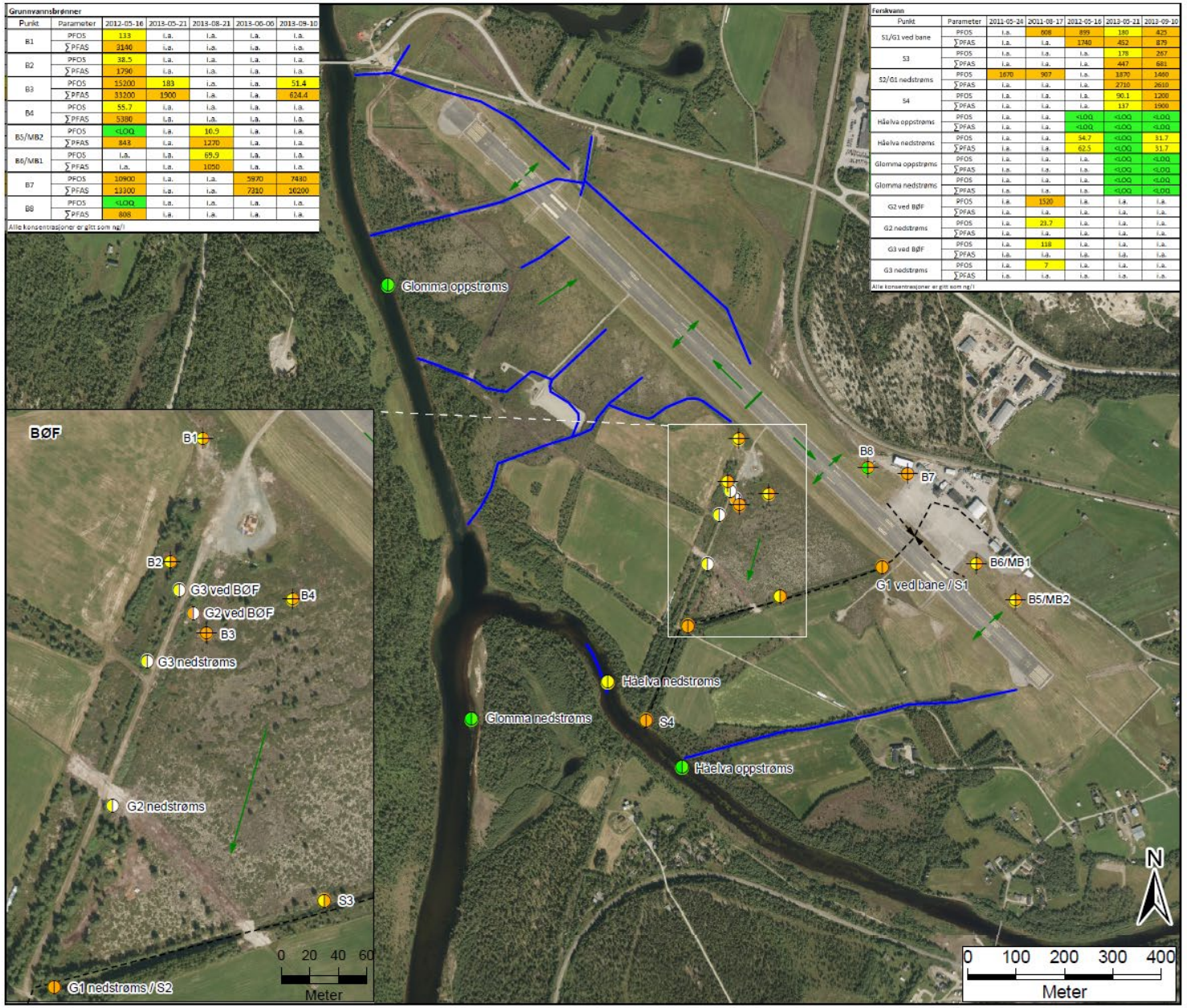
Punkt	Parameter	2012-05-16	2013-05-21	2013-08-21	2013-06-06	2013-09-10
B1	PFOS	133	i.a.	i.a.	i.a.	i.a.
	∑PFAS	3140	i.a.	i.a.	i.a.	i.a.
B2	PFOS	38.5	i.a.	i.a.	i.a.	i.a.
	∑PFAS	1790	i.a.	i.a.	i.a.	i.a.
B3	PFOS	15200	183	i.a.	i.a.	51.4
	∑PFAS	33200	1900	i.a.	i.a.	624.4
B4	PFOS	55.7	i.a.	i.a.	i.a.	i.a.
	∑PFAS	5380	i.a.	i.a.	i.a.	i.a.
B5/MB2	PFOS	<LOQ	i.a.	16.9	i.a.	i.a.
	∑PFAS	843	i.a.	1270	i.a.	i.a.
B6/MB1	PFOS	i.a.	i.a.	69.9	i.a.	i.a.
	∑PFAS	i.a.	i.a.	1050	i.a.	i.a.
B7	PFOS	10900	i.a.	i.a.	5970	7430
	∑PFAS	13300	i.a.	i.a.	7210	10200
B8	PFOS	<LOQ	i.a.	i.a.	i.a.	i.a.
	∑PFAS	808	i.a.	i.a.	i.a.	i.a.

Alle konsentrasjoner er gitt som ng/l

Ferskvann

Punkt	Parameter	2011-05-24	2011-08-17	2012-05-16	2013-05-21	2013-09-10
S1/G1 ved bane	PFOS	i.a.	608	899	180	425
	∑PFAS	i.a.	i.a.	1740	452	879
S3	PFOS	i.a.	i.a.	i.a.	178	267
	∑PFAS	i.a.	i.a.	i.a.	447	681
S2/G1 nedstrøms	PFOS	1670	907	i.a.	1870	1480
	∑PFAS	i.a.	i.a.	i.a.	2710	2610
S4	PFOS	i.a.	i.a.	i.a.	90.1	1200
	∑PFAS	i.a.	i.a.	i.a.	137	1900
Hælva oppstrøms	PFOS	i.a.	i.a.	<LOQ	<LOQ	<LOQ
	∑PFAS	i.a.	i.a.	<LOQ	<LOQ	<LOQ
Hælva nedstrøms	PFOS	i.a.	i.a.	54.7	<LOQ	31.7
	∑PFAS	i.a.	i.a.	62.5	<LOQ	31.7
Glomma oppstrøms	PFOS	i.a.	i.a.	i.a.	<LOQ	<LOQ
	∑PFAS	i.a.	i.a.	i.a.	<LOQ	<LOQ
Glomma nedstrøms	PFOS	i.a.	i.a.	i.a.	<LOQ	<LOQ
	∑PFAS	i.a.	i.a.	i.a.	<LOQ	<LOQ
G2 ved BØF	PFOS	i.a.	1520	i.a.	i.a.	i.a.
	∑PFAS	i.a.	i.a.	i.a.	i.a.	i.a.
G2 nedstrøms	PFOS	i.a.	23.7	i.a.	i.a.	i.a.
	∑PFAS	i.a.	i.a.	i.a.	i.a.	i.a.
G3 ved BØF	PFOS	i.a.	118	i.a.	i.a.	i.a.
	∑PFAS	i.a.	i.a.	i.a.	i.a.	i.a.
G3 nedstrøms	PFOS	i.a.	7	i.a.	i.a.	i.a.
	∑PFAS	i.a.	i.a.	i.a.	i.a.	i.a.

Alle konsentrasjoner er gitt som ng/l



Røros lufthavn (ENRO)

Oversiktskart

Vann

PFOS / ∑ PFAS grunnvannsbrønn (ng/l) *
- Ikke analysert
- 0
- <LOQ
- LOQ-230
- 230-36 000
- >36 000

PFOS / ∑ PFAS ferskvann (ng/l) *
- Ikke analysert
- 0
- <LOQ
- LOQ-230
- 230-36 000
- >36 000

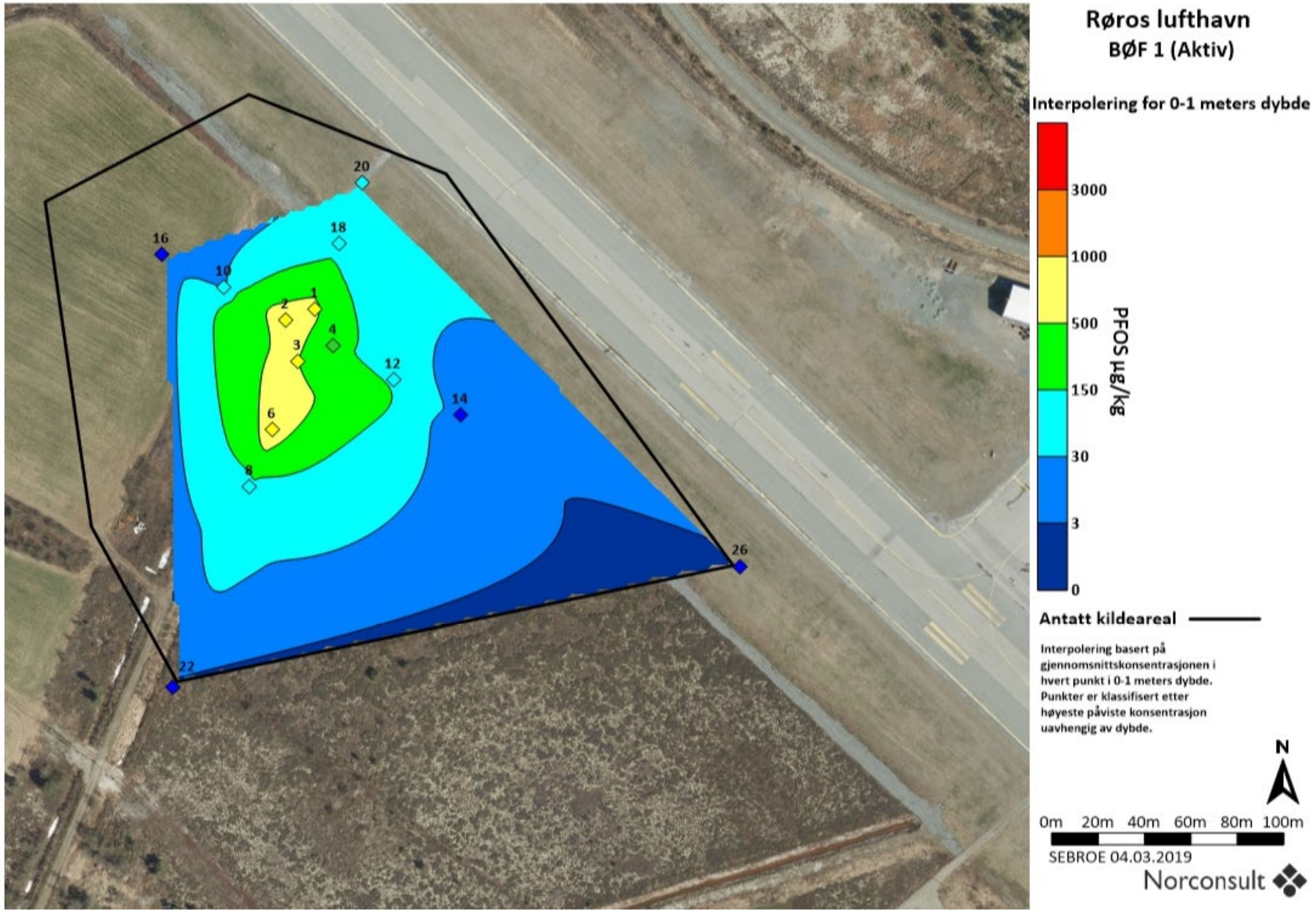
Avløpsledning
- Avløp annet
- SpillVann
- Pumpespillvannsledning
- Overvann
- Glykolholdig spillvann
- Glykolholdig overvann
- Drensvann
- Avløp felles

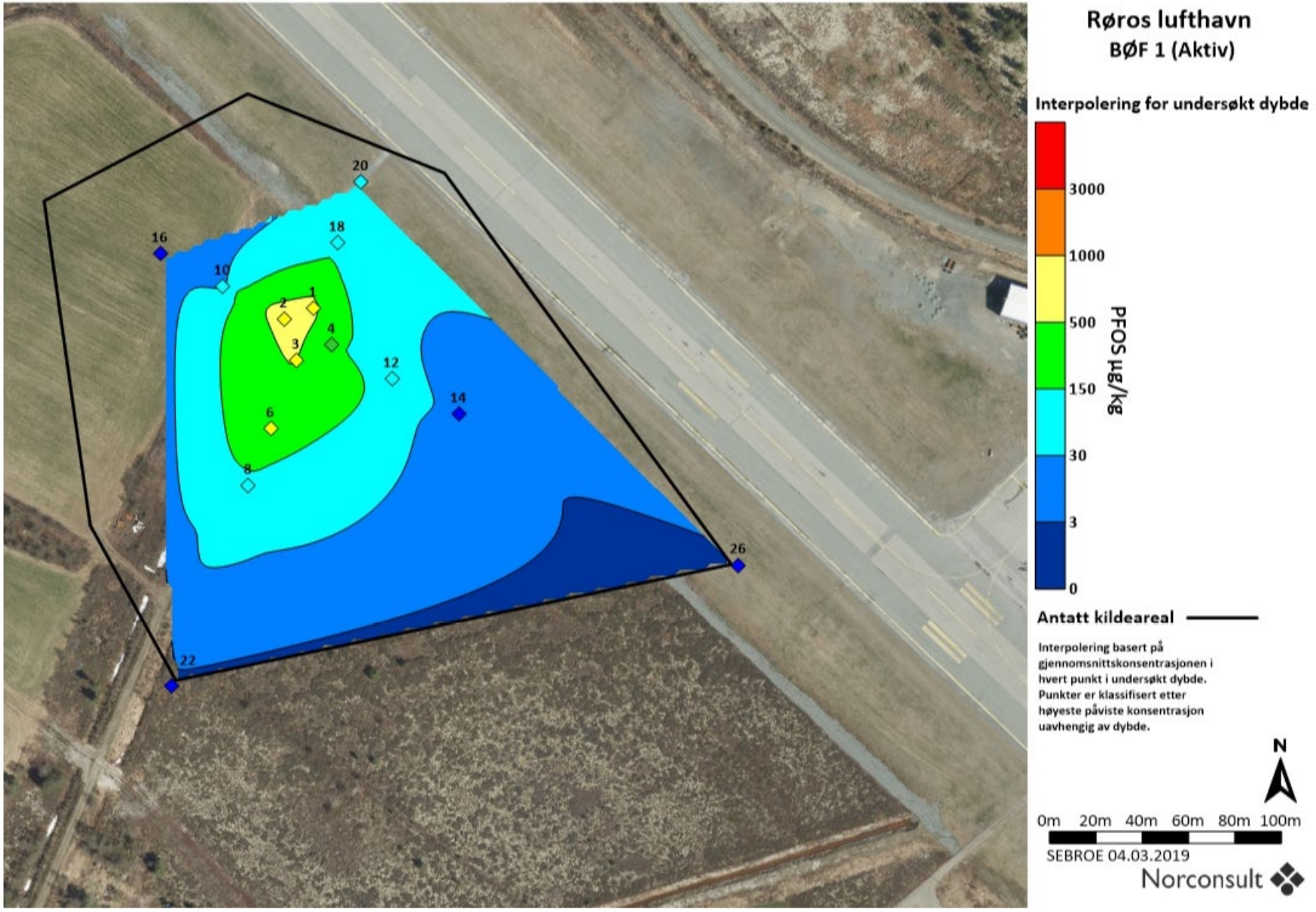
Avrenning
- Deponi glykolforurenset snø
- Overvannsledning
- Avrenningsveg glykol
- Bekkeresipient
- Overvannsystem
- Vannskille rullebane
- Antatt avrenningsveg baneavising

* Venstre halvdel = PFOS
Høyre halvdel = ∑PFAS

LOQ = rapporteringsgrense
i.a. = ikke analysert

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Røros lufthavn
BØF 1 (Aktiv)
Interpolering for 0-1 meters dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i 0-1 meters dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m 20m 40m 60m 80m 100m
SEBROE 04.03.2019
Norconsult
20
16
18
10
2
1
4
3
12
14
6
8
26
22


Røros lufthavn
BØF 1 (Aktiv)
Interpolering for undersøkt dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m 20m 40m 60m 80m 100m
SEBROE 04.03.2019
Norconsult
20
16
18
10
2
1
4
3
12
14
6
8
26
22

23.1 Fire training site (BØF) / contaminated site

Fire training site (BØF) / contaminated site	**BØF 1 (not active)**
	BØF 1 has been in use since the 1970s. PFAS is believed to have been adopted since 1978. The site is no longer active. The 2016 report states: The fire training site is now only used to a limited extent after permission from the County Governor granted in 2007. BØF 1 is used for approximately 3-4 exercises a year, for airport purposes only. Tests of foam cannons are also conducted. Approximately 400 litres of 3% foam and approximately 200 litres of fuel are used per year. The foam is usually blown in a southerly direction. In principle, the exercises are conducted on a concrete platform, but there is no system for collecting contamination from this.

23.2 The use of PFOS and other PFAS

Volume of PFOS used at the site (kg)	480
Comments/uncertainty	Estimated consumption from 1978 to 2001.
Volume of PFAS used at the site (kg)	90
Comments/uncertainty	Estimated consumption of PFAS from 2001 to 2011. In 2011-2012, a change was made to use foam without perfluorinated compounds. Avinor has not used PFAS-containing foam at its airports after 2012.

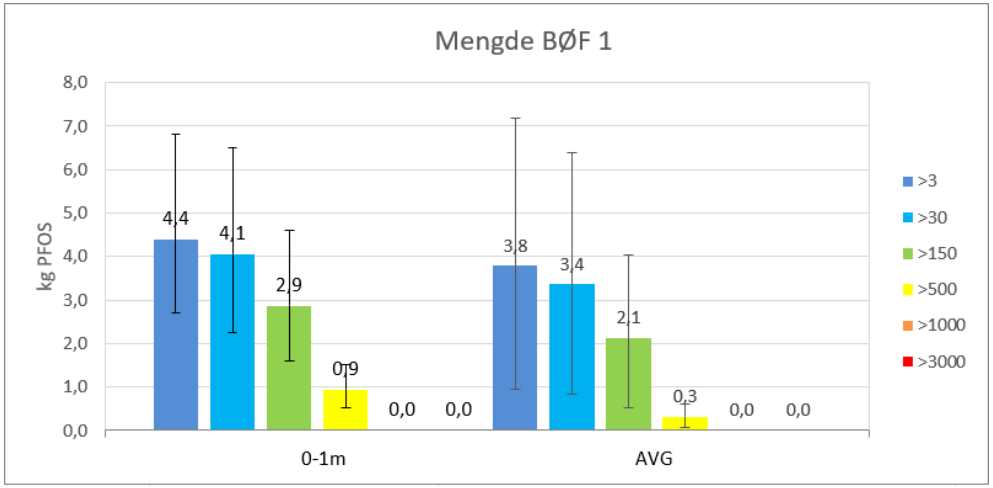
23.3 Soil sampling

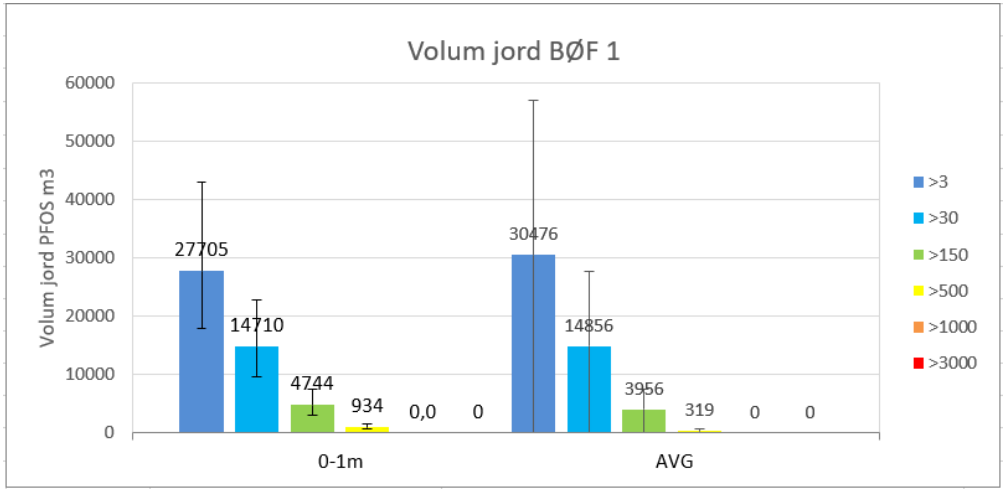
Total number of soil samples	23
Comments/uncertainty (for example, 95% of the samples were taken from 0–0.1 m)	15 of the samples are surface samples taken from varying layers between 0-0.5 metres, four of the samples were taken from varying layers between 0.5-1 metres, and four of the samples were taken at varying depths between 1.1 and 1.6 metres.
Number of soil samples 0-1 m beneath the ground	19
Number of soil samples under 1 m	4
Comments/uncertainty	PFOS at concentrations above detection limit was only detected in one of the deep samples; this is the deepest sample, taken at 1.6 metres below ground.
Highest measured soil concentration of PFOS µg/kg	924
Where	BØF 1-1 (0-0.2 m). The materials consist of sand and gravel.
Highest measured soil concentration of PFAS µg/kg	930

Where	BØF 1-1 (0-0.2 m). The materials consist of sand and gravel.
Comments/uncertainty	The sample "BØF 1-1" was only analysed for PFOS and PFOA. Eight of the samples have been analysed for 11 PFAS compounds (samples from points BØF 8, BØF 10, BØF 14 and BØF 18). The other samples were only analysed for PFOS and PFOA.

23.4 Volume calculation

PFOS average for all depths and points > 3 µg/kg	
Concentration (µg/kg)	73
Area (m2)	27,705
Volume of soil (tonnes)	51,808
Volume of PFOS (kg)	3.8
Uncertainty -	2.8
Uncertainty +	3.4
PFOS average for all depths and points > 30 µg/kg	
Concentration (µg/kg)	133
Area (m2)	13,505
Volume of soil (tonnes)	25,254
Volume of PFOS (kg)	3.4
Uncertainty -	2.5
Uncertainty +	3.0
PFOS average for all depths and points > 150 µg/kg	
Concentration (µg/kg)	315
Area (m2)	3,596
Volume of soil (tonnes)	6,725
Volume of PFOS (kg)	2.1
Uncertainty -	1.6
Uncertainty +	1.9
PFOS average for all depths and points > 500 µg/kg	
Concentration (µg/kg)	593
Area (m2)	290





Volume of soil (tonnes)	542
Volume of PFOS (kg)	0.3
Uncertainty -	0.2
Uncertainty +	0.3
PFOS average for all depths and points > 1,000 µg/kg	
Concentration (µg/kg)	
Area (m2)	
Volume of soil (tonnes)	
Volume of PFOS (kg)	
Uncertainty -	
Uncertainty +	
PFOS average for all depths and points > 3,000 µg/kg	
Concentration (µg/kg)	
Area (m2)	
Volume of soil (tonnes)	
Volume of PFOS (kg)	
Uncertainty -	
Uncertainty +	

Comments regarding calculations of volume	In the DP2 report, it is assumed that most of the remaining contamination is found in the central part of BØF 1 within a range of 100x100 m, and has an average concentration of 500 ug/kg. It is thought that the contaminated materials have an expanse of 1.5 metres. It is calculated that 12.7 kg of PFOS and 0.22 kg PFOA remain in these materials. In the 2016 risk assessment, a residual volume of PFOS of 3 ± 2 kg has been calculated. The calculation is based on an average concentration of 116 ug/kg, an area of 13,000 ± 3,000 m2, and a depth of 1 ± 0.5 metres.
Is the extent of the contaminated area limited horizontally?	The contamination is apparently delimitated in surface materials to the south, at extreme points 22 and 26, where no PFOS or PFOA have been detected. At the extreme point 16 to the northwest, a low concentration of PFOS of 2.9 µg/kg has been detected. At the extreme point to the north (point 20), a concentration of PFOS of 47.3 µg/kg has been detected. The contamination is therefore least delimitated in the north/northeast direction, in the direction of the runway. The samples at all extreme points are only surface samples at a depth of 0.2 metres.
Is the extent of the contaminated area limited vertically?	Samples of materials > 1 metre have been taken at four sampling points. Only at one of these points, point 4, which is centrally located in the BØF, has PFOS been detected in deeper materials of sand/silt at groundwater level, and then in a low concentration

	(2.3 µg/kg at a depth of 1.6 metres). At points 4, 6 and 12, samples have been taken at groundwater level, between 1.1-1.6 metres deep. No PFOS has been detected at this level at points 6 and 12. The contamination is delimitated vertically at the sampling points (6, 10, 12 and 18). At seven of the sampling points, samples have only been taken of the surface materials down to about 0.2 m. For these points there is uncertainty about the contamination situation in the deeper materials.

23.5 Water sampling and annual dispersion

Have water samples been taken?	Yes
Where	From trenches (G2 and G3) at the BØF and southeast of BØF (G1, S1-S4), Håelva (upstream and downstream from the BØF), at Glomma (upstream and downstream from the BØF), as well as at 4 wells around the BØF and 4 wells east of the airstrip.
Highest measured concentration of PFOS in groundwater (ng/l)	15,200
Where	B3 (16.05.2012), southwest of the BØF
Highest measured concentration of PFAS in groundwater (ng/l)	33,200
Where	B3 (16.05.2012), southwest of the BØF
Comments/uncertainty	The well was established by pushing the tip of the well into the permeable materials of sand using an excavator. From the 2016 report: This may have led to greater mobilisation of PFAS from the unsaturated zone than is the case when drilling. At other airports, high initial values have also been found in such pressed wells. Supplementary samples of this well were therefore taken in 2013. The concentrations of PFOS were then 183 ng/l in May and 51.4 ng/l in September, while PFAS was 1900 ng/l in May and 624.4 ng/l in September.
Highest measured concentration of PFOS in surface water (ng/l)	1870
Where	S2 (21.05.2013), at the intersection of the trench that drains the BØF and the trench from the terminal area.
Highest measured concentration of PFAS in surface water (ng/l)	2,710
Where	S2 (21.05.2013), at the intersection of the trench that drains the BØF and the trench from the terminal area.
Comments/uncertainty	
Total annual dispersion of PFOS from the site (g/year)	20 (50)*
Total annual dispersion of PFAS from the site (g/year)	Not calculated
To which recipient	Håelva, which flows into Glomma
Calculated from water or soil concentration.	Water concentration
	The terrain in the area is very flat. It is believed that the groundwater in the area around the BØF mainly drains towards the trench located southwest and south of the BØF, and flows into Håelva. This trench to the south probably also collects water from the terminal building and the apron. It is likely that the direction of flow varies with the seasons. *Annual dispersion has been calculated for the entire airport based on measurements in point S4 at the outlet from the trench systems of Håelva.

23.6 Biota sampling

Have biota samples being taken at the airport?	Yes
What kind of biota?	Grayling and common whitefish
How many samples?	10 individual muscle samples of grayling and 3 individual muscle samples of common whitefish were analysed.
Highest measured concentration of PFOS in biota (µg/kg wet weight)	4.1
Where	Håelva, Grayling no. 5, muscle
Highest measured concentration of PFAS in biota (µg/kg wet weight)	4.1
Where	Håelva, Grayling no. 5, muscle
Median concentration in comparable populations (e.g. in a lake)	The average value of PFOS in muscle samples from common whitefish in Femunden is 0.05 µg/kg wet weight. This figure is taken from the Norwegian Environment Agency's report "Miljøgifter i store norske innsjøer, M-548" (Environmental contaminants in large Norwegian lakes, M-548) from 2015. It has not been possible to find median concentrations of PFOS in grayling in a comparable population. As grayling is a species of the salmon family, the concentrations are compared to samples of trout from Evenes. In six individual muscle samples of trout from Langvatnet at Evenes Airport Harstad, the average content of PFOS was 14.89 ug/kg ww (median 15.64) and for PFAS was 20.53 ug/kg ww (median 23.27).
Comments/references	In general, low concentrations of PFAS have been detected in the biota samples taken in the river Håelva. No PFAS was detected in common whitefish. In grayling, 3 out of 10 individuals had PFAS levels above the detection limit (1 µg/kg ww). The average value for PFOS in these 3 individuals was 3.6 µg/kg ww. No other PFAS compounds were detected. As a rule, higher values of PFAS are found in the liver than in muscle, because PFAS accumulates in blood-filled organs such as the liver, kidneys and in bile.
References and concentrations in other reports.	Environmental quality standard in organisms in the Norwegian Environment Agency's supervisor M-608: 9.1 ug/kg wet weight. The biota samples of grayling and common whitefish show concentrations below this. In a risk assessment from 13 December 2018, EFSA changed the tolerability limit (TDI - tolerable daily intake) for PFOS and PFOA, so these are now far lower than the TDI values set in 2008. This may cause EQS for biota to also be lower in the future.

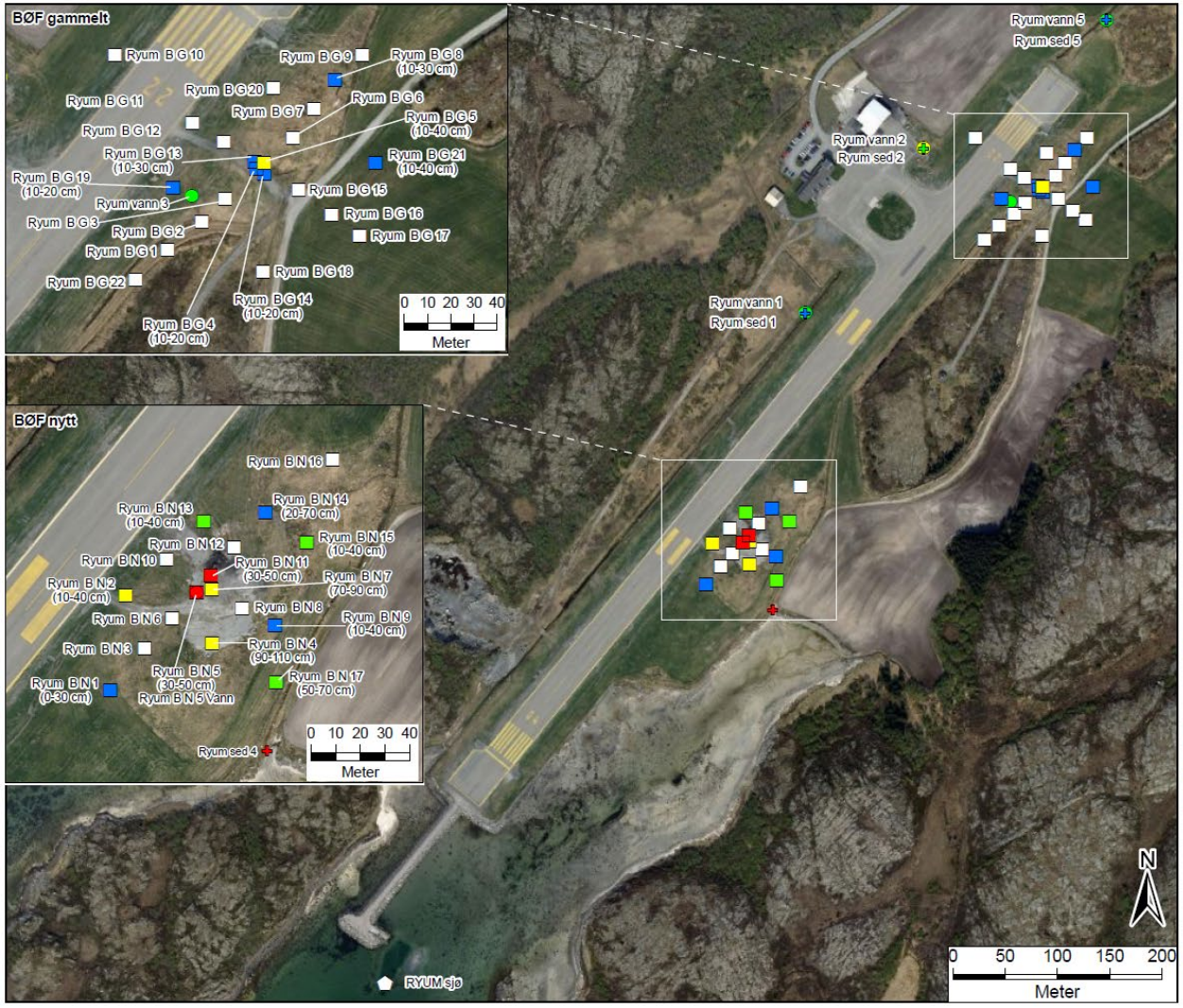
23.7 Uncertainty and other factors

Does the estimate of the volume of PFOS in the ground correspond with the measured concentrations in water and biota?	Cannot be reliably evaluated. Based on the mapping conducted, the concentrations in soil and its extent indicate that there are not such large quantities of PFOS at the BØF, and that the contamination is located in the unsaturated zone. PFOS has only been detected in low concentrations in a soil sample at groundwater level. The materials in the area are sandy and permeable, so contamination of PFAS which reaches groundwater level is expected to spread with groundwater, which has been encountered at levels between 1.1 and 1.6 metres at the BØF. Analysis has been carried out for PFOS and PFAS in groundwater, and for PFOS in trenches downstream of the BØF. Concentrations detected in both groundwater and trench water show an ongoing leaching. Eluviation from the unsaturated zone and concentrations in groundwater will vary with infiltration during precipitation and melting snow.
Evaluations	It is believed that PFAS contamination from the BØF mainly drains via groundwater and into a trench to the southwest, and/or towards the trench in the south. Water from both trenches flows into Håelva. The groundwater wells at the BØF are north, southwest, south and southeast of the BØF. The highest concentration of PFAS in groundwater was detected in well B3, located directly downstream of the BØF. The highest concentrations were detected on establishment in 2012, and lower in 2013, which are believed to be more representative measurements due to the mobilisation of PFAS upon establishment. There is no reason to believe that the contamination in B3 has any source other than the BØF, since B3 is located directly downstream from the BØF. Wells B1, B2 and B4 have only been tested at the time of establishment, and it is therefore uncertain whether concentrations in water from these wells are elevated due to the mobilisation of contamination in the materials. Common to all groundwater samples taken at the BØF is that there are far higher concentrations of total PFAS compared to PFOS. In soil samples, no compounds other than PFOS and PFOA have been analysed in the shafts that have the highest soil concentrations. In the soil samples analysed for 12 PFAS compounds, concentrations of PFOS are the highest, and otherwise the compounds PFHxS, PFHxA, PFOA and PFPeA are present. 6:2 FTS has been detected in two samples. The samples of surface water in the trench flowing from the BØF towards Håelva show high concentrations of PFOS near the BØF (G2), and decreasing with increasing distance from the BØF (G2 downstream). At the intersection where the trench from the BØF meets the trench that leads excess water from the terminal area, the highest concentrations of PFOS and PFAS were detected (S2). Water samples in Håelva nedstrøms trench outlet have PFAS concentrations between 30 and 60 ng/l. No PFAS has been detected in the sample upstream. This suggests dispersion to Håelva from the BØF and the terminal area. Although significant concentrations of other PFAS compounds have been detected in the trench at sample point S1-S4, one other PFAS compound (PFHxS) was detected in only one sample. No PFAS has been detected in the sample from Glomma. One possible reason for the relatively low concentrations of PFOS in grayling is that this species of fish migrates long distances, and does not stay long in one place. The analysis results do not indicate that there is an accumulation of PFAS with increasing body length/age, which may also mean that the fish that were caught do not stay in Håelva all year. Common whitefish is also a migratory species of fish. No samples of more stationary biota types have been taken, and

	based on the sample basis available, it is therefore difficult to conclude the connection between the measured concentrations in the ground and the biota.
Could there be any additional unknown sources of PFOS at the site with run-off to the recipient?	The groundwater samples taken north of the runway (B7), at the Rubb hall and refill cabinet, indicate that there is a source of PFAS contamination in this area as well (PFOS concentrations in three samples taken in the period May 2012 to September 2013 are between 5,900-10,900 ng/l and PFAS of 7,300-13,300 ng/l). It is stated in the 2016 report that the washing of fire engines after exercises at the BØF takes place in this area. However, the concentrations in B7 are higher than in all samples taken from the wells at the BØF, besides the one sample taken from B3 in 2012. PFOS is the predominant component in the samples from B7. The groundwater wells southeast of the terminal area (B5/MB2 and B6/MB1) do not have high concentrations of PFOS (between 10 and 70 ng/l), but the concentrations of PFAS are between 840 and 1,300 ng/l. The different composition of compounds in samples from well B7 compared to wells B5 and B6 may be due to the fact that there are different sources of contamination in these areas. However, this is uncertain. The concentrations are generally much higher at B7. In water samples in the trench coming from the terminal area (S1 and S3) before meeting the trench from the BØF, there are significant concentrations of PFOS (170-900 ng/l) and PFAS (450-1,740 ng/l).
Has the site been sufficiently mapped with a view to assessing the order of prioritisation?	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the volume of PFOS in the soil with the stipulated level of uncertainty.
Comments/uncertainty	4 samples have been taken deeper than 1 metre, and only one of these is in the five shafts with the highest concentrations of PFOS in soil. This provides a limited basis for assessing the contamination rate of the deeper materials in the area, and the scale of the vertical extent of the contamination.

Other factors of significance for any clean-up/initiation of measures (for example, planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	There are several species (animals, birds and plants) around Røros Airport with a high and especially high management interest. Several important types of habitat have also been registered around the airport. Northeast of the airport there is a landscape protection area, "Kvitsanden". In addition, the areas "Floan", "Sundlia", "Mockingmyrene" are located around the airport. In addition, some important cultural monuments have been registered northeast of the airport. Håelva is a fishing river, where trout, grayling, common whitefish, pike and perch are found. The lower parts of the river Håelva are frequently used as fishing grounds for anglers, and the area is one of the best fishing spots for grayling in the region. At the BØF, THC was detected in environmental condition class 2-3 in two of the soil samples, and environmental condition class 4-5 in two of the soil samples.

24 Rørvik Airport, Ryum



Rørvik lufthavn
Ryum (ENRM)

Oversiktskart inkl. brannøvingsfelt

PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

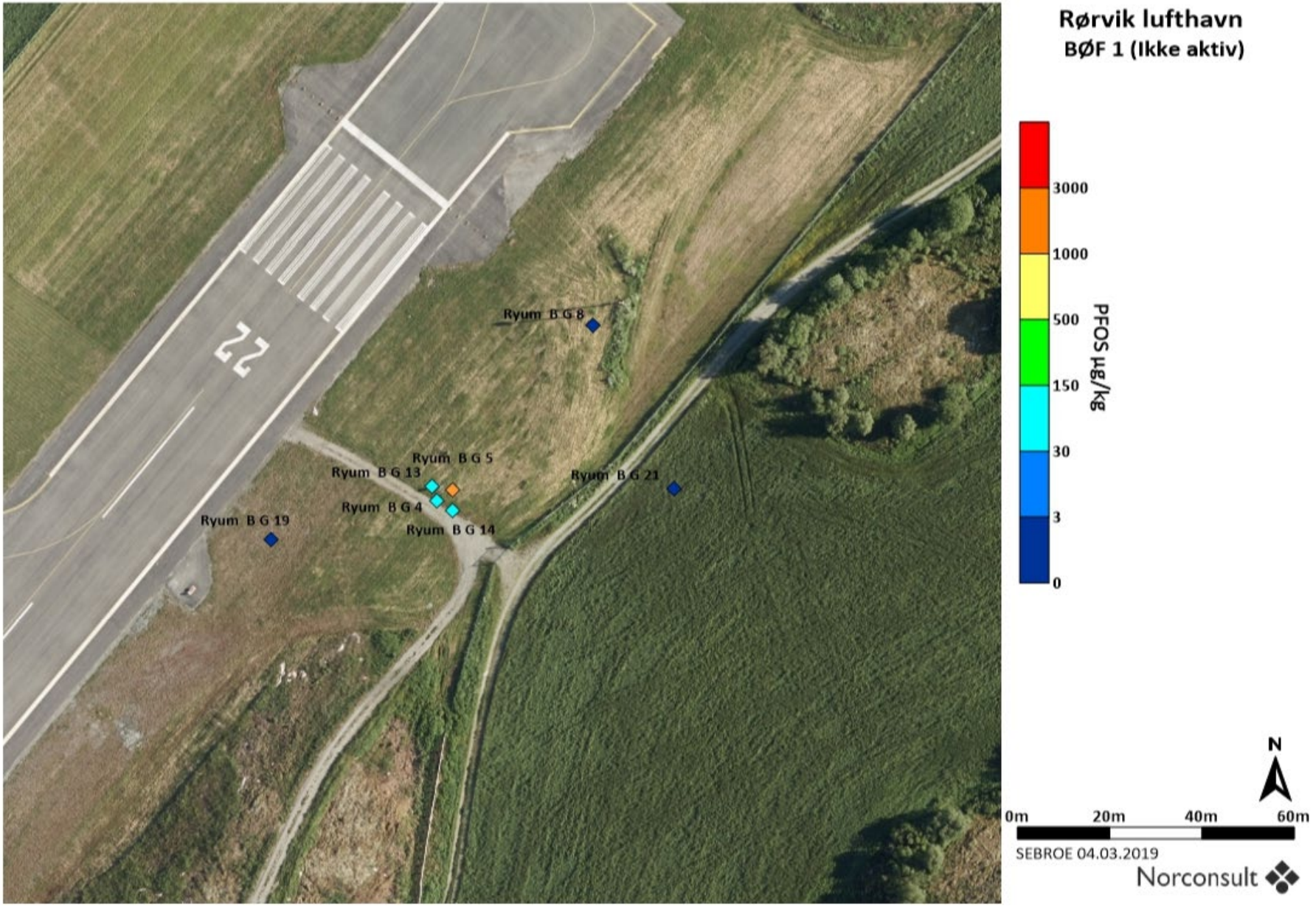
PFOS sediment ferskvann (ug/kg)
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

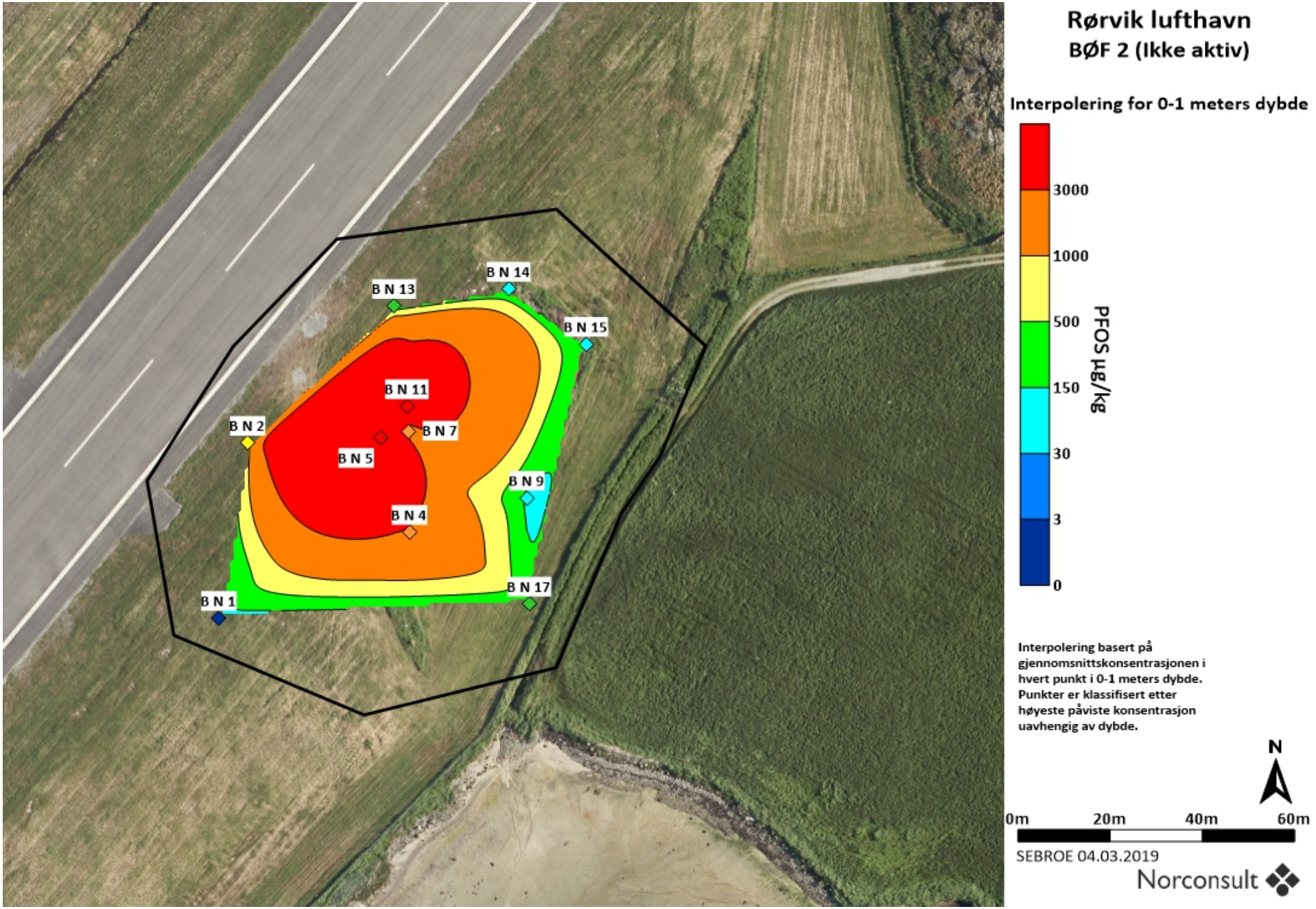
PFOS ferskvann (ug/l)
- <0.002-0.3
- 0.3-1.0
- >1.0
- Ikke analysert

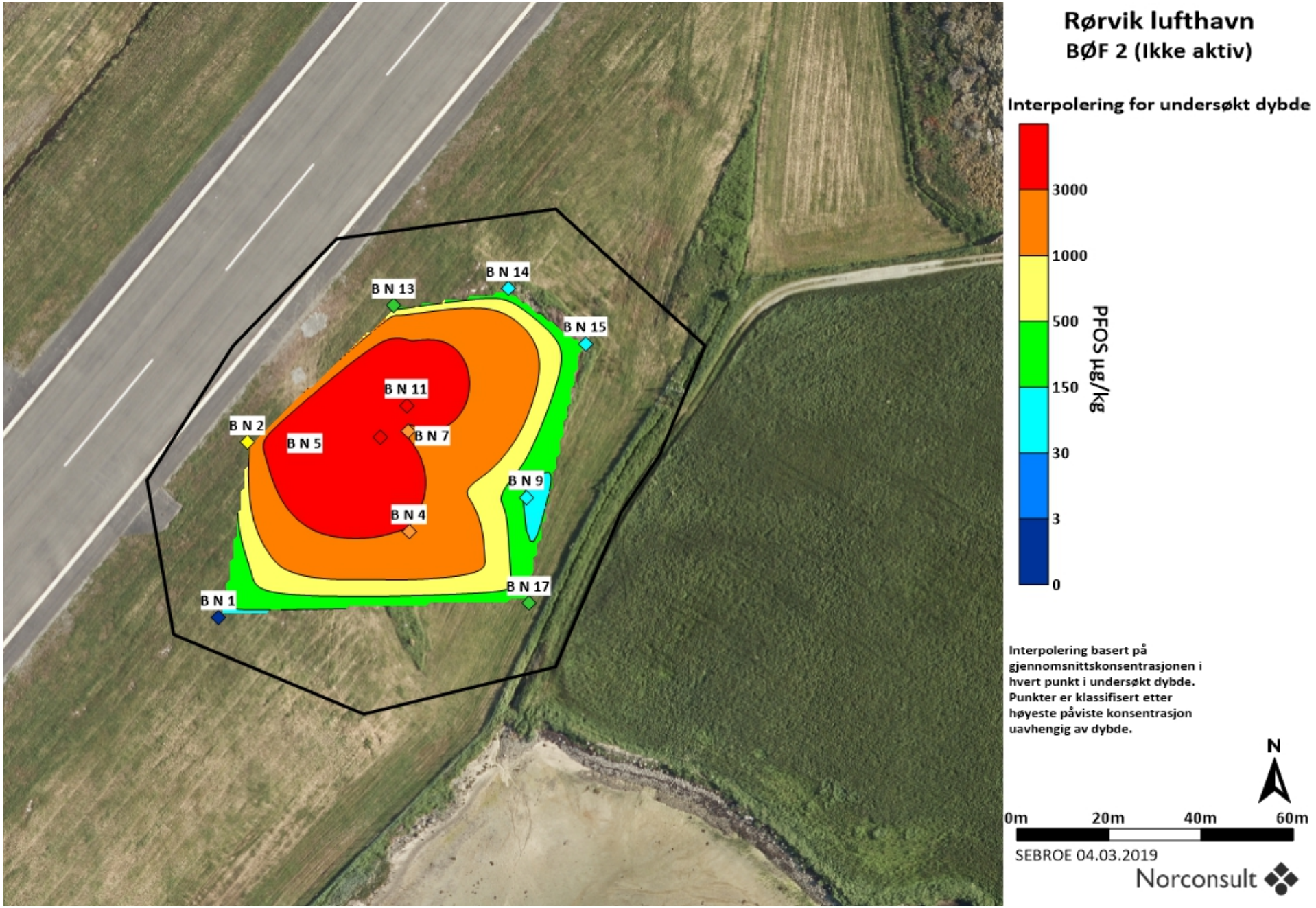
PFOS/PFOA sjøvann (ug/l)
- <25
- 25-72
- 72-360
- >360
- Ikke analysert

* PFOS er dominerende parameter

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Rørvik lufthavn
BØF 1 (Ikke aktiv)
22
Ryum B G 8
Ryum B G 5
Ryum B G 13
Ryum B G 4
Ryum B G 14
Ryum B G 19
Ryum B G 21
3000
1000
500
150
30
3
0
PFOS µg/kg
N
0m
20m
40m
60m
SEBROE 04.03.2019
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Rørvik lufthavn
BØF 2 (Ikke aktiv)
Interpolering for 0-1 meters dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
B N 1
B N 2
B N 4
B N 5
B N 7
B N 9
B N 11
B N 13
B N 14
B N 15
B N 17
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i 0-1 meters dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m
20m
40m
60m
SEBROE 04.03.2019
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Rørvik lufthavn
BØF 2 (Ikke aktiv)
Interpolering for undersøkt dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
B N 1
B N 2
B N 4
B N 5
B N 7
B N 9
B N 11
B N 13
B N 14
B N 15
B N 17
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m
20m
40m
60m
SEBROE 04.03.2019
Norconsult

24.1 Fire training site (BØF) / contaminated site

Fire training site (BØF) / contaminated site	BØF 1 (old)	BØF 2 (younger but not active)
	Undisclosed operating period	BØF 2 was used from 1990-2005

24.2 The use of PFOS and other PFAS

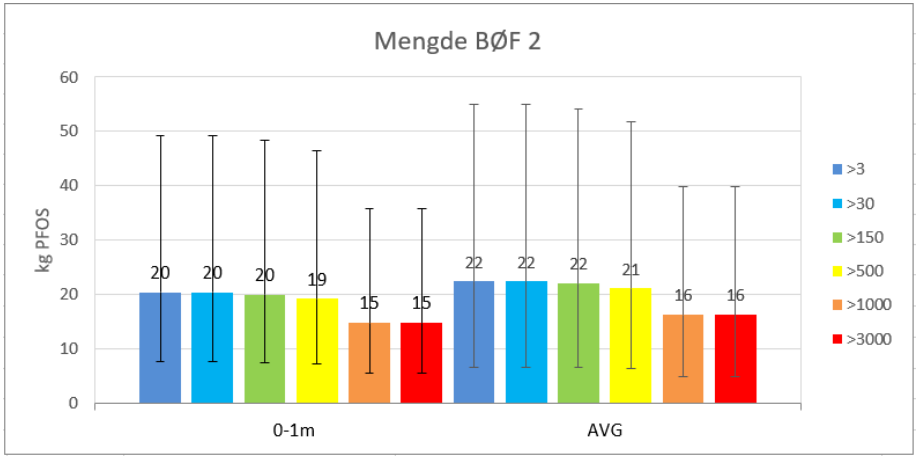
Volume of PFOS used at the site (kg)	Not stated/calculated	Not stated/calculated
Comments/uncertainty	There is no information on the consumption of foam at the site.	Annual consumption AFFF 750 l and 400 kg powder
Volume of PFAS used at the site (kg)	Not stated/calculated	Not stated/calculated
Comments/uncertainty		

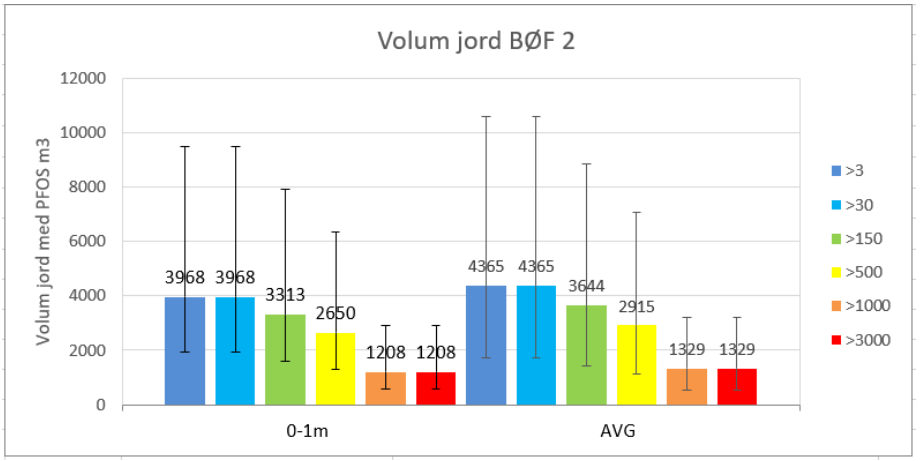
24.3 Soil sampling

Total number of soil samples	7	11
Comments/uncertainty (for example, 95% of the samples were taken from 0–0.1 m)	100% of the samples were taken from 0-0.2 m.	The samples were taken at varying depths within 0-1.1 m.
Number of soil samples 0-1 m beneath the ground	7	11
Number of soil samples under 1 m	0	1
Comments/uncertainty		The sample is from 0.9-1.1 m. A total of 12 soil samples when splitting up samples in the intervals in both the upper metre and deeper.
Highest measured soil concentration of PFOS µg/kg	1,850	25,900
Where	Ryum-B-G-5 (0-0.2 m)	Ryum-B-N-5 (0.3-0.5 m)
Highest measured soil concentration of PFAS µg/kg	1,850	25,900
Where	Ryum-B-G-5 (0-0.2 m)	Ryum-B-N-5 (0.3-0.5 m)
Comments/uncertainty	These samples were only analysed for PFOS and PFOA.	6:2 FTS was measured in four samples, only PFOS and PFOA in the rest of the samples. No analysis reports were attached for the four soil samples, so they can be analyses for multiple compounds. The sample Ryum BN 5 0.3-0.5 m has only been analysed for PFOS and PFOA, the concentration of PFOS in the sample is very high compared to the second highest RYUM-B-N-11 0.3-0.5 m at 7730 ug/kg.

24.4 Volume calculation

PFOS average for all depths and points > 3 µg/kg	No volumes have been calculated for BØF 1	
Concentration (µg/kg)		3,207
Area (m2)		3,968
Volume of soil (tonnes)		6,984
Volume of PFOS (kg)		22
Uncertainty -		16
Uncertainty +		33
PFOS average for all depths and points > 30 µg/kg		
Concentration (µg/kg)		3,207
Area (m2)		3,968
Volume of soil (tonnes)		6,984
Volume of PFOS (kg)		22
Uncertainty -		16
Uncertainty +		33
PFOS average for all depths and points > 150 µg/kg		
Concentration (µg/kg)		3,778
Area (m2)		3,313
Volume of soil (tonnes)		5,831
Volume of PFOS (kg)		22
Uncertainty -		15
Uncertainty +		32
PFOS average for all depths and points > 500 µg/kg		
Concentration (µg/kg)		4,524
Area (m2)		2,650
Volume of soil (tonnes)		4,664
Volume of PFOS (kg)		21
Uncertainty -		15
Uncertainty +		31





PFOS average for all depths and points > 1,000 µg/kg		
Concentration (µg/kg)		7,655
Area (m2)		1,208
Volume of soil (tonnes)		2,126
Volume of PFOS (kg)		16
Uncertainty -		11
Uncertainty +		24
PFOS average for all depths and points > 3,000 µg/kg		
Concentration (µg/kg)		7,655
Area (m2)		1,208
Volume of soil (tonnes)		2,126
Volume of PFOS (kg)		16
Uncertainty -		11
Uncertainty +		24

Fire training site (BØF) / contaminated site	BØF 1 (old)	BØF 2 (younger but not active)
Comments regarding calculations of volume	In the DP2 report from 2012, no residual volume of PFOS/PFAS was calculated, but it was estimated that it was small.	The DP2 report from 2012 calculated a residual volume of 14 kg of PFOS in the soil. A source area of 2,500 m2 and a depth of 1 metre was used.
Is the extent of the contaminated area delimitated horizontally?	Not to the north/northwest or south, but the outermost samples B-G-8 in the northeast, B-G-19 to the west and B-G-21 to the east are below the detection limit.	No, only the sample Ryum BN1 (0-30 cm) to the southwest is below the detection limit.
Is the extent of the contaminated area delimitated vertically?	No, samples have only been taken in the top layer, so there is no information on how deep the contamination extends, or any levels of contamination in deeper layers. It is stated that there is marine clay at a depth of approximately 50 cm.	Yes, samples have been taken all the way down to the estimated bedrock depth
Comments/uncertainty		

24.5 Water sampling and annual dispersion

Fire training site (BØF) / contaminated site	BØF 1 (old)	BØF 2 (younger but not active)
Have water samples been taken?	Yes	Yes
Where	Kum ved BØF, Kulvert ved start bekk (Impact from the terminal area and the oldest BØF), Kum nedstrøms oljeutskiller (Impact from the terminal area), Bekk oppstrøms flyplass (Background concentration)	Sjakt B N 5(2011), Sjø (2012), Bekk oppstrøms flyplass (Background concentration)
Highest measured concentration of PFOS in groundwater (ng/l)	Groundwater not sampled	527,000
Where		In Sjakt B N 5 (2011)
Highest measured concentration of PFAS in groundwater (ng/l)	Groundwater not sampled	541,900
Where		In Sjakt B N 5 (2011), (including PFOA)
Comments/uncertainty		The sample was only analysed for PFOA and PFOS.
Highest measured concentration of PFOS in surface water (ng/l)	307	No relevant samples taken, sample of seawater below detection limit
Where	Water 2 (2011). Kum nedstrøms oljeutskiller (impact from terminal area)	
Highest measured concentration of PFAS in surface water (ng/l)	342	No relevant samples taken, sample of seawater below detection limit
Where	Water 2 (2011). Kum nedstrøms oljeutskiller (impact from terminal area)	
Comments/uncertainty	The water samples from 2011 were only analysed for PFOA and PFOS. The water samples from 2012 were analysed for several compounds, but the analysis appendix was not been attached to the report. Only PFOS, PFOA and 6:2 FTS, as well as total PFC are shown in the tables in the report. Concentrations of PFOS are generally lower in 2012 than in 2011. For BØF 1 (the oldest BØF), PFOS has been detected in water in a manhole at BØF (Vann 3) and in Vann 1, which is a culvert with a stream on the other side of the runway for the BØF downstream of the terminal area, the measurements show 111 and 158 ng/l PFOS respectively from sampling in 2011. Vann 2 which is a manhole downstream of the oil separator at the terminal building (307 ng/l) is directly on the other side of the airstrip from BØF 1. No PFOS has	Water in the shaft has a high content of particles to which PFOS can be bound, in addition to PFOS being mobilized by excavation under the water level. The water samples from 2011 were only analysed for PFOA and PFOS. The water samples from 2012 were analysed for several compounds, but the analysis appendix was not been attached to the report. Only PFOS, PFOA and 6:2 FTS, as well as total PFC are shown in the tables in the report.

	been detected in Vann 5 located upstream of the BØF and upstream of the airport but 15.9 ng/l PFC has been detected.	
Fire training site (BØF) / contaminated site	BØF 1 (old)	BØF 2 (younger but not active)
Total annual dispersion of PFOS from the site (g/year)	82	830
Total annual dispersion of PFAS from the site (g/year)	Not analysed/assessed	Not analysed/assessed
To which recipient	Drainage along the runway to Vikan (sea)	From groundwater to nearby stream southeast of the field (about 60 m from the BØF to sea, Vikan)
Calculated from water or soil concentration.	Water sample in the stream (Vann 1)	Water sample in shaft, and therefore it may be unrepresentative due to mobilization of PFOS.

24.6 Biota sampling

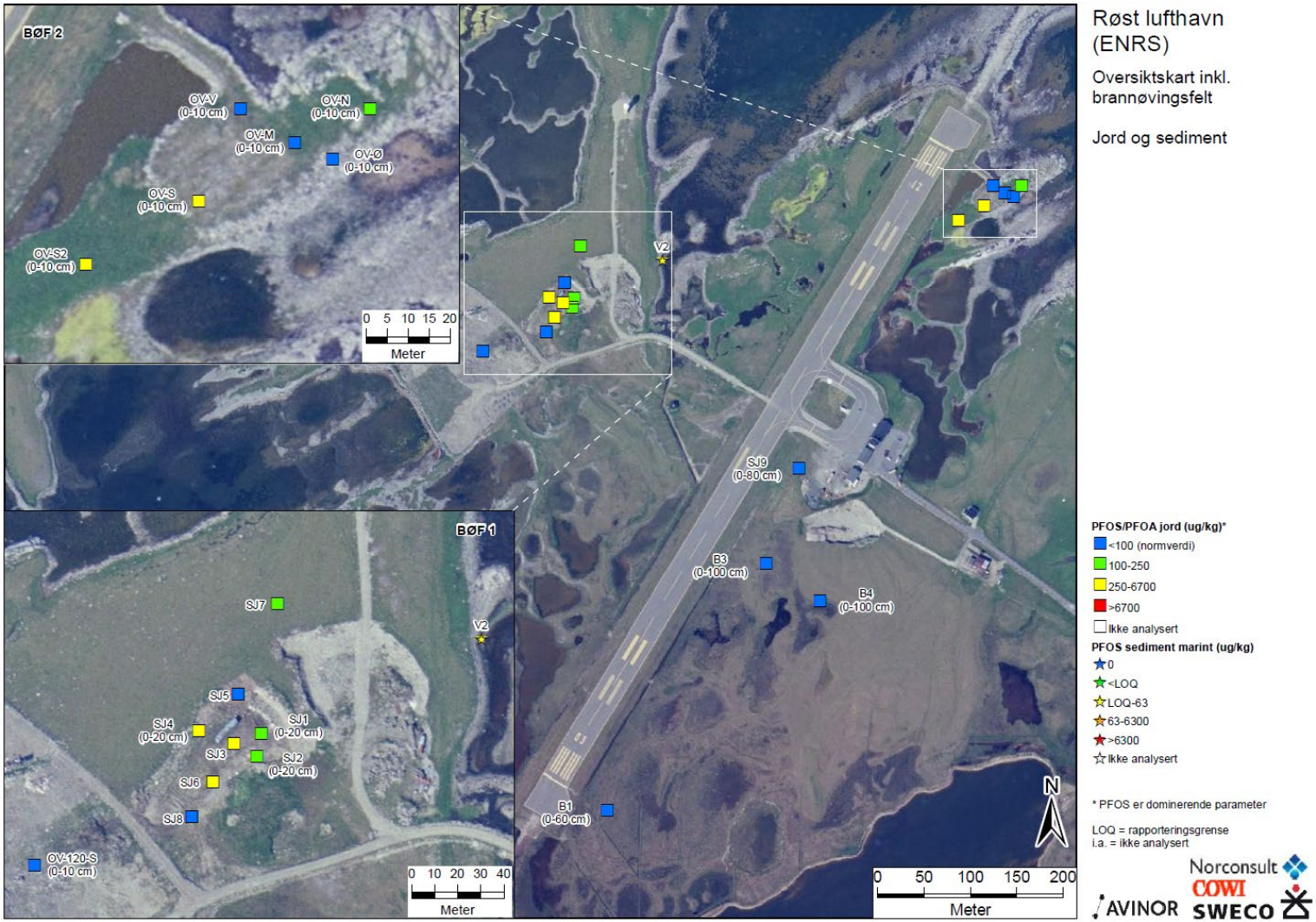
Have biota samples being taken at the airport?	No	No
What kind of biota?		
How many samples?		
Highest measured concentration of PFOS in biota (µg/kg wet weight)		
Where		
Highest measured concentration of PFAS in biota (µg/kg wet weight)		
Where		
Median concentration in comparable populations (e.g. in a lake)		
Comments/references		
References and concentrations in other reports.		

24.7 Uncertainty and other factors

Fire training site (BØF) / contaminated site	BØF 1 (old)	BØF 2 (younger but not active)
Does the estimate of the volume of PFOS in the ground correspond with the measured concentrations in water and biota?	Not assessed. There few samples of soil and water, and none of the biota.	Cannot be safely assessed for water, and no samples of biota have been taken.
Evaluations		In general, Rørvik Airport has marine deposits from fine sand to clay, sometimes with marsh deposits on top. At the BØF, the soil conditions are variable, from sand deposits to bedrock of less than 1 m depth. The centre of the field is on a small hill, there is shallow bedrock on top of this, and more surficial deposits to the southeast. The groundwater level is not stated, but is assumed to be about 0.5 m below terrain based on depth of sjakt B-N-5 where a groundwater sample was taken. The concentration of PFOS in groundwater in sjakt Ryum BN5 shaft is 527,000 ng/l, and may be affected by mobilization during excavation. However, the concentration in soil from 30-50 cm in this shaft is also particularly high (25,900 µg/kg). Incidentally, insufficient samples of water been taken that can be associated with this BØF. A sample of sediment (Sed 4) was taken in the stream just south of the BØF which has a concentration of 6,740 µg/kg.
Comments/uncertainty: (Could there be any additional unknown sources of PFOS at the site with run-off to the recipient?)	It is uncertain where groundwater from (the oldest) BØF 1 drains, and whether there are trenches along the eastern side of the runways between the oldest and the younger BØF. The water samples taken on the west side of the runway (Vann 1 and Vann 2) may be affected by any other activity at the airport. PFC in low concentrations was also detected in the sample taken upstream of the airport.	It is not stated that there are additional sources of PFOS at the site, or otherwise at the airport, but it cannot be ruled out that there are other sites with PFOS or PFAS contamination at the airport. For example, this could be from the use of fire extinguishing foam for testing equipment that has often been carried out in arbitrary places.
Has the site been sufficiently mapped with a view to assessing the order of prioritisation?	No, the site is not well enough mapped with a view to assessing the order of prioritisation (see this report for parts 1 and 2, chapter 2.1.1.6 and chapter 2.1.3.1).	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate

		the volume of PFOS in the soil with the stipulated level of uncertainty.
Comments/uncertainty	There is a soil sample with a high concentration, and this is not delimitated. It is also somewhat uncertain whether the centre of the BØF has been sampled, as there are no installations or anything else that shows exactly where the exercises have been carried out. There are seven soil samples in total, and there are only four soil samples where PFOS was detected, so volumes of PFOS in the soil cannot be calculated. All samples are surface samples.	
General information about the airport		
Other factors of significance for any clean-up/initiation of measures (for example, planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	No protected areas have been registered at the airport in Naturbase, but important habitat types have been registered, such as; natural pastures, replacement biota, sand and gravel beach, rich marsh and old boreal deciduous forest. Species with a high and especially high management interest have been registered; pinkgill mushroom, limestone waxtop mushroom, felted pinkgill mushroom, toasted waxcap mushroom, bitter waxcap mushroom. The water materials outside the airport are feeding and growing areas for herring, haddock, etc. At the BØF, THC was detected in environmental condition class 2 in two soil samples, and environmental condition class 4 in one soil sample.	

25 Røst Airport



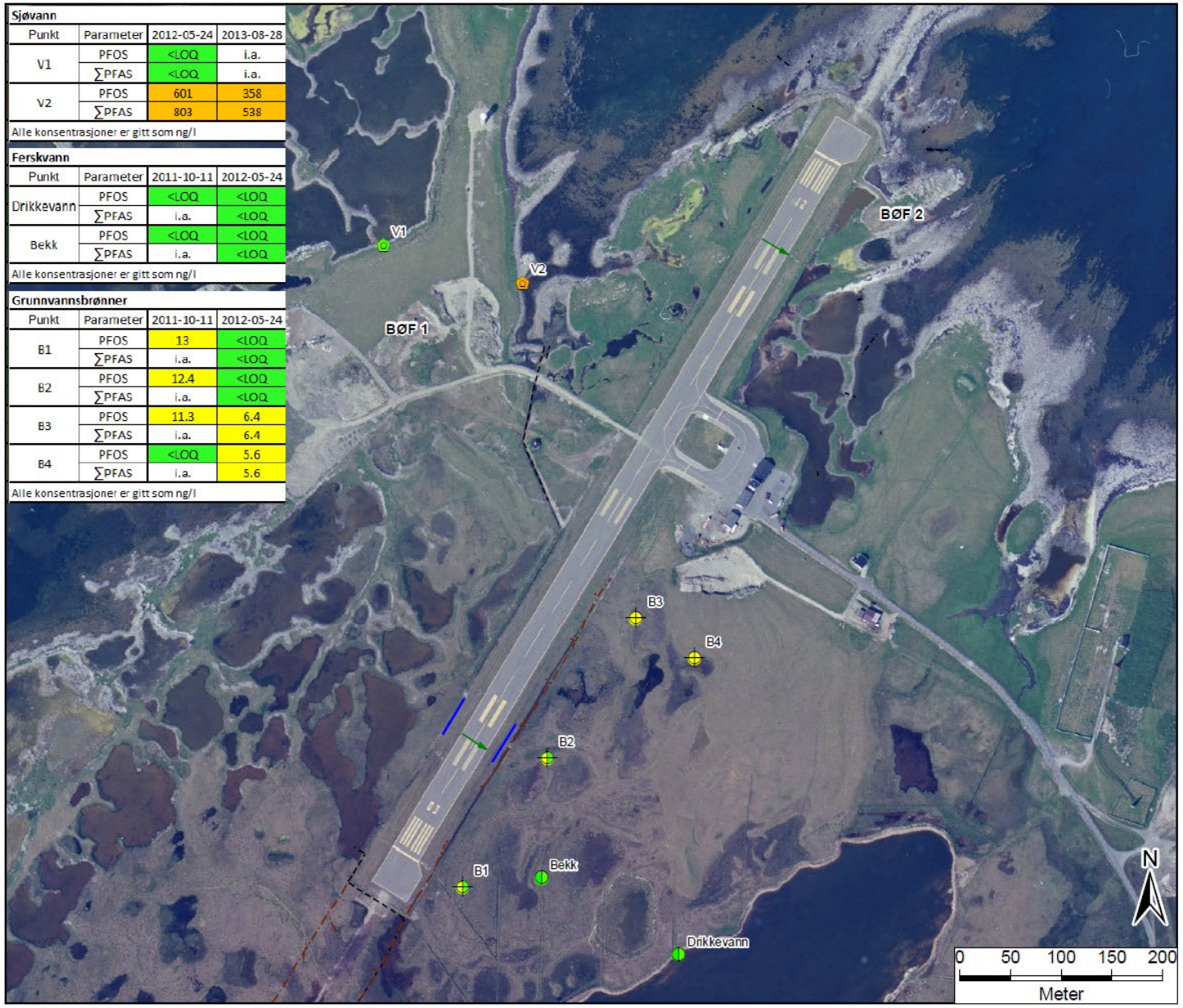
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APPENDIX A

Sjøvann			
Punkt	Parameter	2012-05-24	2013-08-28
V1	PFOS	<LOQ	i.a.
	∑PFAS	<LOQ	i.a.
V2	PFOS	601	358
	∑PFAS	803	538
Alle konsentrasjoner er gitt som ng/l			

Ferskvann			
Punkt	Parameter	2011-10-11	2012-05-24
Drikkevann	PFOS	<LOQ	<LOQ
	∑PFAS	i.a.	<LOQ
Bekk	PFOS	<LOQ	<LOQ
	∑PFAS	i.a.	<LOQ
Alle konsentrasjoner er gitt som ng/l			

Grunnvannsbrønner			
Punkt	Parameter	2011-10-11	2012-05-24
B1	PFOS	13	<LOQ
	∑PFAS	i.a.	<LOQ
B2	PFOS	12.4	<LOQ
	∑PFAS	i.a.	<LOQ
B3	PFOS	11.3	6.4
	∑PFAS	i.a.	6.4
B4	PFOS	<LOQ	5.6
	∑PFAS	i.a.	5.6
Alle konsentrasjoner er gitt som ng/l			



Røst lufthavn (ENRS)

Oversiktskart inkl. brannøvingsfelt

Vann

PFOS / ∑ PFAS grunnvannsbrønn (ng/l) *
- Ikke analysert
- 0
- <LOQ
- LOQ-230
- 230-36 000
- >36 000

* Venstre halvdel = PFOS
Høyre halvdel = PFAS

PFOS / ∑ PFAS ferskvann (ng/l) *
- Ikke analysert
- 0
- <LOQ
- LOQ-230
- 230-36 000
- >36 000

* Venstre halvdel = PFOS
Høyre halvdel = PFAS

PFOS / ∑ PFAS sjøvann (ng/l) **
- Ikke analysert
- 0
- <LOQ
- LOQ-23
- 23-7 200
- >7 200

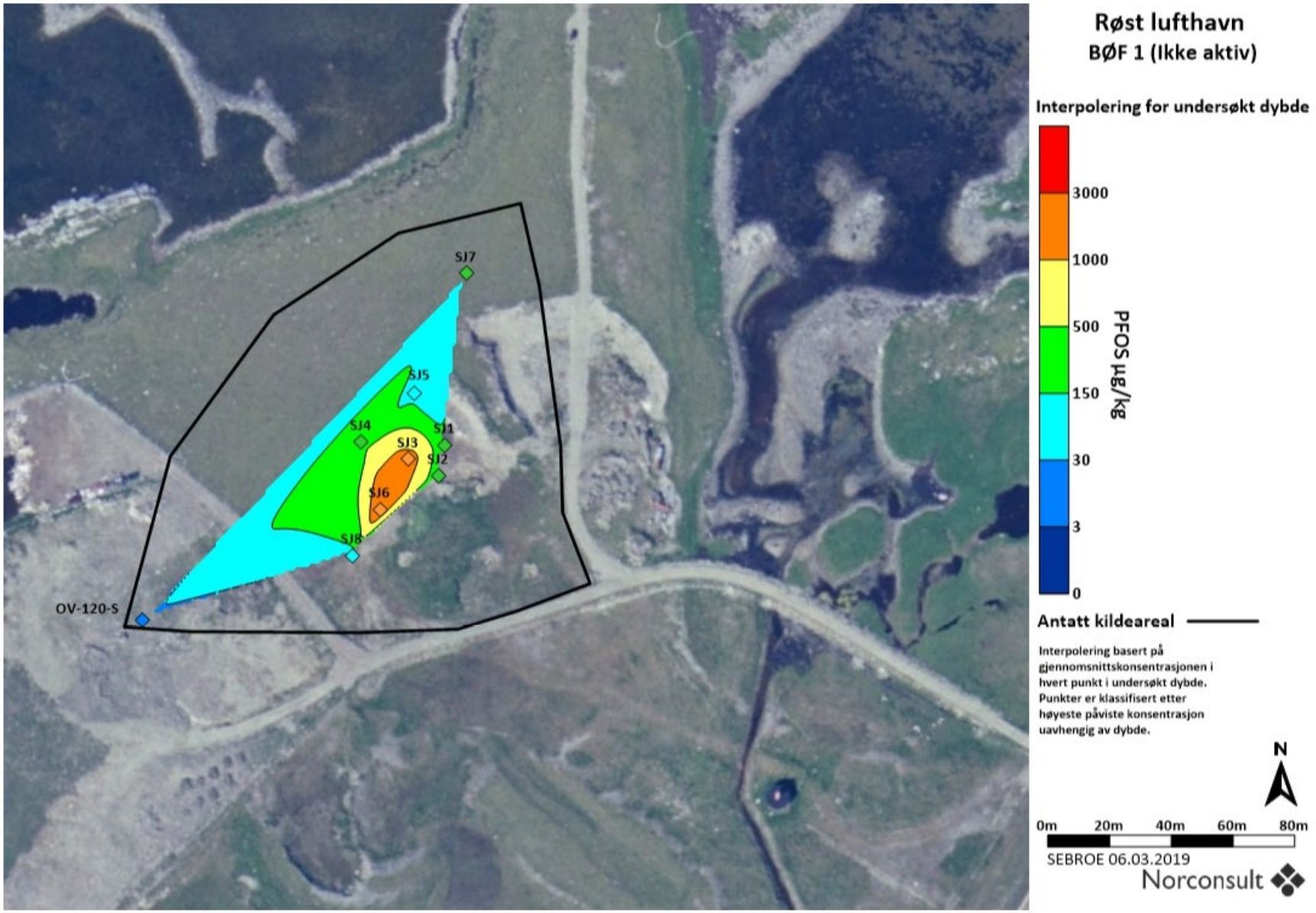
** Senter = PFOS
Ytre ramme = PFAS

Avlopsledning
- Avløp annet
- Avløp Felles
- Drensvann
- Glykolholdig overvann
- Glykolholdig spillvann
- Overvann
- Pumpespillvannsledning
- Spillvann

Avrenning
- Deponi glykolforurenset snø
- Overvannsledning
- Avrenningsveg glykol
- Bekkeresipient
- Overvannsystem
- Vannskille rullebane
- Antatt avrenningsveg baneavising

i.a. = ikke analysert
LOQ = rapporteringsgrense

AVINOR Norconsult SWECO



Røst lufthavn
BØF 1 (Ikke aktiv)

Interpolering for undersøkt dybde

PFOS µg/kg
3000
1000
500
150
30
3
0

Antatt kildeareal

Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.

N

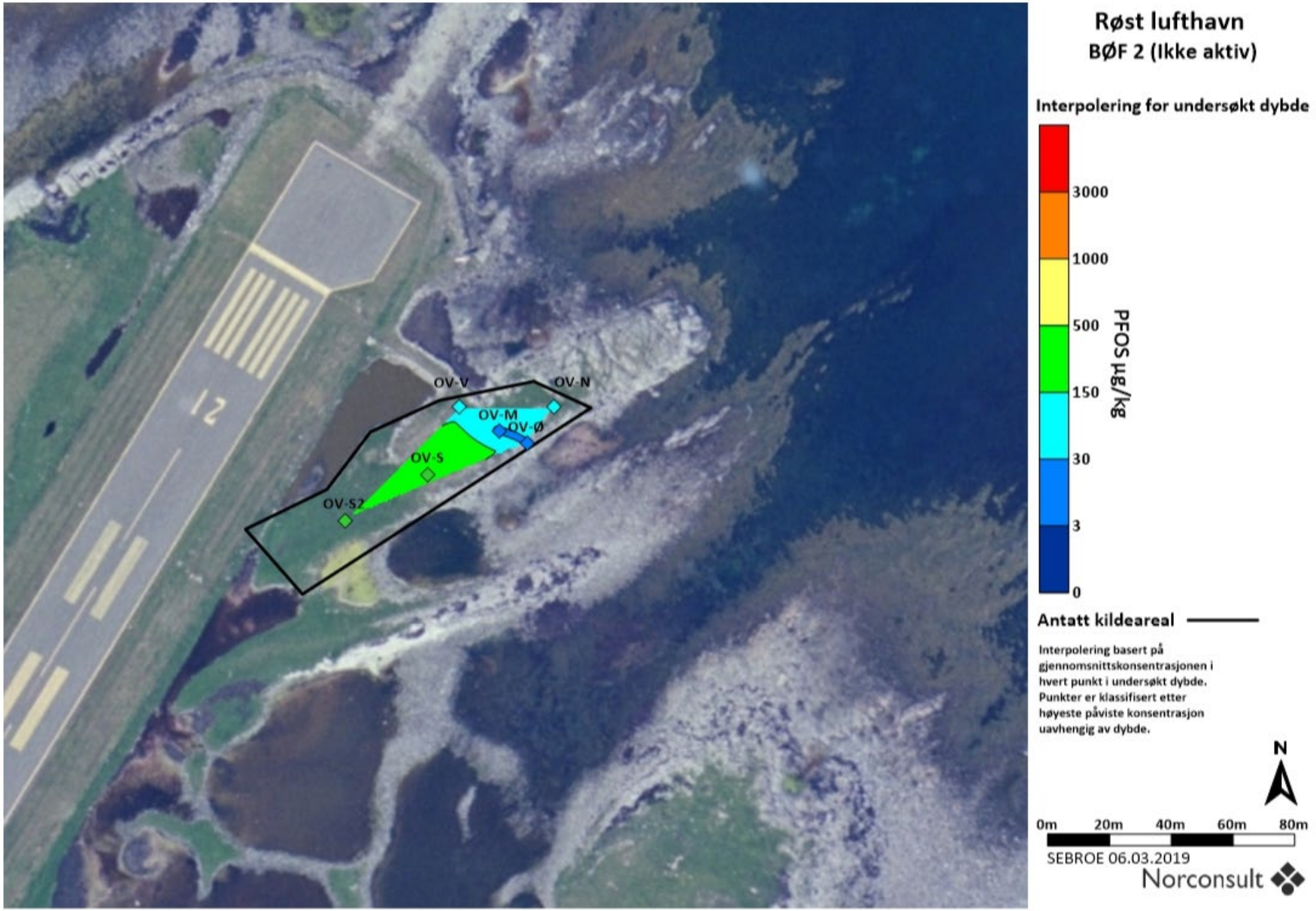
0m 20m 40m 60m 80m

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APPENDIX A



Røst lufthavn
BØF 2 (Ikke aktiv)

Interpolering for undersøkt dybde

PFOS µg/kg
3000
1000
500
150
30
3
0

Antatt kildeareal

Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.

N

0m 20m 40m 60m 80m

SEBROE 06.03.2019

Norconsult

25.1 Fire training site (BØF) / contaminated site

Fire training site (BØF) / contaminated site	BØF1 (not active)	BØF2 (old)
	Has been in use since 1998, but is no longer active. The site was established as an extraction site, and the ground consists of gravel over bedrock. In the training area there is a container (2*12 m), as well as three open rectangular vessels for use during fire training.	BØF 2 was in use from 1987 until it was closed in 1998. There are no visible installations in the area. Materials from this site should have been moved to the outer edge of the safety areas east of the runway.

25.2 The use of PFOS and other PFAS

Volume of PFOS used at the site (kg)	5	15
Comments/uncertainty	Estimated consumption from 1998 to 2001.	Estimated consumption from 1987 to 1998.
Volume of PFAS used at the site (kg)	5	Not stated/calculated
Comments/uncertainty	Estimated consumption from 2002 to 2012. Avinor phased out the use of foam with PFAS as its main component in 2012.	The site was closed before the transition to extinguishing foam with PFAS compounds other than PFOS as main components.

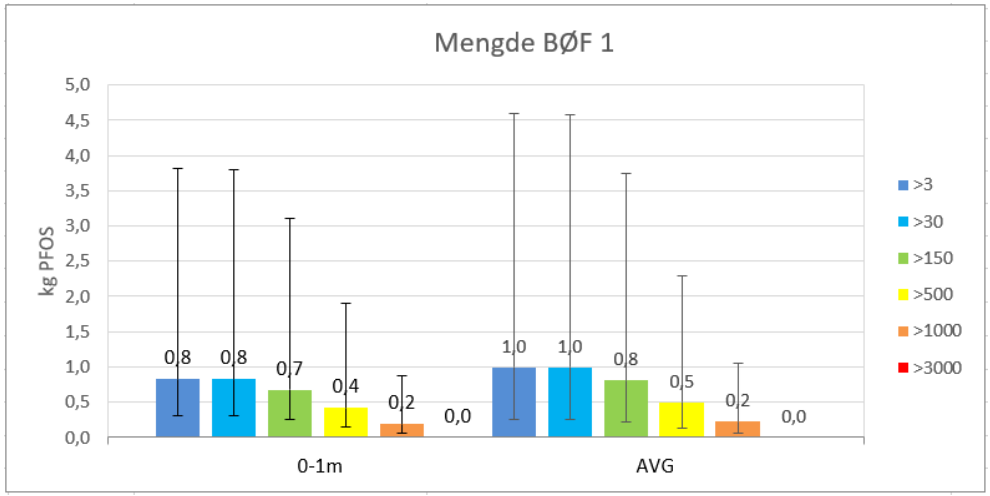
25.3 Soil sampling

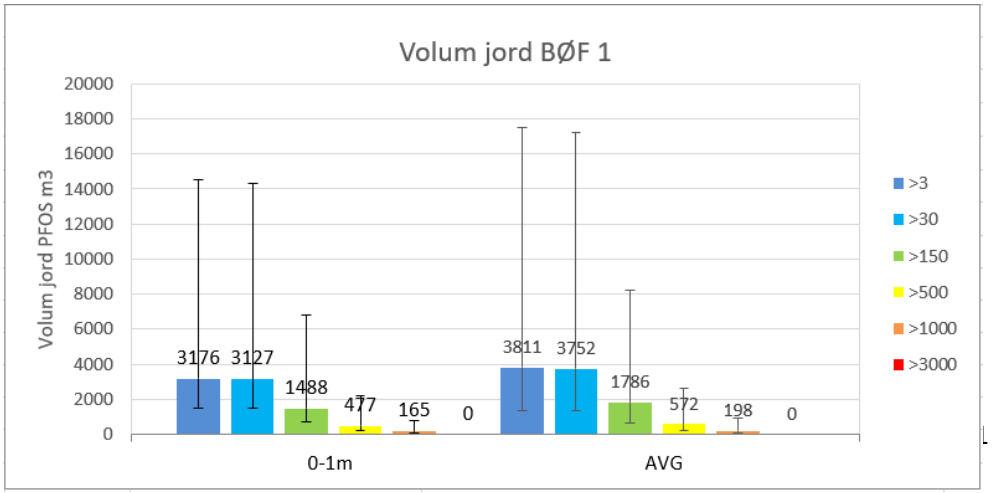
Total number of soil samples	14	6
Comments/uncertainty (for example, 95% of the samples were taken from 0–0.1 m)	Samples were taken from nine sampling points, and nine of the samples are surface samples (0–10 or 0–20 cm). At five of the points, samples were analysed at slightly deeper intervals, but there was only one sample deeper than a metre (down to 1.2 metres). The materials consists of gravel over bedrock.	All samples are of surface materials. The materials at the BØF are stated to consist of a thin gravel layer over bedrock. Samples were only taken in layers 0–10 cm as there is bedrock directly below.
Number of soil samples 0-1 m beneath the ground	14	6
Number of soil samples under 1 m	1	0
Comments/uncertainty	A total of 15 samples when splitting up samples that cover the intervals of both 0-1 metre and > 1 metre.	
Highest measured soil concentration of PFOS µg/kg	2,620	493
Where	Sj3-3 (0-0.1 m). The materials consist of sandy gravel and rock.	OV-S2-23 (0-0.1 m). The materials consist of soil.
Highest measured soil concentration of PFAS µg/kg	2,625.6	496.7

Where	Sj3-3 (0-0.1 m). The materials consist of sandy gravel and rock.	OV-S2-23 (0-0.1 m). The materials consist of soil.
Comments/uncertainty	The sample Sj3-3 was only analysed for PFOS and PFOA. 8 of the samples were only analysed for PFOS and PFOA. 6 of the samples from BØF 1 were analysed for 12 different PFAS compounds. 6:2 FTS was detected in two of the samples, and in one sample some PFHxS and PFHxA was also detected.	All samples were only analysed for PFOS and PFOA.

25.4 Volume calculation

PFOS average for all depths and points > 3 µg/kg	BØF 1	BØF 2
Concentration (µg/kg)	272	216
Area (m2)	3,176	701
Volume of soil (tonnes)	6,098	112
Volume of PFOS (kg)	1.0	0.02
Uncertainty -	0.7	0.02
Uncertainty +	3.6	0.2
PFOS average for all depths and points > 30 µg/kg		
Concentration (µg/kg)	276	223
Area (m2)	3,127	669
Volume of soil (tonnes)	6,004	107
Volume of PFOS (kg)	1.0	0.02
Uncertainty -	0.7	0.02
Uncertainty +	3.6	0.2
PFOS average for all depths and points > 150 µg/kg		
Concentration (µg/kg)	474	319
Area (m2)	1,488	399
Volume of soil (tonnes)	2,857	64
Volume of PFOS (kg)	0.8	0.02
Uncertainty -	0.6	0.01
Uncertainty +	2.9	0.2
PFOS average for all depths and points > 500 µg/kg		





Concentration (µg/kg)	906	
Area (m2)	477	
Volume of soil (tonnes)	916	
Volume of PFOS (kg)	0.5	
Uncertainty -	0.4	
Uncertainty +	1.8	
PFOS average for all depths and points > 1,000 µg/kg		
Concentration (µg/kg)	1,195	
Area (m2)	165	
Volume of soil (tonnes)	317	
Volume of PFOS (kg)	0.2	
Uncertainty -	0.2	
Uncertainty +	0.8	
PFOS average for all depths and points > 3,000 µg/kg		
Concentration (µg/kg)		
Area (m2)		
Volume of soil (tonnes)		
Volume of PFOS (kg)		
Uncertainty -		
Uncertainty +		

Fire training site (BØF) / contaminated site	BØF1 (not active)	BØF2 (old)
Comments regarding calculations	The risk assessment assumes that the contaminated area covers an area of 3,500-5,000 m2. It is assumed that the thickness of the contaminated materials is 1 ± 0.2 m, and that the average concentration of PFOS in this area is 213 µg/kg. This gives a residue of PFOS at BØF 1 of 1 ± 0.5 kg. This is quite consistent with the calculation from 2019, where it is estimated that approximately 1 kg of PFOS remains within the surveyed volume at BØF 1. The volume surveyed	The risk assessment assumes that the contaminated area has an area of 1,500-3,000 m2. It is assumed that the thickness of the contaminated materials is 0.2 ± 0.1 m, and that the average concentration of PFOS in this area is 213 µg/kg. This gives a residue of PFOS at BØF 2 of 0.2 ± 0.1 kg. The calculation from 2019 calculates that 0.02 kg of PFOS remain in the area surveyed at BØF 2. The

	has an area of approximately 3,200 m2 and depth of 1.2 metres. However, the area is not very delimitated, and the amount of PFOS including positive uncertainty (within the estimated source area of about 14,500 m2) is calculated at 4.6 kg.	area examined is approximately 700 m2, and samples have been taken down to a depth of 0.1 metres. However, the area is not very delimitated, but there is a thin deposit cover in the area. The amount of PFOS including positive uncertainty (within the estimated source area of about 2,900 m2) is calculated at 0.3 kg.
Is the extent of the contaminated area delimitated horizontally?	No, concentrations of PFOS above 3 g/kg have been detected at all extreme points. Concentrations at the extreme points to the southwest (surface sample OV-120-S-14) are the lowest, at 10.6 µg/kg. The contamination appears to be least delimitated in the northeast and east directions. At the extreme points to the northeast (surface sample in sj7) and to the east (surface samples SJ1 and SJ2) there are concentrations between 160 and 186 µg/kg. The extreme point to the southeast (surface test SJ8) has a concentration of 59.8 µg/kg.	No, concentrations above 3 µg/kg have been detected at all extreme points. The concentrations at the extreme points to the north and northeast (OV-V and OV-N) are between 72.3 and 102 µg/kg. Contamination appears to be least delimitated in the southwestern direction, and the extreme point to the southwest (OV-S2) has a concentration of 493 µg/kg.
Is the extent of the contaminated area delimitated vertically?	No. The highest concentrations have been detected in materials from a depth of 0-45 cm. Concentrations have been detected above the detection limit in three of the deepest samples (30-90 cm deep), the concentrations are below 30 µg/kg. PFOS was not detected in the deepest sample (120 cm deep).	Yes, bedrock is stated to be directly below the depth surveyed (0.1 metres).
Comments/uncertainty	Groundwater is stated to be between 20-90 cm below terrain. It is believed that concentrations of PFOS will decrease rapidly with depth below groundwater level due to horizontal transport.	

25.5 Water sampling and annual dispersion

Fire training site (BØF) / contaminated site	BØF1 (not active)	BØF2 (old)
Have water samples been taken?	Yes. Most of the water samples, with the exception of two (V1 and V2), were taken relatively far from both the BØFs, therefore a common description of water sampling has been created for BØF 1 and BØF 2. V1 and V2 were taken near BØF 1.	Water samples were taken at the airport but not samples representative for BØF 2. See BØF 1 for descriptions of water samples.

Where	Two samples of seawater were taken outside BØF 1. Groundwater samples have also been taken from 4 wells (B1-B4) east of the southern part of the runway. The wells are located between the runway and the drinking water source Badevannet. Samples of surface water have been taken from a stream in the area between the runway and the drinking water source. In addition, samples of the drinking water source have been taken.	Two samples of seawater were taken outside BØF 1. Groundwater samples have also been taken from 4 wells east of the southern part of the runway. The wells are located between the runway and the drinking water source Badevannet. Samples of surface water have been taken from a stream in the area between the runway and the drinking water source. In addition, samples of the drinking water source have been taken.
Highest measured concentration of PFOS in groundwater (ng/l)	13	
Where	B1 (11-10-2011), located southeast of the terminal area.	
Highest measured concentration of PFAS in groundwater (ng/l)	13	
Where	B1 (11-10-2011), located southeast of the terminal area.	
Comments/uncertainty	Sample B1, which was tested on 11.10.11, was only analysed for PFOS and PFOA. No PFOA was detected in the sample. Samples were taken from all groundwater wells on 24.5.12. These samples were analysed for 12 PFAS compounds. No compounds other than PFOS were detected in any of the samples.	
Highest measured concentration of PFOS in surface water (ng/l)	601	
Where	Sjøvann V2 (24-05-2012)	
Highest measured concentration of PFAS in surface water (ng/l)	803	
Where	Sjøvann V2 (24-05-2012)	
Comments/uncertainty	Sample V2 was analysed for 12 PFAS compounds. PFOS is the predominant compound in the sample, but PFHxS, PFHxA, PFHpA, PFOA and PFPeA were also detected. In the samples of surface water taken from the stream and drinking water source southeast of the airport, no PFOS or other PFAS was detected.	
Total annual dispersion of PFOS from the site (g/year)	5-19 g (from the DP2 report). Not calculated in the risk assessment.	0.63 g (from the DP2 report) Not calculated in the risk assessment.

Total annual dispersion of PFAS from the site (g/year)	Not calculated	Not calculated
To which recipient	Sea, Røsthavet, and possibly Røstlandet Nature Reserve	Røsthavet
Calculated from water or soil concentration.	Calculated concentrations of PFOS in groundwater based on average soil concentrations and a kd of 10.	Calculated concentrations of PFOS in groundwater based on average soil concentrations and a kd of 10.

25.6 Biota sampling

Fire training site (BØF) / contaminated site	BØF1 (not active)	BØF2 (old)
Have biota samples being taken at the airport?	Yes, biota samples have been taken in an area east of BØF 1, where it is assumed that there is run-off from BØF 1.	Yes, but biota samples have only been taken in an area where it is assumed that there is run-off from BØF 1. See BØF 1 for details.
What kind of biota?	Periwinkle and lugworm.	
How many samples?	2	
Highest measured concentration of PFOS in biota (µg/kg wet weight)	55	
Where	Periwinkle, composite sample of whole individuals, n > 15	
Highest measured concentration of PFAS in biota (µg/kg wet weight)	55	
Where	Periwinkle, composite sample of whole individuals, n > 11	
Median concentration in comparable populations (e.g. in a lake)	In connection with surveys in Grandefjæra outside Ørland airbase, samples of periwinkle were taken from four stations. Three of the sampling stations are located in Grandevika outside the airport, and one at Innstrandsfjæra (reference station). The samples were analysed for PFAS. Concentrations of PFAS in the periwinkle ranged between 15.3-0.074 µg/kg wet weight at the four stations. The lowest concentration was detected at the reference station (0.074 µg/kg). Reference: Redegjørelse for miljøtilstanden i Grandefjæra ved Ørland flystasjon (An account of the environmental status in Grandefjæra at Ørland Air Station), report l.nr. 7221-2017, Niva. Dated 20.12.17	
Comments/references	The biota samples at Røst Airport were analysed for 14 PFAS compounds. Only PFOS was detected in the periwinkle sample. Some PFHxS was also detected in the lugworm sample.	
References and concentrations in other reports.	The EQS value in the Water Regulations for PFOS in biota is 9.1 µg/kg wet weight. In a risk assessment from 13 December 2018, EFSA changed the tolerability limit (TDI -	

	tolerable daily intake) for PFOS and PFOA, so these are now far lower than the TDI values set in 2008. This may cause EQS for biota to also be lower in the future.	

25.7 Uncertainty and other factors

Fire training site (BØF) / contaminated site	BØF1 (not active)	BØF2 (old)
Does the estimate of the volume of PFOS in the ground correspond with the measured concentrations in water and biota?	Cannot be reliably evaluated for water or biota.	Cannot be evaluated, as no water samples or biota samples have been taken at the site.

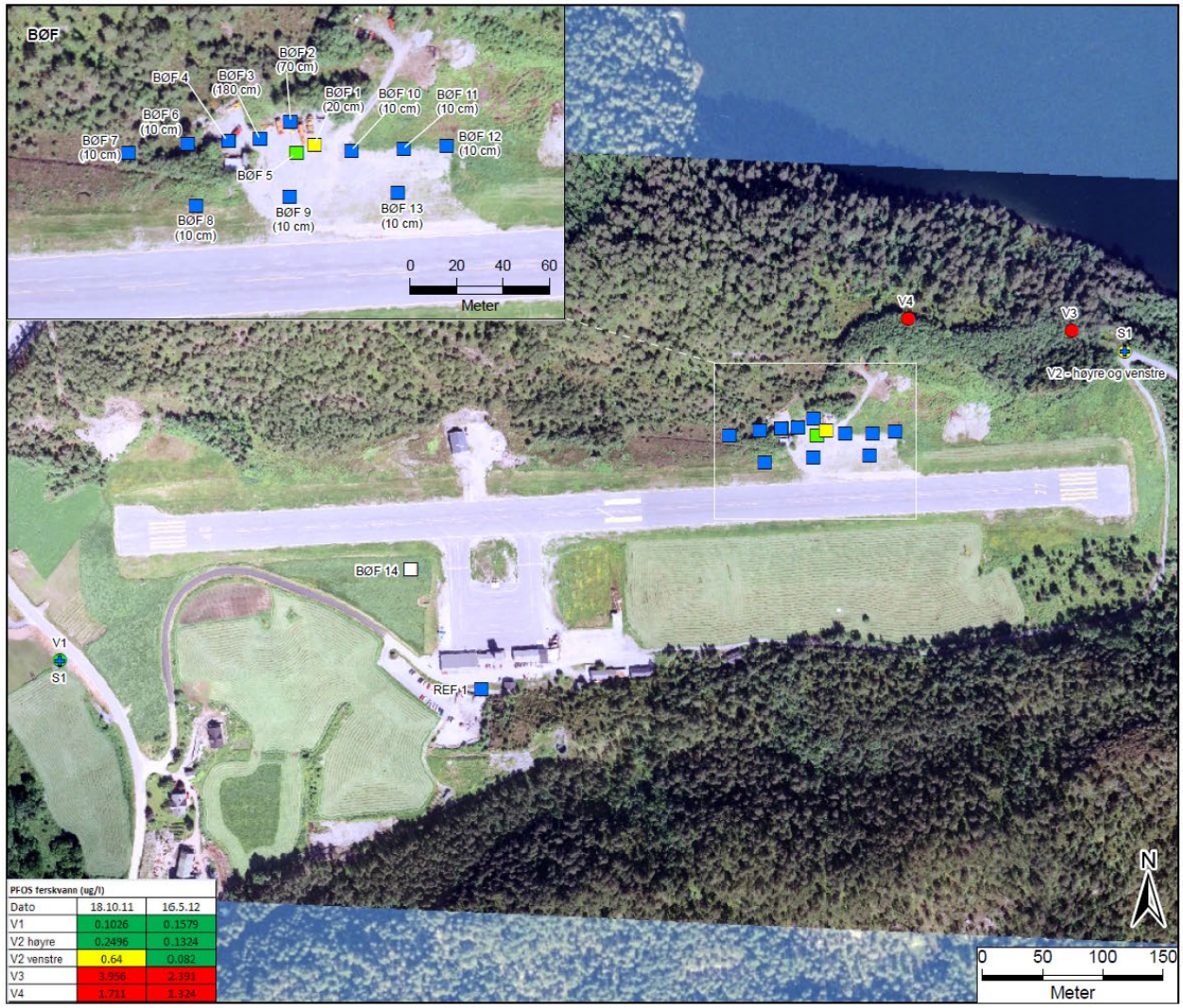
Evaluations	Moderate concentrations of PFOS/PFAS have been detected in the soil samples at BØF 1. PFOS is the predominant PFAS compound in the materials, but 6:2 FTS, PFHxS, PFHxA, and PFPeA have also been detected in low concentrations (in two out of six samples analysed). The points where the highest concentration of PFAS was detected lies in the central part of the fire training site. Relatively high concentrations of PFOS/PFAS were detected in the water samples (V2) taken at sea outside BØF 1. PFOS is the predominant compound in the water sample, but PFHxS, PFHxA, PFHpA and PFPeA were also detected. In sample V1, no PFOS/PFAS was detected. Relatively high concentrations of PFOS were detected in the beach biota, but only two samples have been analysed, and of different species. PFHxS was detected in one of the two beach biota samples. Samples of beach biota were taken in the same area as water sample V2. It is estimated that about 5 kg of PFOS and 5 kg of PFAS (this foam also contains some PFOS) were used at BØF 1, and between approximately 1-4.6 kg of PFOS remains. This shows that a lot of potential has already been washed out/leached to the recipient. The materials at BØF 1 are characterised as sandy gravel. This type of materials has good hydraulic conductivity, so PFOS is likely to sink into the ground and leach out with groundwater. There is also a relatively high groundwater level (0.6-1 metres) in the BØF area.	
Comments/uncertainty: (Could there be any additional unknown sources of PFOS at the site with run-off to the recipient?)	Materials from the old fire training site (BØF 2) should have been moved to the outer edge of the eastern safety areas (runway 21). Besides these relocated materials, there are no other known sources of PFAS contamination at the airport, so PFAS contamination in locations unrelated to the fire training sites is believed to come from diffuse sources such as runoff from cars used during exercises, from unloading and refilling of	See BØF 1 for descriptions.

	foam, foam cannon sight adjustment, testing equipment, washing cars and equipment. Soil samples have been taken at four points south of the terminal area and east of the runway. Only PFAS (PFOS) was detected in the soil sample taken closest to the terminal area, Sj 9. The sample from a depth of 0-80 cm had a concentration of 16.4 µg/kg PFOS. PFAS, in low concentrations (5.6 to 13 ng/l) was detected in water samples from four wells (B1, B2, B3 and B4) from the same area. The highest concentrations are in the wells along the east side of the runway (B1, B2 and B3). Wells B1 and B2 are those closest to the drinking water source Badetjønna south of the airport. PFAS/PFOS have not been detected in two samples (taken in 2011 and 2012) from a stream in this area, nor in two samples (taken in 2011 and 2012) of drinking water. PFOS concentrations detected in soil and groundwater southeast of the terminal area may be related to materials from BØF 2 that was moved to the outer edge of the eastern safety areas (the location of these areas is not described in more detail), and possibly activities in the operating area or in the area east of the runway.	
Has the site been sufficiently mapped with a view to assessing the order of prioritisation?	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the volume of PFOS in the soil with the stipulated level of uncertainty.	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the volume of PFOS in the soil with the stipulated level of uncertainty. It is calculated that between 20 and 300 g PFOS remains at the site. The site will therefore not be prioritised for measures based on a cost/benefit perspective (ref. this report for parts 1 and 2, chap. 2.1.1.6 and chapter 2.1.3.1).
Comments/uncertainty	The site was established as an extraction site, and aerial photos show that changes to the terrain were made between 2004 and 2009. It is uncertain what was done, and whether	Materials from the old fire training site should have been moved to the outer edge of the eastern safety areas (runway 21). In addition, the materials here are slippery and has good hydraulic conductivity. These

	materials were removed from the area during the time it was used as a fire training site.	are conditions that cause PFOS to quickly leach out to sea.
General information about the airport		
Other factors of significance for any clean-up/initiation of measures (for example, planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	Røst Airport borders Røstlandet nature reserve, located southwest of the airport. Røstlandet nature reserve is a protected wetland area, and consists of an open marsh and shallow water area. There is a very rich and varied bird and plant life in the reserve, and many species of high and especially high management interest are registered in the area. In addition, one of Røst's three freshwater ponds is located here. In the sea outside the airport there are porpoises, whales, seals and a variety of fish species. Several important habitats have also been recorded in the area such as sea meadow and mudflats, natural pastures and wetland mudflats. The whole of Røst and the surrounding island areas are registered as a selected cultural landscape. The drinking water source for Røst is located southeast of the airport. There are some old drainage trenches between the side areas of the airport and the drinking water source. The airport is registered with Avinor's vulnerability class 3, which means vulnerable recipients, highest priority and highest level at the facility.	

Norconsult

Sandane Airport, Anda



Sandane lufthavn
Anda (ENSD)

Oversiktskart

PFOS grunnvannsbrønn (ug/l)
- <0.002-0.3
- 0.3-1.0
- >1.0
- Ikke analysert

PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

PFOS sediment ferskvann (ug/kg)
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

PFOS ferskvann (ug/l)
- <0.002-0.3
- 0.3-1.0
- >1.0
- Ikke analysert

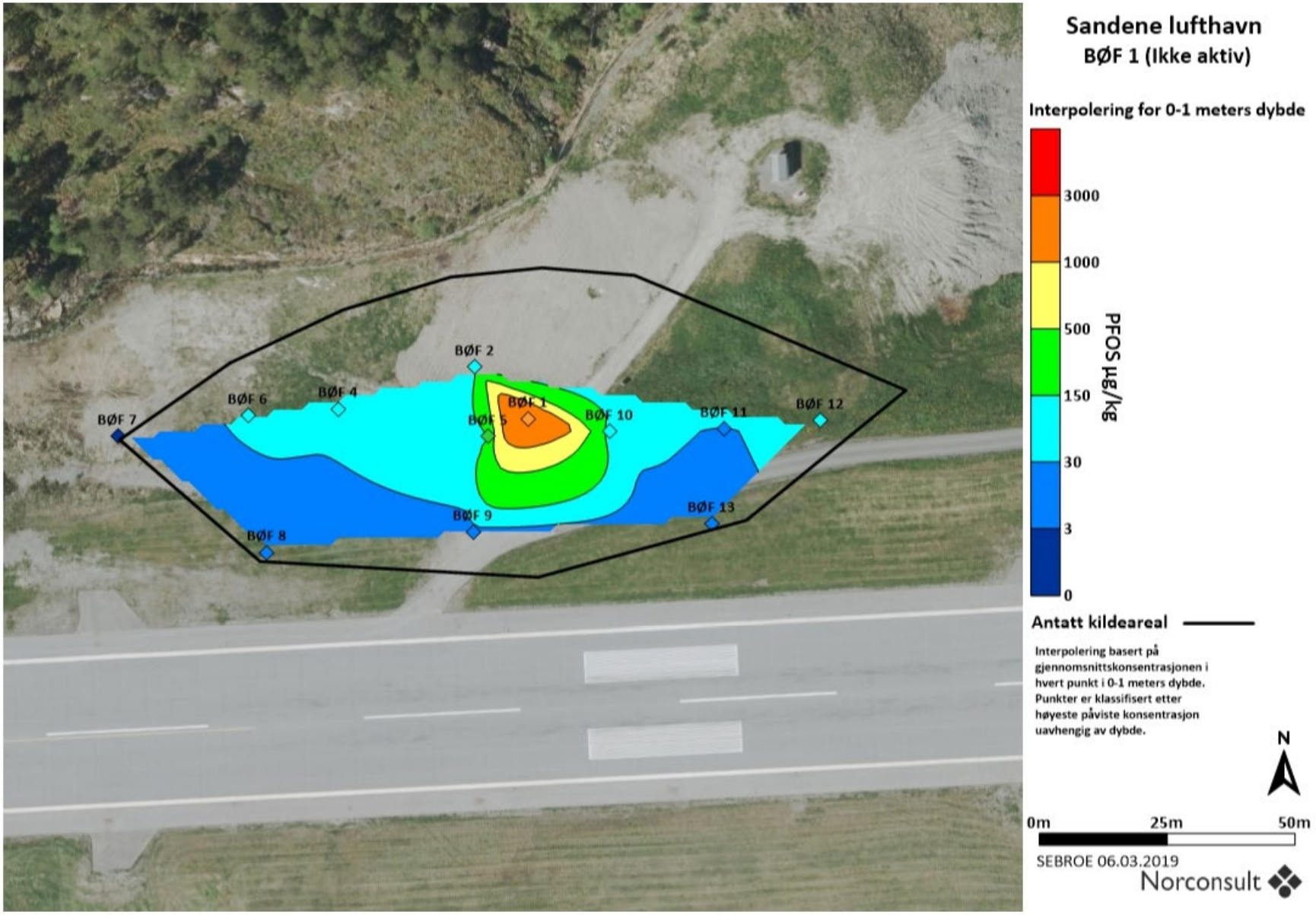
* PFOS er dominerende parameter

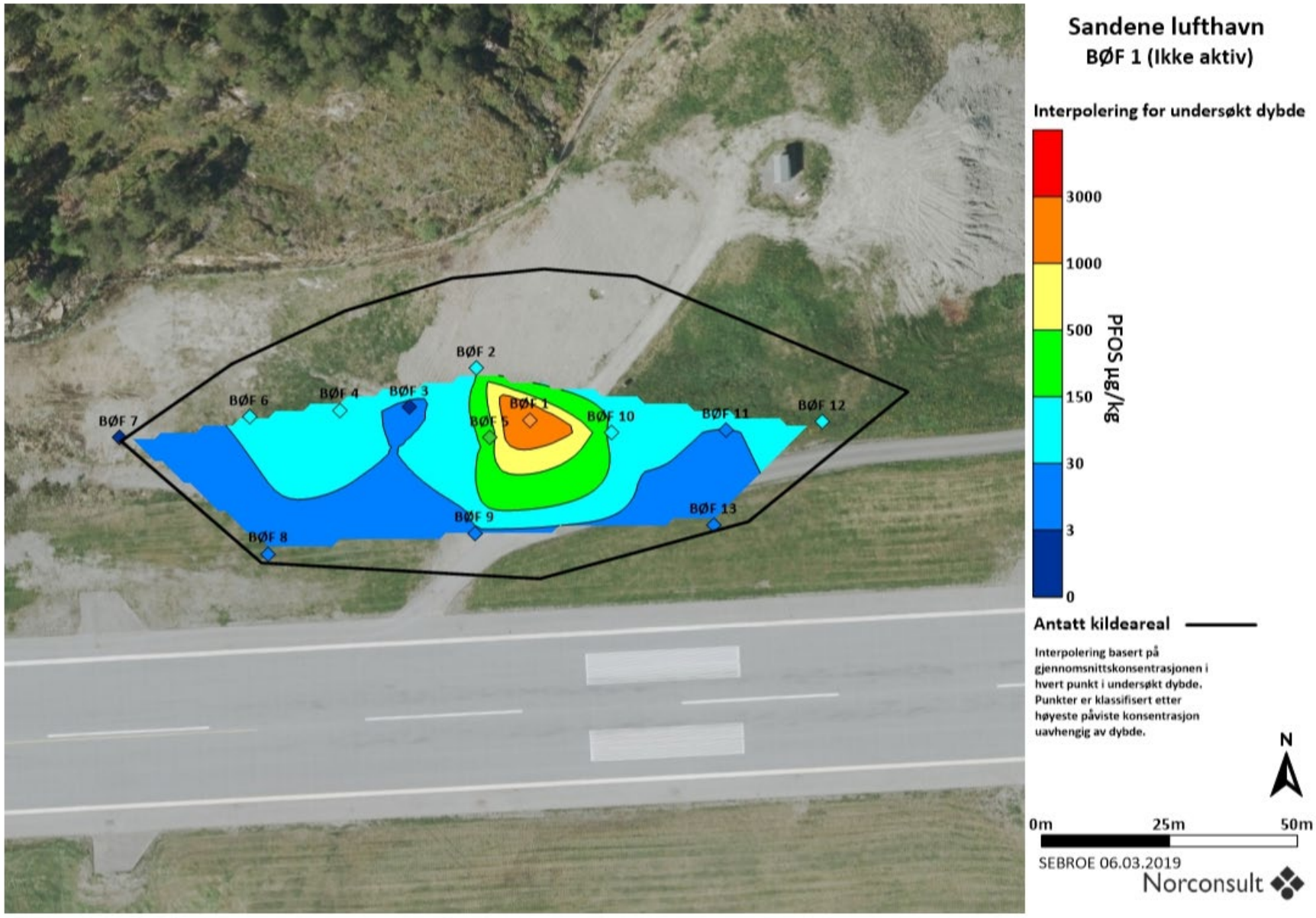
ip = ikke påvist

AVINOR COWI SWECO

Norconsult

APPENDIX A




Sandene lufthavn
BØF 1 (Ikke aktiv)
Interpolering for undersøkt dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m
25m
50m
SEBROE 06.03.2019
Norconsult
BØF 1
BØF 2
BØF 3
BØF 4
BØF 5
BØF 6
BØF 7
BØF 8
BØF 9
BØF 10
BØF 11
BØF 12
BØF 13

26.1 Fire training site (BØF) / contaminated site

Fire training site (BØF) / contaminated site	**BØF 1 (old, not active)**
	The fire training site is no longer in use. It is registered in the ground contamination database with impact level 2. It is not stated when it was established or when it was taken out of use, but it is stated that the site was closed before PFOS was phased out of firefighting foam, which was in 2001. According to a report from the feasibility study for the DP2 project (appendix to the DP2 report), the field should have been used twice a year for a period of 15-20 years. Normal exercise procedure was to fill a tank or car wreck with 20-30 litres of diesel, and then ignite. The fire was extinguished with powder and/or foam. The report states that the BØF has no dense cover, and that it must therefore be assumed that all PFOS from foam and burnt diesel has gone straight into the ground.

26.2 The use of PFOS and other PFAS

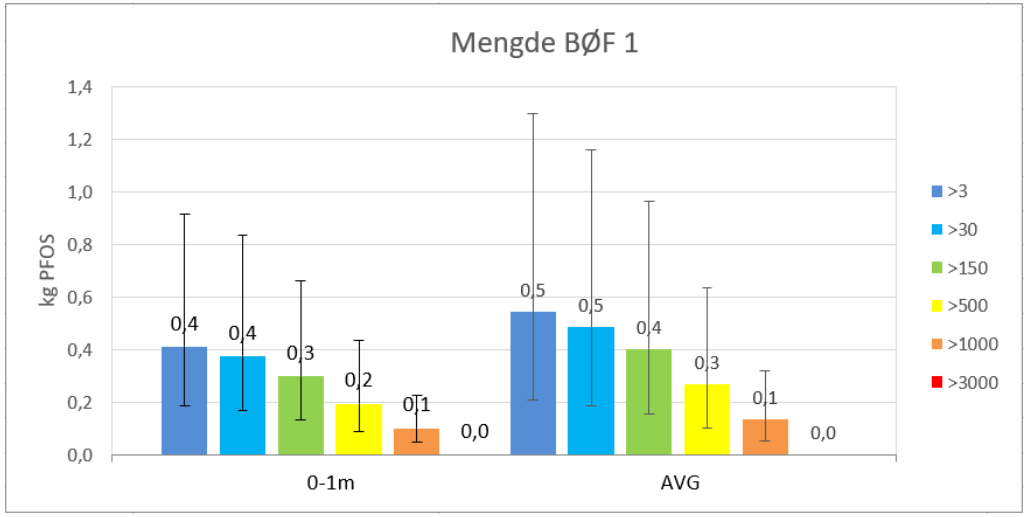
Volume of PFOS used at the site (kg)	Not stated/calculated
Comments/uncertainty	
Volume of PFAS used at the site (kg)	Not stated/calculated
Comments/uncertainty	

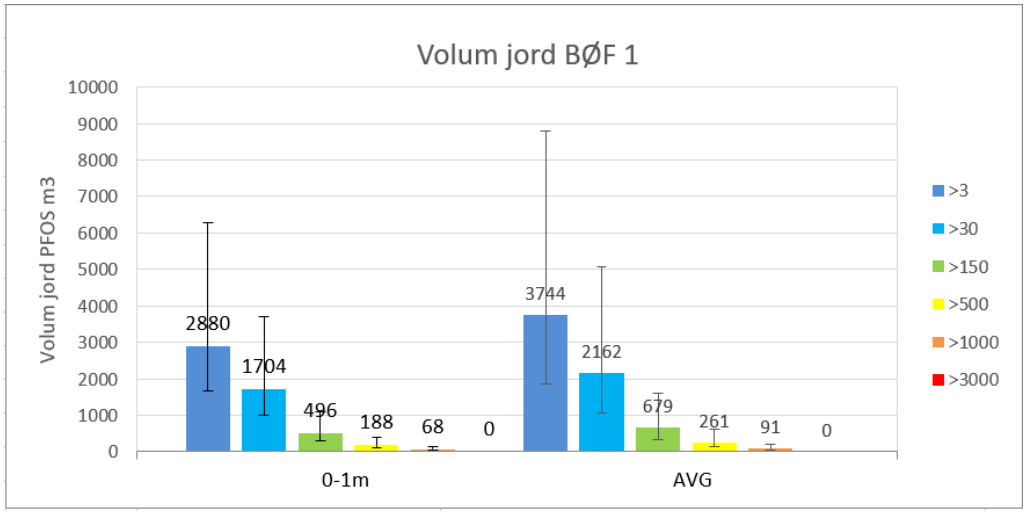
26.3 Soil sampling

Total number of soil samples	17
Comments/uncertainty (for example, 95% of the samples were taken from 0–0.1 m)	11 of the 17 samples (approximately 65%) are surface samples that were taken at a depth of 10-20 cm deep.
Number of soil samples 0-1 m beneath the ground	14
Number of soil samples under 1 m	4
Comments/uncertainty	A total of 18 soil samples when splitting up samples in the intervals of 0-1 m and > 1 m. The materials are described as rock and gravel,
Highest measured soil concentration of PFOS µg/kg	2,480
Where	BØF 1-1 (20 cm). The materials consist of rock and gravel. Groundwater at 20 cm.
Highest measured soil concentration of PFAS µg/kg	2,485
Where	BØF 1-1 (20 cm). The materials consist of rock and gravel. Groundwater at 20 cm.
Comments/uncertainty	All soil samples were only analysed for PFOS and PFOA.

26.4 Volume calculation

PFOS average for all depths and points > 3 µg/kg	
Concentration (µg/kg)	142
Area (m2)	2,880
Volume of soil (tonnes)	6,365
Volume of PFOS (kg)	0.5
Uncertainty -	0.3
Uncertainty +	0.8
PFOS average for all depths and points > 30 µg/kg	
Concentration (µg/kg)	220
Area (m2)	1,663
Volume of soil (tonnes)	3,675
Volume of PFOS (kg)	0.5
Uncertainty -	0.3
Uncertainty +	0.7
PFOS average for all depths and points > 150 µg/kg	
Concentration (µg/kg)	582
Area (m2)	522
Volume of soil (tonnes)	1,154
Volume of PFOS (kg)	0.4
Uncertainty -	0.2
Uncertainty +	0.6
PFOS average for all depths and points > 500 µg/kg	
Concentration (µg/kg)	999
Area (m2)	201
Volume of soil (tonnes)	444
Volume of PFOS (kg)	0.3
Uncertainty -	0.2
Uncertainty +	0.4





PFOS average for all depths and points > 1,000 µg/kg	
Concentration (µg/kg)	1,443
Area (m2)	70
Volume of soil (tonnes)	155
Volume of PFOS (kg)	0.1
Uncertainty -	0.1
Uncertainty +	0.2
PFOS average for all depths and points > 3,000 µg/kg	
Concentration (µg/kg)	
Area (m2)	
Volume of soil (tonnes)	
Volume of PFOS (kg)	
Uncertainty -	
Uncertainty +	

Comments regarding calculations of volume	In the DP2 report, it is calculated that 128 g of PFOS and 0.35 g of PFOA remain. It is thus assumed that the contaminated area is within an area of 20x10 metres, and that the thickness of the contaminated materials is 30 cm. In the calculations, an average concentration in the materials of 1,335 µg/kg PFOS (based on two samples) has been used. The calculated volume in 2019 (0.5 kg) is greater than the calculated amount in the DP2 report. In DP2, this was based on an area ten times smaller and that the contamination only reached 0.3 metres. However, a much higher average concentration of 1,335 µg/kg was calculated.
Is the extent of the contaminated area delimitated horizontally?	No, PFOS below the detection limit was only detected at one extreme point to the west (BØF 7). The extreme points located towards the runway (BØF 8, 9 and 13) have relatively low concentrations of PFOS, between 3.1 and 14.1 µg/kg. Concentrations between 37.8 and 81.4 µg/kg have been detected at the extreme points to the north and west (BØF 2, 6 and 12). Contamination is least delimitated in a northerly direction (BØF 2).
Is the extent of the contaminated area delimitated vertically?	No. The shafts (BØF 1 to BØF 5) have been sampled down to groundwater level. In all of these shafts, except at BØF 3, concentrations of PFOS above the detection limit at groundwater level have been detected. In sjakt BØF 1, a concentration of 2,480 µg/kg has been detected at groundwater level. PFOS concentrations have been detected above the detection limit in most surface samples (BØF 6-BØF13). However, it is uncertain how deep the contamination extends, as only surface samples have been taken at these points.
Comments/uncertainty	In the appendix to the DP2 report (Norconsult report dated 20.6.2011; Miljøprosjektet delprosjekt 2 - Forundersøkelse av Sandane lufthavn Anda(Environmental project sub-project 2 - Preliminary study of Sandane Airport Anda)), drawings and maps show that the BØF is located further northeast of the site that was surveyed and reported in 2012. The site investigated as the BØF is described in the 2011 report as an area for fuel facility vehicles and an area where diesel spills have occurred.

26.5 Water sampling and annual dispersion

Have water samples been taken?	Yes, samples of surface water.
Where	In the stream west of the airport, wastewater as well as leaching water at the BØF, a manhole west of the airport, as well as in the stream below the northeast corner of the landing strip.
Highest measured concentration of PFOS in groundwater (ng/l)	-
Where	
Highest measured concentration of PFAS in groundwater (ng/l)	-
Where	
Comments/uncertainty	
Highest measured concentration of PFOS in surface water (ng/l)	3,780
Where	V 3 Leaching water north of BØF1 (18.10.11)
Highest measured concentration of PFAS in surface water (ng/l)	4,900
Where	V 3 Leaching water north of BØF1 (16.05.12)
Comments/uncertainty	A total of 12 water samples have been taken from 7 points around the BØF. Seven of the samples have been analysed for PFOS and PFOA, while 5 of the samples have been analysed for PFOS, PFOA, 6:2 FTS and total PFC (it is possible they have been analysed for additional PFAS compounds, but the analysis reports are not available in the report). Analysis for PFAS was not carried out in sample V3 taken 18.10.11. This sample shows higher concentrations of both PFOS and PFOA than sample V3 taken on 16.5.12, and therefore it cannot be ruled out that this sample would have provided the highest PFAS concentration if the sample was analysed for multiple PFAS compounds.
Total annual dispersion of PFOS from the site (g/year)	13.64
Total annual dispersion of PFAS from the site (g/year)	27.03

To which recipient	All rainfall on dense surfaces will be carried by surface runoff to the drainage system alongside the runway or infiltrated to groundwater flowing to Gloppenfjorden (west) and Nordfjorden (east) respectively. The main part of the chemically-impacted runoff (central area, snow storage and western half of the runway) is collected in a small outlet stream to the west. This runs into a culvert all the way up to about 150 metres before the outlet to the sea, where it joins another, larger watercourse. The stream has a relatively steep fall to the sea. Leaching water from the fire training site is most likely collected in an open stream that runs northeast of the airport area with an outlet to Nordfjorden.
Calculated from water or soil concentration.	Water concentration

26.6 Biota sampling

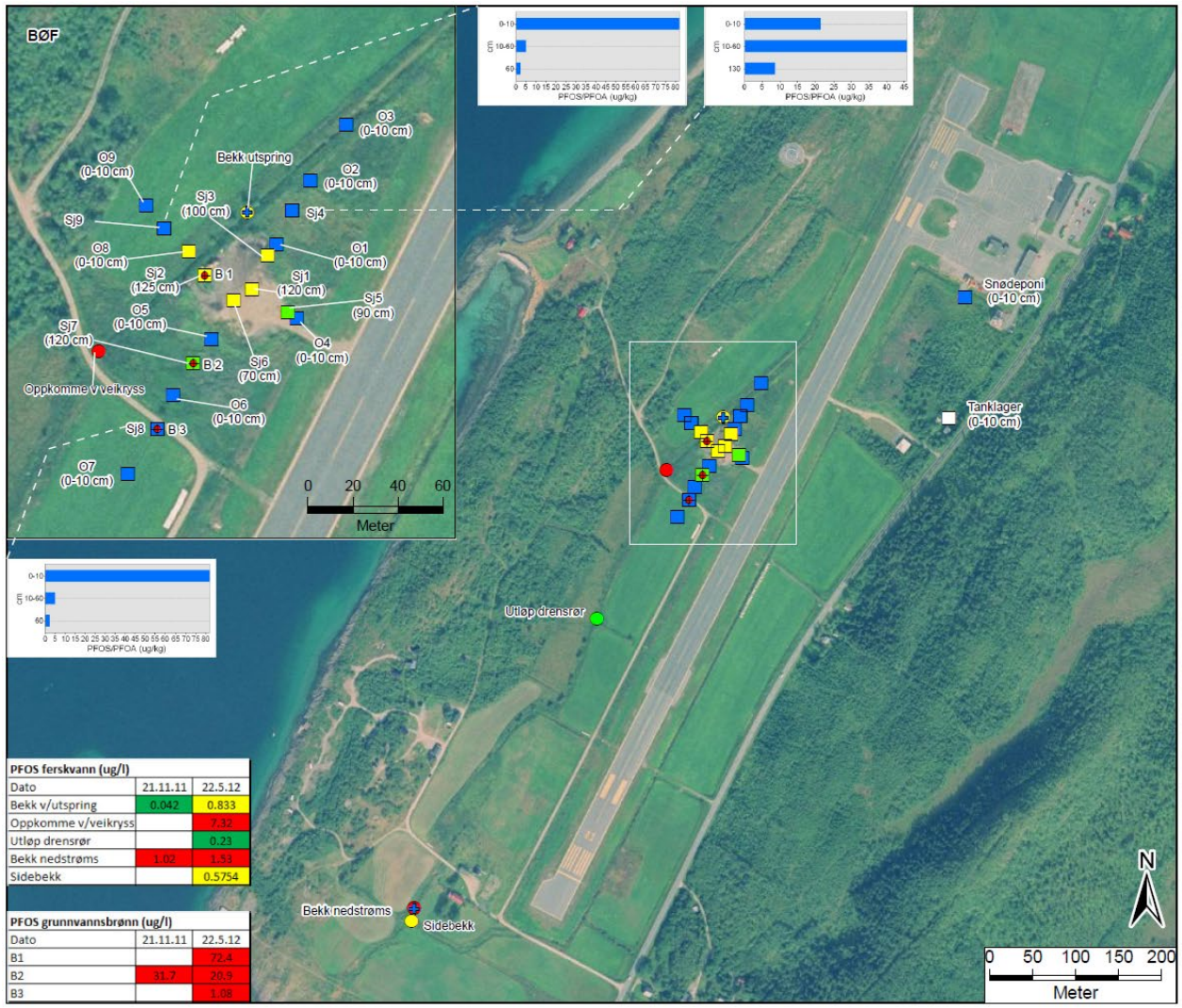
Have biota samples being taken at the airport?	No
What kind of biota?	
How many samples?	
Highest measured concentration of PFOS in biota (µg/kg wet weight)	
Where	
Highest measured concentration of PFAS in biota (µg/kg wet weight)	
Where	
Median concentration in comparable populations (e.g. in a lake)	
Comments/references	
References and concentrations in other reports.	

26.7 Uncertainty and other factors

Does the estimate of the volume of PFOS in the ground correspond with the measured concentrations in water and biota?	Cannot be evaluated for biota, as no biota samples have been taken. It is uncertain whether the BØF has actually been surveyed, as reference is made to another location in the appendix to the DP2 report (Norconsult report dated 20.6.2011; Miljøprosjektet delprosjekt 2 - Forundersøkelse av Sandane lufthavn Anda (Environmental project sub-project 2 - Preliminary study of Sandane Airport Anda)) (figure 2 and figure 9)). Since there are relatively high concentrations of PFOS and PFAS in leaching water and streams downstream of the BØF this may also indicate that not all contamination in the soil has been detected.
Evaluations	Except for the top materials at sampling point BØF 1 and sampling point BØF 5, relatively low concentrations of PFOS have been detected in the materials (below 90 µg/kg). No samples of groundwater have been taken beneath the BØF. The samples taken from leaching water and streams north and east of the BØF (V3, V4 and S2) show relatively high concentrations of PFOS (1,200-3,780 ng/l) and PFAS (3,790-4,900 ng/l). It is uncertain whether the soil surveys were carried out in the area of the old BØF; as previously described reference is made to a different location in a 2011 report than that surveyed in 2012. Aerial photos from 2002 show what could appear to be a burnt bus wreck just northeast of the site surveyed. Aerial photos from 2015 and 2017 show that terrain changes have been made in the area and that a small building has been built in the area where the alleged burnt out bus stood. The highest concentrations in water samples are from sampling points V3 and S2 which are in the stream east of both of these locations. In the likely direction of groundwater flow. Sampling point V4 is located north of both locations and has somewhat lower concentrations, which may be due to a slight elevation in the terrain between the BØF area and V4. PFOA above the detection limit has only been detected in two of the soil samples (BØF1-1 and BØF5-2). PFOA, on the other hand, has been detected in all water samples, with the exception of a water sample taken west of the airport. No soil samples have been analysed for anything other than PFOS and PFOA, and the analysis report for the water samples analysed for PFAS compounds other than PFOS and PFOA is not included in the DP2 report. It is therefore difficult to compare whether there is the same type of PFAS compounds in soil and water. The concentrations in the estimated wastewater for the area, taken to the east, show lower concentrations (97.6-232 ng/l). The DP2 report does not specify what this water is or where it comes from, but it can be surface water from the eastern half of the runway which is led via a pipe to the same stream as the water from the BØF described in the 2011 report.
Comments/uncertainty: (Could there be any additional unknown sources of PFOS at the site with run-off to the recipient?)	In 2011, a water sample (S1) was taken in a manhole located west of the airport. A PFOS concentration of 772 ng/l was detected here. It is stated that runoff water from the aircraft de-icing area, western half of the runway and a large part of the snow depot will be directed towards the stream where the water sample was taken. As this stream collects runoff from a larger area, it is difficult to say what the source of PFOS is in the water sample taken from here. One possibility is that snow containing PFOS from the BØF was placed on the snow depot, and that this is the source of PFOS in the water sample.

Has the site been sufficiently mapped with a view to assessing the order of prioritisation?	No, it is uncertain whether the actual area of the BØF has been surveyed. The site is considered to be inadequately surveyed (see this report for parts 1 and 2, chapter 2.1.1.6 and chapter 2.1.3.1).
Comments/uncertainty	It must be determined whether soil samples were taken in the actual area of the BØF. Samples of groundwater beneath and downstream of the BØF should also be sampled to investigate the degree of contamination here. It is now uncertain whether there is another area used as a BØF, and which is the cause of the relatively high concentrations of PFOS in the stream to the east.
Other factors of significance for any clean-up/initiation of measures (for example, planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	Nordfjord is classified as salmon fjord with edible salmon as aquaculture. The fjord is also a feeding area for herring breeding in the spring as well as a dispersion area for coastal cod. Otherwise, no protected areas are registered in the vicinity of the airport. In Naturebase it can be seen that several species of high and especially high management interest have been registered in Gloppenfjord and Nordfjord. In addition, plants of especially high management interest are registered right next to the airport (west). Several cultural monuments have been registered around the airport, especially in the area at the western end of the runway. In the area surveyed, THC in environmental condition class 2 has been detected in five soil samples.

27 Sandnessjøen Airport, Stokka



PFOS ferskvann (ug/l)

Dato	21.11.11	22.5.12
Bekk v/utspring	0.042	0.833
Oppkomme v/veikryss		7.32
Utløp drensrør		0.23
Bekk nedstrøms	1.02	1.53
Sidebekk		0.5754

PFOS grunnvannsbrønn (ug/l)

Dato	21.11.11	22.5.12
B1		72.4
B2	31.7	20.9
B3		1.08

Sandnessjøen lufthavn Stokka (ENST)

Oversiktskart inkl. brannøvingsfelt

PFOS grunnvannsbrønn (ug/l)
- <0.002-0.3
- 0.3-1.0
- >1.0
- Ikke analysert

PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

PFOS/PFOA sediment ferskvann (ug/kg)
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

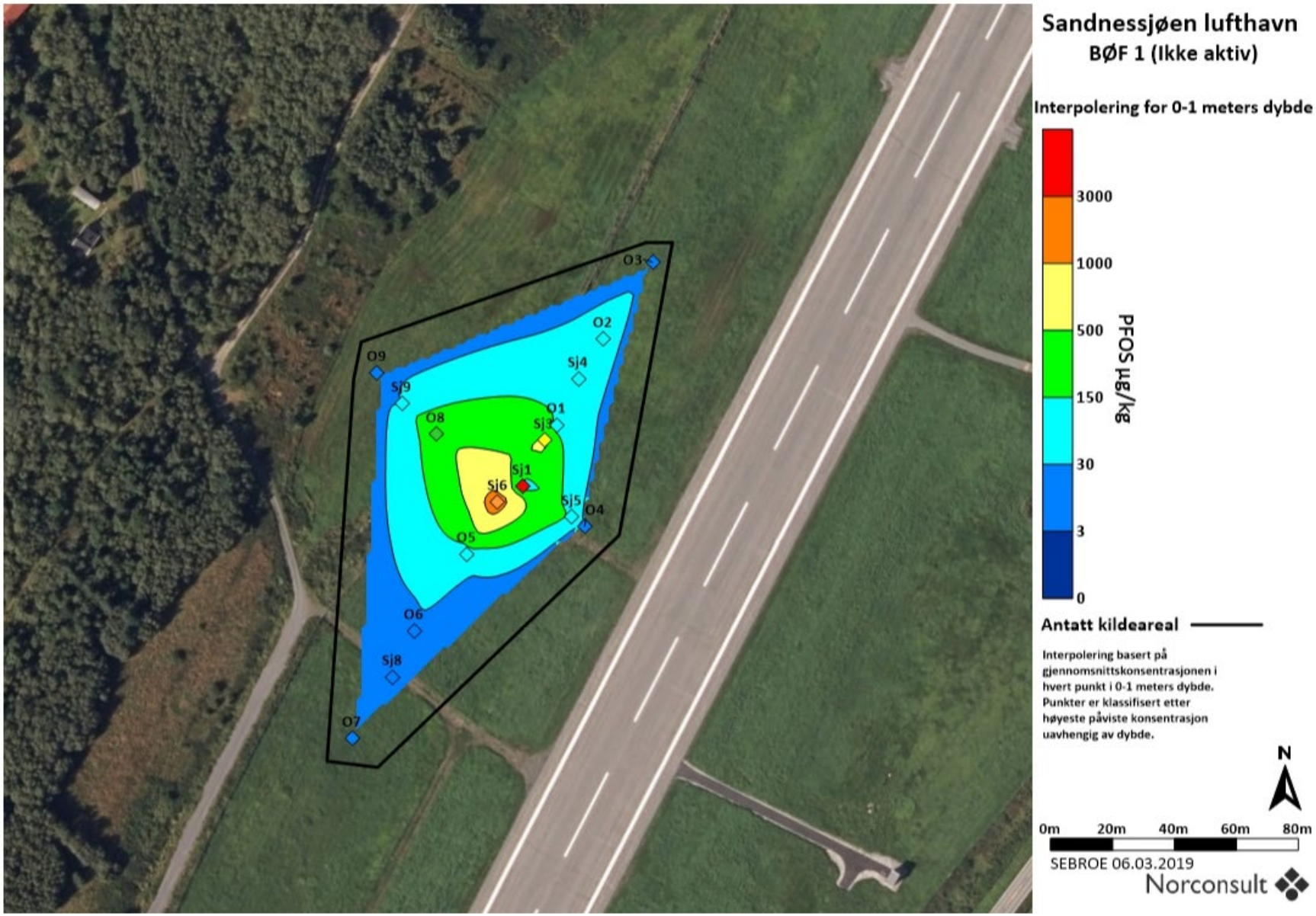
PFOS ferskvann (ug/l)
- <0.002-0.3
- 0.3-1.0
- >1.0
- Ikke analysert

Mrk. varierende skala for x-aksen i diagrammene

* PFOS er dominerende parameter

ip = ikke påvist

AVINOR COWI SWECO



Sandnessjøen lufthavn
BØF 1 (Ikke aktiv)

Interpolering for 0-1 meters dybde

PFOS µg/kg
3000
1000
500
150
30
3
0

Antatt kildeareal

Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i 0-1 meters dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.

N

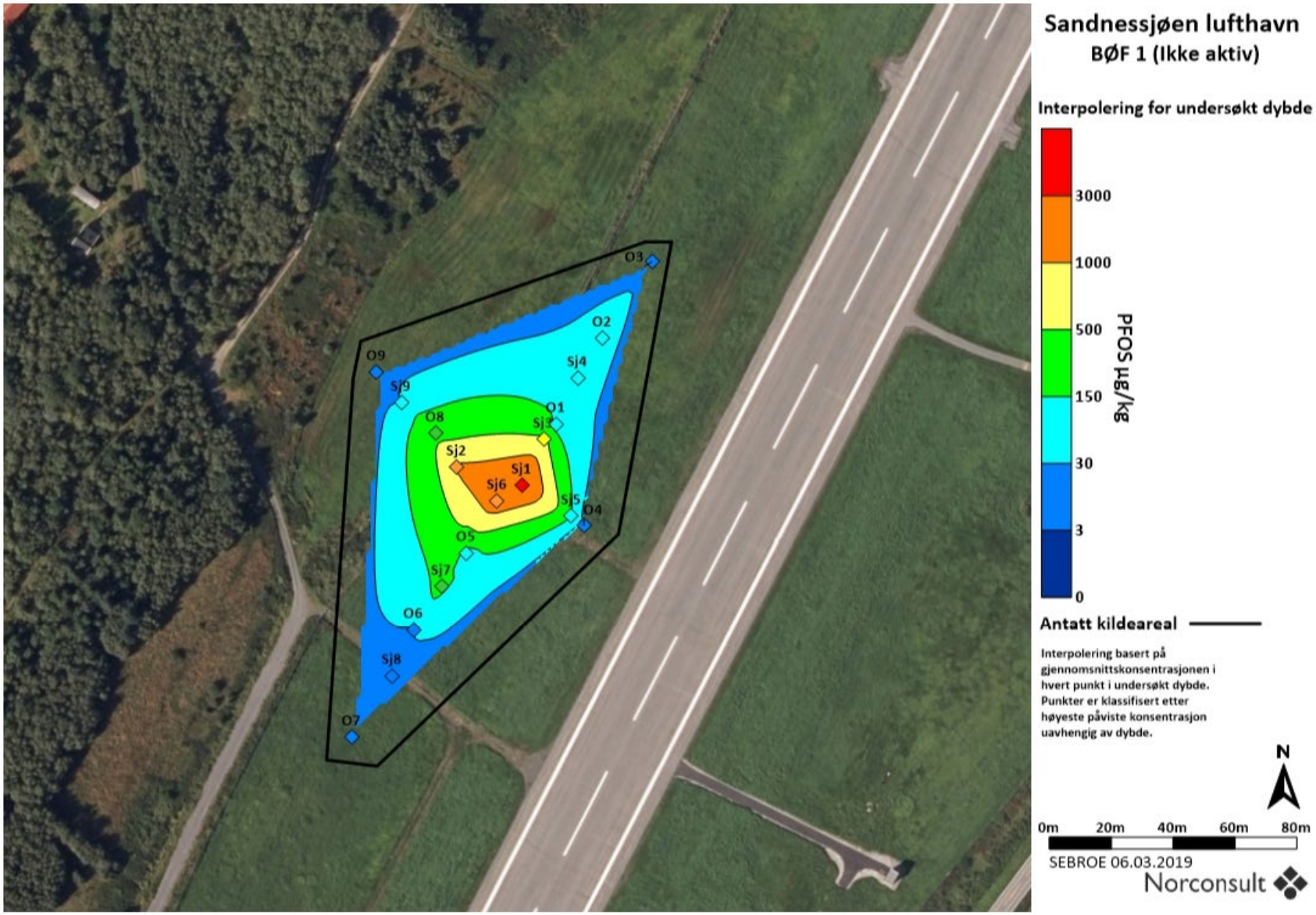
0m 20m 40m 60m 80m

SEBROE 06.03.2019

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APPENDIX A



27.1 Fire training site (BØF) / contaminated site

Fire training site (BØF) / contaminated site	BØF 1 (old)
	There is no written information on when the BØF was used and when it was closed. It was stated verbally by the airport management that the BØF was adopted shortly after the airport was opened in 1968, and that it was in use until about 2006. Until 31.12.05, the airport had permission from the County Governor to conduct fire training up to 16 times per year on paved surfaces. Today, only exercises using water take place at the airport.

27.2 The use of PFOS and other ∑PFAS

Volume of PFOS used at the site (kg)	Not stated/calculated
Comments/uncertainty	
Volume of ∑PFAS used at the site (kg)	Not stated/calculated
Comments/uncertainty	

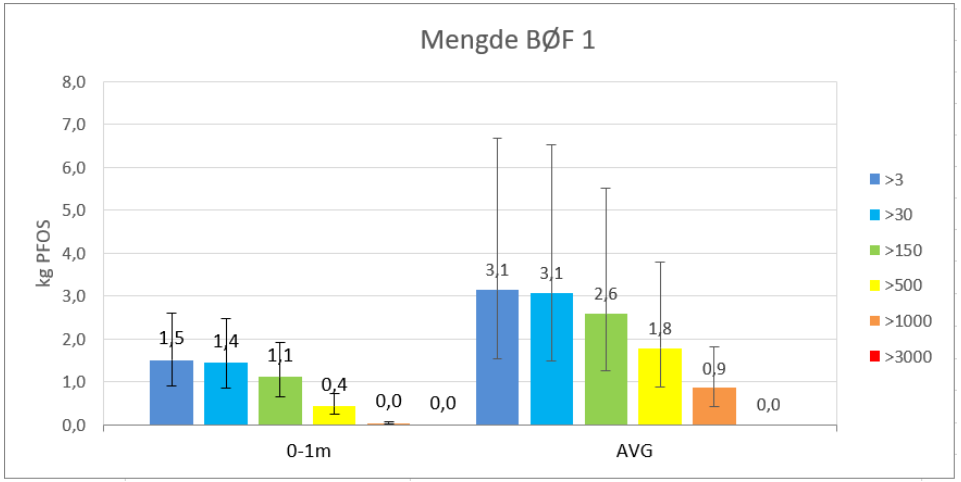
27.3 Soil sampling

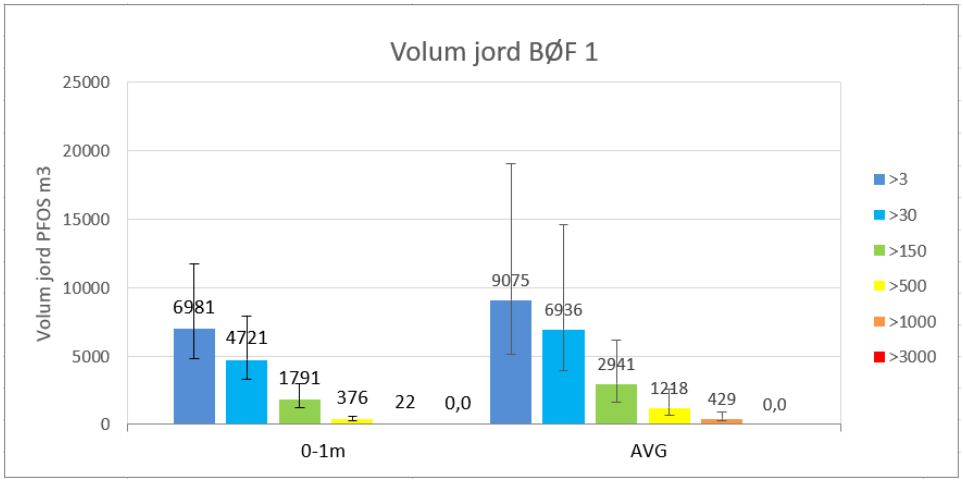
Total number of soil samples	24
Comments/uncertainty (for example, 95% of the samples were taken from 0–0.1 m)	A total of 9 shafts have been dug with samples from various depths between 0-1.3 metres, and surface samples have also been taken from 9 points (0-0.1 metres). In the shafts, soil samples were taken in the form of composite samples from the different layers from terrain to groundwater level. The groundwater level is not stated in the report, but the level must then be <1.3 metres deep. The materials are stated to consist of peat, shell sand and soil. The surface samples are only stated as surface soil.
Number of soil samples 0-1 m beneath the ground	19
Number of soil samples under 1 m	6
Comments/uncertainty	A total of 25 soil samples when splitting up those taken from sampling intervals over both 0-1 metres and > 1 metre.
Highest measured soil concentration of PFOS µg/kg	3,540
Where	Sj 1 (120 cm deep). The materials consist of peat.

Highest measured soil concentration ∑PFAS µg/kg	3,547
Where	Sj 1 (120 cm deep). The materials consist of peat.
Comments/uncertainty	These samples were only analysed for PFOS and PFOA.

27.4 Volume calculation

PFOS average for all depths and points > 3 µg/kg	
Concentration (µg/kg)	216
Area (m2)	6,981
Volume of soil (tonnes)	14,520
Volume of PFOS (kg)	3.1
Uncertainty -	1.6
Uncertainty +	3.5
PFOS average for all depths and points > 30 µg/kg	
Concentration (µg/kg)	276
Area (m2)	5,335
Volume of soil (tonnes)	11,097
Volume of PFOS (kg)	3.1
Uncertainty -	1.6
Uncertainty +	3.5
PFOS average for all depths and points > 150 µg/kg	
Concentration (µg/kg)	549
Area (m2)	2,262
Volume of soil (tonnes)	4,705
Volume of PFOS (kg)	2.6
Uncertainty -	1.3
Uncertainty +	2.9
PFOS average for all depths and points > 500 µg/kg	
Concentration (µg/kg)	915
Area (m2)	937





Volume of soil (tonnes)	1,949
Volume of PFOS (kg)	1.8
Uncertainty -	0.9
Uncertainty +	2.0
PFOS average for all depths and points > 1,000 µg/kg	
Concentration (µg/kg)	1,241
Area (m2)	330
Volume of soil (tonnes)	686
Volume of PFOS (kg)	0.9
Uncertainty -	0.4
Uncertainty +	1.0
PFOS average for all depths and points > 3,000 µg/kg	
Concentration (µg/kg)	
Area (m2)	
Volume of soil (tonnes)	
Volume of PFOS (kg)	
Uncertainty -	
Uncertainty +	

Comments regarding calculations of volume	The DP2 report assumes that the most contaminated area is situated within an area of 4,500 m2, and that the thickness of the contaminated materials is 2 metres. The average concentration within this area is calculated to be 1,000 µg/kg PFOS. On this base it is calculated that 15 kg of PFOS remains in the ground at the BØF. This is a significantly larger volume than calculated in this calculation (3.1 kg). It is primarily the estimated average concentration in the contaminated area (1,000 µg/kg versus 216 µg/kg) that results in the calculations having such varying calculations of the volume of PFOS remaining.

Is the extent of the contaminated area delimitated horizontally?	No. Concentrations above the detection limit have been detected at all extreme points. The concentrations at the extreme points are relatively low, and are between 5.1 - 20.9 µg/kg. All extreme points are surface samples, in the outermost shafts (which have samples of top materials and deeper) to the northeast and southwest (shafts 4 and 8) the highest concentration is 45.8 µg/kg. The sampling carried out appears to cover the most heavily contaminated area.
Is the extent of the contaminated area delimitated vertically?	No. At several of the points, relatively contaminated materials have been detected down to groundwater level. The highest concentrations (> 100 µg/kg) are in samples between 0.7-1.2 metres deep in the shafts 1-3 and 5-7, as well as in a surface sample (O8). It is uncertain how much deeper the contaminated materials extend, but as samples have been taken down to groundwater level it is assumed that the concentrations below groundwater level decrease rapidly with the depth.
Comments/uncertainty	

27.5 Water sampling and annual dispersion

Have water samples been taken?	Yes
Where	Samples of surface water have been taken at five points; at the BØF and downstream BØF in the stream (Sandnesbekken) that flows west of the BØF, at the outlet of a drainage pipe south of the BØF, at a junction at a crossroads southwest of the BØF and from a side stream flowing from the south end of the runways and to the west. Three groundwater wells have also been bored in shafts at the BØF, and groundwater samples have been taken from these, as well as a sample of water in the shaft. At the points Brønn B2, oppstrøms BØF and nedstrøms BØF samples were taken twice (21.11.11 and 22.5.12). The other points have been sampled once (22.5.12). The samples taken on 21.11.11 were only analysed for PFOS/PFOA. The samples taken on 22.5.12 were analysed for 11 ∑PFAS compounds.
Highest measured concentration of PFOS in groundwater (ng/l)	72,400
Where	Sandnessjøen B1 (22.05.2012)
Highest measured concentration of PFAS in groundwater (ng/l)	90,500
Where	Sandnessjøen B1 (22.05.2012)

Comments/uncertainty	All three groundwater samples from 2012 have been analysed for 11 ∑PFAS compounds. In the sample "Sandnessjøen B1", PFOS is the predominant compound, but high concentrations of 6:2 FTS, PFHxS, PFHxA, PFOA and PFPeA were also detected. This also applies to the other groundwater samples.
Highest measured concentration of PFOS in surface water (ng/l)	7,320
Where	Junction before crossroads
Highest measured concentration of ∑PFAS in surface water (ng/l)	9,990
Where	Junction before crossroads
Comments/uncertainty	The sample "oppkomme før veikryss" has been analysed for 11 PFAS compounds. PFOS is the predominant compound in the sample. Relatively high concentrations of 6:2 FTS, PFHxS, and PFPeA have also been detected in this water sample.
Total annual dispersion of PFOS from the site (g/year)	Not calculated
Total annual dispersion of ∑PFAS from the site (g/year)	147
To which recipient	Alstenfjorden
Calculated from water or soil concentration.	In chapter 3.1.3.5 of the DP2 report it is stated that the calculations are based on the average concentrations of PFOS and 6:2 FTS in the groundwater. It is further stated that based on this, the calculated emission of PFOS/PFOA has been calculated. It is therefore not certain what substances are calculated for in addition to PFOS.

27.6 Biota sampling

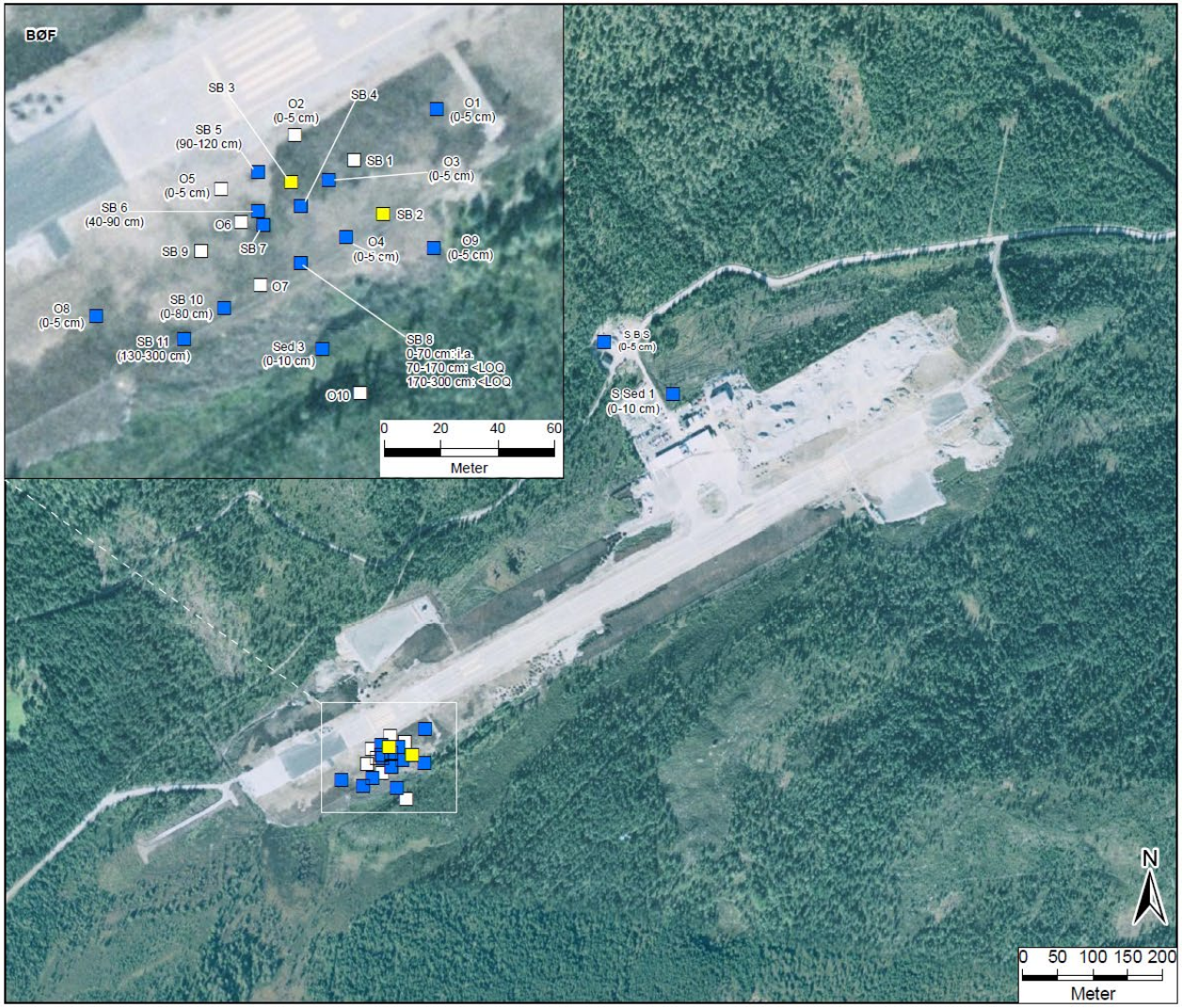
Have biota samples being taken at the airport?	No
What kind of biota?	
How many samples?	
Highest measured concentration of PFOS in biota (µg/kg wet weight)	
Where	
Highest measured concentration of ∑PFAS in biota (µg/kg wet weight)	
Where	
Median concentration in comparable populations (e.g. in a lake)	
Comments/references	
References and concentrations in other reports.	

27.7 Uncertainty and other factors

Does the estimate of the volume of PFOS in the ground correspond with the measured concentrations in water and biota?	Cannot be evaluated for biota, as no biota samples have been taken. Cannot be reliably evaluated for water. The concentrations in the groundwater samples are high, but groundwater samples were only taken once in May 2012 (as well as a sample of water in shaft in B2 in 2011). It is uncertain what the conditions were like at the time of sampling (precipitation, snow melt, etc.). Concentrations in soil are highest in peat materials, and there are lower concentrations in shell sand and soil elsewhere at the BØF. There are material types with very different binding capacity for ∑PFAS, and the materials composition and concentrations in soil at the BØF are uncertain except at the surveyed points. It is therefore difficult to assess leaching for the site as a whole.
Evaluations	The fire training site was built with a sand/gravel support layer and was originally asphalted. The asphalt, however, is significantly broken and torn. The fire training site drains to the southwest and towards the stream/trench just outside the airport fence to the northwest. Relatively high concentrations of PFOS have been detected in several of the shafts dug in the central part of the BØF. It can seem that the highest concentrations are in peat materials deeper than 0.7 metres and down to groundwater level. Most of the soil samples have been analysed for PFOS and PFOA, but some of the soil samples have been analysed for 11 different ∑PFAS compounds. It can be seen that PFOS is the predominant compound in all soil samples. In some of the samples analysed for 11 ∑PFAS compounds, some PFPeA, PFHxS and PFOA have been detected. High concentrations of PFAS have been detected in groundwater samples. PFOS is the predominant compound in all groundwater samples, but relatively high concentrations of other ∑PFAS compounds have also been detected. The high concentrations in groundwater indicate that there is vertical transport of ∑PFAS in the ground, with leaching to groundwater, and with further dispersion to the surroundings and the maritime recipient. The DP2 report concludes that dispersion is likely to lead to an undesirable environmental impact in the maritime recipient, without this being documented. Concentrations of PFOS above the detection limit have been detected in all surface water samples. In Sandnesbekken, which runs by the BØF, a sample was taken directly at the BØF, and one downstream (about 650 metres south of the BØF). In the sample taken at the BØF, the concentration of PFOS was 833 ng/l, and in the sample taken downstream PFOS was 1,530 ng/l. There was also PFOS (230 ng/l) in the outlet of a drainage pipe that leads to the stream midway between these points, and in the side stream (575 ng/l) that flows from the south end of the runway and west to the stream that comes from the BØF. ∑PFAS can be therefore be supplied to the stream from multiple sources or diffuse contamination at the airport area.
Calculation	Soil samples have been taken in shafts, and wells have been bored in three of the shafts. By looking at soil and groundwater concentrations at these three points in isolation, Kd values are calculated (DP2 report chapter 3.1.2.4). The calculations show a very low Kd for peat around well B1, compared to what is expected for an equilibrium between the concentrations in soil and water. At equilibrium, the Kd for PFOS in peat is expected to be between 70-520 l/kg (taken from the action plan for Harstad/Narvik Airport Evenes 2015 which refers to the thesis by Løland, 2014), as ∑PFAS is well retained in peat soil.

	B1: Peat 1,080 µg/kg / 72.4 µg/l gives 14.9 l/kg B3: Material type not specified 15.3 µg/kg / 1.08 µg/l gives 13.4 l/kg. B2: Shell sand 212 µg/kg / 20.9 µg/l gives 10.14 l/kg. The concentrations in water are based on one measurement only, and it is not known what the sampling conditions were at this time. In the event of rain or snow melt, for example, PFOS washed out of the unsaturated zone can give elevated concentrations in groundwater.
Comments/uncertainty: (Could there be any additional unknown sources of PFOS at the site with run-off to the recipient?)	High concentrations of PFOS have been detected in the water sample taken in Sandnesbekken downstream of the BØF. The sampling point where this sample was taken is located approximately 650 metres south of BØF. In addition, PFOS has been detected in the outlet from a drainage pipe that is led to the stream and in a side stream that flows to the same stream. Because PFOS has been detected at these sampling points, and in the stream such a distance from the BØF, it cannot be ruled out that there are several sources of PFOS contamination to the stream.
Has the site been sufficiently mapped with a view to assessing the order of prioritisation?	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the volume of PFOS in the soil with the stipulated level of uncertainty.
Comments/uncertainty	The dispersion of contamination to the maritime recipient should be further mapped. It should also be investigated whether there may be other sources/areas of ground contaminated with PFOS at the airport, as PFOS has been detected in all samples of surface water, including those taken relatively far away from the BØF.
Other factors of significance for any clean-up/initiation of measures (for example, planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	From Naturbase: Several species of high and especially high management interest have been registered around and at the airport. Several types of habitat have also been registered around the airport. Just south of the airport is an area registered as a soft-bottomed area in the coastal zone. This area receives runoff from the airport via Sandnesbekken. Both north and east of the airport are areas that are registered as rich marshland. Some cultural monuments have also been around at the airport. The airport is registered with Avinor's vulnerability class 1, which means non-vulnerable recipients, standard level at the facility. The areas around the airport are mainly used for agriculture/cultivated land.

28 Sogndal Airport, Haukåsen



Sogndal lufthamn
Haukåsen (ENSG)

Oversiktskart

Jord og sediment

PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

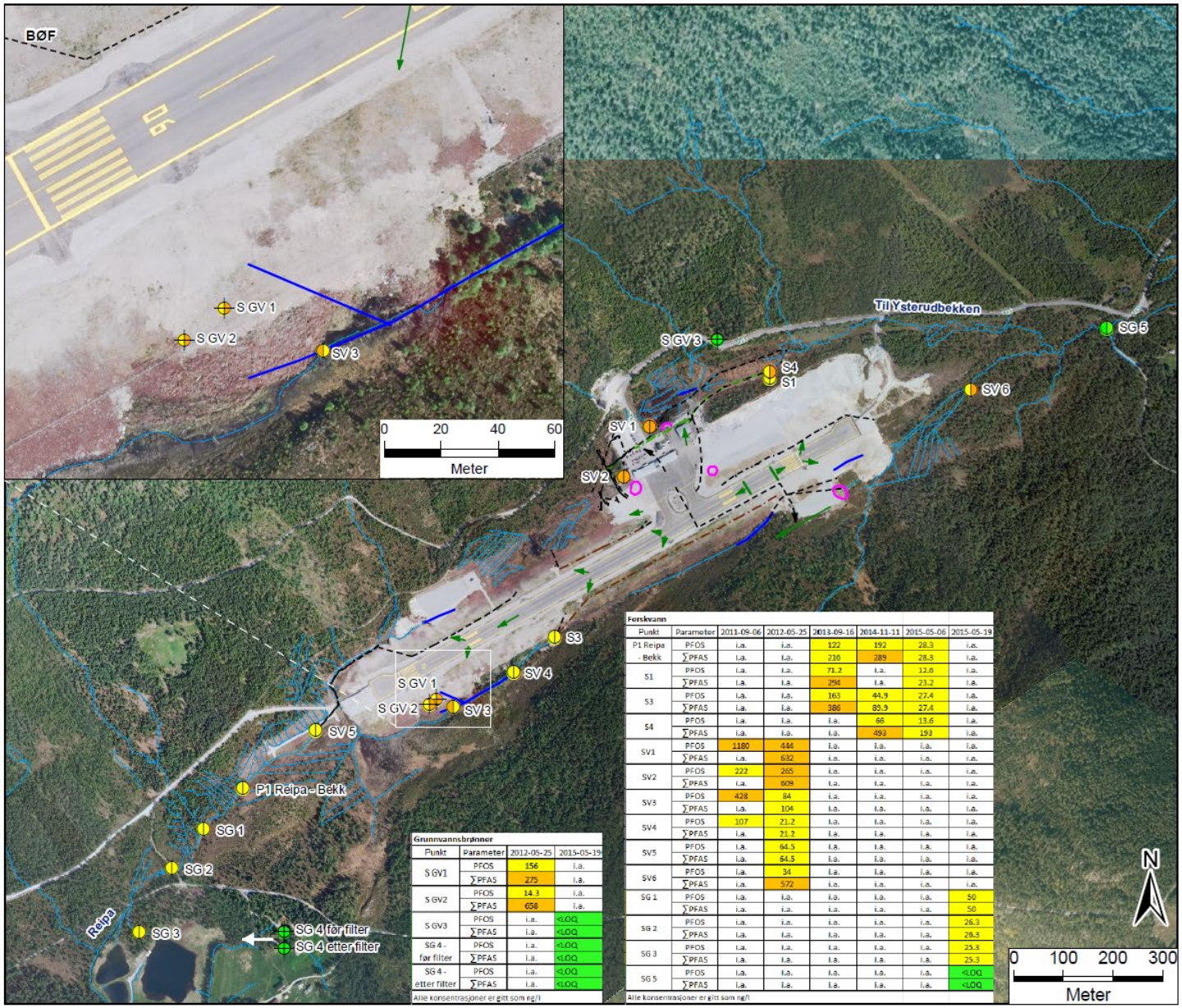
* PFOS er dominerende parameter

LOQ = rapporteringsgrense
i.a. = ikke analysert

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APPENDIX A



Grunnvannsbrønner

Punkt	Parameter	2012-05-25	2015-05-19
S GV1	PFOS	156	i.a.
	∑PFAS	275	i.a.
S GV2	PFOS	14.3	i.a.
	∑PFAS	658	i.a.
S GV3	PFOS	i.a.	<LOQ
	∑PFAS	i.a.	<LOQ
SG 4 - før filter	PFOS	i.a.	<LOQ
	∑PFAS	i.a.	<LOQ
SG 4 - etter filter	PFOS	i.a.	<LOQ
	∑PFAS	i.a.	<LOQ

Alle konsentrasjoner er gitt som ng/l

Ferskvann

Punkt	Parameter	2011-09-06	2012-05-25	2013-09-16	2014-11-11	2015-05-06	2015-05-19
P1 Reipa - Bekk	PFOS	i.a.	i.a.	122	192	28.3	i.a.
	∑PFAS	i.a.	i.a.	210	289	28.3	i.a.
S1	PFOS	i.a.	i.a.	71.2	i.a.	12.6	i.a.
	∑PFAS	i.a.	i.a.	256	i.a.	23.2	i.a.
S3	PFOS	i.a.	i.a.	163	44.9	27.4	i.a.
	∑PFAS	i.a.	i.a.	386	85.9	27.4	i.a.
S4	PFOS	i.a.	i.a.	i.a.	66	13.6	i.a.
	∑PFAS	i.a.	i.a.	i.a.	493	193	i.a.
SV1	PFOS	1180	444	i.a.	i.a.	i.a.	i.a.
	∑PFAS	i.a.	632	i.a.	i.a.	i.a.	i.a.
SV2	PFOS	222	265	i.a.	i.a.	i.a.	i.a.
	∑PFAS	i.a.	609	i.a.	i.a.	i.a.	i.a.
SV3	PFOS	428	84	i.a.	i.a.	i.a.	i.a.
	∑PFAS	i.a.	104	i.a.	i.a.	i.a.	i.a.
SV4	PFOS	107	21.2	i.a.	i.a.	i.a.	i.a.
	∑PFAS	i.a.	21.2	i.a.	i.a.	i.a.	i.a.
SV5	PFOS	i.a.	64.5	i.a.	i.a.	i.a.	i.a.
	∑PFAS	i.a.	64.5	i.a.	i.a.	i.a.	i.a.
SV6	PFOS	i.a.	34	i.a.	i.a.	i.a.	i.a.
	∑PFAS	i.a.	572	i.a.	i.a.	i.a.	i.a.
SG 1	PFOS	i.a.	i.a.	i.a.	i.a.	i.a.	50
	∑PFAS	i.a.	i.a.	i.a.	i.a.	i.a.	50
SG 2	PFOS	i.a.	i.a.	i.a.	i.a.	i.a.	26.3
	∑PFAS	i.a.	i.a.	i.a.	i.a.	i.a.	26.3
SG 3	PFOS	i.a.	i.a.	i.a.	i.a.	i.a.	25.3
	∑PFAS	i.a.	i.a.	i.a.	i.a.	i.a.	25.3
SG 5	PFOS	i.a.	i.a.	i.a.	i.a.	i.a.	<LOQ
	∑PFAS	i.a.	i.a.	i.a.	i.a.	i.a.	<LOQ

Alle konsentrasjoner er gitt som ng/l

Sogndal lufthamn Haukåsen (ENSG)

Oversiktskart inkl. brannøvingsfelt

Vann

PFOS / ∑ PFAS grunnvannsbrønn (ng/l) *
- Ikke analysert
- 0
- <LOQ
- LOQ-230
- 230-36 000
- >36 000

PFOS / ∑ PFAS ferskvann (ng/l) *
- Ikke analysert
- 0
- <LOQ
- LOQ-230
- 230-36 000
- >36 000

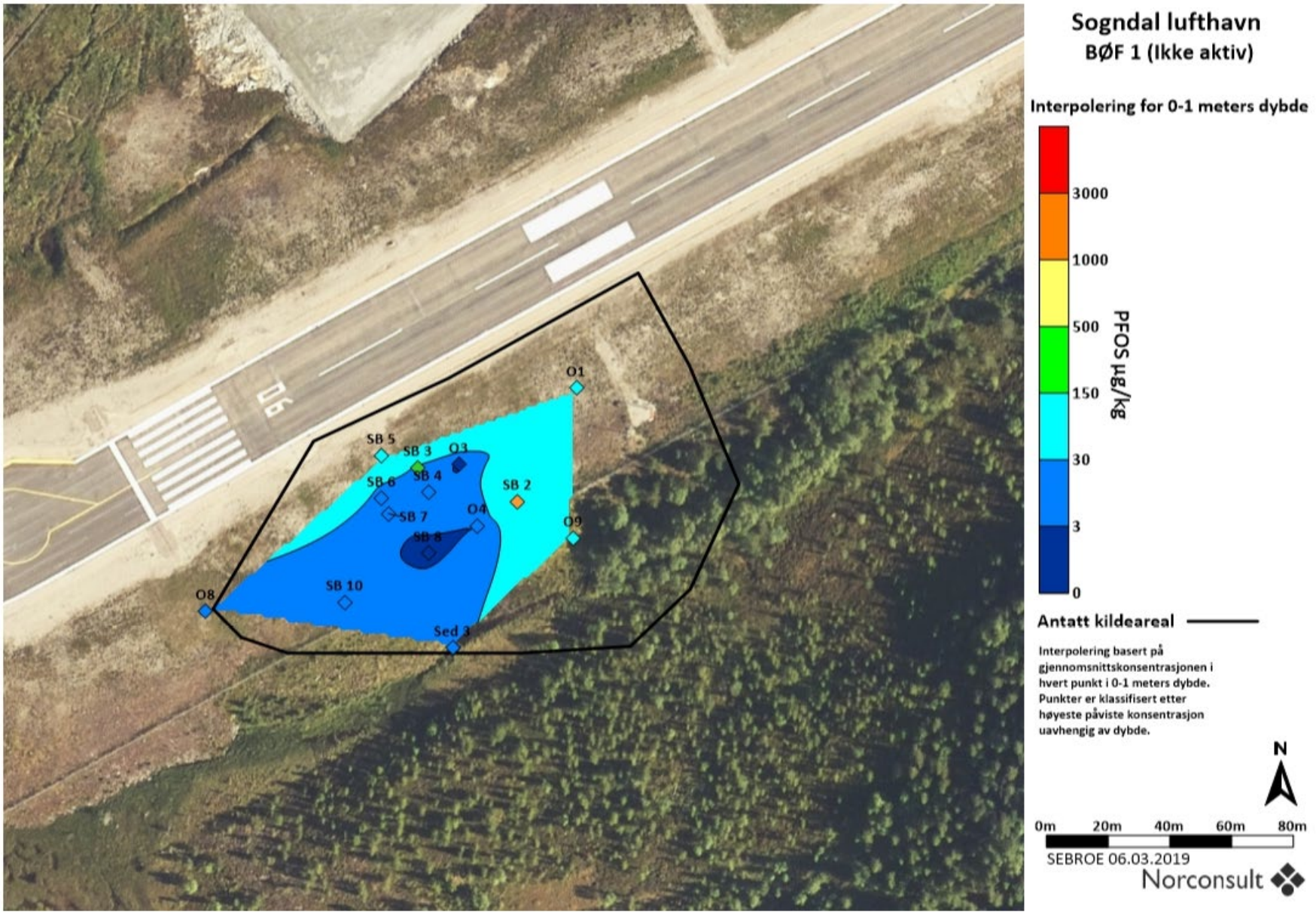
Avlopsledning
- Avløp annet
- Avløp Felles
- Drensvann
- Glykolholdig overvann
- Glykolholdig spillvann
- Overvann
- Pumpespillvannsledning
- Spillvann

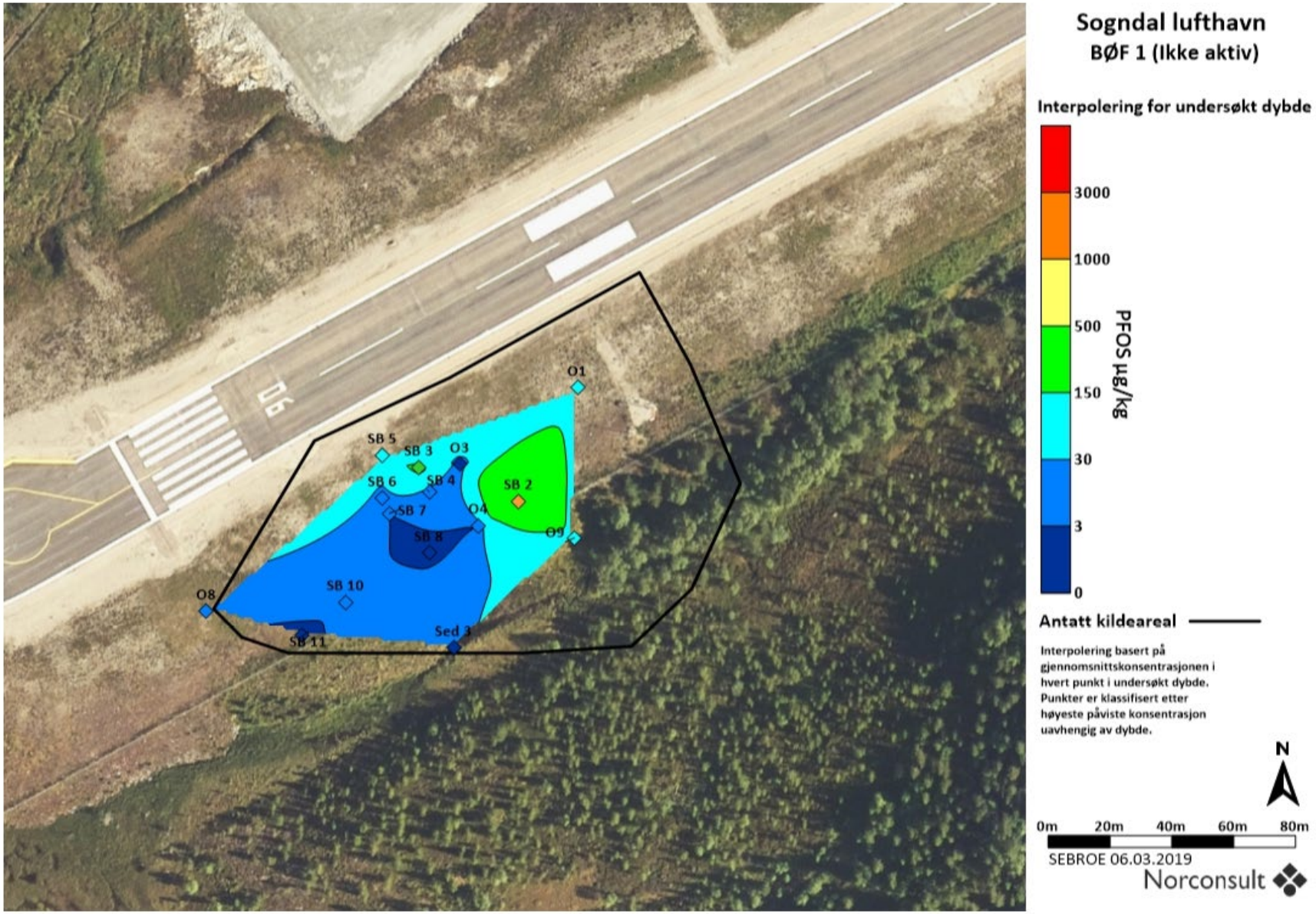
Avrenning
- Deponi glykolforurenset snø
- Overvannsledning
- Avrenningsveg glykol
- Bekkeresipient
- Overvannsystem
- Vannskille rullebane
- Antatt avrenningsveg baneavising

* Venstre halvdel = PFOS
Høyre halvdel = ∑PFAS

i.a. = ikke analysert
LOQ = rapporteringsgrense
(tilsv. ikke påvist for ∑PFAS)

AVINOR Norconsult COWI SWECO


Sogndal lufthavn
BØF 1 (Ikke aktiv)
Interpolering for 0-1 meters dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i 0-1 meters dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m 20m 40m 60m 80m
SEBROE 06.03.2019
Norconsult
O1
O3
O4
O8
O9
SB 2
SB 3
SB 4
SB 5
SB 6
SB 7
SB 8
SB 10
Sed 3



Sogndal lufthavn
BØF 1 (Ikke aktiv)

Interpolering for undersøkt dybde

PFOS µg/kg
3000
1000
500
150
30
3
0

Antatt kildeareal

Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.

N

0m 20m 40m 60m 80m

SEBROE 06.03.2019

Norconsult

28.1 Fire training site (BØF) / contaminated site

Fire training site (BØF) / contaminated site	BØF1 (not active)
	One fire training site has been registered at Sogndal Airport. The BØF is located southwest of the runway. The BØF was established southwest of the runway, and was in use when the airport was established in 1971. The site was taken out of use in 2005.

28.2 The use of PFOS and other PFAS

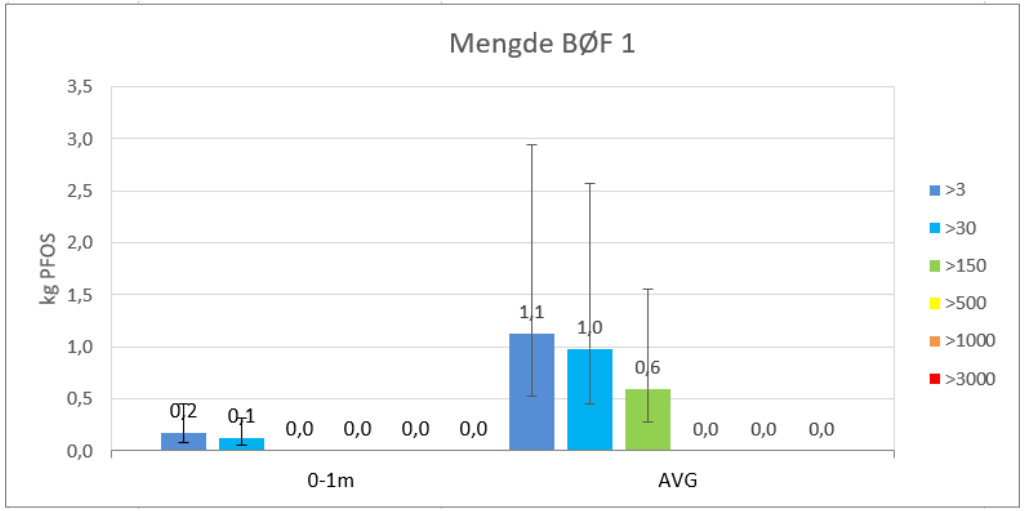
Comments/uncertainty	Estimated consumption from the 1970s to 2001. Firefighting foam containing PFOS was probably used from the late 1970s.
Volume of PFAS used at the site (kg)	15
Comments/uncertainty	Estimated consumption from 2001 to 2005.

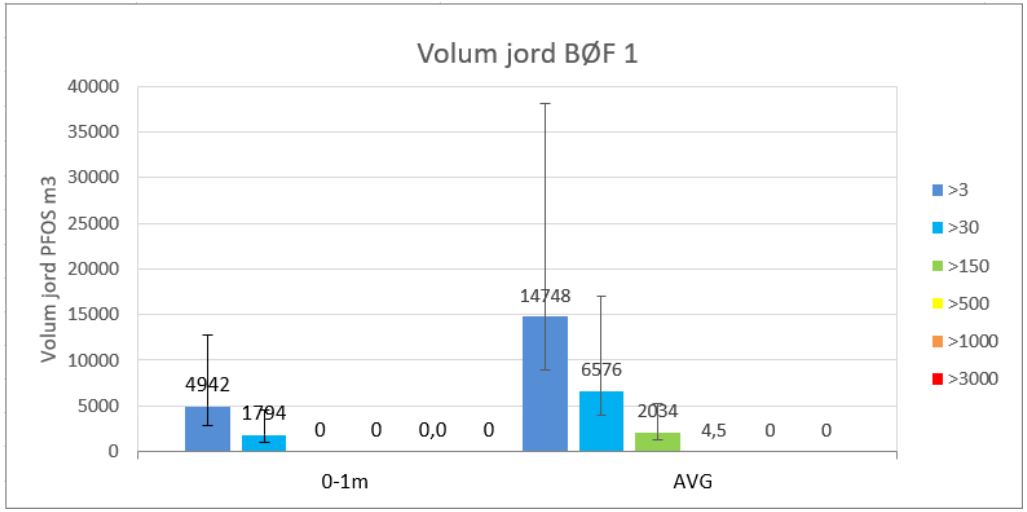
28.3 Soil sampling

Total number of soil samples	21
Comments/uncertainty (for example, 95% of the samples were taken from 0–0.1 m)	At five of the sampling points at the BØF, only surface samples (0-0.05 m) have been taken, there are samples of top soil only between 0-90 cm at two points, and then there are five shafts with samples from top soil and deeper materials. The materials are (as stated in the Cowi report which is an appendix to the DP2 report) a mixture of moraine, organic soil, rock, sand, clay, rubble with fine material and marshy soil.
Number of soil samples 0-1 m beneath the ground	14
Number of soil samples under 1 m	10
Comments/uncertainty	A total of 24 soil samples when splitting up samples in the intervals of 0-1 m and > 1 m.
Highest measured soil concentration of PFOS µg/kg	1410
Where	SB 2-3 (150-300 cm). The materials consist of soil. Content of asphalt, iron scrap, concrete.
Highest measured soil concentration of PFAS µg/kg	1,413
Where	SB 2-3 (150-300 cm). The materials consist of soil. Content of asphalt, iron scrap, concrete.
Comments/uncertainty	The sample SB2-3 was only analysed for PFOS and PFOA. The soil samples have been analysed for PFOS and PFOA, in addition, a total of eight soil samples have been analysed for 12 PFAS compounds.

28.4 Volume calculation

PFOS average for all depths and points > 3 µg/kg	
Concentration (µg/kg)	68
Area (m2)	4,916
Volume of soil (tonnes)	23,597
Volume of PFOS (kg)	1.1
Uncertainty -	0.6
Uncertainty +	1.8
PFOS average for all depths and points > 30 µg/kg	
Concentration (µg/kg)	133
Area (m2)	2,192
Volume of soil (tonnes)	10,522
Volume of PFOS (kg)	1.0
Uncertainty -	0.5
Uncertainty +	1.6
PFOS average for all depths and points > 150 µg/kg	
Concentration (µg/kg)	260
Area (m2)	678
Volume of soil (tonnes)	3,254
Volume of PFOS (kg)	0.6
Uncertainty -	0.3
Uncertainty +	1.0
PFOS average for all depths and points > 500 µg/kg	
Concentration (µg/kg)	510
Area (m2)	1.5
Volume of soil (tonnes)	7.2
Volume of PFOS (kg)	0.0
Uncertainty -	0.0





Uncertainty +	0.0
PFOS average for all depths and points > 1,000 µg/kg	
Concentration (µg/kg)	
Area (m2)	
Volume of soil (tonnes)	
Volume of PFOS (kg)	
Uncertainty -	
Uncertainty +	
PFOS average for all depths and points > 3,000 µg/kg	
Concentration (µg/kg)	
Area (m2)	
Volume of soil (tonnes)	
Volume of PFOS (kg)	
Uncertainty -	
Uncertainty +	

Comments regarding calculations of volume	In the DP2 report, it is calculated that 446 g of PFOS and 17 g of PFOA remain at the source area. This assumes that the contaminated area is within an area of 30x50 metres, and that the thickness of the contaminated materials is 1.5 metres. In the 2016 risk assessment report, it is calculated that 2 ± 1 kg PFOS remains at the BØF. The calculation is based on an area of 4,500 ± 2,000 m2, and a depth of 3 ± 1 metres. The reason why a smaller volume of remaining PFOS is calculated in the DP2 report than in the calculations from 2016 and the new calculations in 2019 is mainly because a much smaller contaminated area was used as the basis for DP2 report. The basis for the calculation in 2019 was a surveyed area of 5,300 m2 and depth of 3 metres. The uncertainty is greater in the calculation from 2019 than 2016 due to the fact that an attempt was made to delimitate the contaminated area to concentrations of 3 µg/kg. The proportion of fine material has also been taken into account in the calculation from 2019, which makes the quantities lower than for the calculations in 2016.

Is the extent of the contaminated area delimitated horizontally?	No. Concentrations of PFOS above the detection limit have been detected at all extreme points. The concentration at the extreme points O8 to the west and sed 3 to the south (both surface samples only) are the lowest (<20 µg/kg). The extreme point to the north (SB5 from 90-120 cm deep and surface sample O1) and to the east (surface sample O9) have concentrations between 73 and 85.9 µg/kg.
Is the extent of the contaminated area delimitated vertically?	No, in the two most contaminated of the test points (SB2 and SB3), the highest concentrations were detected in the deepest samples (1.5-3 metres), and it is uncertain how much deeper the contamination extends. Furthermore, the depth to bedrock or low-permeable materials (clay) is uncertain. There was seepage of water in some of the shafts (between 1.7-3 metres in shaft 8 and 1.1-3 metres in shaft 11), but there were major differences in nearby shafts. The DP2 report states that it is therefore uncertain whether there is a consistent groundwater level or whether groundwater can be found in recesses in the rock surface and/or in pockets in the loose materials. At sampling points SB7 and 8, which are central to the surveyed area, and at SB11 to the west, no PFOS (or PFAS) has been detected in deeper materials (about 1.5-3 metres).
Comments/uncertainty	The DP2 report describes how there have been construction works in the area where the BØF is located, and that the materials at the BØF was clearly processed and rearranged. This may be the reason why the highest PFOS concentrations are found in relatively deep materials. Nor can it be ruled out that materials have spread from the BØF to other parts of the airport.

28.5 Water sampling and annual dispersion

Have water samples been taken?	Yes. Samples of groundwater and surface water have been taken.
Where	Groundwater samples were taken from 2 wells (established in shaft) at the BØF (S GV 1 and S GV 2), from the groundwater well that supplies the airport with water (S GV 3, which is a 120 metre deep bedrock well) and from a well adjacent to the farm located southwest of the airport (S GV 4, bedrock well drilled in July 2013). Samples of surface water have been taken from the snow depot, from the sewage treatment plant and from surface water northeast of the runway/taxiway. Water from these areas drains towards the Ytstrudbekken. Samples have also been taken from Ytstrudbekken downstream of the airport. Samples have been taken from the snow depot southwest of the terminal area, from a trench system that runs past the BØF and from a trench system that drains the southern part of the runway. All these sources are led to Reipa. In addition, water samples have been taken of Reipa, downstream of the airport.
Highest measured concentration of PFOS in groundwater (ng/l)	156
Where	S GV1 (groundwater well at the BØF)
Highest measured concentration of PFAS in groundwater (ng/l)	658

Where	S GV2 (groundwater well at the BØF)
Comments/uncertainty	PFOS is predominant in the sample from S GV1. There are six other compounds detected (not 6:2 FTS). The highest level of PFPeA was detected in the S GV2 water sample. Thereafter the highest concentrations are (of those detected) of PFHxA, PFHxS, PFBA, PFHpA, 6:2 FTS, PFOA and finally PFOS.
Highest measured concentration of PFOS in surface water (ng/l)	1,180
Where	Surface water SV1 (06-09-2011). The water sample contains run-off from the terminal area and snow depots.
Highest measured concentration of PFAS in surface water (ng/l)	1,216
Where	Surface water SV1 (06-09-2011). The water sample contains run-off from the terminal area and snow depots.
Comments/uncertainty	The sample taken on 6.9.2011 was only analysed for PFOS/PFOA. A sample was analysed in 2012 for several compounds (eight were detected). Concentrations of total PFAS were lower in this sample than for PFOS in the sample from 2011. PFOS was not detected in a water supply well north of the airport or at the farm (approximately 500 metres) southwest of the airport. Samples have only been analysed for one sampling date from each location.
Total annual dispersion of PFOS from the site (g/year)	144
Total annual dispersion of PFAS from the site (g/year)	Not calculated
To which recipient	Reipa. The marsh area around the airport drains in two different directions; towards Ytstrudbekken in the northeast and towards Reipa/Eitregilet in the southwest. Both streams flow into Sognefjord. The dispersion of PFOS to Ytstrudbekken (based on measurements at point SV6) has been calculated as 10 g/year.
Calculated from water or soil concentration.	Water concentration at sampling point P1 Reipa bekk

28.6 Biota sampling

Have biota samples being taken at the airport?	Yes
What kind of biota?	River trout, farmed salmon and vegetation samples (blueberry bushes, grass (not species specific), grey aldor and yew).
How many samples?	24 samples in 2013 (individual samples and composite samples of river trout and salmon), 9 muscle samples of salmon in 2015, vegetation samples from two stations in 2015 (8 samples) and 9 samples of trout in 2016 (composite samples of fish of equal length).
Highest measured concentration of PFOS in biota (µg/kg wet weight)	2,200

Where	Station 2, homogenised composite sample of 10 trout, liver
Highest measured concentration of PFAS in biota (µg/kg wet weight)	2,355.3
Where	Station 2, homogenised composite sample of 10 trout, liver Nine different PFAS (PFNA, PFDA, PFHxS, PFOS, FTS-6:2, FTS-8:2, PFDS, PFUnDA and PFDoDA) were found, with PFOS being the most significant with 2,200 µg/kg of wet weight.
Median concentration in comparable populations (e.g. in a lake)	In 11 liver samples from trout caught in Kjerkvatnet by Evenes Airport, the average content of PFOS was 753.6 µg/kg ww (median 880), and for PFAS of 759.5 µg/kg ww (median 880). In six individual muscle samples of trout from Langvatnet by Evenes Airport Harstad, the average content of PFOS was 14.89 ug/kg ww (median 15.64) and for PFAS was 20.53 ug/kg ww (median 23.27). Average concentration of PFOS in liver from trout in some large Norwegian lakes; Mjøsa: 8.39 ng/g ww, Randsfjorden: 4.06 ng/g ww, Femunden: 2.95 ng/g ww.
Comments/references	The figures for trout at Evenes Airport are taken from Avinor report from 2015; Harstad/Narvik lufthavn, Evenes, undersøkelser av jord, vann og biota med risikovurdering (Harstad/Narvik Airport, Evenes, surveys of soil, water and biota with risk assessment). The figures for PFOS in the liver of trout in the lakes are taken from the report "Miljøgifter i store norske innsjøer, M-548" (Environmental contaminants in large Norwegian lakes, M-548) published by the Norwegian Environment Agency. It can be seen that the highest concentration of PFOS in the liver of trout at Sogndal Airport is almost three times as high as PFOS values in the liver of trout at Evenes Airport, and over 260 times higher than the highest of the average values in the lakes.
References and concentrations in other reports.	The EQS value in the Water Regulations for PFOS in biota is 9.1 ng/g wet weight. PFOS has been detected in all of the biota samples taken at Sogndal Airport, and the concentrations in all samples are significantly higher than this limit value. In a risk assessment from 13 December 2018, EFSA changed the tolerability limit (TDI - tolerable daily intake) for PFOS and PFOA, so these are now far lower than the TDI values set in 2008. This may cause EQS for biota to also be lower in the future. In 2015, the Norwegian Food Safety Authority conducted assessments for Sogndal Airport based on analyses of biota from 2013. The conclusion of the Norwegian Food Safety Authority was as follows: *Nobody should fish, nor eat river trout from Eitregilbekken/Reipa at Sogndal Airport (Haukåsen).*

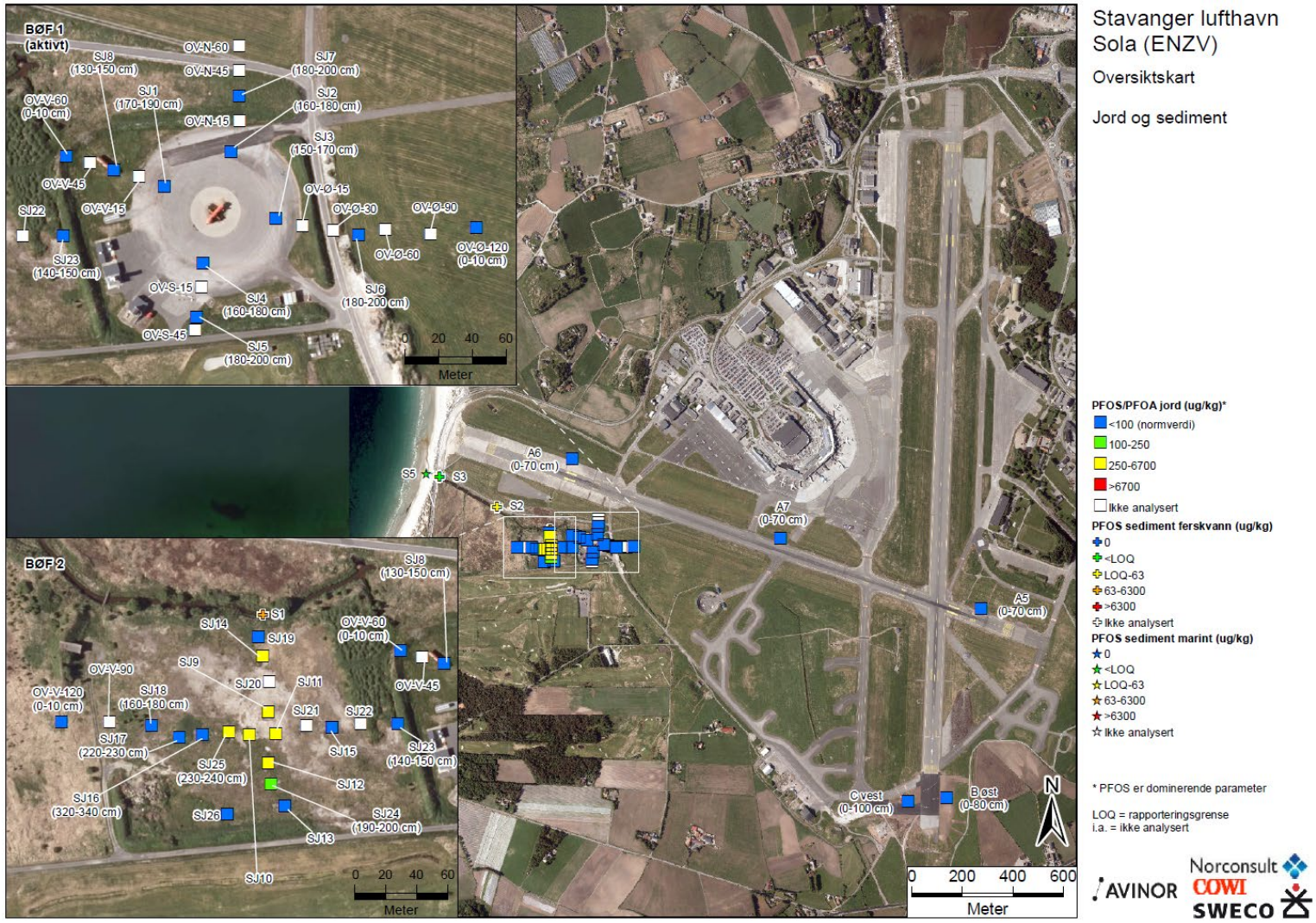
28.7 Uncertainty and other factors

Does the estimate of the volume of PFOS in the ground correspond with the measured concentrations in water and biota?	Cannot be reliably evaluated. Reipa receives runoff from the airport's southwestern areas, including the fire training site. Runoff from the snow depot southwest of the terminal area (point SV2) is led under the runway and into a trench system (S3 and SV4) that runs past the old fire training site (point SV3) and further out into Reipa. Reipa is also supplied with water from a pipe/trench system from the north of the southern part of the runway (point SV5). PFOS has been detected at all these points, as well as in groundwater samples from the BØF and Reipa.
Evaluations	With the exception of the deepest specimens (1-3 m) at points SB2 and SB3, low to moderate concentrations (<100 µg/kg) of PFOS have been detected in the soil materials at the BØF. In the deepest samples from SB2 and SB3, some PFHxS and PFHxA has also been detected. No concentrations above the detection limit of any other PFAS compounds have been detected in the other five soil samples analysed for this. Points SB2 and 3 are not directly adjacent to each other, and in deeper materials (2.5-3 m) at test point SB4 which lies between these two points there are low concentrations (<9 µg/kg). The soil surveys do not indicate that there are large amounts of PFOS at the BØF. PFOS and PFAS have been detected in the groundwater wells at the BØF, but the concentrations of PFOS are not particularly high. There is somewhat high PFAS content in groundwater from Brønn S GV2. The degree of contamination to the materials deeper than 3 metres is unknown. PFOS has been detected at all test points of the stream Reipa downstream of the airport, from test point SV 5 and further southwest. The concentrations from samples at points P1 and further southwest to SG3 show a reduction with increasing distance from the airport. At P1, several PFAS compounds have been analysed and detected. This point has been sampled several times, and there are variations in the concentrations between different samples. The concentration is lowest in 2015. At test points S3 and SV 4 in a trench that runs towards the BØF and then towards Reipa, PFOS and PFAS have also been detected. Therefore, there is evidence of ongoing dispersion to this stream from one or more sources in addition to the fire training site. The BØF has not been used for the last 15 years, so many of the PFOS/PFAS compounds may have already leached into the ground over time. High concentrations of PFAS compounds have been detected in the river trout caught in Reipa. This applies to both the fish caught at the top of the stream and after the confluence with streams from Hovden. PFOS is clearly the most dominant PFAS compound in all the biota samples, but in some of the samples a number of other PFAS compounds have also been detected. Trout in the ponds have significantly higher concentrations compared to trout from Evenes, for example, which also had contamination from fire training. The airport is located about 500 metres above sea level, and the river trout in the stream and ponds are believed to live their entire life in this stream system without migrating to sea. Leaching to the stream over a long period of time, and the exposure time for biota to contamination in this stream may be factors that have contributed to the trout in Reipa having such high concentrations. Every year, farmed salmon are released into the fish ponds. The farmed salmon stays for a few weeks to several months in the fish ponds. Analyses of the farmed salmon show that these also contain PFOS, but at significantly lower concentrations than the trout. Vegetation samples were taken from two stations in 2015, one near the BØF and one near Reipa. No PFOS or PFOA were detected in the vegetation samples, but small amounts of 6:2 FTS and PFBA were detected. There are many deer in the area, which graze on this vegetation.

	A new biota study was carried out in 2016 to examine whether there had been a downward trend in PFAS concentrations in biota. The measured values of PFAS in the river trout in 2016 were somewhat lower than in 2013, but the fish still contained concentrations of PFAS and PFOS that were far higher than the limit value for EQS for biota. The average concentration of PFAS in the fish samples (whole trout fish) at the sampling station closest to the airport was 527 µg/kg, while at the sampling station which was further away from the airport it was 230 µg/kg. By comparison, the average PFAS in the trout samples (whole fish) in 2013 was 694 µg/kg. Water samples were also taken in Reipa in 2016. The results of the water samples from 2016 showed higher concentrations of PFOS than the water samples from 2013, 2014 and 2015. As previously, the results showed a dilution down the river. This indicates that there is still dispersion of PFAS to surface water and fish in Reipa.
Comments/uncertainty: (Could there be any additional unknown sources of PFOS at the site with run-off to the recipient?)	Since 2006, foam tests of the cannons have been carried out at the snow depot in the northeast, in rubble, with runoff towards Ytstrudsbekken. A fire training log from 2001 showed that there have been occasional drills held elsewhere, both in a quarry at the airport entrance, and at Vikaleitet, approximately 1 km on the road towards Sogndal. A composite sample of surface soil at Vikaleitet (SBV), as well as a composite sample and a trench sample at the quarry (SBS and S sed 1) have been taken. 21.3 µg/kg was detected in the surface sample at Vikaleitet, and 2.4 µg/kg in the surface sample at the quarry. In the sample from the trench at the quarry, 38.7 µg/kg was detected. Ytstrudsbekken east of the airport receives runoff from the terminal area, the snow depots (point SV1), the sewage treatment plant (point S1) and the runway, taxiway and parts of the aircraft stand (point SV6). These water flows are independent of each other, but all end up in Ytstrudsbekken. PFOS has been detected in water samples from all these sampling points. No PFOS/PFAS has been detected in the sample from Ytstrudsbekken downstream of the airport in the northeast. Crash drills were mainly performed in both approach sectors. The fire engine was previously washed in the terminal area, but since 2006 it has been washed inside the washing hall. From the DP2 report: The terrain has been smoothed and materials from the area has probably been filled in the southwest direction. The ground consists of various filler such as marsh soil, moraine, rock and gravel. There is waste in the materials in some areas. Runoff flows towards the stream and on to fish ponds and farms in the southwest. It is stated in the risk assessment report for Sogndal Airport that the relocation/excavation of materials to level the terrain in the southern area of the airport may have mobilized a large amount of PFOS, and increased leaching to Reipa, which is reflected in the high biota concentrations. It is uncertain when this excavation took place and whether the excavation may have resulted in the most contaminated materials at the BØF being moved elsewhere.
Has the site been sufficiently mapped with a view to assessing the order of prioritisation?	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the volume of PFOS in the soil with the stipulated level of uncertainty.

Comments/uncertainty	The contamination situation deeper than 3 metres at the BØF is not known.
Other factors of significance for any clean-up/initiation of measures (for example, planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	Avinor has an assessment of natural values at and around the airport carried out in 2013, and a site of the habitat wetland massif (Haukåsmyrene) was registered, which was considered locally important. Black grouse, golden eagle and sparrowhawk were also observed, and it was stated that common crane (mates annually, does not nest), eagles (possibly both white-tailed eagle and golden eagle) and wood grouse are seen in the area. The following is registered in Naturbase; About 500 metres north of the airport is Rodeholene, which is a protected nature reserve. Located northeast of the airport is an area of the habitat "old coniferous forest". Within a radius of about 2 km there are also several areas of the habitat "hayfield". North of the airport there is a groundwater well (bedrock) that supplies the airport with water. In addition, a farm southwest of the airport have drilled its own groundwater well in the bedrock, which was drilled in July 2013 and Avinor became aware of this in 2015. The airport is registered with Avinor's vulnerability class 3, which means vulnerable recipients, highest priority and highest level at the facility. The Reipa stream has salmon and trout. Jordi farm has operated organised tourist fishing for farmed salmon, which are released in the three fish ponds west of the farm. The salmon are in the ponds between 0-6 months before fishing. In 2015, the Norwegian Food Safety Authority conducted assessments for Sogndal Airport based on analyses of biota from 2013. The conclusion of the Norwegian Food Safety Authority was as follows: Nobody should fish, nor eat river trout from Eitregilbekken/Reipa at Sogndal Airport (Haukåsen).

29 Stavanger Airport, Sola



Stavanger lufthavn
Sola (ENZV)

Oversiktskart

Jord og sediment

PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

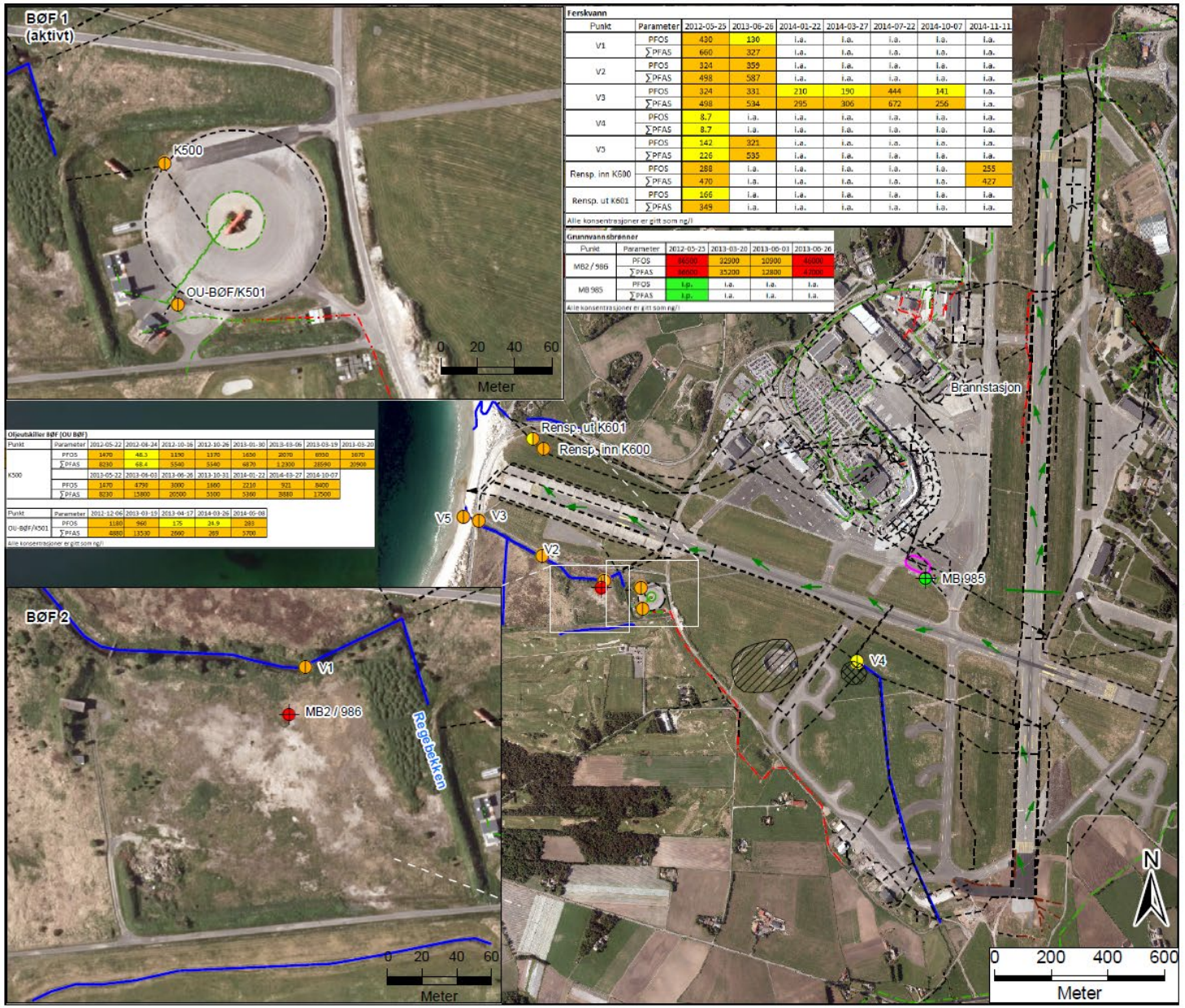
PFOS sediment ferskvann (ug/kg)
- 0
- <LOQ
- LOQ-63
- 63-6300
- >6300
- Ikke analysert

PFOS sediment marint (ug/kg)
- 0
- <LOQ
- LOQ-63
- 63-6300
- >6300
- Ikke analysert

* PFOS er dominerende parameter

LOQ = rapporteringsgrense
i.a. = ikke analysert

AVINOR Norconsult COWI SWECO



Stavanger lufthavn Sola (ENZV)

Oversiktskart inkl. brannøvingsfelt

Vann

PFOS / ∑ PFAS grunnvannsbrønn (ng/l) *
- Ikke analysert
- 0
- <LOQ
- LOQ-230
- 230-36 000
- >36 000

PFOS / ∑ PFAS ferskvann (ng/l) *
- Ikke analysert
- 0
- <LOQ
- LOQ-230
- 230-36 000
- >36 000

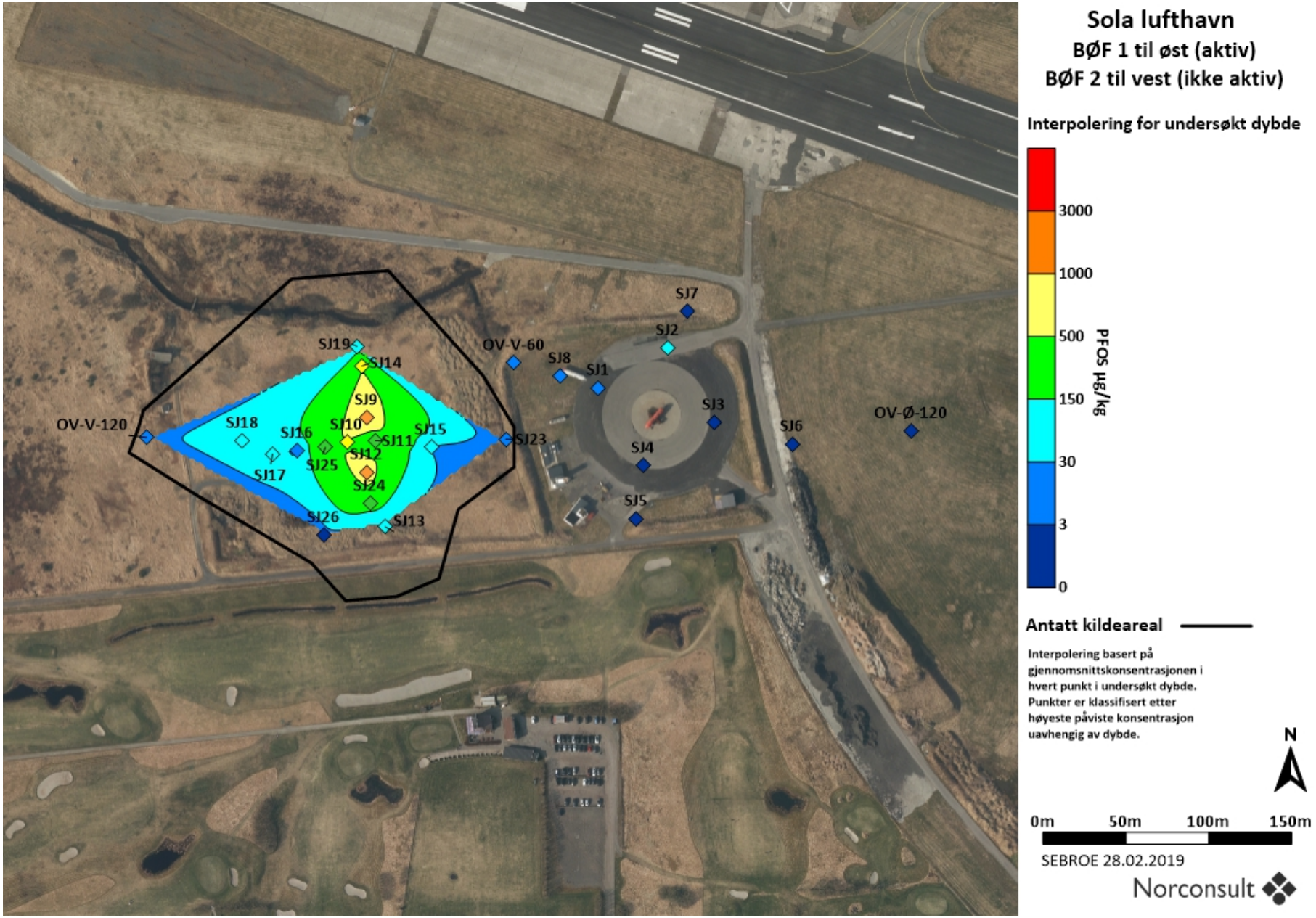
Avlopsledning
- Avløp annet
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- Glykolholdig overvann
- Glykolholdig spillvann
- Overvann
- Pumpespillvannsledning
- Spillvann

Avrenning
- Deponi glykolforurenset snø
- Overvannsledning
- Avrenningsveg glykol
- Bekkeresipient
- Overvannsystem
- Vannskille rullebane
- Antatt avrenningsveg baneavising
- PFAS-lokalitet
- Deponi

* Venstre halvdel = PFOS
Høyre halvdel = ∑PFAS

i.a. = ikke analysert
LOQ = rapporteringsgrense

AVINOR Norconsult SWECO


Sola lufthavn
BØF 1 til øst (aktiv)
BØF 2 til vest (ikke aktiv)
Interpolering for undersøkt dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m 50m 100m 150m
SEBROE 28.02.2019
Norconsult
SJ19
SJ14
SJ9
SJ18
SJ16
SJ10
SJ11
SJ15
SJ12
SJ25
SJ17
SJ24
SJ26
SJ13
SJ23
OV-V-120
OV-V-60
SJ8
SJ1
SJ7
SJ2
SJ3
SJ4
SJ5
SJ6
OV-Ø-120

29.1 Fire training site (BØF) / contaminated site

Fire training site (BØF) / contaminated site	BØF 1 (active)	BØF 2 (old)
	Used from 2000.	BØF 2 has been in operation between 1984 and 2000.

29.2 The use of PFOS and other PFAS

Volume of PFOS used at the site (kg)	110	1,790
Comments/uncertainty	Estimated consumption in the period for the year 2000-2001 (one year only), before the transition to AFFF which did not have PFOS as its main component.	Estimated consumption during the period from 1984 to 2000.
Volume of PFAS used at the site (kg)	500 kg	Not stated/calculated
Comments/uncertainty	Calculation is based on use during the period 2000 to 2012. Avinor completely phased out firefighting foam containing PFAS in 2012 and now uses only PFAS-free firefighting foam.	

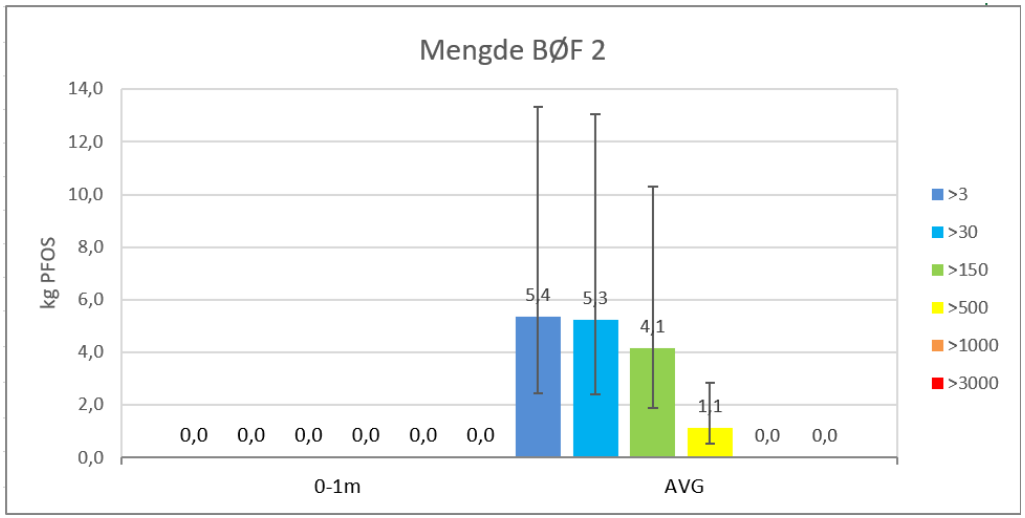
29.3 Soil sampling

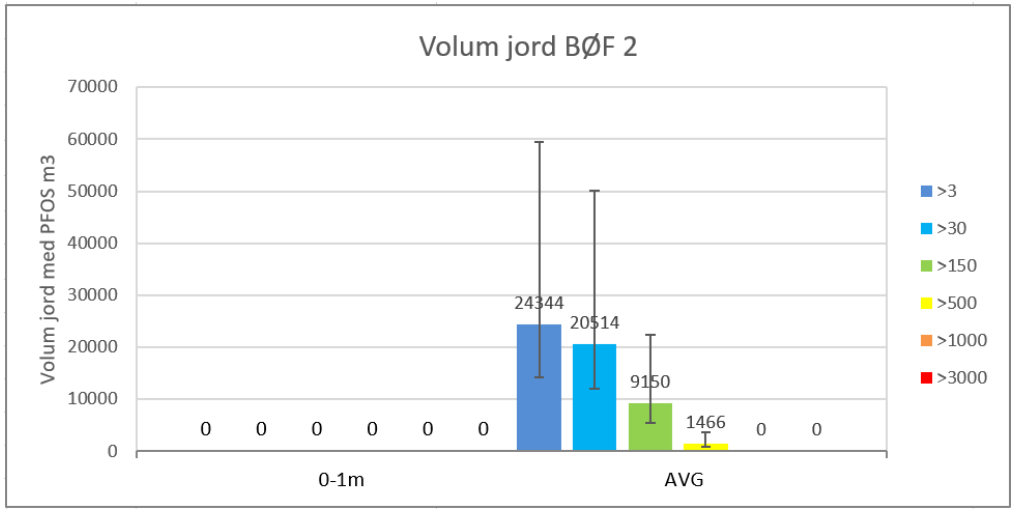
Total number of soil samples	10	24
Comments/uncertainty (e.g. 95% of the samples were taken from 0-0.1 m)	At the active fire training site, no shafts were established through the impermeable membrane.	In the last few years before environmental technical soil surveys studies were carried out at the site in 2012, approximately 1.5 m of surplus materials from excavator work was laid at various locations in the airport area on top of the old fire training platform. The materials at BØF 2 from the terrain and down to approximately 1.5 m have not been analysed as these were added after the site was taken out of use as a fire training site. The original terrain level for BØF 2 was about 2.5 metres above sea level.
Number of soil samples 0-1 m beneath the ground	2	1
Number of soil samples below 1 m	8	24
Comments/uncertainty	10 material samples have been analysed; 4 from groundwater level at the platform, 4 from groundwater level at a greater distance from the platform, 2 from the surface at the extremes in separate directions from the platform in the E-W direction.	A total of 25 soil samples when splitting up samples in the intervals of 0-1 m and > 1 m.
Highest measured soil concentration of PFOS µg/kg	43.3	1,470
Where	Shaft SJ2-6, in materials of light brown fine sand from 160-180 cm deep.	Shaft SJ9-39, in materials of sand/gravel at 140-240 cm deep.

Highest measured soil concentration of PFAS µg/kg	43.3*	1,490
Where	Shaft SJ2-6, in materials of light brown fine sand from 160-180 cm deep.	Shaft SJ9-39, in materials of sand/gravel at 140-240 cm deep.
Comments/uncertainty	These samples were only analysed for PFOS and PFOA.	The sample was analysed for 12 PFAS compounds.

29.4 Volume calculation

PFOS average for all depths and points > 3 µg/kg	No volumes have been calculated for BØF 1	
Concentration (µg/kg)		172
Area (m2)		12,172
Volume of soil (tonnes)		38,950
Volume of PFOS (kg)		5.4
Uncertainty -		2.9
Uncertainty +		8.0
PFOS average for all depths and points > 30 µg/kg		
Concentration (µg/kg)		200
Area (m2)		10,257
Volume of soil (tonnes)		32,822
Volume of PFOS (kg)		5.3
Uncertainty -		2.9
Uncertainty +		7.8
PFOS average for all depths and points > 150 µg/kg		
Concentration (µg/kg)		354
Area (m2)		4,575
Volume of soil (tonnes)		14,640
Volume of PFOS (kg)		4.1
Uncertainty -		2.3
Uncertainty +		6.2
PFOS average for all depths and points > 500 µg/kg		





Concentration (µg/kg)		609
Area (m2)		733
Volume of soil (tonnes)		2,346
Volume of PFOS (kg)		1.1
Uncertainty -		0.6
Uncertainty +		1.7
PFOS average for all depths and points > 1,000 µg/kg		
Concentration (µg/kg)		
Area (m2)		
Volume of soil (tonnes)		
Volume of PFOS (kg)		
Uncertainty -		
Uncertainty +		
PFOS average for all depths and points > 3,000 µg/kg		
Concentration (µg/kg)		
Area (m2)		
Volume of soil (tonnes)		
Volume of PFOS (kg)		
Uncertainty -		
Uncertainty +		

Fire training site (BØF) / contaminated site	BØF 1 (active)	BØF 2 (old)
Comments regarding calculations of volume	In the risk assessment for BØF 1 carried out in 2016, it was calculated that there is a residual volume of 0.2 kg ± 0.1 kg of PFOS in the ground distributed across an area of 11,000 ± 2,000 m2 and to a depth 3 ± 1.5 metres.	In the risk assessment for BØF 2 carried out in 2016, it was calculated that there is a residual volume of 9 kg ± 5 kg of PFOS in the ground distributed across an area of 13,000 ± 2,000 m2 and to a depth 2.5 ± 1.3 metres.

Is the extent of the contaminated area delimitated horizontally?	The of PFOS is apparently relatively well delimitated to the east, south and north, but not in the predicted direction of groundwater flow (northwest). PFOS has not been detected at the extreme points to the east (surface sample OV-Ø-120), to the south (SJ5) and to the north (SJ7). The sampling points SJ4 and SJ6 to the south and east have concentrations of approximately 2 µg/kg.	The sample is only below the detection limit for extreme point Sj26 to the southwest. Furthermore, there are PFOS concentrations of approximately 5 µg/kg at the extreme points to the east (SJ23) and west (surface sample OV-V-120). Extreme point SJ13 to the southeast and SJ19 to the north have a PFOS concentration of approximately 40 µg/kg.
Is the extent of the contaminated area delimitated vertically?	No, the deepest samples to the northwest of BØF do not show concentrations below the detection limit.	No, the deepest samples do not show concentrations below the detection limit, but they are higher to the north which is the flow direction for groundwater.
Comments/uncertainty	The samples in shafts are taken of materials > 1 metre. The samples were only analysed for PFOS and PFOA.	All samples in shafts are taken at > 1 metre, but 1.5 metres of materials were filled over the original terrain for the old BØF.

29.5 Water sampling and annual dispersion

Fire training site (BØF) / contaminated site	BØF 1 (active)	BØF 2 (old)
Have water samples been taken?	Yes	Yes
Where	Oil separator, collection manhole and stream (Regebekken). The site has two run-off collection systems. During active use/exercises, water is directed from the concrete slab and asphalt surface to an oil separator and on to the municipal wastewater network and treatment plants, before being discharged into the Håsteinsfjord. When there are no exercises on the site, the drainage from the concrete surface is still directed to the oil separator, while the water from the asphalt surface goes to a drainage pipe that goes to a collection manhole (K500) with discharge to Regebekken.	Groundwater well downstream from the old BØF and stream (Regebekken).
Highest measured concentration of PFOS in groundwater (ng/l)	Not measured at the BØF	86,500
Where		MB2/986 (25-05-2012). Groundwater from the groundwater well located approx. 30 metres downstream of the platform, towards Regebekken.
Highest measured concentration of PFAS in groundwater (ng/l)	Not measured at the BØF	86,600
Where		MB2/986 (25-05-2012). Groundwater from the groundwater well located approx. 30 metres downstream of the platform, towards Regebekken.
Comments/uncertainty		Analysed for 12 PFAS compounds.

Highest measured concentration of PFOS in surface water (ng/l)	430	430
Where	Sample V1 (25-05-2012) of water in Regebekken directly northwest of the new BØF.	Sample V1 (25-05-2012) of water in Regebekken directly north of the old BØF.
Highest measured concentration of PFAS in surface water (ng/l)	660	660
Where	Sample V1 (25-05-2012) of water in Regebekken directly northwest of the new BØF.	Sample V1 (25-05-2012) of water in Regebekken directly north of the old BØF.
Comments/uncertainty	Analysed for 12 PFAS compounds. Sampling point V1 applies to both BØFs at the airport as they are located next to each other and groundwater direction is assumed to be towards the stream to the north/northwest. During exercises, all water is directed from the concrete platform and asphalt area outside to the oil separator. Water from the concrete platform is also directed to the oil separator when exercises are not taking place. Water from the oil separator is directed to the municipal sewage system and then to the Håsteinsfjord. Water samples from the oil separator are not considered to be representative of the surface water in the area. Water samples have been taken from the oil separator on four occasions from 2013 to 2014, with concentrations of total PFAS in water samples varying between 269-13,530 ng/l. 15 samples were taken in collection manhole for water outside the concrete platform during the period 2012 to 2014 (the water is directed to Regebekken), with concentrations of PFAS varying between 68.4-28,590 ng/l. The main compounds in the samples from the oil separator and collection manhole are 6:2 FTS and PFOS. According to information in the annual report for the oil separator from 2016, cleaning and emptying of the oil separator was performed for PFAS clean-up in 2014. Avinor has not used PFAS foam at its airports since 2012 and the oil separators are emptied and normally cleaned once a year (unless they produce < 1kg oil during the course of a year), or more often if necessary.	Analysed for 12 PFAS compounds. Sampling point V1 applies to both BØFs at the airport as they are located next to each other and groundwater direction is assumed to be towards the stream to the north/northwest.
Total annual dispersion of PFOS from the site (g/year)	11 g [1 g]* (220 g)**	220 g
Total annual dispersion of PFAS from the site (g/year)	50 g [6 g]* (not calculated)**	Not calculated
To which recipient	Regebekken which goes to Solavika and water from the oil separator that is directed to the municipal sewage system and then to the Håsteinsfjord.	Regebekken which goes to Solavika.

Calculated from water or soil concentration.	Water concentration in samples from the collection manhole that are directed to Regebekken. *water concentration in samples from the oil separator **water samples from Regebekken (V3) – applies to both BØFs	Water concentration in Regebekken (V3) – applies to both BØFs
	That which goes to Regebekken from the collection manhole is given without brackets, that which goes to the oil separator that is directed to the municipal sewage system is given in square brackets, and that which goes to Regebekken from both fire training sites together is given in ordinary brackets. It is uncertain whether the dispersion from oil separators is representative of the current situation, as Avinor has not used foam containing PFAS since 2012. For the airport, a discharge of 140 g of PFOS per year was also calculated from the treatment park for handling surface water from the terminal area.	It is stated as likely that most of the PFOS used (estimated at 1,790 kg) at the old BØF has leached out already and been transported into the sea. **Applies to the entire area as run-off from both BØF 1 and 2 goes to Regebekken. For the airport, a discharge of 140 g of PFOS per year was also calculated from the treatment park for handling surface water from the terminal area.

29.6 Biota sampling

Fire training site (BØF) / contaminated site	BØF 1 (active)	BØF 2 (old)
Have biota samples being taken at the airport?	Yes, the sampling was performed in the recipient for both BØFs.	Yes, the sampling was performed in the recipient for both BØFs. See BØF 1
What kind of biota?	Flounder, common limpet, common shore crab, lugworms	
How many samples?	5	
Highest measured concentration of PFOS in biota (µg/kg wet weight)	1,000	
Where	Composite sample of flounder (10 individual whole fish) St. 2 freshwater, Regebekken	
Highest measured concentration of PFAS in biota (µg/kg wet weight)	1,128.5	
Where	Composite sample of flounder (10 individual whole fish) St. 2 freshwater, Regebekken	
Median concentration (µg/kg ww) in comparable populations (for example, in a lake)	1,000	

Comments/references	Samples of flounder were taken in a drainage ditch at an old fire training site at Kristiansand Airport in 2013, and in Topdalselva just outside this drainage ditch in 2012. In the sample from the drainage ditch from 2013, concentrations of PFOS of 3,600 µg/kg and PFAS of 3,670.8 µg/kg were detected in the sample of flounder whole fish (n=24). In the sample from Topdalselva in 2012, almost equal concentrations of PFOS (1000 µg/kg), and PFAS (1040.9 µg/kg) were detected in the composite sample of flounder whole fish (n=22) as at Stavanger Airport. Extracted from Avinor 2015, Kristiansand Airport Kjevik surveys of PFAS in soil, water and biota. For Stavanger Airport, Skeiekanalen about 20 km south of the airport was used as a reference station (st. 6). No PFAS was detected in the sample of flounder from st. 6. Biota samples were also taken at two different sampling stations at Solastranda, st.4 just outside the outlet to Regebekken and st. 5 which is 500 yards away from the Regebekken outlet. These are composite samples of samples of lugworm (station 4) and common shore crab (station 5), both of which samples had PFOS of 7 µg/kg, while the sample at station 4 had a total of PFAS of approximately 50 µg/kg, and the sample at station 5 had about 12 µg/kg.	

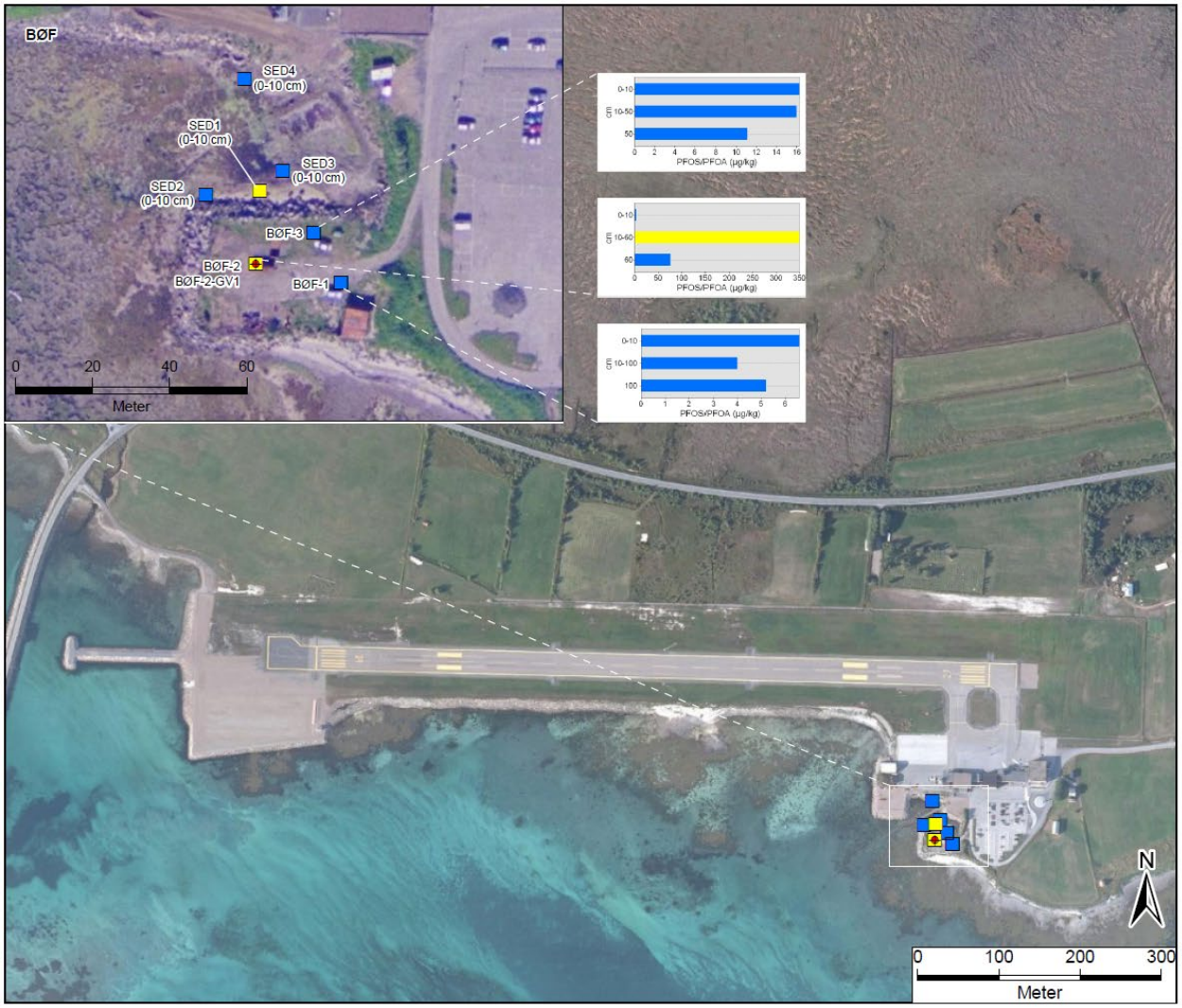
29.7 Uncertainty and other factors

Fire training site (BØF) / contaminated site	BØF 1 (active)	BØF 2 (old)
Does the estimate of the volume of PFOS in the ground correspond with the measured concentrations in water and biota?	Cannot be reliably evaluated.	Cannot be reliably evaluated.

Evaluations	The concentrations of PFOS in the ground at the new BØF are low, but soil samples have not been analysed for other PFAS compounds that were the main components of foam used from 2001-2012. The contaminated area is not delimitated to the northwest. Both BØFs drain to Regebekken so that there will be no distinction between the impact in water and biota caused by runoff from BØF 1 and BØF 2. Both sites are believed to have had/have significant dispersion to Regebekken and Solavika, as there were high concentrations of PFAS. (6:2 FTS and PFOS are the main components) in water that is directed from the collection manhole at the new BØF to Regebekken, combined with high concentrations of PFOS in soil and groundwater at the old BØF with groundwater flow towards Regebekken. However, analysed biota samples do not contain 6:2 FTS or 8:2 FTS. PFOS (approximately 9 ng/l) has been detected in water sample V4 from Regebekken upstream. After the use of foam containing PFAS ceased in 2012, dispersion from the collection manhole can only be linked to any old contamination in sediments and pipes.	The concentrations of PFOS in the soil at the old BØF are relatively high (the average for all samples is about 280 µg/kg), and there is low content of other PFAS compounds relative to PFOS. Only water samples have been taken in a groundwater well, and this is located at the BØF (at shaft SJ14 to the north) which has relatively high concentrations of PFOS (average of 476 µg/kg), so this will reflect the pore water concentration in soil at the location of the well, and cannot be used to assess the quantities dispersed from the site as there are no more wells and varying concentrations in soil. The measured concentration of PFOS in the groundwater in the well is relatively high and indicates that there is a high degree of leaching from the materials at the location of the well. Both BØFs drain to Regebekken so that there will be no distinction between the impact in water and biota caused by runoff from BØF 1 and BØF 2. Both sites are believed to have had/have significant dispersion to Regebekken and Solavika, as there were high concentrations of PFAS. (6:2 FTS and PFOS are the main components) in water that is directed from the collection manhole at the new BØF to Regebekken, combined with high concentrations of PFOS in soil and groundwater at the old BØF with groundwater flow towards Regebekken. However, analysed biota samples do not contain 6:2 FTS or 8:2 FTS. PFOS (approximately 9 ng/l) has been detected in water sample V4 from Regebekken upstream. After the use of foam containing PFAS ceased in 2012, dispersion from the collection manhole at the new BØF can only be linked to any old contamination in sediments and pipes.
Calculation		The groundwater well MB2/986 has the same location as sjakt 14. Viewing the average concentration of PFOS in the groundwater samples at this point in isolation, which is 44,075 ng/l in four samples from 2012 and 2013, and the average concentration in soil (fine sand) in SJ14 which is 476 µg/kg in two samples from different depths, a Kd of 10.8 l/kg can be calculated. This is considered to be a realistic kd for sand when compared to kd values from laboratory experiments in sand (Master's theses Nygård, 2017; Nordskog, 2013). However, kd will vary, among other things, with the contamination level relative to groundwater levels (Nygård, 2017).

Comments/uncertainty: (Could there be any additional unknown sources of PFOS at the site with run-off to the recipient?)	There is an engine testing pen southeast of the active fire training site. The engine testing pen and the surrounding area were used by both Avinor and the Norwegian Armed Forces for fire drills and fire engine cannon testing until 1984. The area at the fire station has been used for cleaning the fire engine etc., and foam containing PFOS may have been washed out. Drainage from this area is piped west to a treatment park with discharge to Solavika. PFAS concentrations of approximately 350-500 ng/l were detected at the treatment plant that handles surface water from the terminal area which includes the fire station. A water sample (V4) has been taken in Regebekken upstream of the fire training site, at a landfill site. The sample was intended as a reference sample, but traces of PFOS/PFAS were detected in the water. The airport carries out a separate project for handling the landfill.	There is an engine testing pen southeast of the active fire training site. The engine testing pen and the surrounding area were used by both Avinor and the Norwegian Armed Forces for fire drills and fire engine cannon testing until 1984. The area at the fire station has been used for cleaning the fire engine etc., and foam containing PFOS may have been washed out. Drainage from this area is piped west to a treatment park with discharge to Solavika. PFAS concentrations of approximately 350-500 ng/l were detected at the treatment plant that handles surface water from the terminal area which includes the fire station. A water sample (V4) has been taken in Regebekken upstream of the fire training site, at a landfill site. The sample was intended as a reference sample, but traces of PFOS/PFAS were detected in the water. The airport carries out a separate project for handling the landfill. Another uncertainty factor is that PFOS (approximately 9 ng/l) has been detected in water sample V4 from Regebekken upstream of the BØFs.
Has the site been sufficiently mapped with a view to assessing the order of prioritisation?	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the volume of PFOS in the soil with the stipulated level of uncertainty. Only low concentrations of PFOS have been detected in six of 10 samples (2-43 µg/kg), and only one sample has a concentration above 20 µg/kg. It has therefore been concluded that the sampling indicates that there are small quantities of PFOS in the ground, and that the site will not be prioritised for measures regarding PFOS based on a cost-benefit perspective. The site is too poorly mapped for other PFAS compounds (ref. this report for sections 1 and 2, chapter 2.1.1.6 and chapter 2.1.3.1).	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the volume of PFOS in the soil with the stipulated level of uncertainty.
Comments/uncertainty:	No soil samples have been analysed for compounds other than PFOS and PFOA.	
General information about the airport		
Other factors of significance to possible clean-up/implementation of measures (for example, planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	Solavika is part of a landscape protection area, and is also a widely used outdoor area. Ølbergskogen which is characterised as particularly important is directly southwest of Stavanger Airport. There is a bird conservation area directly north of Solavika which is part of a larger conservation area for birds along Jærstrendene. Indre Hafrsfjord which is a fjord threshold characterised as an important habitat; fjords with a naturally low oxygen content in the bottom water, is directly north of the airport. In addition, there are several important habitats around the airport, such as coastal moorland at Storaberget at Sande. In addition, many plants and animals on the red list have also been recorded. For example, several observations of corn crake have been made within the airport's area in the southeast.	

30 Stokmarknes Airport, Skagen



Stokmarknes lufthavn
Skagen (ENSK)

Oversiktskart inkl. brannøvingsfelt

PFOS grunnvannsbrønn (ug/l)
- <0.002-0.3
- 0.3-1.0
- >1.0
- Ikke analysert

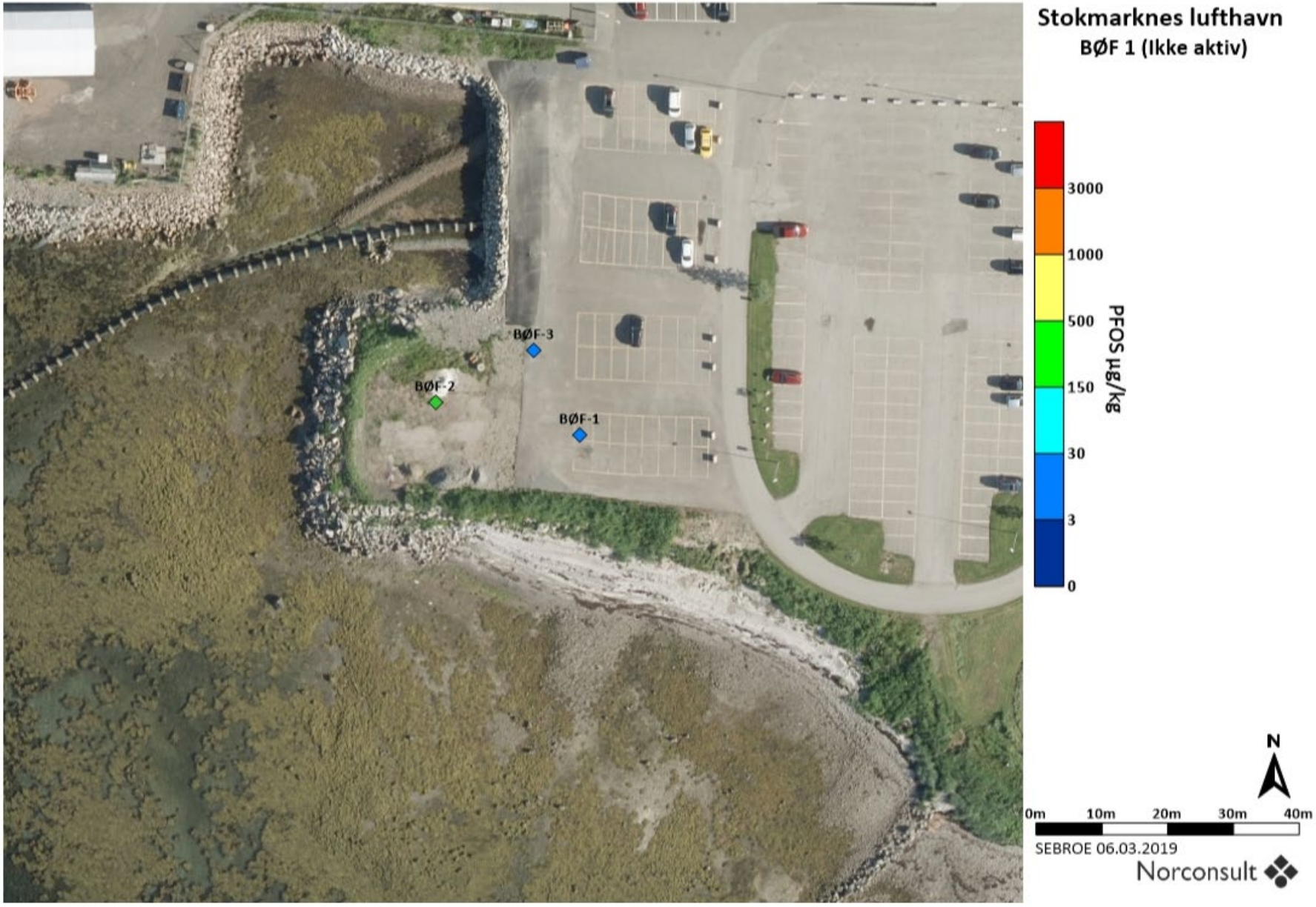
PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

Mrk. varierende skala for x-aksen i diagrammene

* PFOS er dominerende parameter

ip = ikke påvist

AVINOR COWI SWECO


Stokmarknes lufthavn
BØF 1 (Ikke aktiv)
BØF-3
BØF-2
BØF-1
3000
1000
500
150
30
3
0
PFOS µg/kg
N
0m 10m 20m 30m 40m
SEBROE 06.03.2019
Norconsult

30.1 Fire training site (BØF) / contaminated site

Fire training site (BØF) / contaminated site	BØF 1 (old)
	The fire training site is from the 1990s or earlier, and is no longer active, but it is not known when it was taken out of service. No new fire training site has been established.

30.2 The use of PFOS and other PFAS

Volume of PFOS used at the site (kg)	Not calculated/stated
Comments/uncertainty:	
Volume of PFAS used at the site (kg)	Not calculated/stated
Comments/uncertainty:	

30.3 Soil sampling

Total number of soil samples	9
Comments/uncertainty (for example, 95% of the samples were taken from 0–0.1 m)	Three shafts have been dug at BØF 1. The depth of the shafts varies between 0.5-1 metres. Samples of the top 10 cm, a sample from the bottom of the shaft, and a sample between the top layer and the bottom were taken from each shaft.
Number of soil samples 0-1 m beneath the ground	9
Number of soil samples below 1 m	0
Comments/uncertainty:	The surficial deposits generally consist of filled materials of blocks, rubble, sand and gravel.
Highest measured soil concentration of PFOS µg/kg	350
Where	BØF-2-2 (0.1-0.6 m). The materials consist of stones, block, gravel and sand.
Highest measured soil concentration of PFAS µg/kg	350
Where	BØF-2-2 (0.1-0.6 m). The materials consist of stones, block, gravel and sand.
Comments/uncertainty:	All the samples were analysed for PFOS and PFOA.

30.4 Volume calculation

No volume has been calculated for the site.	There are only three sampling points, and therefore the volumes in soil were not calculated at this location.
Comments	The DP2 report assumes that the most contaminated area is situated within an area of 10*10 metres. It is assumed that the thickness of the contaminated materials is approximately 2 metres, and that the average concentration of PFOS in this area is 96.2 µg/kg. On this basis it is calculated that 31 g of PFOS and 0.09 g of PFOA remain at the BØF.
Is the extent of the contaminated area delimitated horizontally?	No, concentrations above the detection limit were detected in all the nine soil samples, and in the four sediment samples taken north of the BØF. In two of the soil samples in sjakt 2 (taken between 0-60 cm deep), and in one sediment sample, concentrations of PFOS were between 260-350 µg/kg. In sjakt 1 and sjakt 3, concentrations above 20 µg/kg were not detected in any of the samples.
Is the extent of the contaminated area limited vertically?	Concentrations above the detection limit have been detected in the samples from the bottom of the shaft in all three shafts. The contamination is therefore not delimitated vertically. However, low concentrations have been detected in the samples of the from the bottom of the shafts, between 5.2-76.5 µg/kg. In sjakt 2 which has the highest concentrations in soil, the concentration in the deepest sample (at 60cm) is the lowest (76.5 µg/kg).
Comments/uncertainty:	

30.5 Water sampling and annual dispersion

Have water samples been taken?	Yes
Where	Groundwater sample in shaft BØF-2. No samples of surface water were taken.
Highest measured concentration of PFOS in groundwater (ng/l)	387
Where	BØF-2-GV1
Highest measured concentration of PFAS in groundwater (ng/l)	387
Where	BØF-2-GV1
Comments/uncertainty:	The sample was only analysed for PFOS and PFOA. Only PFOS, not PFOA, was detected in the sample.
Highest measured concentration of PFOS in surface water (ng/l)	Not sampled/analysed
Where	
Highest measured concentration of PFAS in surface water (ng/l)	
Where	
Comments/uncertainty:	

Total annual dispersion of PFOS from the airport (g/year)	2
Total annual dispersion of PFAS from the airport	Not calculated
To which recipient	Langøysundet
Calculated from water or soil concentration.	Calculated concentration in groundwater based on average soil concentration and a kd of 30.

30.6 Biota sampling

Have biota samples being taken at the airport?	No
What kind of biota?	
How many samples?	
Highest measured concentration of PFOS in biota (µg/kg wet weight)	
Where	
Highest measured concentration of PFAS in biota (µg/kg wet weight)	
Where	
Median concentration in comparable populations (e.g. in a lake)	
Comments/references	
References and concentrations in other reports.	

30.7 Uncertainty and other factors

Does the estimate of the volume of PFOS in the ground correspond with the measured concentrations in water and biota?	Cannot be evaluated. The volume of PFOS remaining in the ground at this site was not calculated, as samples were only taken from 3 points. One sample of groundwater was taken from one excavation shaft. Experience shows that such a sample will contain unusually high concentrations of PFAS due to significant mobilisation at the excavation, and it is therefore uncertain how representative the analysis result is for the concentrations in the groundwater in the area.
Evaluations	
Comments/uncertainty: (Could there be any additional unknown sources of PFOS at the site with run-off to the recipient?)	It is not stated that there are additional sources of PFOS contamination at the site or elsewhere at the airport, but the possibility cannot be ruled out.
Has the site been sufficiently mapped with a view to assessing the order of prioritisation?	No, samples have only been taken from three points. The site is not well enough mapped with a view to assessing the order of prioritisation (see this report for parts 1 and 2, chapter 2.1.1.6 and chapter 2.1.3.1).
Comments/uncertainty:	

Other factors of significance to possible clean-up/implementation of measures (for example, planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	Several species with a high and especially high management interest have been recorded around the airport. North of the airport, a large area where the red-listed species great black-backed gull is located has been registered. Northeast of the BØF, an area where the endangered bird species northern lapwing is located has been registered. Northeast of the BØF is an important outdoor recreation area (Skagen/Marken). East of the BØF there is a cultural heritage site. Stokmarknes Airport is registered with Avinor's vulnerability class 1, which means non-vulnerable recipients, standard level at the facility.

31 Svolvær Airport, Helle



Svolvær lufthavn
Helle (ENSH)

Oversiktskart

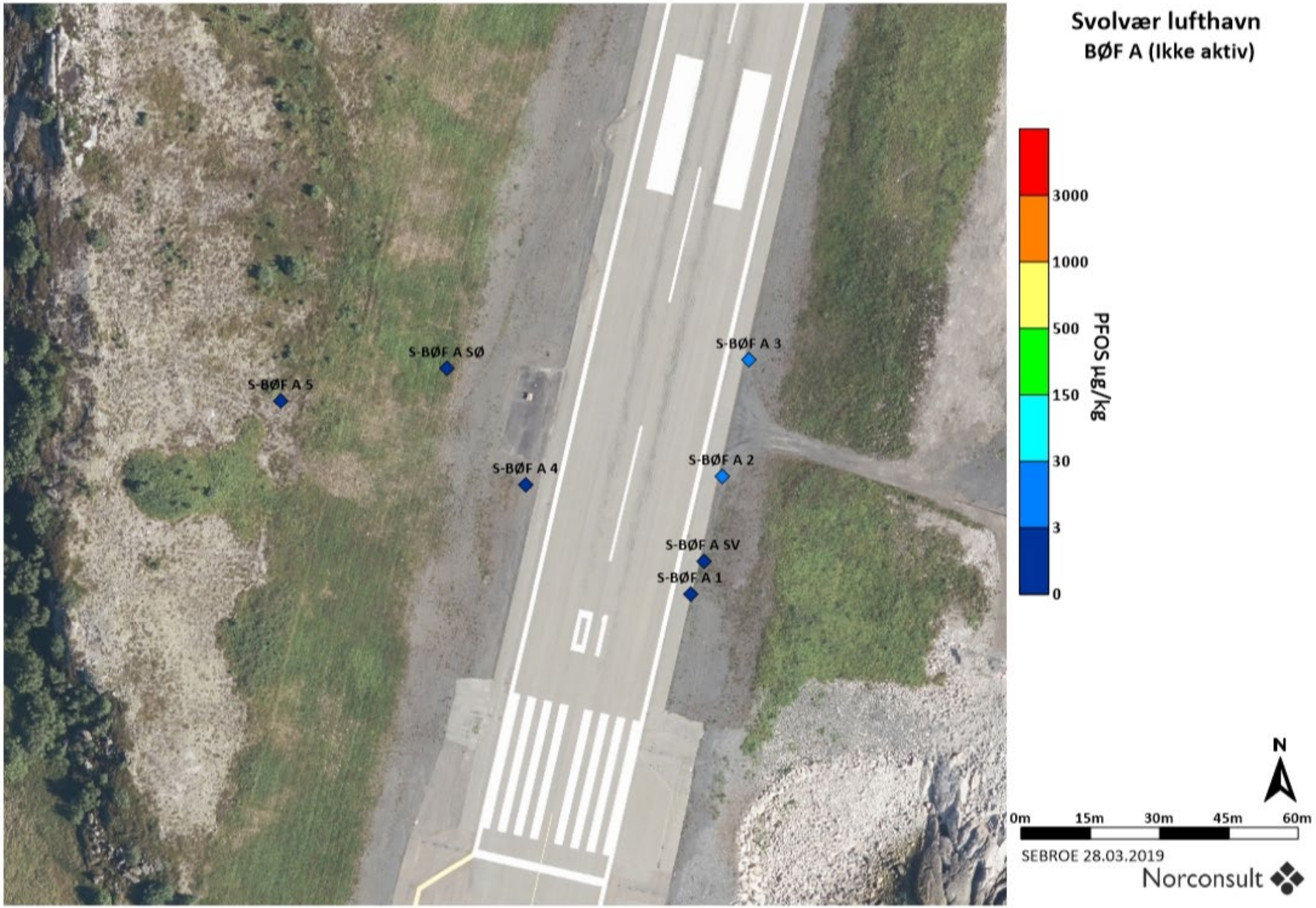
PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

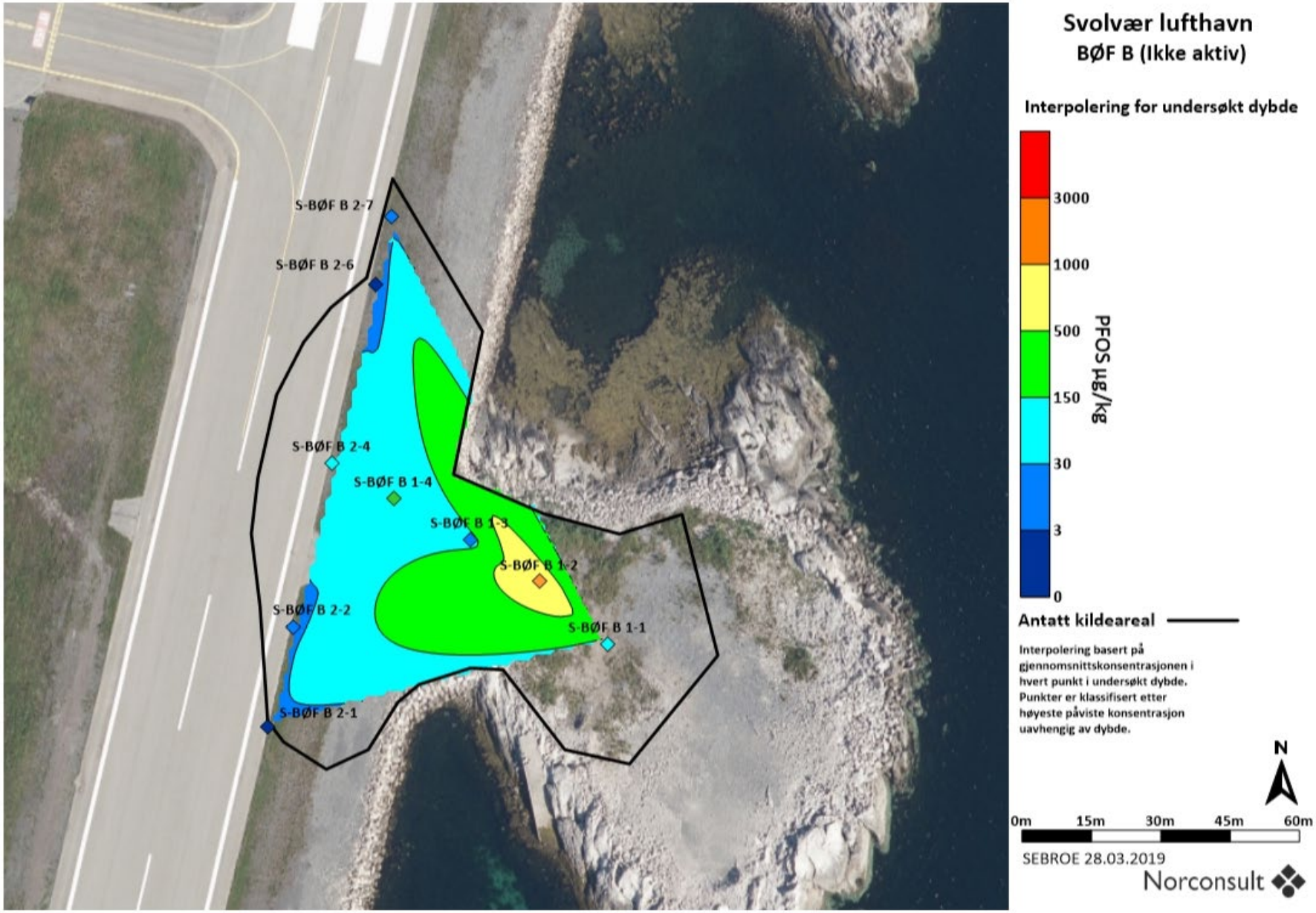
PFOS sediment marint (ug/kg)
- ★ <0,17
- ★ 0,17-220
- ★ 220-630
- ★ 630-3100
- ★ >3100
- ☆ Ikke analysert

Biota
- ✱

* PFOS er dominerende parameter

AVINOR COWI SWECO


Svolvær lufthavn
BØF A (Ikke aktiv)
S-BØF A SØ
S-BØF A 3
S-BØF A 5
S-BØF A 4
S-BØF A 2
S-BØF A SV
S-BØF A 1
3000
1000
500
150
30
3
0
PFOS µg/kg
N
0m 15m 30m 45m 60m
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S-BØF B 2-7
S-BØF B 2-6
S-BØF B 2-4
S-BØF B 1-4
S-BØF B 1-3
S-BØF B 1-2
S-BØF B 2-2
S-BØF B 1-1
S-BØF B 2-1
Svolvær lufthavn
BØF B (Ikke aktiv)
Interpolering for undersøkt dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m 15m 30m 45m 60m
SEBROE 28.03.2019
Norconsult

31.1 Fire training site (BØF) / contaminated site

Fire training site (BØF) / contaminated site	BØF B (inactive)	BØF A (inactive)
	Neither of the two fire training sites at the airport are still in use. It is uncertain when BØF B was established and when it was taken out of use. BØF B is the youngest site, and is located east of the runway, slightly further north than the oldest. Foam cannons are tested at locations along the runway.	Neither of the two fire training sites at the airport are still in use. It is uncertain when BØF A was established and when it was taken out of use. BØF A is the oldest site. Foam cannons are tested at locations along the runway. BØF A is located east of the southernmost part of the runway. It was probably located right on the bedrock, but is now covered with rocks and filler in connection with the expansion of the runway.

31.2 The use of PFOS and other PFAS

Volume of PFOS used at the site (kg)	Not stated/calculated	Not stated/calculated
Comments/uncertainty:		
Volume of PFAS used at the site (kg)	Not stated/calculated	Not stated/calculated
Comments/uncertainty:		

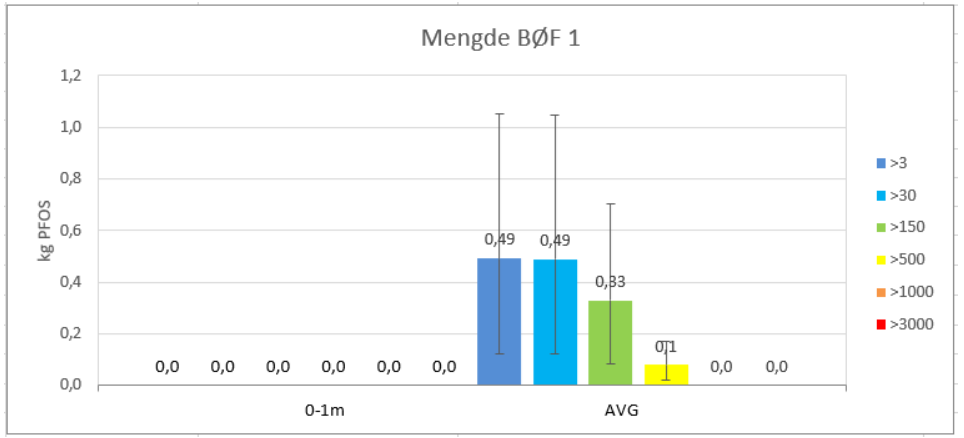
31.3 Soil sampling

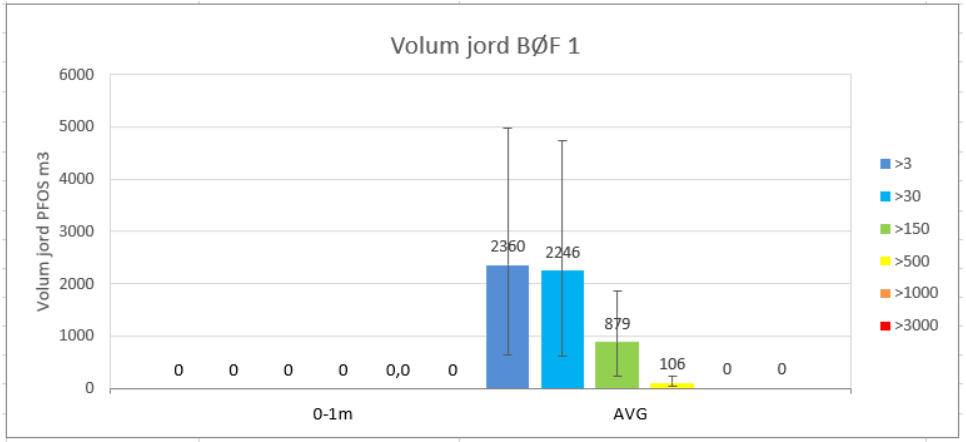
Total number of soil samples	12	7
Comments/uncertainty (for example, 95% of the samples were taken from 0–0.1 m)	8 the samples are surface samples (taken from the upper 0.2 metres). One of the sampling points was dug down to 1.3 metres.	5 of 7 of the samples are surface samples taken from 0-0.2 metres. It was not possible to dig down to the fire training site itself, and samples were taken at the surface where it was most assumed most likely that there was no overlying filler. Proximity to the runway meant that digging deep shafts was out of the question.
Number of soil samples 0-1 m beneath the ground	11	7
Number of soil samples below 1 m	1	0
Comments/uncertainty:	The materials are stated to consist of soil, rock, gravel and sand.	
Highest measured soil concentration of PFOS µg/kg	1,900	19.1
Where	S-BØF B 1-2 (0-0.1 m). The materials consist of rock, gravel and sand.	S-BØF A3 (0-0.2 m). The materials consist of soil, sand and gravel.

Highest measured soil concentration of PFAS µg/kg	1,905	19.1
Where	S-BØF B 1-2 (0-0.1 m). The materials consist of rock, gravel and sand.	S-BØF A3 (0-0.2 m). The materials consist of soil, sand and gravel.
Comments/uncertainty:	All samples were only analysed for PFOS and PFOA. PFOA has been detected in four of the samples, in concentrations between 4.6-3.4 µg/kg.	All samples were only analysed for PFOS and PFOA. PFOS has only been detected in 2 of the 7 samples, with concentrations of 7.9 and 19.1 µg/kg. No PFOA has been detected in any of the samples.

31.4 Volume calculation

PFOS average for all depths and points > 3 µg/kg		No volumes have been calculated for BØF A
Concentration (µg/kg)	175	
Area (m2)	3,372	
Volume of soil (tonnes)	4,013	
Volume of PFOS (kg)	0.5	
Uncertainty -	0.4	
Uncertainty +	0.6	
PFOS average for all depths and points > 30 µg/kg		
Concentration (µg/kg)	183	
Area (m2)	3,208	
Volume of soil (tonnes)	3,818	
Volume of PFOS (kg)	0.5	
Uncertainty -	0.4	
Uncertainty +	0.6	
PFOS average for all depths and points > 150 µg/kg		
Concentration (µg/kg)	313	
Area (m2)	1,256	
Volume of soil (tonnes)	1,495	
Volume of PFOS (kg)	0.3	
Uncertainty -	0.2	





Uncertainty +	0.4	
PFOS average for all depths and points > 500 µg/kg		
Concentration (µg/kg)	630	
Area (m2)	151	
Volume of soil (tonnes)	180	
Volume of PFOS (kg)	0.1	
Uncertainty -	0.1	
Uncertainty +	0.1	
PFOS average for all depths and points > 1,000 µg/kg		
Concentration (µg/kg)		
Area (m2)		
Volume of soil (tonnes)		
Volume of PFOS (kg)		
Uncertainty -		
Uncertainty +		
PFOS average for all depths and points > 3,000 µg/kg		
Concentration (µg/kg)		
Area (m2)		
Volume of soil (tonnes)		
Volume of PFOS (kg)		
Uncertainty -		
Uncertainty +		

Fire training site (BØF) / contaminated site	BØF B (inactive)	BØF A (inactive)
Comments regarding calculations	In the DP2 report, it is estimated that there are approximately 700 m3 of contaminated materials, equivalent to 1,200 tonnes, at BØF B, and that the average concentration of PFOS in the materials is 338 µg/kg. On this basis it is calculated that approximately 400 g of PFOS and 4 g of PFOA remain at BØF B.	No volume calculations have been performed for BØF A, because very little PFOS has been detected in the soil samples, and it is uncertain if the most contaminated materials have been detected.

	In the 2019 calculation, the area surveyed is approximately 3,370 m2, with approximately 4,000 tonnes of contaminated materials at BØF B. The average concentration of PFOS in these materials is 175 µg/kg. On this basis it is calculated that approximately 500 g of PFOS remains at BØF B. The volume of PFOS including positive uncertainty (within the estimated source area of about 6,560 m2) is calculated as approximately 1 kg. The two calculations arrive at approximately the same volume of residual PFOS at BØF B, although the volume of contaminated materials and their concentration assumed are different.	
Is the extent of the contaminated area delimitated horizontally?	No, the contamination of PFOS is not delimitated vertically, as concentrations above 3 µg/kg have been detected at several of the extreme points. At the extreme points to the northwest and southwest (S-BØF B 2-1, 2-2, 2.6 and 2.7) the concentrations are lower than 5 µg/kg. At the extreme points to the east and west, the concentrations of PFOS are 82.7 and 76.5 µg / kg respectively. The contamination therefore appears to be least delimitated in the eastern and western directions. However, the extent of contamination is limited in the eastern direction, as the sea is close by. The runway is to the west.	No samples were taken of the centre of the site because this area was inaccessible. Therefore, there are uncertainties related to the degree of contamination here. In the DP2 report, however, it is assumed that there is little contamination here, due to the fact that the site lay almost directly on the bedrock (thin cover of surficial deposits), and that there has therefore been a limited possibility of PFOS accumulation.
Is the extent of the contaminated area delimitated vertically?	Samples of deeper materials have only been taken at one point (S-BØF B 1-4). Here, a concentration of 287 µg/kg has been detected. Since only samples of deeper materials were taken at one point, there is uncertainty as to the degree of contamination of the deeper materials at BØF B. The vertical extent of the contamination will be limited by the depth to bedrock which is estimated to be 0.7 metres on average (about 0.5 m in the centre of the site, about 1.3 m at the runway and the exposed bedrock by the sea).	It is stated that BØF A was almost directly on the bedrock. Therefore, it is assumed that there will be no vertical spread of contamination.
Comments/uncertainty:		

31.5 Water sampling and annual dispersion

Have water samples been taken?	No	No
Where		
Highest measured concentration of PFOS in groundwater (ng/l)		
Where		
Highest measured concentration of PFAS in groundwater (ng/l)		
Where		

Comments/uncertainty:		
Highest measured concentration of PFOS in surface water (ng/l)		
Where		
Highest measured concentration of PFAS in surface water (ng/l)		
Where		
Comments/uncertainty:		
Total annual dispersion of PFOS from the site (g/year)	0.3	Not calculated
Total annual dispersion of PFAS from the site (g/year)	Not calculated	Not calculated
To which recipient	Austnesfjorden	Austnesfjorden
Calculated from water or soil concentration.	Soil concentration	

31.6 Biota sampling

Fire training site (BØF) / contaminated site	BØF B (inactive)	BØF A (inactive)
Have biota samples being taken at the airport?	Yes	Yes
What kind of biota?	Composite sample of common limpet and periwinkle.	Composite sample of common limpet and periwinkle.
How many samples?	2	1
Highest measured concentration of PFOS in biota (µg/kg wet weight)	7.1	1
Where	S-BØF B Biota 1	S-BØF A Biota
Highest measured concentration of PFAS in biota (µg/kg wet weight)	7.1	1
Where	S-BØF B Biota 1. The sample was only analysed for PFOS and PFOA. No PFOA was detected in the sample.	The sample S-BØF A Biota was only analysed for PFOS and PFOA. No PFOA was detected in the sample.
Median concentration in comparable populations (e.g. in a lake)	The average concentration PFOS in a composite sample of approximately 500 g of common limpet at a reference station "Vardetangen" at Fonnesflaket in Nord Hordaland was 0.229 µg/kg of wet weight. The concentration of total PFAS was 0.356 µg/kg. Reference: Uni Research Miljø SAM-Marlin: "Undersøkelse av miljøgifter i sediment og albuesnegl ved Fonnesflaket i Lindås 2016" ("Survey of environmental contaminants in sediment and	See description under BØF B

	common limpet at Fonnesflaket in Lindås 2016"), SAM e-report: 7-2016.	
Comments/references	The median concentration of total PFAS in common limpet (n=6) was 33.75 µg/kg ww in a bay just outside BØF at Statoil Mongstad in 2015. The median concentration of PFOS in the same samples was 7.2 µg/kg. Retrieved from Statoil Petroleum report; "Environmental contaminants in biota at Statoil Mongstad 2015, SAM e-report no: 35-2015.	See description under BØF B
References and concentrations in other reports.	The EQS value in the Water Regulations for PFOS in biota is 9.1 µg/g wet weight. PFOS was detected in the biota tests taken at Svolvær Airport, but none of the samples show concentrations above the EQS value. In a risk assessment from 13 December 2018, EFSA changed the tolerability limit (TDI - tolerable daily intake) for PFOS and PFOA, so these are now far lower than the TDI values set in 2008. This may cause EQS for biota to also be lower in the future.	See description under BØF B

31.7 Uncertainty and other factors

Fire training site (BØF) / contaminated site	BØF B (inactive)	BØF A (inactive)
Does the estimate of the volume of PFOS in the ground correspond with the measured concentrations in water and biota?	Water could not be evaluated as no water samples have been taken at the airport. Cannot be reliably evaluated for biota.	Water could not be evaluated as no water samples have been taken at the airport. There is considerable uncertainty regarding the volume of PFOS in the ground, as it has not been possible to collect samples from the centre of the fire training site. It is therefore difficult to conclude whether there is any link

		between concentrations in soil and concentrations in biota.
Evaluations	The biota samples are of common limpet and periwinkle, which are stationary species. PFAS detected in these will therefore be due to local contamination and activity at the BØF or the airport. Relatively low concentrations have been detected in the biota samples (but only two samples have been analysed), and a low remaining volume of PFOS has also been calculated in the materials at the BØF (between 0.5-1 kg). In the DP 2 report it is stated that it is likely that the contamination in one biota sample with a concentration of 7.1 µg/kg is due to direct impact from testing foam cannons. In the second biota sample taken at BØF B, a concentration of 0.9 µg/kg has been detected. The concentrations of PFOS in both biota samples are below the EQS value specified in the water regulations.	The biota samples are of common limpet and periwinkle, which are stationary species. PFAS detected in these will therefore be due to local contamination and activity at the BØF or the airport. Low concentrations of PFOS have been detected both in the soil samples and in the biota sample taken outside BØF A. No samples have been taken of the centre of BØF B, but due to the limited thickness of surficial deposits over bedrock, it is assumed that the extent of any contamination will be small. A biota sample provides a limited basis for assessing dispersion, but the low concentrations in one sample indicate that there is little dispersion from BØF B to biota.
Comments/uncertainty: (Could there be any additional unknown sources of PFOS at the site with run-off to the recipient?)	It is stated in the DP2 report that foam cannons were tested in locations along the runway. This suggests that there may be PFOS contaminated materials elsewhere than at the two fire training sites. No soil samples have been analysed for PFOS anywhere other than at the fire training sites, and no water samples have been taken.	It is stated in the DP2 report that foam cannons were tested in locations along the runway. This suggests that there may be PFOS contaminated materials elsewhere than at the two fire training sites. No soil samples have been analysed for PFOS anywhere other than at the fire training sites, and no water samples have been taken.

Has the site been sufficiently mapped with a view to assessing the order of prioritisation?	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the volume of PFOS in the soil with the stipulated level of uncertainty.	No, samples were not taken from the centre of BØF B, and the site is therefore not well enough mapped with a view to assessing the order of prioritisation (see this report for parts 1 and 2, chapter 2.1.1.6 and chapter 2.1.3.1).
Comments/uncertainty:	The degree of contamination of the deeper materials at the site is uncertain, as samples of deeper materials have only been taken at one point. However, the average depth of surficial deposits is approximately 0.7 m above the bedrock.	
General information about the airport		
Other factors of significance to possible clean-up/implementation of measures (for example, planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	Species of high and particularly high management interest have been recorded at the northern end of the airport, as well as in the marine area outside the airport. The coastal zone alongside the whole airport is registered as the habitat "extensive instances of kelp forest". A cultural heritage site is registered inside the airport area, and some cultural heritage sites west of the southern part of the airport. The airport is registered with Avinor's vulnerability class 2, which means somewhat less vulnerable recipients. Moderate priority and level at the facility. Six samples were analyses for THC content at BØF B. THC content in environmental condition class 4-5 has been detected in two of the samples, and environmental condition class 2-3 in two.	

32 Sørkjosen Airport



Sørkjosen lufthavn (ENSR)

Oversiktskart

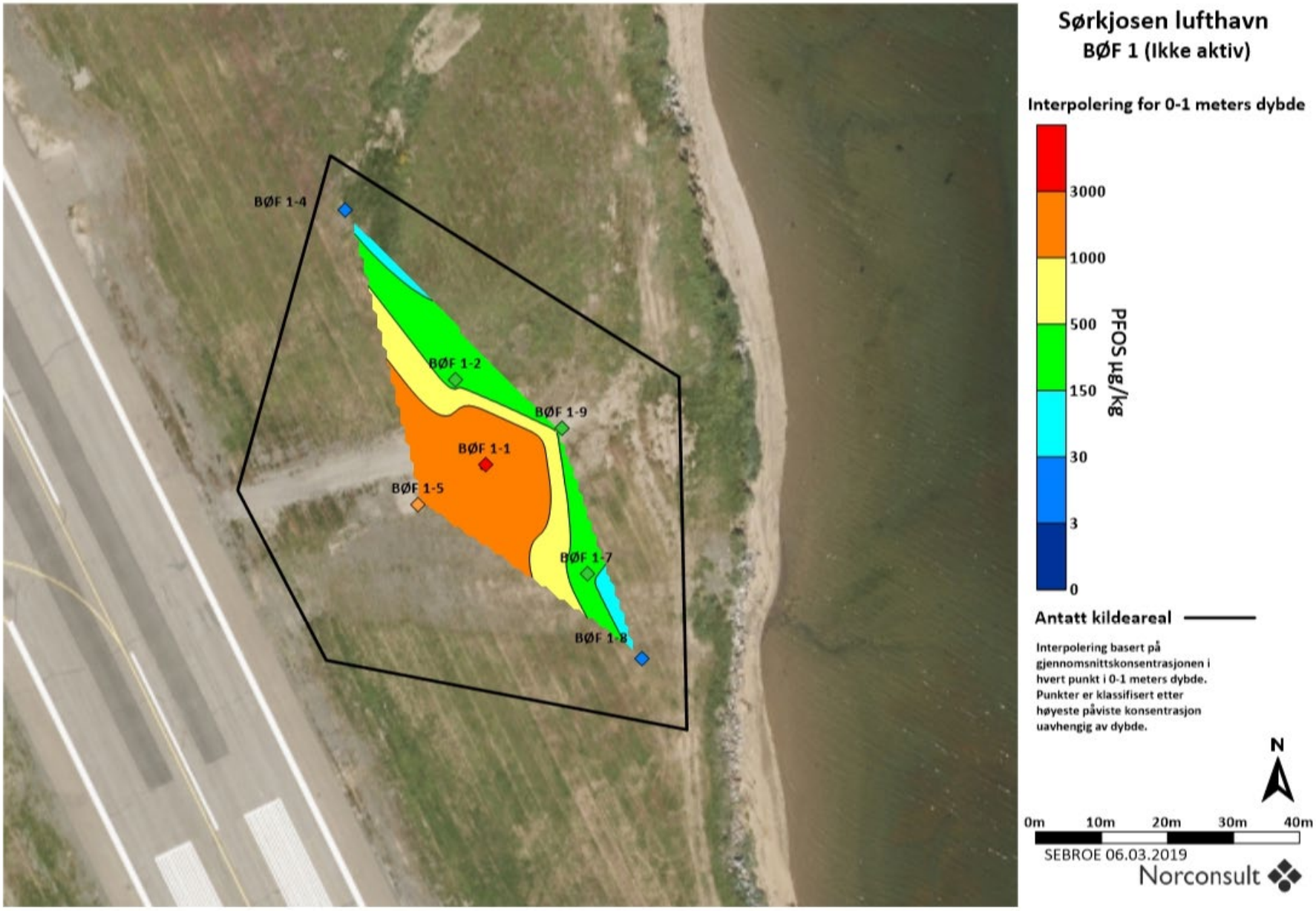
PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

PFOS sediment marint (ug/kg)
- ★ <0,17
- ★ 0,17-220
- ★ 220-630
- ★ 630-3100
- ★ >3100
- ☆ Ikke analysert

EEI 1, 2 og 3 er blandprøver av overflatejord. Fargekoder som for PFOS/PFOA jord.

* PFOS er dominerende parameter

AVINOR COWI SWECO



Sørkjosen lufthavn
BØF 1 (Ikke aktiv)

Interpolering for 0-1 meters dybde

PFOS µg/kg
3000
1000
500
150
30
3
0

Antatt kildeareal

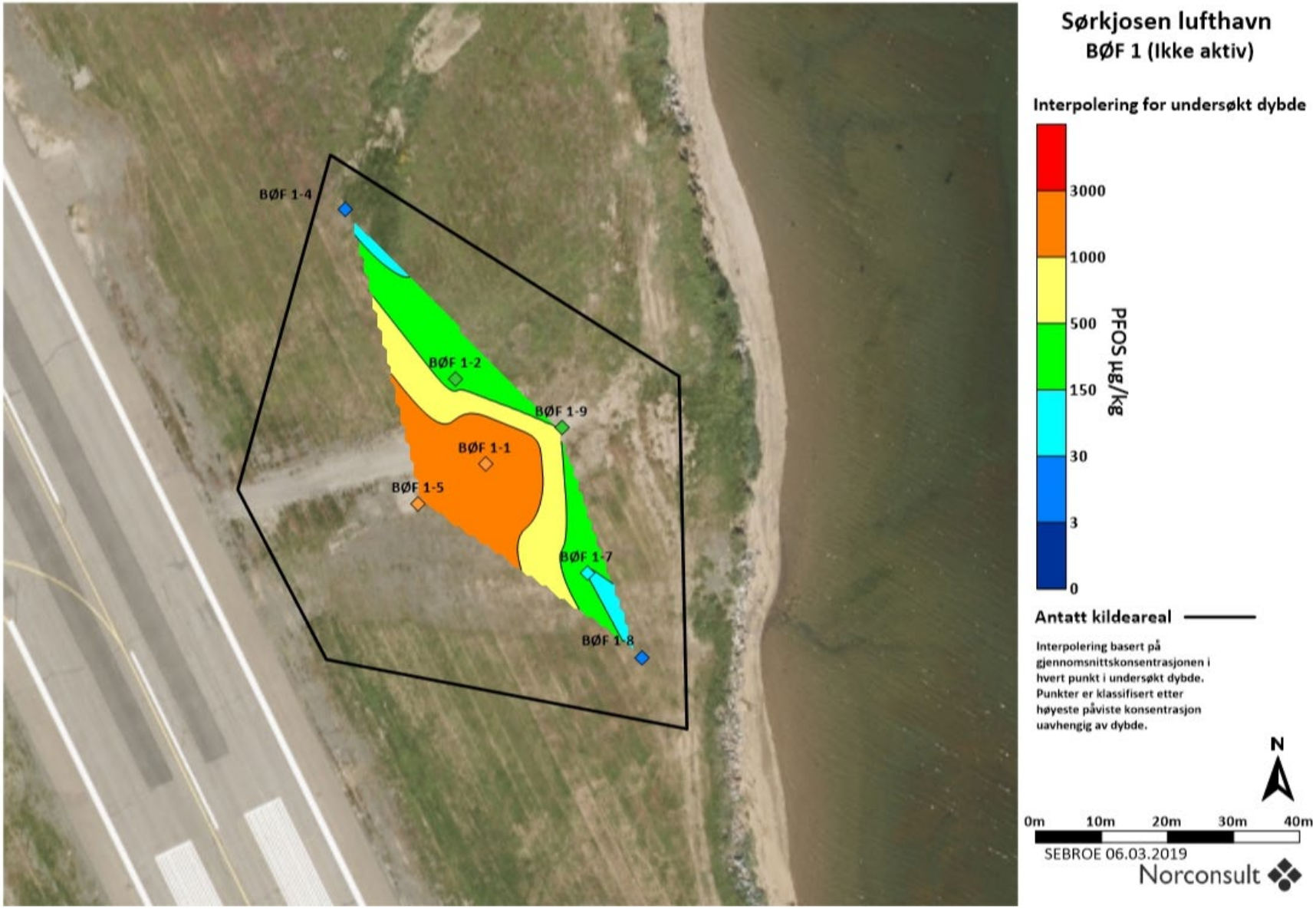
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i 0-1 meters dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.

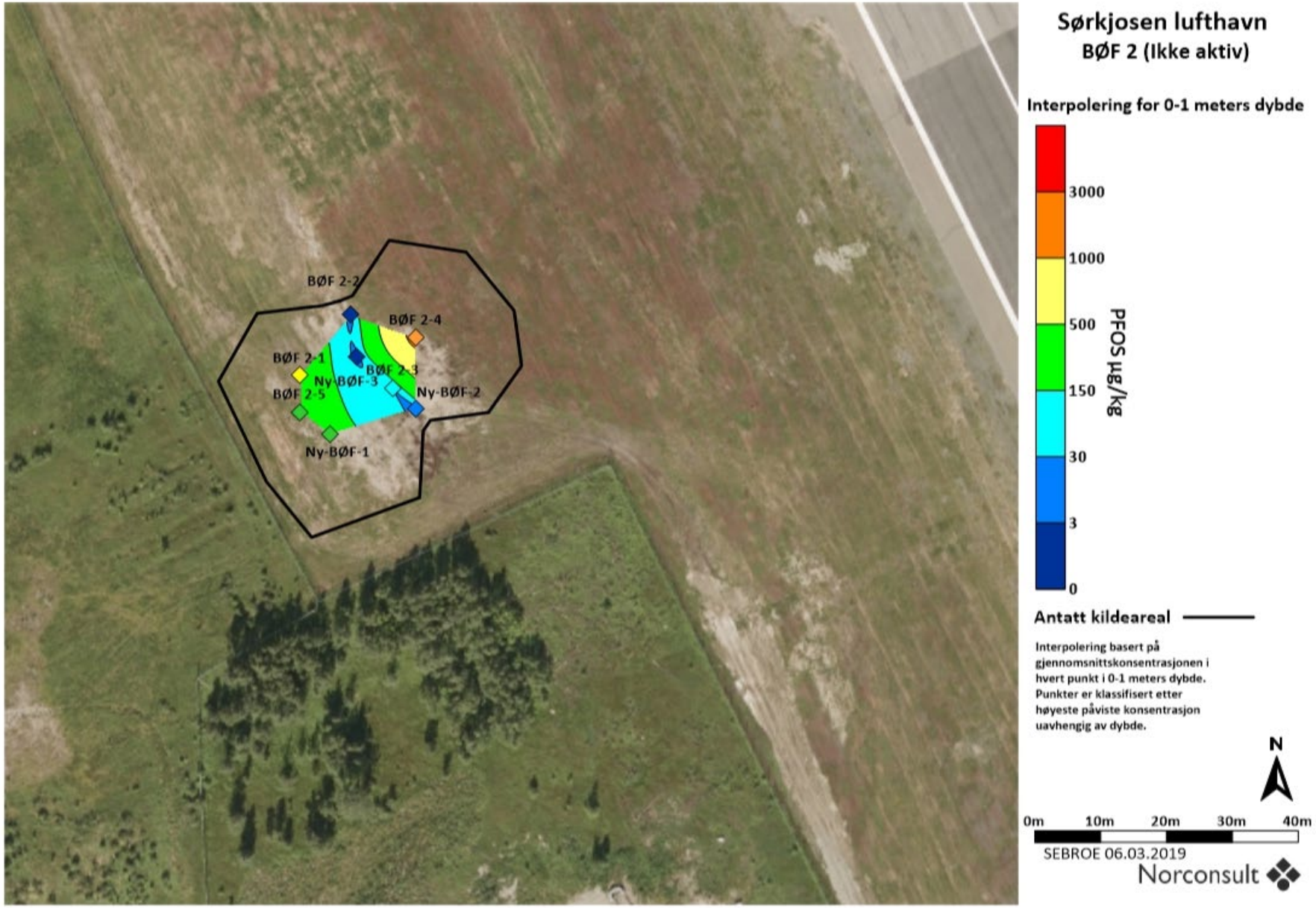
N

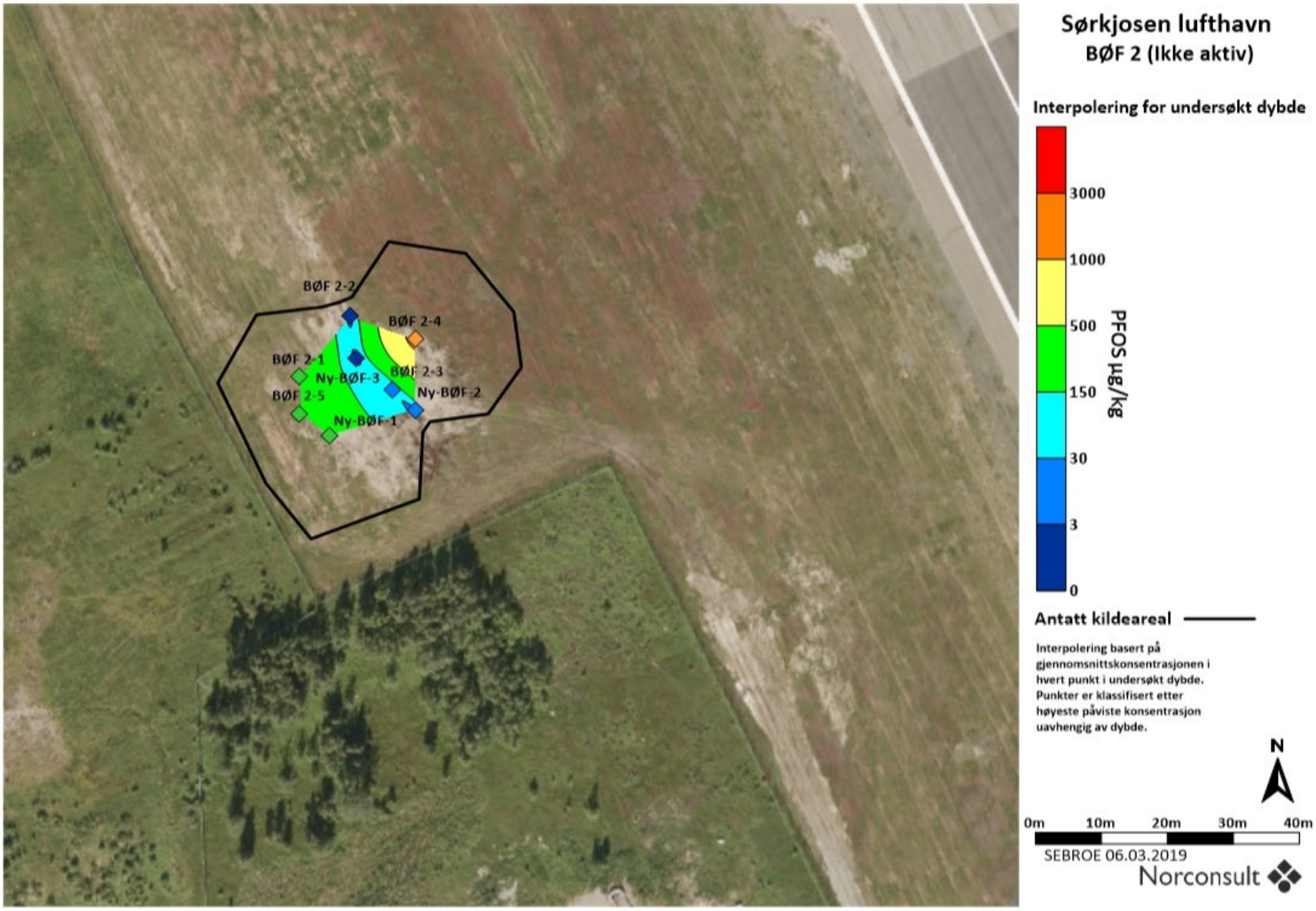
0m 10m 20m 30m 40m

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BØF 1-4
BØF 1-2
BØF 1-9
BØF 1-1
BØF 1-5
BØF 1-7
BØF 1-8
Sørkjosen lufthavn
BØF 1 (Ikke aktiv)
Interpolering for undersøkt dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m 10m 20m 30m 40m
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BØF 2-2
BØF 2-4
BØF 2-1
BØF 2-3
Ny-BØF-3
BØF 2-5
Ny-BØF-2
Ny-BØF-1
Sørkjosen lufthavn
BØF 2 (Ikke aktiv)
Interpolering for 0-1 meters dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i 0-1 meters dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m 10m 20m 30m 40m
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Sørkjosen lufthavn
BØF 2 (Ikke aktiv)

Interpolering for undersøkt dybde

PFOS µg/kg
3000
1000
500
150
30
3
0

Antatt kildeareal

Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.

N

0m 10m 20m 30m 40m

SEBROE 06.03.2019

Norconsult

32.1 Fire training site (BØF) / contaminated site

Fire training site (BØF) / contaminated site	BØF 1 (old)	BØF 2 (inactive)
	BØF 1 was taken out of use in 2006.	BØF 2 was established in 2006, but has not been widely used. The site was operational during the surveys in 2012, but it says in the report that the use of the site would not be continued. Run-off from the fire training site follows surface and groundwater. The fire training site has no visible sealing or controlled runoff.

32.2 The use of PFOS and other PFAS

Volume of PFOS used at the site (kg)	Not stated/calculated	Not stated/calculated
Comments/uncertainty:		
Volume of PFAS used at the site (kg)	Not stated/calculated	Not stated/calculated
Comments/uncertainty:		According to verbal information, no firefighting foam containing PFOS has been used at BØF 2.

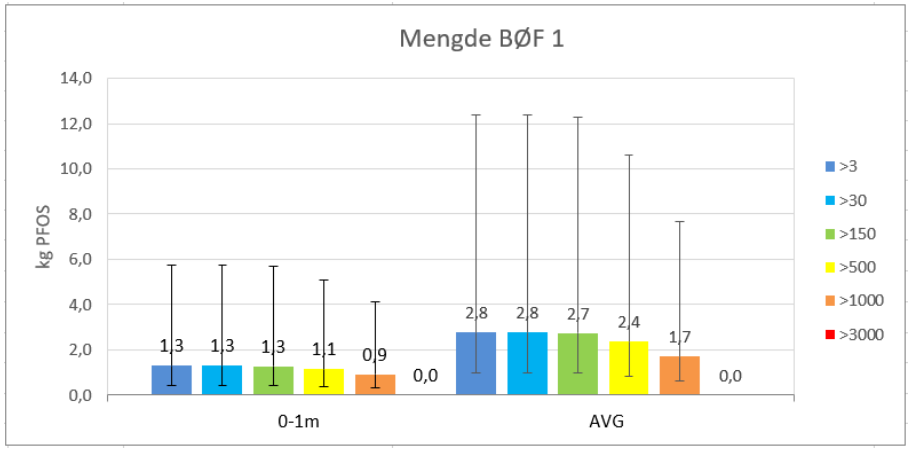
32.3 Soil sampling

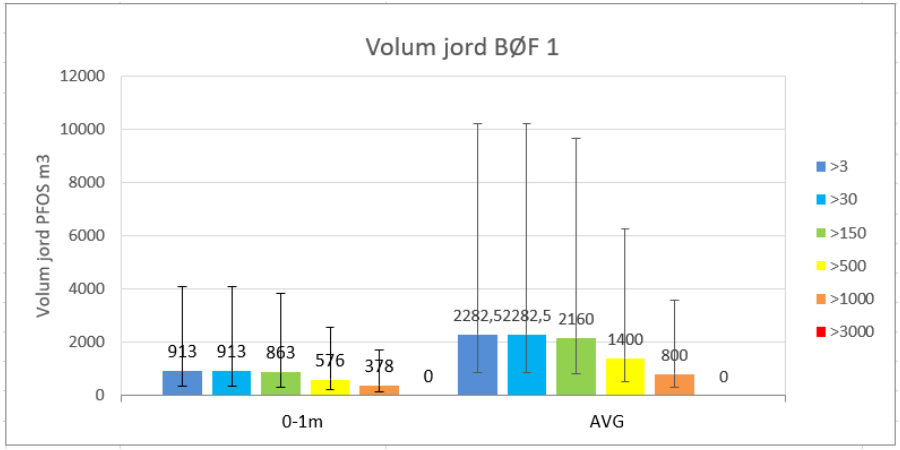
Total number of soil samples	21	22
Comments/uncertainty (for example, 95% of the samples were taken from 0–0.1 m)	At each sampling point, three samples have been taken out and analysed; a sample of the surface materials, a sample from about 0.2-2 metres and a sample from the bottom of the shaft. The materials are described as a thin gravel and crushed stone layer with soil. The deeper coastal deposits include layers of medium sand to fine sand and coarse sand. Groundwater at a depth of 2.5 m in some shafts.	Five shafts were dug down to 1.3-1.5 m in 2011 and three shafts down to 2.2 metres in 2012. From each shaft, samples of the top 10 cm, samples of the materials between the top layer and bottom of the shaft and samples from the bottom of the shaft were taken. The materials are stated to consist of a thin sand, gravel and crushed stone with roots. The deeper coastal deposits include a few layers of fine sand, medium sand and coarse sand. Groundwater at a depth of about 1.3 to 2.2 m in some shafts.
Number of soil samples 0-1 m beneath the ground	14	15
Number of soil samples below 1 m	14	14

Comments/uncertainty:	There are a total of 28 samples if the samples that cover both depth intervals of 0-1 m and> 1 m are split up.	There are a total of 29 samples if the samples that cover both depth intervals of 0-1 metre and > 1 metre are split up.
Highest measured soil concentration of PFOS µg/kg	4,890	1,190
Where	BØF 1-1-1 (0-0.2 m). The materials consist of sand, with gravel, roots, crushed stone layers.	BØF 2-4-2 (0-0.2 m). The materials consist of gravel with sand, crushed stone and roots.
Highest measured soil concentration of PFAS µg/kg	4,890	1,210
Where	BØF 1-1-1 (0-0.2 m). The materials consist of sand, with gravel, roots, crushed stone layers.	BØF 2-4-2 (0-0.2 m). The materials consist of gravel with sand, crushed stone and roots.
Comments/uncertainty:	All samples were only analysed for PFOS and PFOA.	9 of the samples were analysed for 12 different PFAS compounds. The remaining 13 samples were analysed for PFOS and PFOA.

32.4 Volume calculation

PFOS average for all depths and points > 3 µg/kg	BØF 1	BØF 2
Concentration (µg/kg)	842	219
Area (m2)	913	226
Volume of soil (tonnes)	3,652	759
Volume of PFOS (kg)	2.8	0.15
Uncertainty -	1.8	0.11
Uncertainty +	9.6	0.69
PFOS average for all depths and points > 30 µg/kg		
Concentration (µg/kg)	842	227
Area (m2)	913	216
Volume of soil (tonnes)	3,652	726
Volume of PFOS (kg)	2.8	0.15
Uncertainty -	1.8	0.11
Uncertainty +	9.6	0.68
PFOS average for all depths and points > 150 µg/kg		
Concentration (µg/kg)	881	344
Area (m2)	864	116
Volume of soil (tonnes)	3,456	390
Volume of PFOS (kg)	2.7	0.12
Uncertainty -	1.8	0.09
Uncertainty +	9.5	0.55
PFOS average for all depths and points > 500 µg/kg		
Concentration (µg/kg)	1,174	722
Area (m2)	560	23
Volume of soil (tonnes)	2,240	77
Volume of PFOS (kg)	2.4	0.05
Uncertainty -	1.5	0.04
Uncertainty +	8.2	0.23





PFOS average for all depths and points > 1,000 µg/kg		
Concentration (µg/kg)	1,487	1,058
Area (m2)	320	1.0
Volume of soil (tonnes)	1,280	3.4
Volume of PFOS (kg)	1.7	0.003
Uncertainty -	1.1	0.002
Uncertainty +	6.0	0.015
PFOS average for all depths and points > 3,000 µg/kg		
Concentration (µg/kg)		
Area (m2)		
Volume of soil (tonnes)		
Volume of PFOS (kg)		
Uncertainty -		
Uncertainty +		

Fire training site (BØF) / contaminated site	BØF 1 (old)	BØF 2 (inactive)
Comments regarding calculations	In the DP2 report it is estimated that BØF 1 has a contaminated area of about 3,500 m2, with a depth down to 2.5 metres below terrain. It states that the density of the materials is calculated at 1.5 kg/m3, but it is estimated to be 1.5 tonnes/m3. With an average PFOS concentration of 854 µg/kg, this gives a residual volume of 11.2 kg PFOS (not 11.2 g as stated in the report). In 2019, it is estimated that the volume of PFOS within the estimated volume (which has an area of 900 m2 and depth of 2.5 metres) is 2.8 kg. The contaminated area is not very delimitated, and the volume of PFOS including positive uncertainty (within the estimated source area of about 4,060 m2) is calculated to be 12.4 kg.	In the DP2 report it is assumed that BØF 2 has a contaminated area of about 2,500 m2. It is assumed that the thickness of the contaminated materials is approximately 2.2 metres, that the density is 1,600 kg/m3 and that the average concentration of PFOS in this area is 315 µg/kg. This gives an estimated residual volume of PFOS of approximately 2.8 kg. In 2019, it was calculated that the volume of PFOS within the surveyed volume is 0.15 kg. The surveyed area is 226 m2, and the depth is 2.1 metres. The contaminated area is not very delimitated, and positive uncertainty for the volume of PFOS (within the estimated source area of about 1,250 m2) is calculated to be 0.85 kg.

Is the extent of the contaminated area delimitated horizontally?	No, to a minor degree. Concentrations of PFOS above the detection limit have been detected at all extreme points (between 41.6-2,800 µg/kg). The contamination appears to be least delimitated in the northeastern and eastern directions.	No, the contamination is not delimitated horizontally. The highest concentrations of PFOS (557-1,190 ug/kg) have been detected in surface samples at the extreme points to the east (BØF 2-4) and to the west (BØF 2-1, 2-5, and Ny-BØF 1). It is uncertain how much further to the east and west this contamination extends. The DP2 report states that there is an old bus on the site and that there are some metal barrels that are set on fire in front of this bus. In the aerial photo, the bus stands west and southwest (location slightly varying from year to year) from the area surveyed. It is therefore uncertain whether the most contaminated area has been uncovered.
Is the extent of the contaminated area delimitated vertically?	No, relatively high PFOS concentrations were detected in many of the deepest samples, and it is uncertain how much deeper the contamination extends.	The highest concentrations have been detected in surface materials (a depth of 0-20 cm). PFOS concentrations have been detected above the detection limit in three of the deepest samples (14.4 cm deep), but the PFOS concentrations are low 32.9 µg/kg). In the five remaining deepest samples from the shafts, no PFOS has been detected.
Comments/uncertainty:	Groundwater was at approximately 2.5 metres deep in some shafts. It is assumed that the groundwater is tidal. It is expected that the concentrations of PFOS will decrease rapidly with depth below groundwater level, where the contamination will have a horizontal dispersion in the groundwater flow direction.	Groundwater was at a depth of about 1.3 to 2.2 m in some shafts. It is assumed that the groundwater is tidal. It is expected that the concentrations of PFOS will decrease rapidly with depth below groundwater level, where the contamination will have a horizontal dispersion in the groundwater flow direction.

32.5 Water sampling and annual dispersion

Fire training site (BØF) / contaminated site	BØF 1 (old)	BØF 2 (inactive)
Have water samples been taken?	No	No
Where		
Highest measured concentration of PFOS in groundwater (ng/l)		
Where		
Highest measured concentration of PFAS in groundwater (ng/l)		
Where		
Comments/uncertainty:		
Highest measured concentration of PFOS in surface water (ng/l)		
Where		
Highest measured concentration of PFAS in surface water (ng/l)		
Where		
Comments/uncertainty:		
Total annual dispersion of PFOS from the site (g/year)	15	190
Total annual dispersion of PFAS from the site (g/year)	Not calculated	196.35 g if you add together the calculations for PFOS and PFOA. It is uncertain whether these calculations are correct, as it is stated in chapter 3.2.3.4 of the report that no samples of groundwater have been taken, and in chapter 3.2.3.5 it is stated that the calculation is based on average concentrations measured in groundwater. No water sampling is described in the report, and no water sampling results are included either.
To which recipient	Reisafjorden (located about 50 metres in the eastern direction from the BØF).	Reisafjorden (which is located about 200 metres in an easterly direction).
Calculated from water or soil concentration.	Calculated concentrations in groundwater based on average soil concentrations and a kd of 30.	Uncertain.

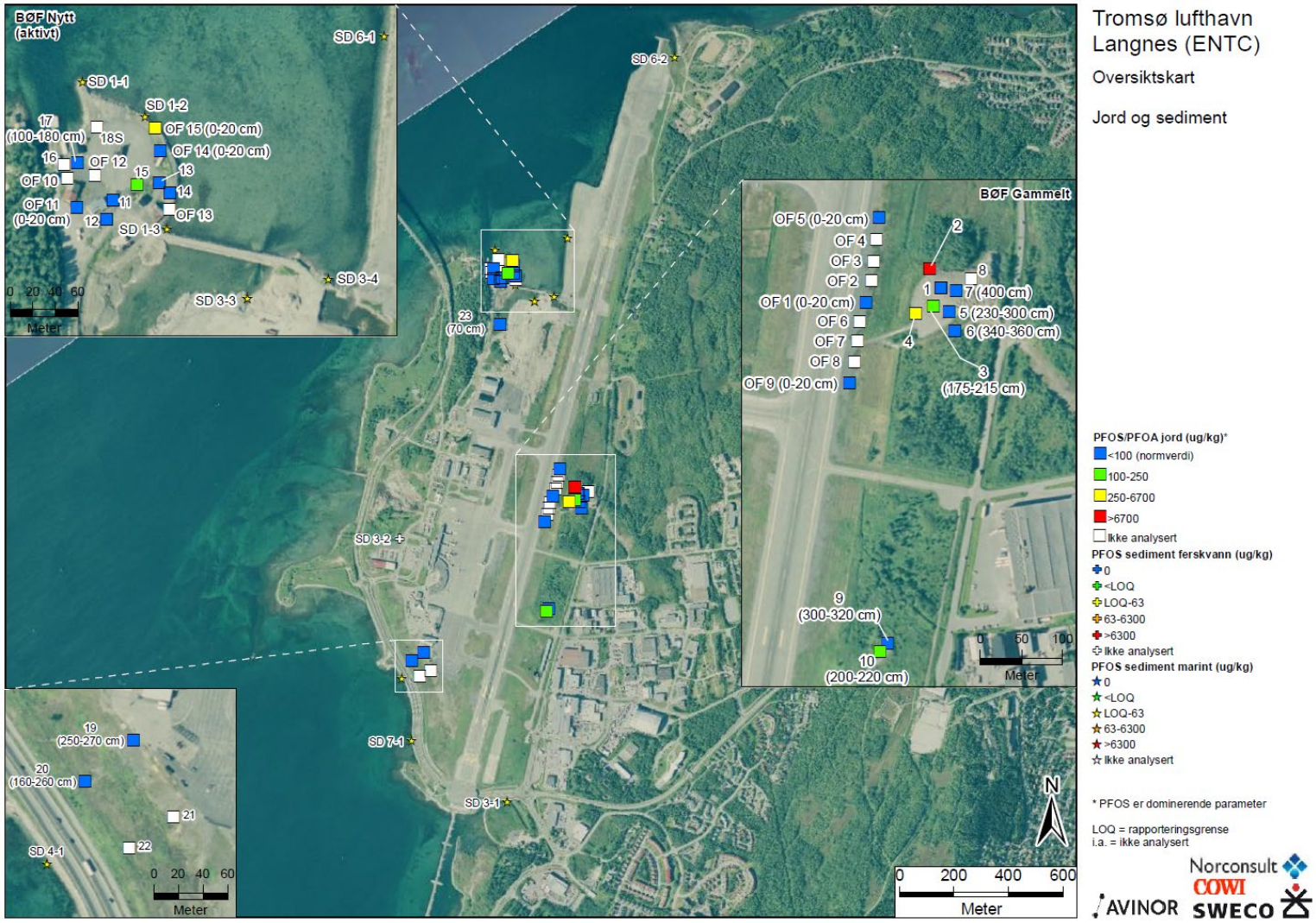
32.6 Biota sampling

Fire training site (BØF) / contaminated site	BØF 1 (old)	BØF 2 (inactive)
Have biota samples being taken at the airport?	No	No
What kind of biota?		
How many samples?		
Highest measured concentration of PFOS in biota (µg/kg wet weight)		
Where		
Highest measured concentration of PFAS in biota (µg/kg wet weight)		
Where		
Median concentration in comparable populations (e.g. in a lake)		
Comments/references		
References and concentrations in other reports.		

32.7 Uncertainty and other factors

Fire training site (BØF) / contaminated site	BØF 1 (old)	BØF 2 (inactive)
Does the estimate of the volume of PFOS in the ground correspond with the measured concentrations in water and biota?	Cannot be evaluated, as no water samples or biota samples have been taken at the airport.	Cannot be evaluated, as no water samples or biota samples have been taken at the airport.
Evaluations		
Comments/uncertainty: (Could there be any additional unknown sources of PFOS at the site with run-off to the recipient?)	As no biota samples or water samples have been analysed for PFOS from anywhere other than at the two fire training sites, and no biota samples or water samples have been taken, this cannot be evaluated. Sediment samples have been taken in the Reisafjord, but PFOS was not detected.	As no biota samples or water samples have been analysed for PFOS from anywhere other than at the two fire training sites, and no biota samples or water samples have been taken, this cannot be evaluated. Sediment samples have been taken in the Reisafjord, but PFOS was not detected.
Has the site been sufficiently mapped with a view to assessing the order of prioritisation?	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the volume of PFOS in the soil with the stipulated level of uncertainty.	No, the site is not well enough mapped with a view to assessing the order of prioritisation (see this report for parts 1 and 2, chapter 2.1.1.6 and chapter 2.1.3.1). The contaminated area is not very delimitated, and training may have taken place south/southwest of the surveyed area. The DP2 report states that there is an old bus on the site and that there are some metal barrels that are set on fire in front of this bus. In the aerial photo, the bus stands west and southwest (location slightly varying from year to year) from the area surveyed. It is therefore uncertain whether the most contaminated area has been uncovered.
Comments/uncertainty:	There is considerable uncertainty regarding the extent of the contaminated area, especially in the western and easterly directions.	
General information about the airport		
Other factors of significance to possible clean-up/implementation of measures (for example, planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	The marine area on the east side of the airport is protected as Reisautløpet nature reserve (wetland area). This marine area is also registered as a Ramsar site that forms an estuary. From Naturbase: A number of species of particularly high management interest have been recorded in and around the airport. Several important habitats have also been registered around the airport (soft-bottomed areas in the coastal zone, sea meadow and mudflats and grey alder). Just west of the airport is Goppa, which is a state-protected outdoor recreation area. The airport is registered with Avinor's vulnerability class 2, which means somewhat less vulnerable recipients. Moderate priority and level at the facility. THC has been detected above the norm value at BØF 2, in one of the 22 analysed soil samples, in environmental condition class 5.	

33 Tromsø Airport, Langnes



Tromsø lufthavn
Langnes (ENTC)

Oversiktskart

Jord og sediment

PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

PFOS sediment ferskvann (ug/kg)
- 0
- <LOQ
- LOQ-63
- 63-6300
- >6300
- Ikke analysert

PFOS sediment marint (ug/kg)
- 0
- <LOQ
- LOQ-63
- 63-6300
- >6300
- Ikke analysert

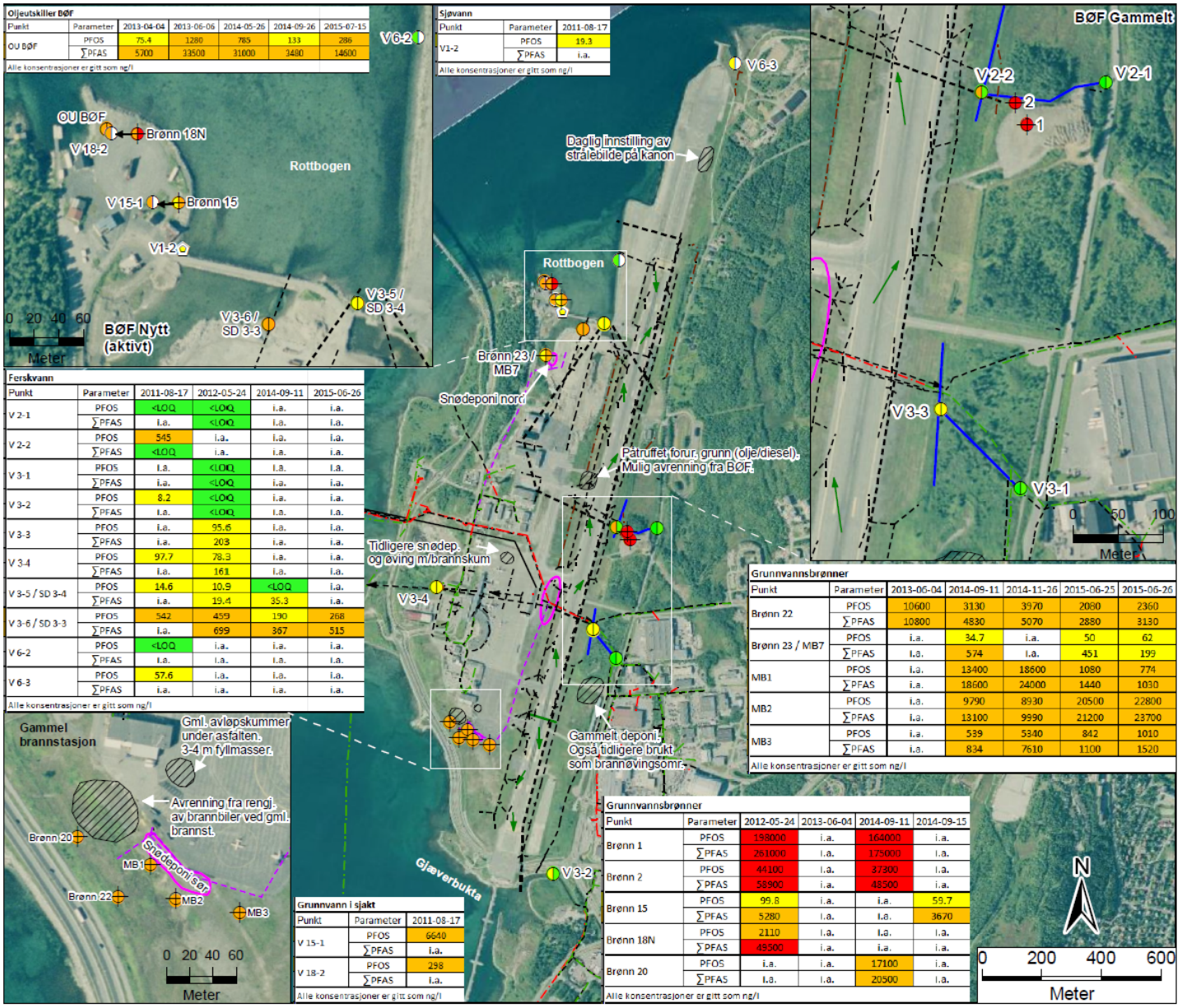
* PFOS er dominerende parameter

LOQ = rapporteringsgrense
i.a. = ikke analysert

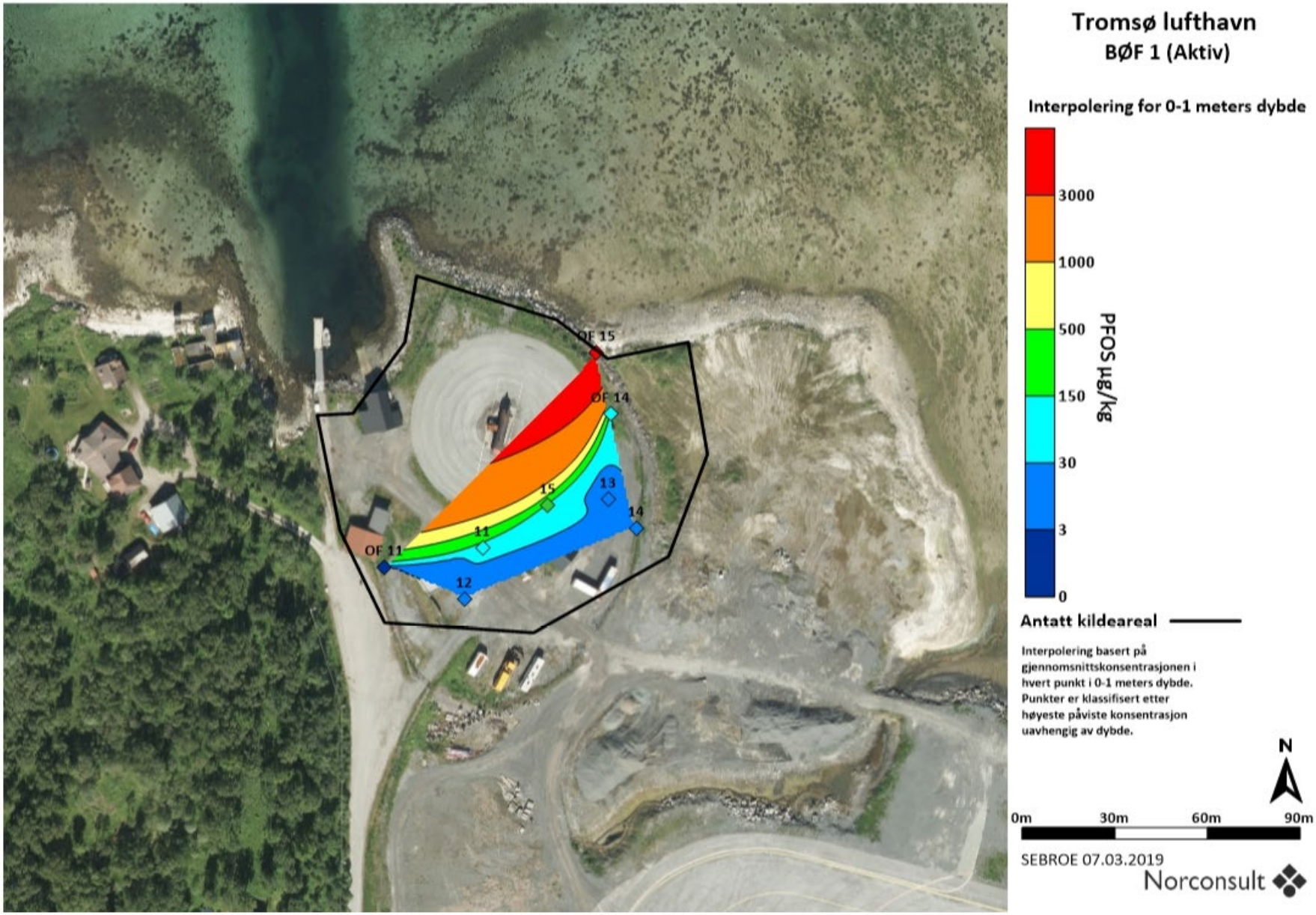
AVINOR Norconsult COWI SWECO

Norconsult

APPENDIX A



AVINOR Norconsult SWECO



Tromsø lufthavn
BØF 1 (Aktiv)

Interpolering for 0-1 meters dybde

PFOS µg/kg
3000
1000
500
150
30
3
0

Antatt kildeareal

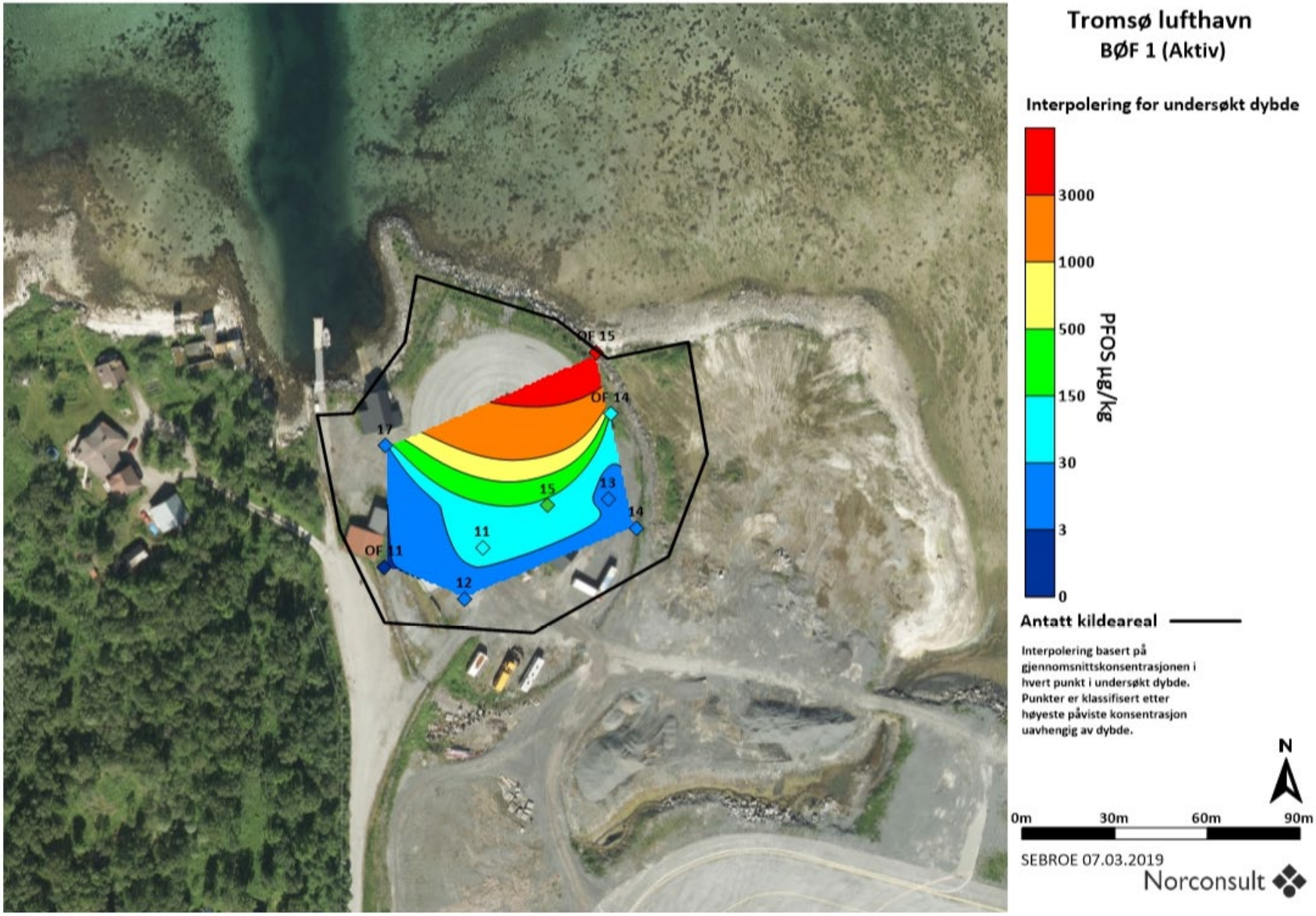
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i 0-1 meters dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.

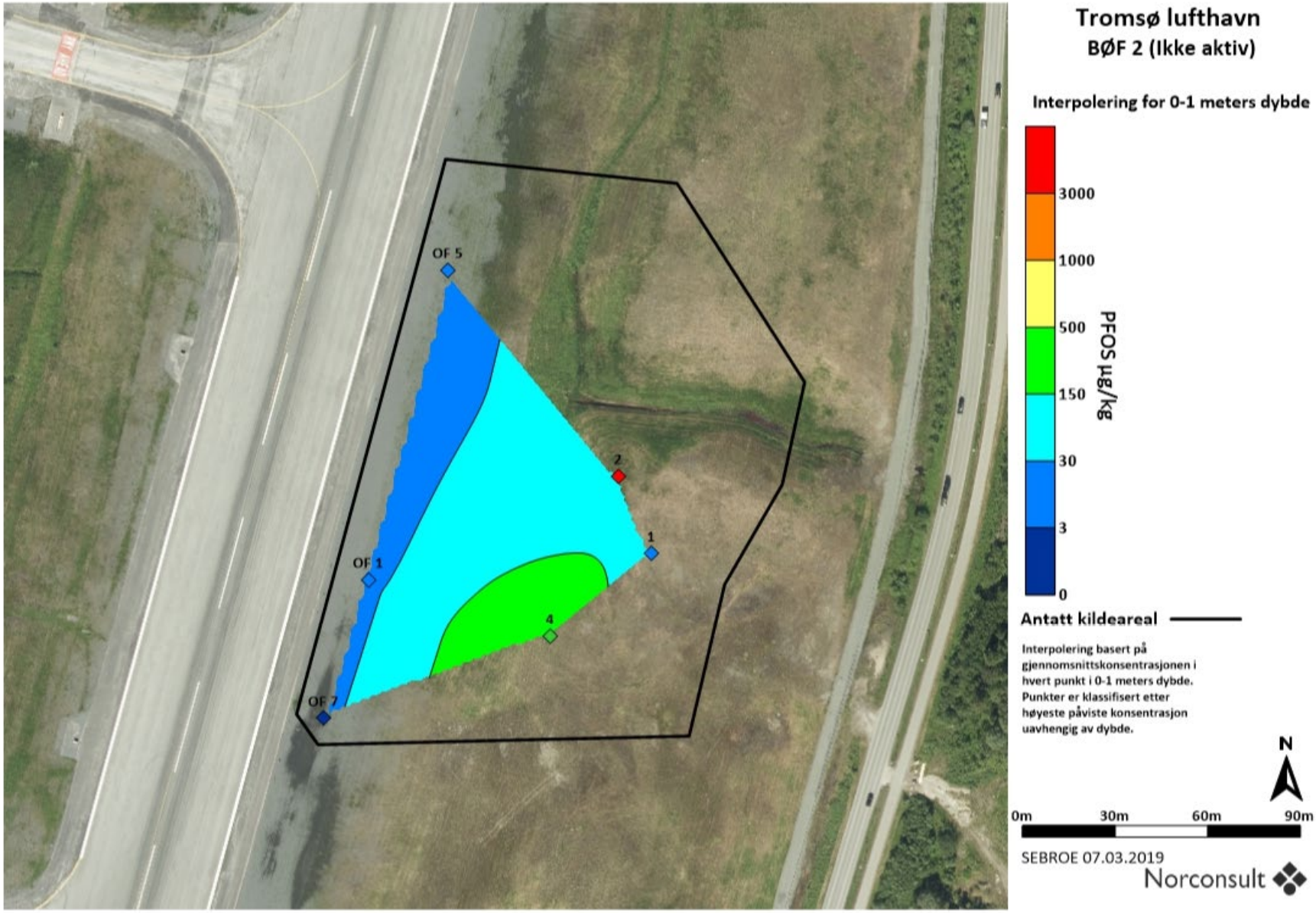
N

0m 30m 60m 90m

SEBROE 07.03.2019

Norconsult


Tromsø lufthavn
BØF 1 (Aktiv)
Interpolering for undersøkt dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m
30m
60m
90m
SEBROE 07.03.2019
Norconsult
OF 15
OF 14
17
15
13
14
11
OF 11
12



Tromsø lufthavn
BØF 2 (Ikke aktiv)

Interpolering for 0-1 meters dybde

PFOS µg/kg
3000
1000
500
150
30
3
0

Antatt kildeareal

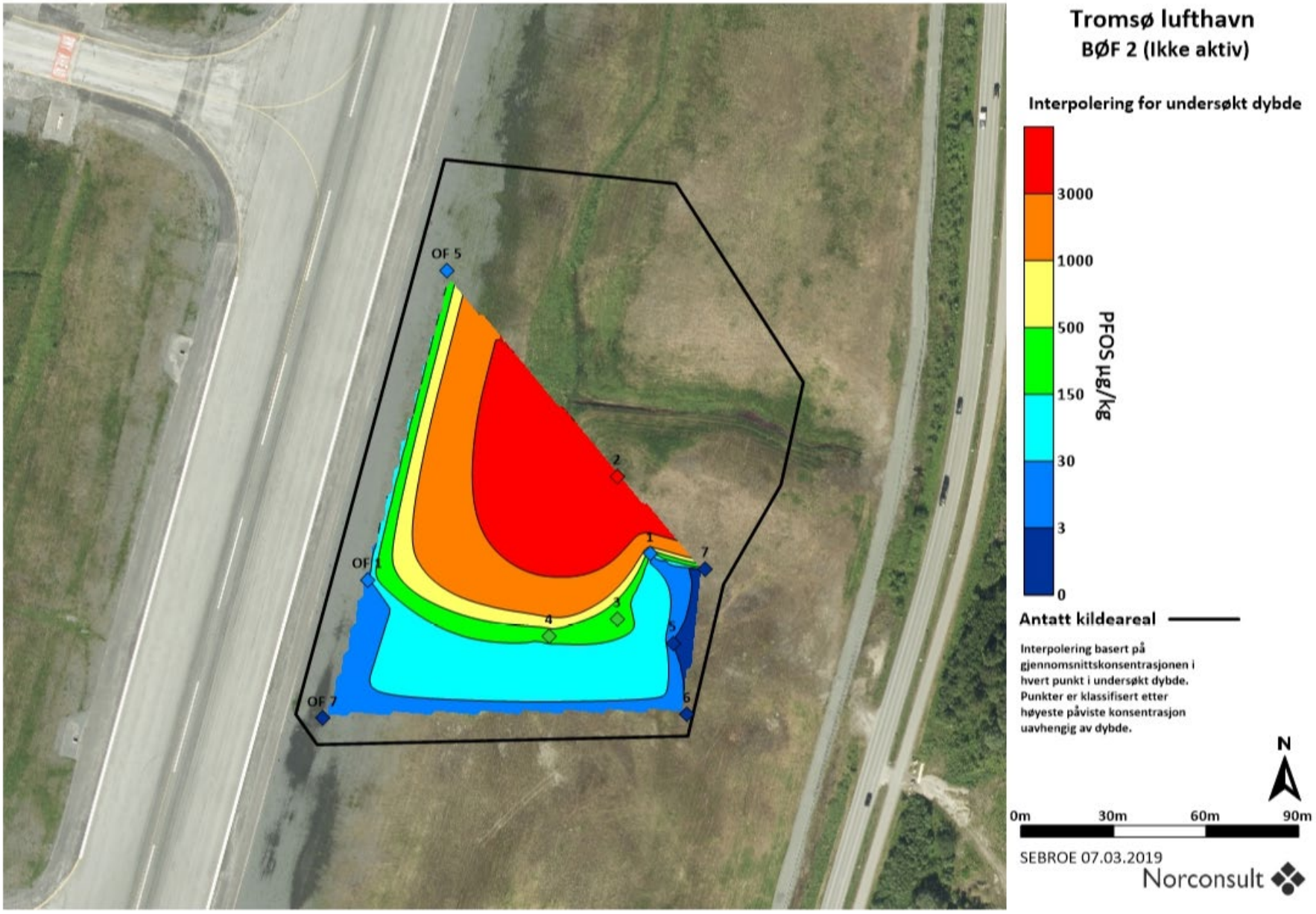
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i 0-1 meters dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.

N

0m 30m 60m 90m

SEBROE 07.03.2019

Norconsult


Tromsø lufthavn
BØF 2 (Ikke aktiv)
Interpolering for undersøkt dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m
30m
60m
90m
SEBROE 07.03.2019
Norconsult
OF 5
OF 1
OF 7
1
2
3
4
5
6
7

33.1 Fire training site (BØF) / contaminated site

Fire training site (BØF) / contaminated site	BØF 1 (active)	BØF 2 (old)	Old fire station
	Used from 2001. BØF 1 is used as a training site for several other airports. The site consists of a circular platform with a slope towards the central point where a drain has been installed. The airport has stated that oil-contaminated materials on the site have been removed and delivered to an approved landfill at an earlier date. Avinor has decided that the active fire training site at Tromsø will be closed after the 2019 training season.	Used in the period 1985-2001. The materials at BØF 2 are said to have been replaced, but it is uncertain when. It is uncertain where the replaced materials were placed. There may be original materials from the area alongside the runway west of fire training site. At BØF 2, everything from car wrecks to rubbish was previously set fire during fire training.	Southwest of the runway there is an old operations building that was used as a fire station until the year 2000. Cleaning of fire engines took place outside the station (south side of the building) with run-off to the fence line and retention in the ground. There is also a snow depot (Snødeponi sør) in the same area where the fire station is located.

33.2 The use of PFOS and other PFAS

Volume of PFOS used at the site (kg)	Not stated/calculated	7,000	Not stated/calculated
Comments/uncertainty:	The site has only been used after 2001 when Avinor switched to "PFOS-free" foam with other PFAS as its main components. The foam used in the period 2001-2012 also had small volumes of PFOS in the foam.	Estimated for the period from 1985 to 2001.	It is not known whether there has been direct use of firefighting foam at the site, but remnants of firefighting foam may have ended up in the soil and been dispersed to groundwater by washing fire trucks with remnants of firefighting foam containing PFAS. Snow with remnants of firefighting foam can also have been deposited at the snow depot.
Volume of PFAS used at the site (kg)	1,900	Not stated/calculated	Not stated/calculated
Comments/uncertainty:	Estimated use of "PFOS-free" foam with other PFAS compounds as main components, for the period 2001 to 2012. This foam also contained small volumes of PFOS (up to 0.001 weight	The site has only been used after 2001 when Avinor switched to "PFOS-free" foam with other PFAS as its main components.	The station has only been used before Avinor switched to "PFOS-free" foam with other PFAS as its main components.

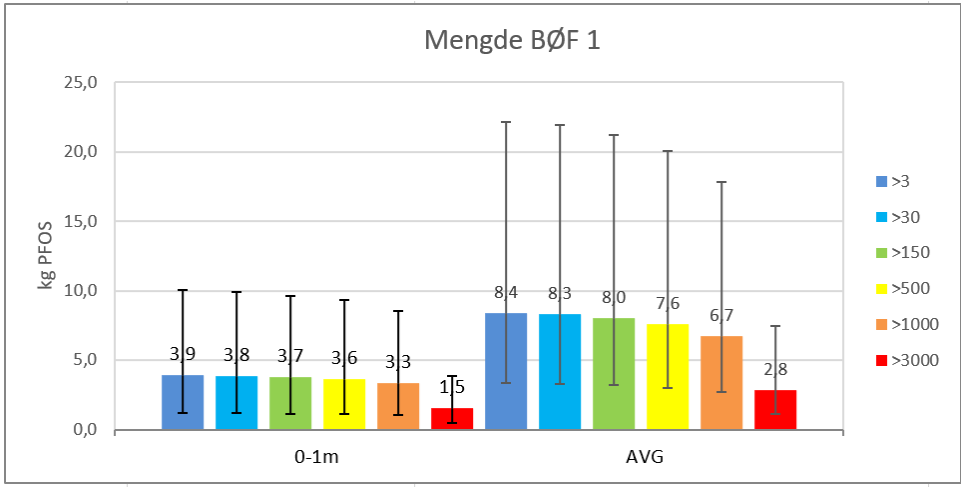
	percentage or 10 mg/l, cf. the Product regulations).		

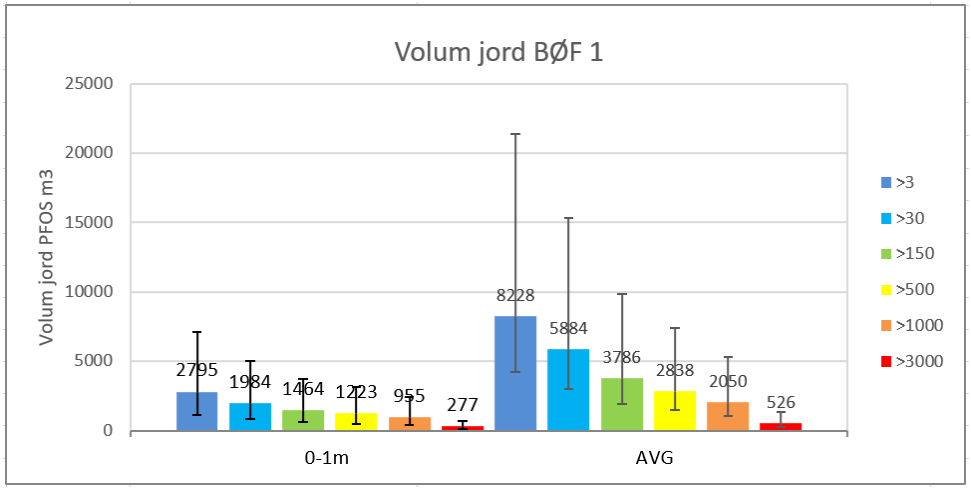
33.3 Soil sampling

Fire training site (BØF) / contaminated site	BØF 1 (active)	BØF 2 (old)	Old fire station
Total number of soil samples	15	15	2
Comments/uncertainty (for example, 95% of the samples were taken from 0–0.1 m)	Three surface samples from 0-20 cm deep, and 12 samples from six shafts at varying depths between 20-250 cm.	Three surface samples from 0-20 cm deep, and 12 samples from six shafts at varying depths between 30-460 cm.	Only two deeper specimens have been taken at the site. The materials are described as sand, rock, marsh and shell sand.
Number of soil samples 0-1 m beneath the ground	10	6	0
Number of soil samples below 1 m	9	11	2
Comments/uncertainty:	A total of 19 soil samples when splitting up samples in the intervals of 0-1 m and > 1 m. The materials are stated to consist mainly of a layer of rock, gravel and sand over shell sand, clay and silt.	A total of 16 soil samples when splitting up samples in the intervals of 0-1 m and > 1 m. The materials are stated to consist of gravel in the surface, then rock, coarse sand, soil, sand over marsh and/or clay.	The two deeper samples were taken at 2.5-2.7 m and 1.6-2.4 m respectively.
Highest measured soil concentration of PFOS µg/kg	6,260	28,300	60.6
Where	Surface 15, from 0-20 cm deep. Material type not specified.	Sjakt 2-3, from 125-145 cm deep, marsh.	Sjakt 20-3 (1.6-2.4 m). The materials consist of marsh/shell sand.
Highest measured soil concentration of PFAS µg/kg	6,260	30,400	60.6
Where	Surface 15, from 0-20 cm deep. Material type not specified.	Sjakt 2-3, from 125-145 cm deep, marsh.	Sjakt 20-3 (1.6-2.4 m). The materials consist of marsh/shell sand.
Comments/uncertainty:	The sample "surface 15" was only analysed for PFOS/PFOA, but had the highest concentration. Six of the samples have been analysed for a total of 12 PFAS compounds.	The sample "Sjakt 2-3" was analysed for 12 PFAS compounds. A total of seven of the samples have been analysed for 12 PFAS compounds.	The two samples taken at the site have only been analysed for PFOS and PFOA. No PFOA has been detected in any of the samples.

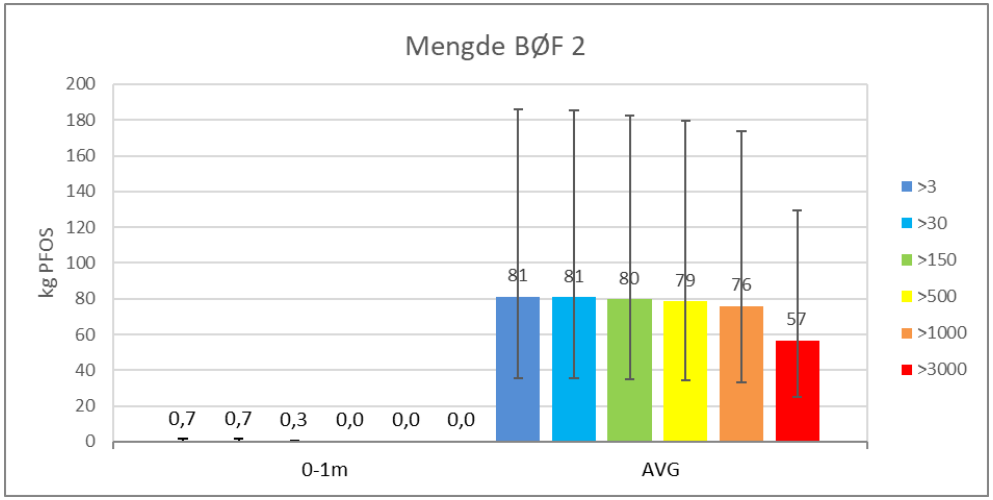
33.4 Volume calculation

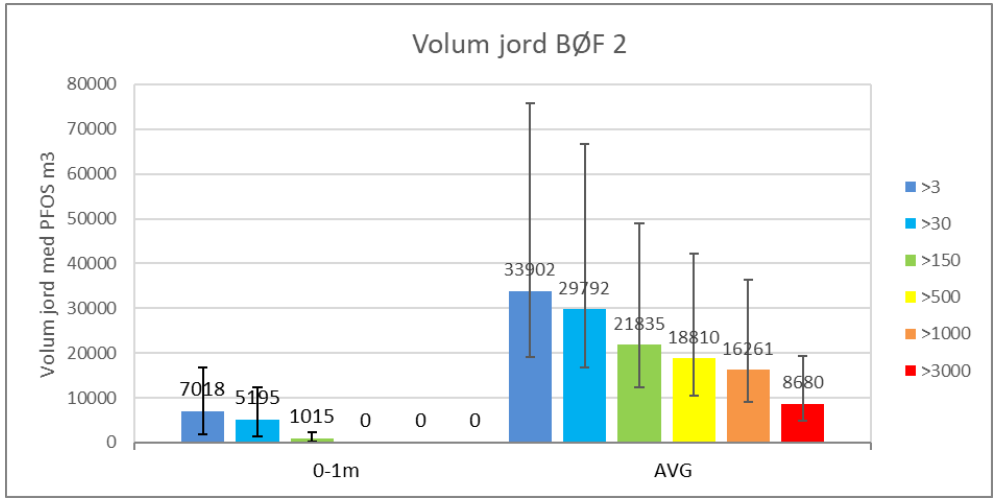
PFOS average for all depths and points > 3 µg/kg	BØF 1	BØF 2
Concentration (µg/kg)	751	1,872
Area (m2)	4,114	10,120
Volume of soil (tonnes)	13,988	54,243
Volume of PFOS (kg)	8.4	81
Uncertainty -	5.1	46
Uncertainty +	14	105
PFOS average for all depths and points > 30 µg/kg		
Concentration (µg/kg)	1,037	2,124
Area (m2)	2,942	8,893
Volume of soil (tonnes)	10,003	47,666
Volume of PFOS (kg)	8.3	81
Uncertainty -	5.0	46
Uncertainty +	14	104
PFOS average for all depths and points > 150 µg/kg		
Concentration (µg/kg)	1,563	2,858
Area (m2)	1,893	6,518
Volume of soil (tonnes)	6,436	34,936
Volume of PFOS (kg)	8.0	80
Uncertainty -	4.9	45
Uncertainty +	13	103
PFOS average for all depths and points > 500 µg/kg		
Concentration (µg/kg)	1,966	3,263
Area (m2)	1,419	5,615
Volume of soil (tonnes)	4,825	30,096
Volume of PFOS (kg)	7.6	79
Uncertainty -	4.6	44





Uncertainty +	12	101
PFOS average for all depths and points > 1,000 µg/kg		
Concentration (µg/kg)	2,420	3,650
Area (m2)	1,025	4,854
Volume of soil (tonnes)	3,485	26,017
Volume of PFOS (kg)	6.7	76
Uncertainty -	4.1	43
Uncertainty +	11	98
PFOS average for all depths and points > 3,000 µg/kg		
Concentration (µg/kg)	3,963	5,101
Area (m2)	263	2,591
Volume of soil (tonnes)	894	13,888
Volume of PFOS (kg)	2.8	57
Uncertainty -	1.7	32
Uncertainty +	4.6	73





Fire training site (BØF) / contaminated site	BØF 1 (active)	BØF 2 (old)	Old fire station
Comments regarding calculations	The DP2 report assumes that the most contaminated area is situated within an area of 2,830 m2, and that the thickness of the contaminated materials is 1 metre. It is estimated that the mean concentration of PFOS within this area is 171 µg/kg, and based on this it is estimated that 774 g of PFOS and 8.6 g PFOA remain. In the 2016 risk assessment, a residual volume of PFOS in the ground of 15 ± 7 kg has been calculated. A contaminated area of 5,000 ± 2,000 m2, a depth of 2.5 ± 0.5 metres, a density of the materials of 1,600 ± 200 kg/m3 and an average concentration of 746 µg/kg have been used. This is a higher residual volume than calculated in the 2019 calculation, mainly due to the fact that the risk assessment from 2016 has not taken out the proportion of larger fractions (crushed stone/rock) in the contaminated volume, and that it is assumed that the contaminated area is somewhat larger than that surveyed, and that the thickness of the contaminated materials is somewhat greater than the surveyed area. In the calculations in 2019, the volume in the surveyed area is 8.4 kg, and the volume including the positive uncertainty (within the estimated source area) is approximately 22 kg.	The DP2 report assumes that the most contaminated area is situated within an area of 7,850 m2, and that the thickness of the contaminated materials is 3 metres. The average concentration within this area is calculated to be 292 µg/kg PFOS . On this basis it is calculated that 11 kg of PFOS, 226 g of PFOA and 124g of 6:2 FTS remain at the BØF. In the 2016 risk assessment, a residual volume of PFOS in the ground of 60 ± 40 kg has been calculated. A contaminated area of 13,000 ± 2,000 m2, a depth of 3 ± 1 metres, a density of the materials of 1,000 ± 600 kg/m3 and an average concentration of 1,460 µg/kg have been used. In the new calculation, the uncertainty is higher due to the fact that the most contaminated part of the area is not very delimitated and calculation is for the estimated area (estimated source area of approximately 22,700 m2) with concentrations down to 3 µg/kg. In the new calculations, a higher density (1,600 kg/m3) is used, which also explains why the volumes are greater. The density is set based on the materials being made up of filler over a marsh layer, and then clay. Based on the descriptions of the samples, the thickness of the contaminated marsh layer at the BØF is not expected to increase. Furthermore, in the 2019 calculation the interpolated average concentration of PFOS within the surveyed area is somewhat higher (1,872 µg/kg) than was interpolated in the calculation in 2016.	No volume calculation of the site has been carried out, since only two soil samples have been taken.

Is the extent of the contaminated area delimitated horizontally?	No, but there are concentrations of PFOS <4 µg/kg at the extreme points to the west and south (sjakt 12 and 17 (at point 17 only samples of deeper materials were taken)). To the southwest (OF11), no PFOS has been detected above the detection limit. PFOS has only been detected in the surface sample from the extreme point to the east (sjakt 14), and the concentration is 8.7 µg/kg. The highest concentration of PFOS has been detected at the extreme point to the northeast (overflate 15), very close to the sea. The contamination is least delimitated in a north-northwest direction towards Rottbogen.	No, the highest concentrations have been detected at an extreme point to the northeast (sjakt 2, in materials from 125 to 240 cm deep). At the extreme points to the southeast and east (sjakt 5, 6 and 7) no PFOS has been detected. The samples are from deeper materials (230-400 cm deep). At the extreme points to the southwest, west and northwest (surface samples OF1, OF5 and OF7) the concentrations of PFOS are <6 µg/kg.	No. Relatively low concentrations of PFOS have been detected in the two soil samples taken at the site. Given that only two soil samples have been taken, it is uncertain how representative these are for the contamination situation in the area.
Is the extent of the contaminated area delimitated vertically?	The site is located right on the water's edge, groundwater is assumed to be about two metres below ground level. It is assumed that PFOS and PFAS are washed out from the groundwater level and deeper, and it is not believed to have dispersed much deeper than this. PFOS has not been detected in the deepest samples from sjakt 13 and 14 that are between 200-250 cm deep. In shaft 15, the highest concentration (171 µg/kg) in the deepest sample is from 130-140 cm deep.	Apparently delimitated in depth in the eastern part of the BØF, but not the central or western part. PFOS has not been detected in samples from deeper materials to the east (sjakt 1, 5, 6 and 7). However, 1,810 µg/kg PFOS has been detected in clay 145-240 cm deep in shaft 2, and in shafts 3 and 4 there are 219 and 9 µg/kg, respectively, in deeper materials.	No. No samples above 1.6 m were taken at the site, so no information is available on the degree of contamination of the top materials in the area.
Comments/uncertainty:	Most of the samples were only analysed for PFOS and PFOA. The six samples analysed for multiple compounds indicate that the concentrations of total PFAS are up to three times higher than PFOS. No samples were taken under the platform which has a diameter of 60 metres and there has been a leakage under the asphalt by the flight simulator discovered in 2011.	In the samples sjakt 7 and sjakt 1-4 no PFOS has been detected, however, PFOA of 4.6 µg/kg has been detected in sjakt 7, and PFHxA of 3.6 µg/kg in sjakt 1-4. PFOS is otherwise the dominant compound in the samples, except in the sample sjakt 4-3. The BØF is about 10 metres above sea level, and the terrain slopes somewhat from east to west. Filler that lies above a marsh layer and clay is found in the central part of the BØF. The contamination is not believed to have spread deeper than 4 metres, as there is a marsh layer that binds PFAS and then clay. No PFOS has been	

		detected in the three samples taken deeper than 3.35 metres below ground. Groundwater is about two metres below ground. It is stated in the risk assessment report that the materials at BØF 2 have been replaced, but it is uncertain when. It is uncertain where the replaced materials were placed.	

33.5 Water sampling and annual dispersion

Fire training site (BØF) / contaminated site	BØF 1 (active)	BØF 2 (old)	Old fire station
Have water samples been taken?	Yes	Yes	Yes
Where	Oil separator, seawater and two wells established in sjakt 15 and 18 at the BØF in 2011.	Surface water from ditches, as well as two wells at the BØF established in sjakt 1 and 2 at the BØF in 2011.	Water samples from five groundwater wells (brønn 20 and 22 and MB1-3). Brønn 20 is located just southwest of the area where fire engines were cleaned. The remaining four wells are located south/southeast of the area for cleaning fire engines, and south/southeast of snødeponi sør. Brønn MB3 is located furthest away (east of) the area for cleaning fire engines and the snow depot.
Highest measured concentration of PFOS in groundwater (ng/l)	8,000	350,000	22,800
Where	Well 15 at the active BØF was sampled on 26.9.2017 (the information is taken from Avinor's environmental monitoring report from Tromsø airport 2017-2018).	Groundwater in brønn 1 at the abandoned BØF taken on 23.2.2017 (the information is taken from Avinor's environmental monitoring report from Tromsø airport 2017-2018).	Brønn MB2 - sampled 26.6.15
Highest measured concentration of PFAS in groundwater (ng/l)	49,500	355,000	24,000
Where	Groundwater sample in brønn 18N, taken on 24.05.2012.	Groundwater in brønn 1 at the abandoned BØF taken on 23.2.2017 (the information is taken from Avinor's environmental monitoring report from Tromsø airport 2017-2018).	Brønn MB1 - sampled 26.11.14
Comments/uncertainty:	In the risk assessment report (2016), the sample with the highest PFOS concentration (6,640 ng/l) is groundwater sample V-15-1 from brønn 15, in a water sample taken on establishment (well in shaft) on 17.08.2011. This water sample also had	From the risk assessment report (2016), the sample with the highest PFAS concentration is the groundwater sample Brønn 1 (24-05-2012), with a concentration of PFOS of 198,000 ng/l and PFAS of 261,000 ng/l. In this and in a water sample taken from brønn 1 on 11.9.2014, the	The groundwater samples were analysed for 12 different PFAS compounds PFOS is the predominant compound in all water samples. In addition, some PFHxS, PFHxA, PFNA and PFPeA have been detected in the samples. 6:2 FTS has been detected in 9 of 18

	THC content in environmental condition class 5. In the sample taken from brønn 18N there are particularly high concentrations of 6:2 FTS (39,800 ng/l). Two samples taken from brønn 18N on 29.6.2017 and 18.4.2018 both show total PFAS of 18,000 ng/l, the PFOS concentrations are between 11,000 and 13,000 ng/l in these samples (the information is taken from Avinor's environmental monitoring report from Tromsø airport 2017-2018)	compounds PFHxS and PFHxA have the highest concentrations after PFOS.	samples, but in low concentrations compared to PFOS. The PFOS concentrations in the groundwater samples are between 539-22,800 ng/l. The PFAS concentrations in the groundwater samples are between 834-24,000 ng/l. The highest concentrations were detected in Brønn 20, as well as in MB1 and MB2. The lowest concentrations were detected in MB3 (which is farthest from the site).
Highest measured concentration of PFOS in surface water (ng/l)	19.3	1,000	No samples of surface water were taken at the fires station.
Where	V1-2, water sample from the sea southeast of BØF 1. Sampled 17.8.11.	Sampling point V2-2, stream downstream of the abandoned fire training site, tested on 26.9.2017 (the information is taken from Avinor's environmental monitoring report from Tromsø airport 2017-2018).	
Highest measured concentration of PFAS in surface water (ng/l)	19.3	1,300	
Where	V1-2, water sample from the sea east of BØF 1. Sampled 17.8.11.	Sampling point V2-2, stream downstream of the abandoned fire training site, tested on 26.9.2017 (the information is taken from Avinor's environmental monitoring report from Tromsø airport 2017-2018).	
Comments/uncertainty:	The sample V1-2 was only analysed for PFOS and PFOA. No PFOA was detected in the sample. The active fire training site is established with an oil separator and drain to the sea. Water samples from the oil separator are not considered to be representative of the surface water in the area. The water from the oil separator was sampled several times in 2013, 2014 and 2015. The analysis results showed PFAS concentrations of 3,480-33,500 ng/l, of which PFOS accounted for <5% and the newer telomeres (6:2 and 8:2 FTS) accounted for approx. 75-96%. In the September 2014 sampling, perfluoropentanoic acid (PFPeA) dominated. It is not known whether the sampling was carried out in connection with cleaning or	A water sample taken at the same sampling point V2-2 on 18.4.2018 has concentrations of PFOS and total PFAS of about 100 ng/l. From the risk assessment report (2016), the surface test with the highest PFAS concentration V2-2, vann i grøft nedstrøms BØF, was sampled on 17.8.11. The concentration of PFOS was 545 ng/l and includes PFOA of 527 ng/l (not analysed for multiple compounds). Sample V2-2 was taken downstream of BØF 2. Two samples have also been taken in the same ditch just upstream of BØF 2 (V2-1), PFOS/PFAS was not detected in these samples.	

	other special situations. No foam containing PFAS has been used at Avinor's airports since 2012. In new measurements from 26.9.2017 and 9.5.2018, the concentrations of PFAS in the oil separator are 15,000 and 10,000 ng/l respectively (the information is taken from Avinor's environmental monitoring report from Tromsø airport 2017-2018).		
Total annual dispersion of PFOS from the site (g/year)	35 (2)*	120	385
Total annual dispersion of PFAS from the site (g/year)	Not calculated (60)*	Not calculated	Not calculated
To which recipient	Rottbogen. The recipients of surface water from the airport are shallow water areas in Rottbogen in the north, Giæverbukta in the south, and the low-tide zone in between (Sandnessundet). Surface water mostly infiltrates locally into the ground. *Estimated discharge via oil separator. The discharge is carried out into the fjord in the north by seawater pipe. It is uncertain whether the dispersion from the oil separator is still representative of the current situation, as foam containing PFAS is no longer used at Avinor's airports. Several measurements are needed to see if there is a downward trend in the content of PFAS in water in the oil separator.	The recipients of surface water from the airport are shallow water areas in Rottbogen in the north, Giæverbukta in the south, and the low-tide zone in between (Sandnessundet). Surface water mostly infiltrates locally into the ground.	Giæverbukta
Calculated from water or soil concentration.	Groundwater concentration	Concentration in water in the stream	Groundwater concentrations

33.6 Biota sampling

Fire training site (BØF) / contaminated site	BØF 1 (active)	BØF 2 (old)	Old fire station
Have biota samples being taken at the airport?	Yes. For BØF 1, biota was taken at the northern end of the runway, as well as west of the runway.	Yes. For BØF 2, all biota samples taken at the airport are stated. BØF 2 can have runoff both to the north and west. It is uncertain whether the site could have runoff/drainage to the south.	Yes, see description under BØF 1 and BØF 2.
What kind of biota?	Common seaweed flea, bristle worm, cod, ocean quahog, flounder, lemon sole and polychaete).	Common seaweed flea, bristle worm, cod, ocean quahog, flounder, lemon sole and polychaete).	

How many samples?	8	11	
Highest measured concentration of PFOS in biota (µg/kg wet weight)	14	38	
Where	Common seaweed flea composite sample n=13, station at the north end of the runway.	Polychaete, composite sample n=10, sampling station TF-3 is located southwest of the runway.	
Highest measured concentration of PFAS in biota (µg/kg wet weight)	34.4	42.7	
Where	Bristle worm composite sample n = 14, station at the north end of the runway. 6:2 FTS (25 µg/kg) has been detected in this sample.	Polychaete, composite sample n=10, sampling station TF-3 is located southwest of the runway.	
Median concentration (ug/kg ww) in comparable populations (for example, in a lake)	17	26	
Comments/references	In a composite sample of common seaweed flea (n>30) in Vågen outside Kristiansund Airport Kvernberget (active BØF), 17 µg/kg PFOS and 22.6 µg/kg PFAS were detected. A composite sample of common seaweed flea (n>20) was also taken at the outlet of Byskogbekken (at the old BØF) at the same airport, the sample had 12 µg/kg PFOS and 20.4 µg/kg PFAS. Retrieved from Avinor report from 2016, Kristiansund Airport Kvernberget; Surveys of PFAS in soil, water and biota with risk assessment.	In three mixed samples of bristle worm taken in the sea just outside the BØF at Alta Airport, the median concentration of PFOS was 26 µg/kg and PFAS 29.4 µg/kg. Extracted from an Avinor report in 2016, Alta Airport: Surveys of PFAS in soil, water and biota.	
References and concentrations in other reports.	Avinor 2018, Action plan for PFAS-contaminated land as a result of fire training, Longyearbyen, Svalbard. Two samples of common seaweed flea in the coastal zone downstream of the closed BØF had PFOS concentrations of between 1.2-2.5 µg/kg, no other PFAS compounds were detected. Avinor 2016, Leknes Airport. Investigations of PFAS in soil, water and biota. No PFAS was detected in a mixed sample of n=50 common seaweed fleas collected from the sea off Leknes Airport in 2013.	The average concentration of PFOS in three composite samples of polychaete in the inner Oslo fjord was 1.35 ug/kg ww. Source: Norwegian Environment Agency report M-812, 2017.	

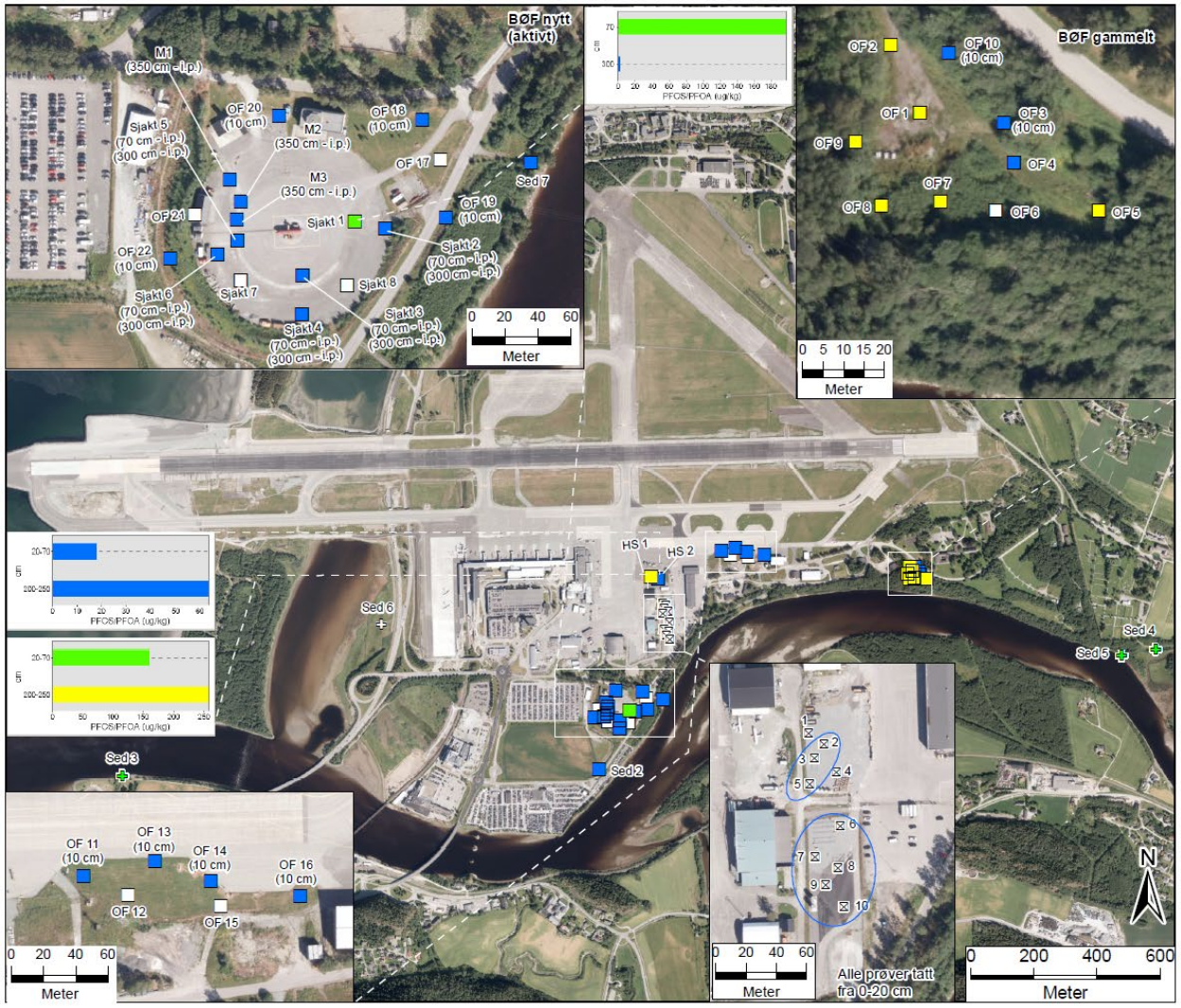
33.7 Uncertainty and other factors

Fire training site (BØF) / contaminated site	BØF 1 (active)	BØF 2 (old)	Old fire station
Does the estimate of the volume of PFOS in the ground correspond with the measured concentrations in water and biota?	Cannot be reliably evaluated.	Cannot be reliably evaluated.	Cannot be considered as only two soil samples have been taken, and therefore no volume calculations have been made for the locality.
Evaluations	It states in the DP2 report that it was not possible to take samples in the area where the most contamination was expected, only around it. No samples of the materials were taken under the platform itself. Water samples contaminated by PFOS and PFAS have been taken at snødeponi nord just south of active BØF 1. This indicates that runoff to the sea north of the runway may be from more sources than the BØF. It is also clear from both soil and water samples that there is contamination by other PFAS compounds in addition to PFOS. From the 2016 report: There are few analyses of other PFAS in the samples, but the results may indicate that there is as much 6:2 FTS in the soil as PFOS, and that the concentration of PFAS can be up to three times higher than the concentration of PFOS. The groundwater samples also have a significant contribution of 6:2 FTS. Only 6:2 FTS has been detected in a biota sample, but at a relatively high concentration (25 µg/kg). This was a composite sample of 14 bristle worms taken in the sea outside BØF 1. The training site slopes towards the central point where one drain is mounted. In June 2011, leakage was detected in the sand trap manhole under the flight simulator and in pipelines between the site and the oil separator facility. Free-phase hydrocarbons were found in groundwater (several cm thick) and the site was closed by the County Governor in the autumn of 2011 until satisfactory remedial action was taken. In addition to sealing all leaks, three environmental wells were established that pump oil-contaminated water from the edge of the site for purification in the oil separator.	It is stated in the 2016 report that the materials at BØF 2 have been replaced, but it is uncertain when. It is uncertain where the replaced materials were placed. BØF 2 can have runoff both to the north and west. It is uncertain whether the site could have runoff/drainage to the south. From the 2016 report: In addition to the natural drainage directions for groundwater and surface water, runoff from the airport area is largely controlled by the established water and drainage infrastructure. The piping systems have been laid in various stages throughout the life of the airport and are now very complex and obtaining an overview is a challenge. This makes it somewhat uncertain which areas/sources the various discharge points (pipes) to the sea receive water from. Samples V2-2 are taken downstream of BØF 2, and are clearly impacted by leaching from BØF. Two samples have also been taken in the same ditch just upstream of BØF 2 (V2-1), PFOS/PFAS was not detected in these samples. Langnes wastewater treatment plant has discharges to Sandnessundet (just west of the airport). There are also other wastewater treatment plants with discharges to the fjord in the area. It is estimated that there is about 81 kg of PFOS remaining in the surveyed area at BØF 2, and	Relatively low concentrations of PFOS have been detected in the two soil samples taken at the site. This does not match the proven concentrations in the groundwater. This is particularly true for brønn 20 that was put in sjakt 20, where the soil sample (1.6-2.4 m) had a measured concentration of 60.6 µg/kg. This well is located just south of the area where washing of fire engines took place, and in 2014 a PFOS concentration of 17,100 ng/l, and PFAS of 20,500 ng/l was detected in the groundwater. The two soil samples may have been taken outside the most contaminated area, and the contamination may also be mainly higher up in the soil profile. Avinor states that it is uncertain whether the sampled materials are representative because the area may have been filled for a road that went through the area. It is visible from the aerial photo from 1998 that materials have been filled in the area where shaft 20 is located, and that there is a road directly next tot shaft 19. No soil samples have been taken in the area downstream of the snow depot, so the contamination situation in the materials here is not known. In addition to soil samples and groundwater samples, two sediment samples have been taken at the beach edge just south (SD 4-1) and southeast (SD 3-1) of the old fire station. In these samples, concentrations of

	Langnes wastewater treatment plant has discharges to Sandnessundet (just west of the airport). There are also other wastewater treatment plants with discharges to the fjord in the area. It is estimated that there is about 8 kg of PFOS remaining in the surveyed area at BØF 2, and that this could be 22 kg if positive uncertainty is considered (within the estimated source area). It is estimated that 1,900 kg of PFOS was used at the site. This shows that most of the PFAS has already been leached out to the recipient.	that this could be as much as 185 kg if positive uncertainty is considered (within the estimated source area). It is estimated that 7,000 kg of PFOS was used at the site. This shows that most of PFOS has already been leaked to the recipient, or possibly removed in connection with the replacement of materials at BØF 2.	PFOS of 3.4 and 2.4 µg/kg were detected. It is likely that the impact found in the biota sampled at Giæverneset may be due to dispersal from the area at the fire station and snoødeponi sør, as the contaminated groundwater has a short distance to the sea.
Comments/uncertainty: (Could there be any additional unknown sources of PFOS at the site with run-off to the recipient?)	See description below, common to the three sites.	See description below, common to the three sites.	See description below, common to the three sites.
	PFAS has been detected in more places at the airport than at the fire training sites. The largest source of PFOS after the fire training sites is probably the area around the old fire station, where fire engines were cleaned (see separate site). The station was shut down in 2000. There is also a snow depot in this area (Snødeponi sør). The well at the snow depot in the north (Brønn 23/MB7) has concentrations of PFAS between 199 and 574 ng/l. South of the old fire training site is a landfill site with wood, garbage and iron scrap. The landfill is registered in the Norwegian Environment Agency's database, severity rating 02 - Little/No known impact with the current area/recipient use. From the mid-1990s, certain fire drills with foam consumption and paraffin were also held in this area. It is unclear what direction the drainage/seepage water from the landfill is taking. In the materials from the landfill (sjakt 10-3, 200-220 cm), PFOS was detected just above the norm value. While in more local materials (shaft 9-3, 300-320 cm), PFOS was not detected above the reporting limit. PFAS has been detected in a water sample (V3-3) taken in this area, with a concentration of 95.6 ng/l PFOS, and total PFAS of 203 ng/l. About 220 metres northwest of sampling point V3-4, there was an open oasis where snow was stored until 1997-1998. Some fire drills have been carried out here in the mid-1990s. (information from the airport). Water cannon sight adjustment is carried out almost daily on the runway to the north. In the middle of the airport area, between stand 24 and stand 25, there was an open oasis where snow was stored until the year 1997/98. Fire drills with the consumption of foam and paraffin were held here several times in the mid-90s. Retention in the ground and into drains. Incidentally, the fire engines have flushed onto asphalt in general on the entire runway and taxiways over time. Sometimes the act of turning off the foam before flushing had started was inadvertently forgotten, which may have resulted in the spread of PFAS.		
Has the site been sufficiently mapped with a view to assessing the order of prioritisation?	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the volume of PFOS in the soil with the stipulated level of uncertainty.	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to	The site is not well enough mapped with a view to assessing the order of prioritisation (see this report for parts 1 and 2, chapter 2.1.1.6 and chapter 2.1.3.1).

		calculate the volume of PFOS in the soil with the stipulated level of uncertainty.	
Comments/uncertainty:	High concentrations of PFOS (6,260 ug/kg) have been detected in a surface sample to the northeast, and no samples have been taken north or west of this point. There is therefore considerable uncertainty as to the degree of contamination of the materials in the area between the platform and the sea. Also, no samples were taken under the platform where there has been a leak that has contaminated groundwater. It is also recommended that the soil is surveyed more extensively for other PFAS compounds.	The highest concentrations have been detected in the extreme north-east (28,300 µg/kg in sjakt 2, in materials from 125 to 240 cm deep), and the contamination is not further delimitated to the northeast. There are also few sampling points just west of sjakt 2, which adds to the uncertainty in the interpolation of concentrations.	
General information about the airport			
Other factors of significance to possible clean-up/implementation of measures (for example, planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	Grindøysundet about 4 kilometres to the southwest of the airport is a protected area (nature reserve). The wetlands and tidal zone at the southern, western and northern directions are important grazing areas for waders and ducks, including common eiders, and are considered particularly. Black-legged kittiwake, common guillemot, otter, razorbill, ruff and common tern have also been recorded, all of which are on the red list. In addition, several important habitats have been registered at and around the airport, both on land and at sea (soft bottom areas in the coastal zone, birch forest with perennials, wash margin and rich marsh). Tromsø airport is registered under Avinor's vulnerability class 2, which means somewhat less vulnerable recipients, moderate priority and level of facilities. At BØF 1, THC was detected in environmental condition class 2-3 in two surface samples, and in environmental condition class 4 in one surface sample. One sample of materials from 130-140 cm deep is in environmental condition class 5. At BØF 2, THC was detected in environmental condition class 2 in three soil samples (one surface sample and two of deeper materials), and in environmental condition class 4 in one sample of deeper materials.		

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Trondheim lufthavn Værnes (ENLK)

Oversiktskart inkl. brannøvingsfelt

Jord og sediment

☒ Punkter som inngår i blandprøver

PFOS/PFOA jord - blandpr. (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

PFOS sediment ferskvann (ug/kg)
- 0
- <LOQ
- LOQ-63
- 63-6300
- >6300
- Ikke analysert

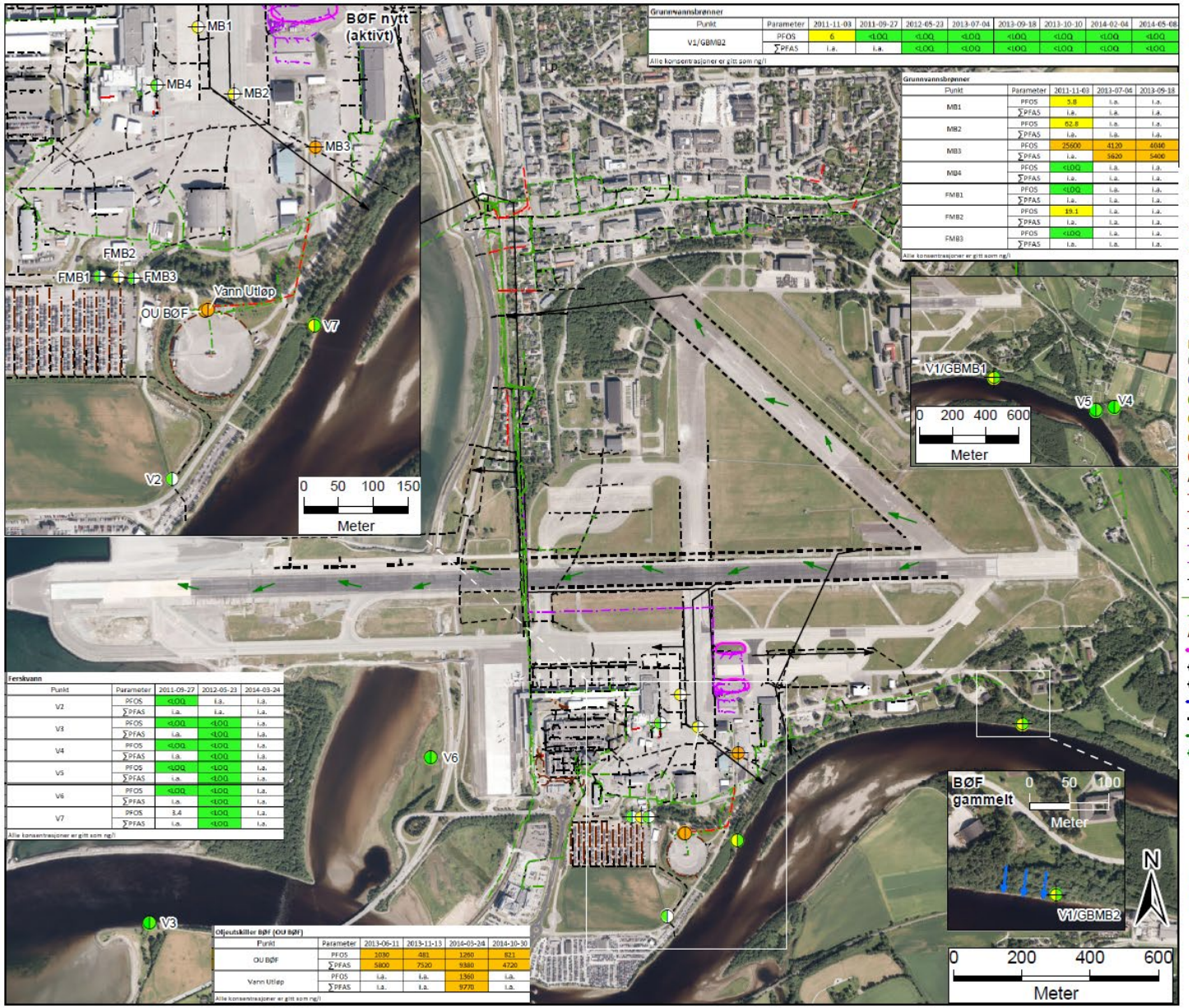
Mrk. varierende skala for x-aksen i diagrammene

* PFOS er dominerende parameter

LOQ = rapporteringsgrense
i.a. = ikke analysert

Norconsult

APPENDIX A



Grunnvannsbrønner

Punkt	Parameter	2011-11-03	2011-09-27	2012-05-23	2013-07-04	2013-09-18	2013-10-10	2014-02-04	2014-05-08
V1/GBMB2	PFOS	6	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
	∑PFAS	i.a.	i.a.	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ

Alle konsentrasjoner er gitt som ng/l

Grunnvannsbrønner

Punkt	Parameter	2011-11-03	2013-07-04	2013-09-18
MB1	PFOS	5.8	i.a.	i.a.
	∑PFAS	i.a.	i.a.	i.a.
MB2	PFOS	62.8	i.a.	i.a.
	∑PFAS	i.a.	i.a.	i.a.
MB3	PFOS	25600	4120	4040
	∑PFAS	i.a.	5620	5400
MB4	PFOS	<LOQ	i.a.	i.a.
	∑PFAS	i.a.	i.a.	i.a.
FMB1	PFOS	<LOQ	i.a.	i.a.
	∑PFAS	i.a.	i.a.	i.a.
FMB2	PFOS	19.1	i.a.	i.a.
	∑PFAS	i.a.	i.a.	i.a.
FMB3	PFOS	<LOQ	i.a.	i.a.
	∑PFAS	i.a.	i.a.	i.a.

Alle konsentrasjoner er gitt som ng/l

Ferskvann

Punkt	Parameter	2011-09-27	2012-05-23	2014-03-24
V2	PFOS	<LOQ	i.a.	i.a.
	∑PFAS	i.a.	i.a.	i.a.
V3	PFOS	<LOQ	<LOQ	i.a.
	∑PFAS	i.a.	<LOQ	i.a.
V4	PFOS	<LOQ	<LOQ	i.a.
	∑PFAS	i.a.	<LOQ	i.a.
V5	PFOS	<LOQ	<LOQ	i.a.
	∑PFAS	i.a.	<LOQ	i.a.
V6	PFOS	<LOQ	<LOQ	i.a.
	∑PFAS	i.a.	<LOQ	i.a.
V7	PFOS	8.4	<LOQ	i.a.
	∑PFAS	i.a.	<LOQ	i.a.

Alle konsentrasjoner er gitt som ng/l

Oljeutskiller BØF (OU BØF)

Punkt	Parameter	2013-06-11	2013-11-13	2014-05-24	2014-10-30
OU BØF	PFOS	1030	481	1260	821
	∑PFAS	5800	7520	9380	4720
Vann Utløp	PFOS	i.a.	i.a.	1360	i.a.
	∑PFAS	i.a.	i.a.	9270	i.a.

Alle konsentrasjoner er gitt som ng/l

Trondheim lufthavn Værnes (ENLK)

Oversiktskart inkl. brannøvingsfelt

Vann

PFOS / ∑ PFAS grunnvannsbrønn (ng/l) *
- Ikke analysert
- 0
- <LOQ
- LOQ-230
- 230-36 000
- >36 000

PFOS / ∑ PFAS ferskvann (ng/l) *
- Ikke analysert
- 0
- <LOQ
- LOQ-230
- 230-36 000
- >36 000

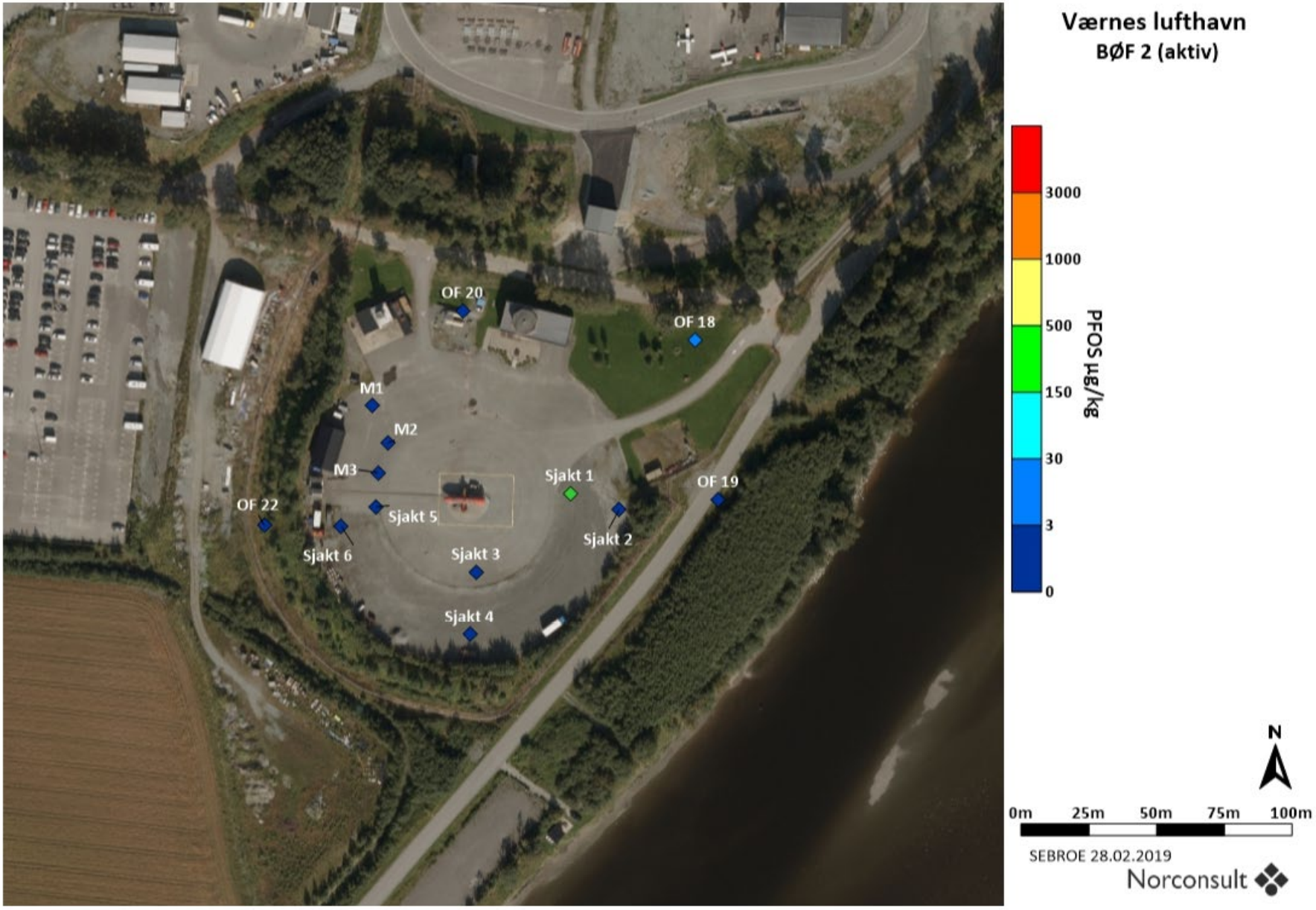
Avlopsledning
- Avløp annet
- Avløp Felles
- Drensvann
- Glykolholdig overvann
- Glykolholdig spillvann
- Overvann
- Pumpespillvannsledning
- Spillvann

Avrenning
- Deponi glykolforurenset snø
- Overvannsledning
- Avrenningsveg glykol
- Bekkeresipient
- Overvannsystem
- Vannskille rullebane
- Antatt avrenningsveg baneavising

* Venstre halvdel = PFOS
Høyre halvdel = ∑PFAS
Basert på snittverdi av alle målinger i punkte
Antall prøver kan varierer for hhv. PFOS og ∑PFAS.

i.a. = ikke analysert
LOQ = rapporteringsgrense
(tilsv. ikke påvist for ∑PFAS)

AVINOR Norconsult SWECO


Værnes lufthavn
BØF 2 (aktiv)
PFOS µg/kg
3000
1000
500
150
30
3
0
OF 20
OF 18
M1
M2
M3
OF 22
Sjakt 5
Sjakt 6
Sjakt 1
Sjakt 2
Sjakt 3
Sjakt 4
OF 19
N
0m 25m 50m 75m 100m
SEBROE 28.02.2019
Norconsult

34.1 Fire training site (BØF) / contaminated site

Fire training site (BØF) / contaminated site	BØF 2 (active)
	Put into use in October 2006. There is also an older fire training site, BØF 1, which is the property and responsibility of the Norwegian Armed Forces and is therefore not reported here. The old fire training site (BØF 1) at Værnes was established by the Norwegian Armed Forces on the Norwegian Armed Forces gnr/bnr. 107/1 around 1982. In the period 2001 to autumn 2006, the site was operated by Avinor in agreement with the Norwegian Armed Forces. The site was closed down and returned to the Norwegian Armed Forces in 2006/2007. The Norwegian Armed Forces has been the landowner of the site throughout the period and remains so.

34.2 The use of PFOS and other PFAS

Volume of PFOS used at the site (kg)	Not calculated
Comments/uncertainty:	Foam containing PFOS as its main PFAS component has probably not been used, as this was phased out in 2001.
Volume of PFAS used at the site (kg)	150
Comments/uncertainty:	Estimated consumption of PFAS during the period 2006 to 2012. Avinor completely phased out firefighting foam containing PFAS in 2012 and now uses only PFAS-free firefighting foam.

34.3 Soil sampling

Total number of soil samples	19
Comments/uncertainty (for example, 95% of the samples were taken from 0–0.1 m)	Four samples from 10 cm deep, six samples from 70 cm deep, six samples from 300 cm deep and three samples from 350 cm deep.
Number of soil samples 0-1 m beneath the ground	10
Number of soil samples below 1 m	9
Comments/uncertainty:	Samples of top soil are described as soil/sandy/clay (10 cm), 70 cm crushed stone and gravel at 300 cm deep.
Highest measured soil concentration of PFOS µg/kg	198
Where	Sjakt 1-2, sample of crushed stone of 70 cm.
Highest measured soil concentration of PFAS µg/kg	198
Where	Sjakt 1-2.
Comments/uncertainty:	All the samples at the new BØF were only analysed for PFOS and PFOA.

34.4 Volume calculation

Volumes have not been calculated at this site.	The site has 13 sampling points, and 19 samples outside the platform were analysed. PFOS has been detected in only two samples (198 µg/kg in sjakt 1-2 and 14.8 µg/kg in surface sample 18).
Comments	In the risk assessment for BØF 2 carried out in 2016, it was calculated that there is a residual volume of 1 kg ±0,5 kg of PFOS in the ground distributed across an area of 17,500 ± 4,000 m2 and to a depth 2 ± 0,5 metres.
Is the extent of the contaminated area delimitated horizontally?	The contaminated area is delimitated to the east (Sjakt 2 and OF 19), west (Sjakt M1-M3 and Sjakt 5 and 6, OF22), and south (Sjakt 3 and 4), as well as OF20 to the north. This gives sampling points in four directions where no PFOS was detected. However, 14.8 µg/kg of PFOS was detected in the surface sample OF18 at the extreme point to the northeast .
Is the extent of the contaminated area delimitated vertically?	Yes. Samples were taken in 9 shafts and four surface samples. The total of 19 samples are from four different depth levels down to 350 cm deep. PFOS has only been detected in a sample from 70 cm, and the sample from 300 cm in the same shaft is below the detection limit.
Comments/uncertainty:	The area has not been surveyed or delimited for other PFAS compounds.

34.5 Water sampling and annual dispersion

Have water samples been taken?	Yes
Where	Groundwater northwest of the site, bekk/grøft V7 downstream of the active BØF near the outlet to Stjørdalselven, ditch water and Søndre river bed, as well as the oil separator.
Highest measured concentration of PFOS in groundwater (ng/l)	19.1
Where	FMB2 (04.11.2011) Environmental well located northwest of the active BØF.
Highest measured concentration of PFAS in groundwater (ng/l)	27.1

Where	FMB2 (04.11.2011) Environmental well located northwest of the active BØF.
Comments/uncertainty:	The groundwater flow direction at BØF 2 is expected to be south towards Stjørdalselven. Therefore, groundwater wells located to the northwest (FMB1-FMB3) are not believed to be representative of runoff from the site. These samples were only analysed for PFOS and PFOA.
Highest measured concentration of PFOS in surface water (ng/l)	3.4
Where	V7, taken on 27.09.2011, from stream/ditch downstream of the active BØF near the outlet to Stjørdalselven
Highest measured concentration of PFAS in surface water (ng/l)	3.4
Where	V7, taken on 27.09.2011, from stream/ditch downstream of the active BØF near the outlet to Stjørdalselven
Comments/uncertainty:	The sample was only analysed for PFOS and PFOA. A sample taken in May 2012 from the same sampling point was analysed for 12 compounds, but no PFAS has been detected. Water samples from the oil separator are not considered to be representative of the surface water in the area. Four samples of water in the oil separator were taken during the period 2013 to 2014, these have concentrations of total PFAS from 4,720 ng/l to 9,380 ng/l, the majority of which consists of 6:2 FTS, and then PFOS. This is directed to wastewater networks that go to the municipal wastewater treatment plant. The sample of effluent water immediately after the oil separator taken in 2014 has 9,770 ng/l PFAS. Avinor has not used PFAS foam at its airports since 2012 and the oil separators are emptied and cleaned once a year (unless they produce < 1kg oil during the course of a year), or more often if necessary.
Total annual dispersion of PFOS from the site (g/year)	not calculated (7)*
Total annual dispersion of PFAS from the site (g/year)	not calculated (56)*
To which recipient	Stjørdalselva which goes to Stjørdalsfjord and *water from the oil separator which goes to the municipal wastewater treatment plant. It is uncertain whether the dispersion from the oil separator is representative of the current situation, as Avinor has not used foam containing PFAS since 2012.
Calculated from water or soil concentration.	*Water concentrations in oil separator.

34.6 Biota sampling

Have biota samples being collected at the site?	Yes
What kind of biota?	Earthworm, three-spined stickleback, flounder and brackish water shrimp.
How many samples?	4
Highest measured concentration of PFOS in biota (µg/kg wet weight)	10

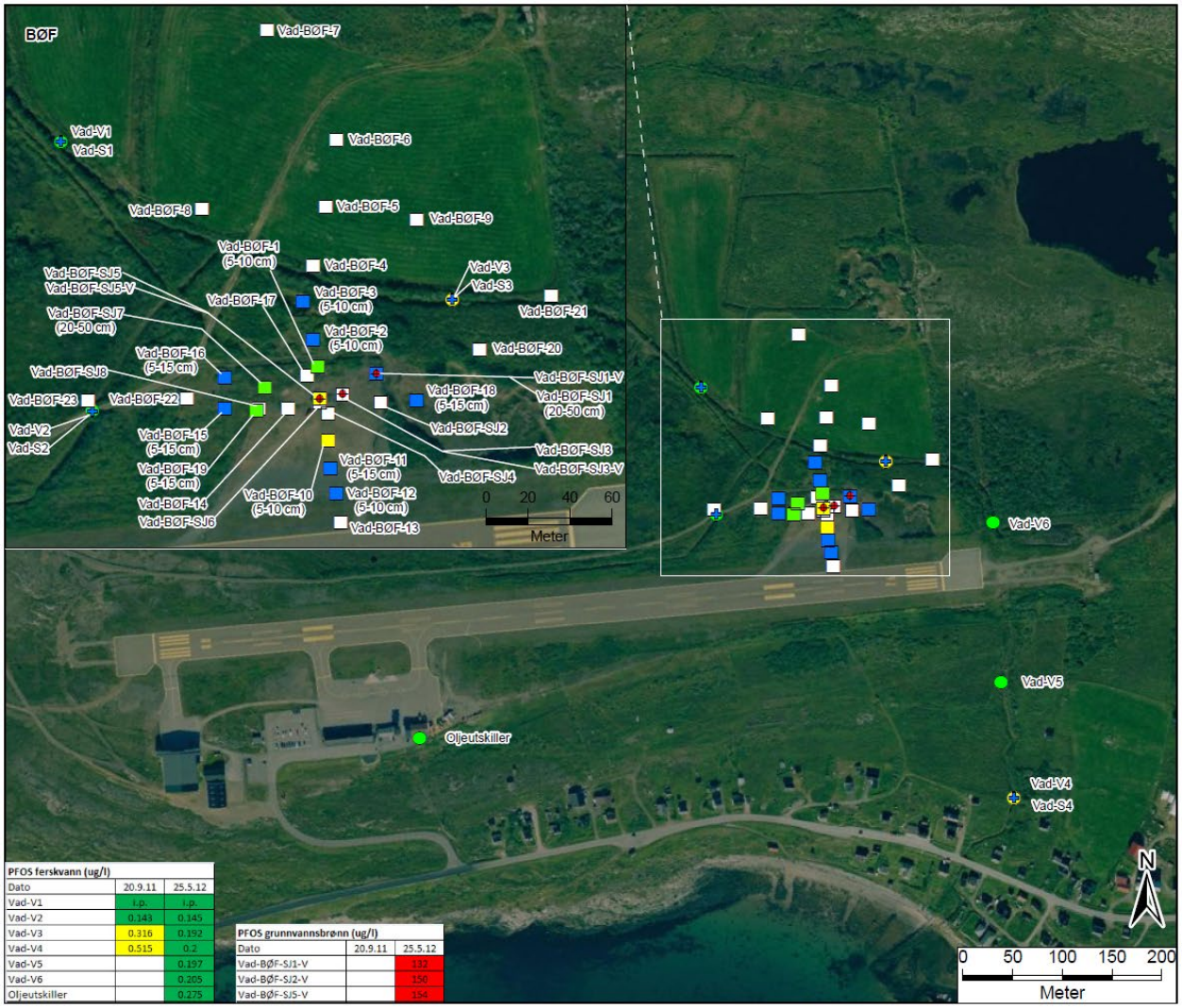
Where	Three-spined stickleback, composite sample of three individuals. Station 3 in Stjørdalselva. Stjørdalselva has runoff from both the active and old BØF.
Highest measured concentration of PFAS in biota (µg/kg wet weight)	49.7
Where	Earthworm, composite sample of more than 10 individuals. Station 2 at the new BØF. The concentration of 8:2 FTS (28 µg/kg), 6:2 FTS (9.2 µg/kg) and PFPeA (5.4 µg/kg) are all higher than PFOS (5.1 ug/kg) in this sample.
Median concentration (ug/kg ww) in comparable populations (for example, in a lake)	62.7
Comments/references	62.7 is the median concentration of PFAS in five samples of earthworm from different localities that are either close to urban or may be impacted by activities such as skiing, a former airport, industry and sewage treatment plants (Slottet, Frognerseteren, Fornebu, Alna and VEAS). The median concentration of PFOS in the same samples was 26 µg/kg. Obtained from the Norwegian Environment Agency's report M-1076 from 2018, Environmental pollutants in the terrestrial and urban environment 2017.
References and concentrations in other reports.	

34.7 Uncertainty and other factors

Does the estimate of the volume of PFOS in the ground correspond with the measured concentrations in water and biota?	No quantities of PFOS in the soil have been calculated as it has only been detected in two soil samples. There are low concentrations of PFOS in soil at the active BØF, and low concentrations of PFOS and PFAS in grøft/bekk (V7) about 100 metres southeast of the BØF. In earthworm from the BØF, there are far lower concentrations of PFOS (5.1 µg/kg) than from the old BØF (2,200 µg/kg). However, there are relatively high concentrations of total PFAS in earthworm (49.7 µg/kg), and in particular 6:2 FTS and 8:2 FTS which have been the main component of foam used in the period 2001-2012. The water in the oil separator also has high concentrations of 6:2 FTS. No survey has been conducted into the level of contamination of other PFAS compounds in soil and in groundwater.
Evaluations	At the site there is a circle of impermeable asphalt that collects chemicals and surface water (diameter approx. 65 m). The fuselage is positioned in the centre of the circle. There is also a membrane with a diameter of approximately 70 metres below the circle, and this one slopes towards the centre of the drains. With the exception of very strong winds, it is assumed that all the fire extinguishing water is collected on the area with the membrane. The run-off from the site is directed to the wastewater system via the oil separator, and on to the municipal sewage system. Outside the circle there is a gravel covering. It can be seen in historical aerial photos that asphalt was also laid north of the platform between 2009 and 2010. There have probably been some spills outside the platform, based on aerial photos from 2009 and 2012 at finn.no there are small volumes of foam outside the platform during practice.

Comments/uncertainty: (Could there be any additional unknown sources of PFOS at the site with run-off to the recipient?)	At the old flight simulator, sampling points OF11, 13, 14 and 16 east of the terminal area, cannon sight adjustment is carried out on the fire engines every day. The process is carried out with water, but there may be residual foam in the system that comes out with the water. Only 13 µg/kg of PFOS was detected in one of the four surface samples analysed in this area, the remaining samples being below the detection limit. Previously, according to airport personnel, this activity was conducted in an area north of surveillance well MB3, west of the flight simulator. Here, the groundwater sample shows very high concentrations of PFOS (25,000 ng/l in one sample taken in 2011 and 4,000 ng/l in two samples taken in 2013)/PFAS (approximately 5,500 ng/l in samples from 2013). During the period from 1971 to 1980, fire drills were also performed to a limited extent in this area. Samples from two shafts, HS1 and HS2, were sampled at an area previously used for testing the fire trucks' fire extinguishing guns. PFOS was detected in both shafts. In HS1, 159 µg/kg and 256 µg/kg were detected at 20-70 cm deep and 200-250 cm deep respectively. In HS2, 15.8 µg/kg and 61.4 µg/kg were detected at 20-70 cm deep and 200-250 cm deep respectively. In addition, low concentrations of two other PFAS (PFHxS and PFNA) were detected. The old BØF is also expected to have runoff to Stjørdalselva.
Has the site been sufficiently mapped with a view to assessing the order of prioritisation?	The site has been sufficiently mapped for PFOS, but it has not been surveyed for other PFAS compounds and the site is active. The site is not well enough mapped with a view to assessing the order of prioritisation (see this report for parts 1 and 2, chapter 2.1.1.6 and chapter 2.1.3.1).
Comments/uncertainty:	The site has 13 sampling points, and 19 samples outside the platform were analysed. Samples have been taken at four different depth levels down to 350 cm deep. PFOS has been detected in only two samples (198 µg/kg in sjakt 1-2 and 14.8 µg/kg in surface sample 18). However, analysis has only been conducted for PFOS and PFOA, so that contamination by other PFAS compounds used in the foam cannot be ruled out. In "PFOS-free" foam containing PFAS that was used until 2012, PFOS is usually also detected. Earthworms at the BØF show the impact of PFAS.
Other factors of significance to possible clean-up/implementation of measures (for example, planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	Three protected areas have been registered near the airport, including two nature reserves in Stjørdalselva (Reppesleiret and Måsøra-Hofstadøra) and one animal conservation area in Vikanbukta. Within a radius of approximately 1 km around the airport area there are 22 registered habitats. Among these, some are located in and at the outlet of Stjørdalselva and receive run-off from the airport area. This includes marine kelp forest, sea meadow and mudflats and soft-bottomed areas in the coastal zone. There is a diversity of wading birds, gull and duck that have a rest area, grazing area and breeding area associated with the areas around the airport. Several species of birds with red list status have been recorded at the airport site and in the surrounding area, including common swift, common sandpiper, starlings, northern lapwing and ruff (www.naturbase.no, www.artskart.no). Stjørdalselva has anadromous salmon, and freshwater pearl mussel is also recorded.

35 Vadsø Airport



PFOS ferskvann (ug/l)		
Dato	20.9.11	25.5.12
Vad-V1	i.p.	i.p.
Vad-V2	0.143	0.145
Vad-V3	0.316	0.192
Vad-V4	0.515	0.2
Vad-V5		0.197
Vad-V6		0.205
Oljeutskiller		0.275

PFOS grunnvannsbrønn (ug/l)		
Dato	20.9.11	25.5.12
Vad-BØF-SJ1-V		132
Vad-BØF-SJ2-V		150
Vad-BØF-SJ5-V		154

Vadsø lufthavn (ENVD)

Oversiktskart

PFOS grunnvannsbrønn (ug/l)
- <0.002-0.3
- 0.3-1.0
- >1.0
- Ikke analysert

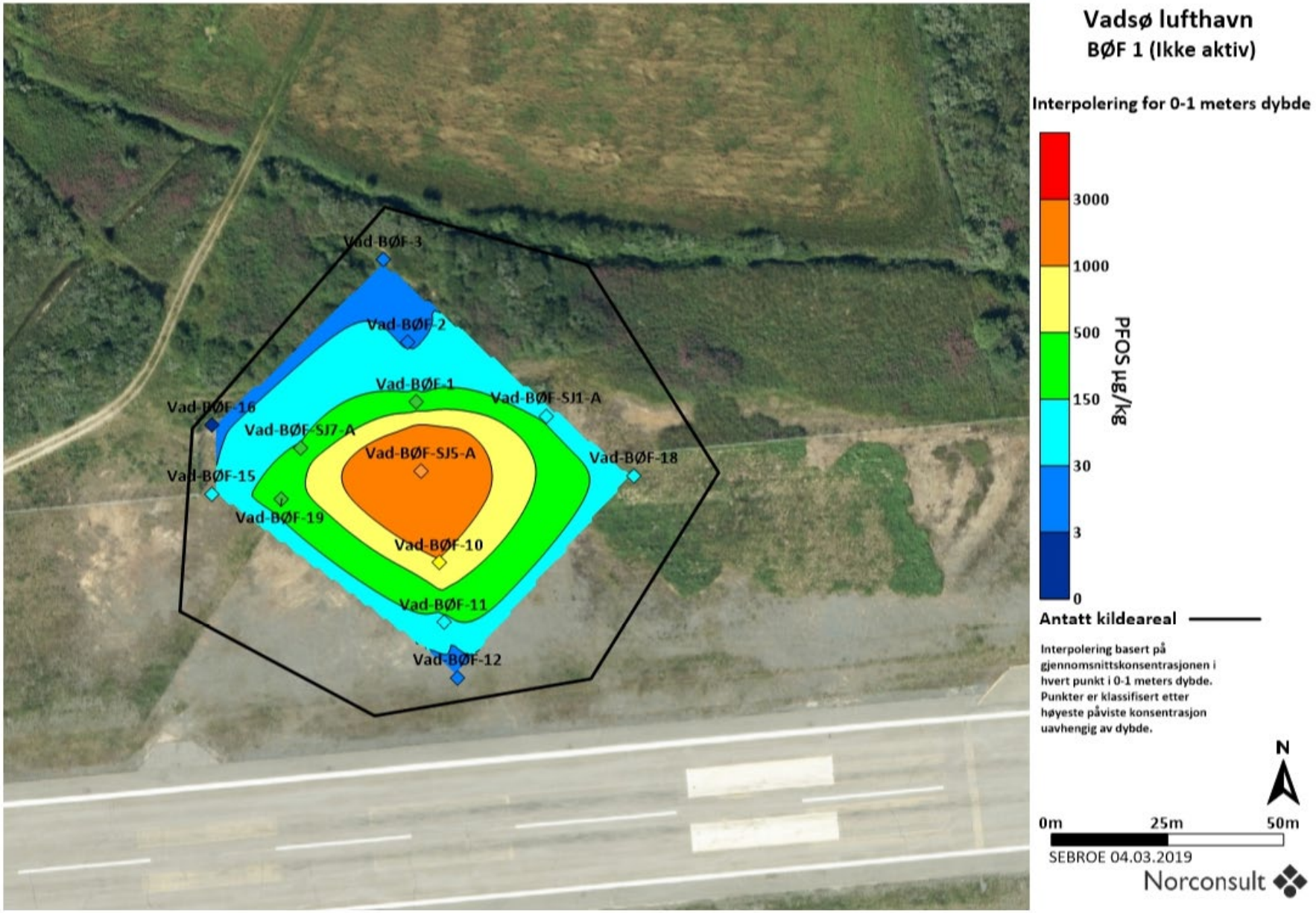
PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

PFOS sediment ferskvann (ug/kg)
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

PFOS ferskvann (ug/l)
- <0.002-0.3
- 0.3-1.0
- >1.0
- Ikke analysert

* PFOS er dominerende parameter

AVINOR COWI SWECO



Vadsø lufthavn
BØF 1 (Ikke aktiv)

Interpolering for 0-1 meters dybde

PFOS µg/kg
3000
1000
500
150
30
3
0

Antatt kildeareal

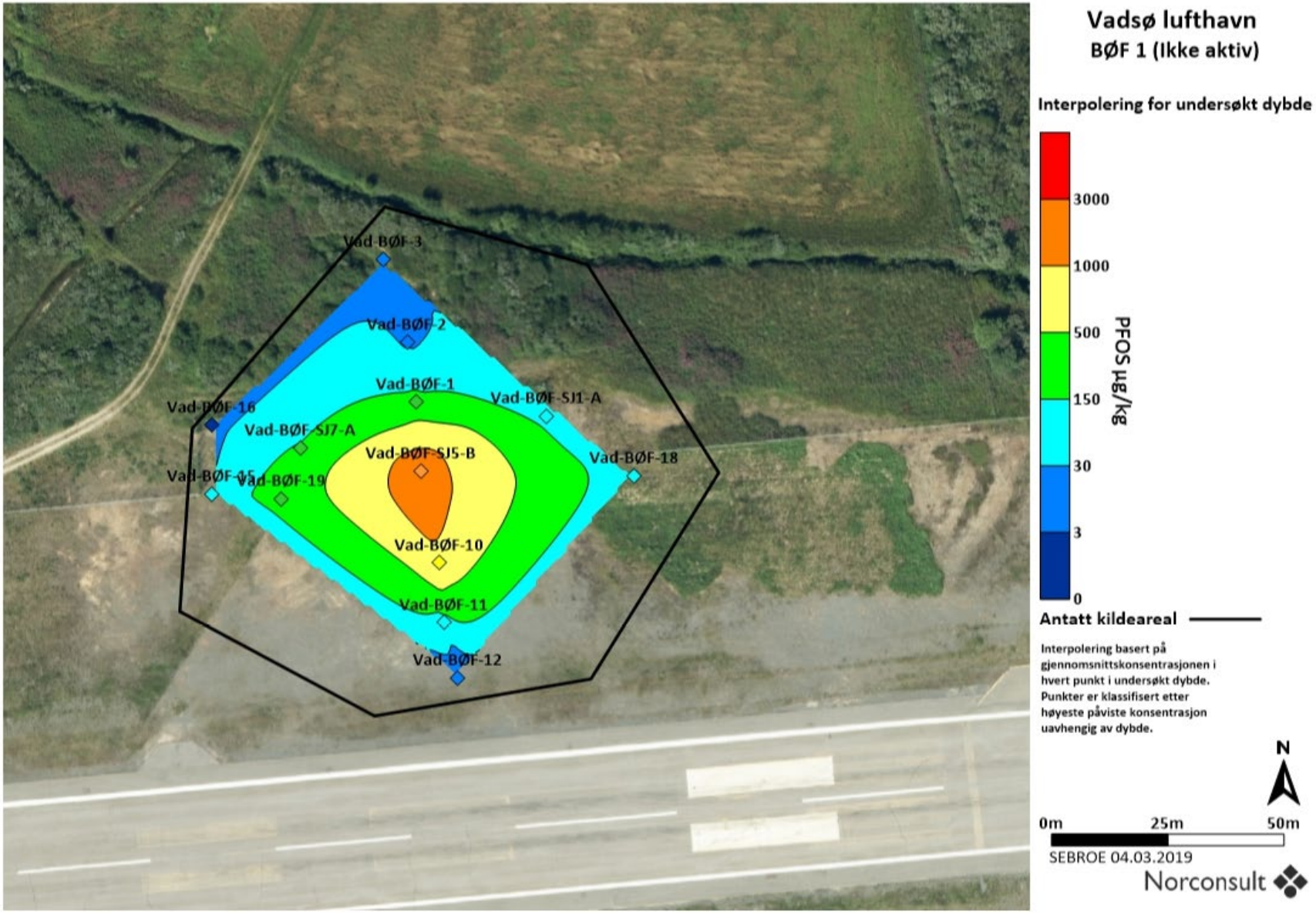
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i 0-1 meters dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.

N

0m 25m 50m

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Vadsø lufthavn
BØF 1 (Ikke aktiv)
Interpolering for undersøkt dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m
25m
50m
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Vad-BØF-3
Vad-BØF-2
Vad-BØF-1
Vad-BØF-SJ1-A
Vad-BØF-16
Vad-BØF-SJ7-A
Vad-BØF-SJ5-B
Vad-BØF-18
Vad-BØF-15
Vad-BØF-19
Vad-BØF-10
Vad-BØF-11
Vad-BØF-12

35.1 Fire training site (BØF) / contaminated site

Fire training site (BØF) / contaminated site	BØF 1 (inactive)
	The area manager states that the fire training site was probably put into use in 1984-1985 and was widely used in the late 1980s. It was closed in 2007, and today's fire drills take place at Kirkenes When the BØF was in use, the foam was usually blown to the northwest, north and northeast.

35.2 The use of PFOS and other PFAS

Volume of PFOS used at the site (kg)	Not stated/calculated
Comments/uncertainty:	
Volume of PFAS used at the site (kg)	Not stated/calculated
Comments/uncertainty:	Foam should not have been used on the site in recent times (since 2007).

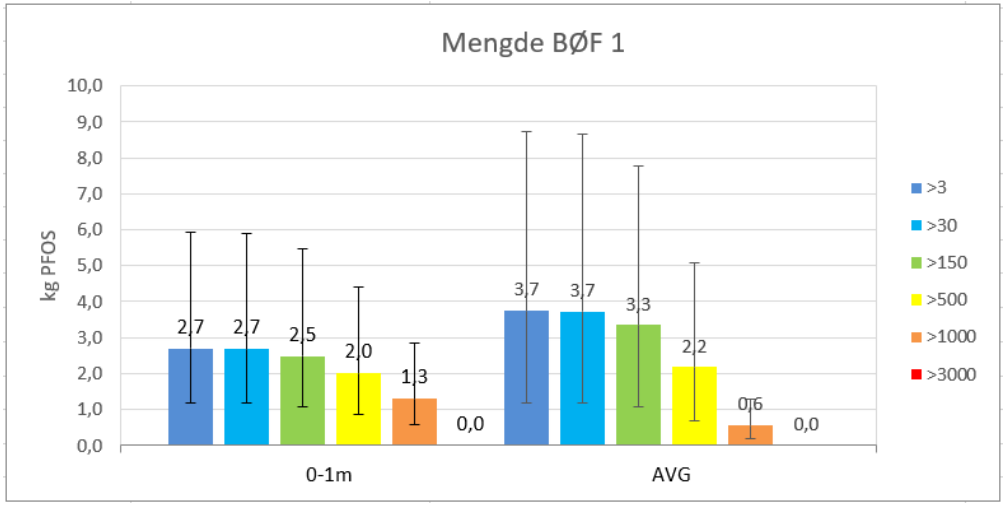
35.3 Soil sampling

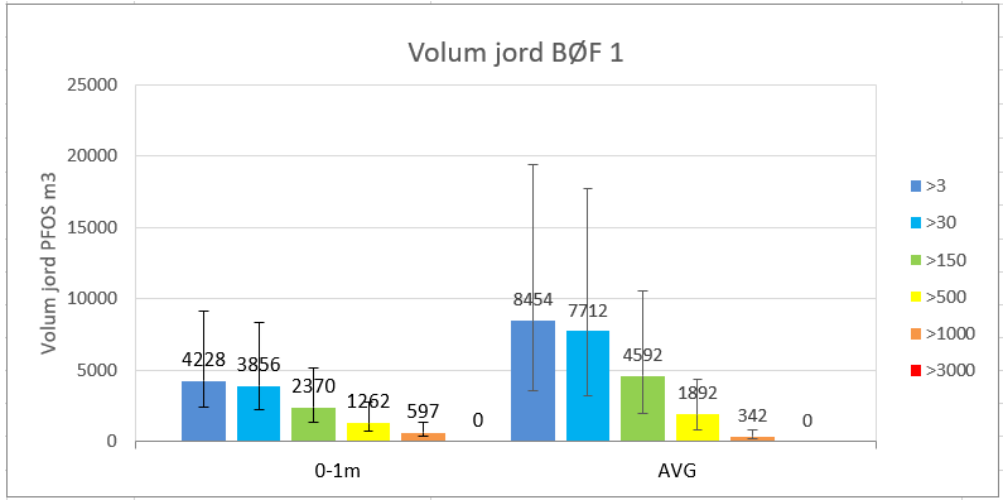
Total number of soil samples	14
Comments/uncertainty (for example, 95% of the samples were taken from 0–0.1 m)	10 of the samples are taken from between 5 to 10 or 15 cm under terrain. One sample is from 150-200 cm deep.
Number of soil samples 0-1 m beneath the ground	13
Number of soil samples below 1 m	1
Comments/uncertainty:	No samples were taken from the layer 0.5-1.5 m. The deepest sample was taken at a depth of 2 metres. The materials are stated to mainly consist of gravel, sand, sandy soil and soil.
Highest measured soil concentration of PFOS µg/kg	2,780
Where	Vad-BØF-SJ5-A (20-50 cm). The materials consist of gravel and sand.
Highest measured soil concentration of PFAS µg/kg	2,796.8
Where	Vad-BØF-SJ5-A (20-50 cm). The materials consist of gravel and sand.
Comments/uncertainty:	The sample (Vad-BØF-SJ5-A) has only been analysed for PFOA and PFOS. It is uncertain whether the sample is actually from 20-50 cm deep as stated in the DP2 report table 2, since table 4 of the report shows that this sample is from 150-200 cm deep. In the analysis report, the sample with the highest concentration is marked with SJ5-A and the sample with the lowest concentration is marked with SJ5-B.

	Four of the soil samples taken were analysed for 12 PFAS compounds; there are compounds other than PFOS present, but PFOS is the predominant component.

35.4 Volume calculation

PFOS average for all depths and points > 3 µg/kg	
Concentration (µg/kg)	308
Area (m2)	4,227
Volume of soil (tonnes)	13,526
Volume of PFOS (kg)	3.7
Uncertainty -	2.6
Uncertainty +	5.0
PFOS average for all depths and points > 30 µg/kg	
Concentration (µg/kg)	335
Area (m2)	3,856
Volume of soil (tonnes)	12,339
Volume of PFOS (kg)	3.7
Uncertainty -	2.5
Uncertainty +	4.9
PFOS average for all depths and points > 150 µg/kg	
Concentration (µg/kg)	506
Area (m2)	2,296
Volume of soil (tonnes)	7,347
Volume of PFOS (kg)	3.3
Uncertainty -	2.3
Uncertainty +	4.4
PFOS average for all depths and points > 500 µg/kg	
Concentration (µg/kg)	799
Area (m2)	946
Volume of soil (tonnes)	3,027





Volume of PFOS (kg)	2.2
Uncertainty -	1.5
Uncertainty +	2.9
PFOS average for all depths and points > 1,000 µg/kg	
Concentration (µg/kg)	1,130
Area (m2)	171
Volume of soil (tonnes)	547
Volume of PFOS (kg)	0.6
Uncertainty -	0.4
Uncertainty +	0.7
PFOS average for all depths and points > 3,000 µg/kg	
Concentration (µg/kg)	
Area (m2)	
Volume of soil (tonnes)	
Volume of PFOS (kg)	
Uncertainty -	
Uncertainty +	

Comments regarding calculations of volume	Different figures are given in the DP2 report regarding the remaining volume of PFOS in the soil, and it is uncertain which figure is correct. It has therefore been decided not to report any figures here.
Is the extent of the contaminated area delimitated horizontally?	No concentrations of PFOS above the detection limit have been detected at one of the extreme points (Vad-BØF-16). At the other extreme points, concentrations above the detection limit from 19.5µg/kg - 54.3 µg/kg have been detected. The contamination is therefore not delimitated horizontally. The most heavily contaminated area (with detected concentrations between 163 and 2,780 ug/kg) is apparently delimitated.
Is the extent of the contaminated area delimitated vertically?	No. Samples have only been taken of the materials deeper than 1 metre at one point. There is therefore a great deal of uncertainty as to the degree of contamination in the deeper materials. One point (Vad-BØF-SJ5), where a sample of the materials was taken between 150-200 cm deep, is the point with the highest detected concentration. However, it is uncertain whether the sample with the highest concentration is from 20-50 cm deep or from 150-200 cm deep, as reference is made to two different levels in table 2 and table 4 in the report. The other sample taken in the same shaft has a PFOS concentration of 60.1 ug/kg.

Comments/uncertainty:	Groundwater level is stated to be 130-140 cm deep at the BØF. The sample with the lowest concentration in SJ5 is stated in the report's text in section 3.1.2.1 to be taken over water level, which may point to the fact that it is the sample with the highest concentration that is from deeper materials. However, it is highly uncertain which sample comes from which level. It is believed that the contamination in soil at the BØF has a somewhat limited depth below groundwater level due to leaching.

35.5 Water sampling and annual dispersion

Have water samples been taken?	Yes
Where	Samples of both surface water and groundwater have been taken. Samples of surface water are taken from Kibybekken which flows north of the BØF, heading east, before turning south and under the runway towards the sea. The samples in the stream are taken upstream of the BØF, at the BØF and three sampling points downstream of the BØF. In addition, a sample of surface water has been taken in the ditch located west of the BØF, which also flows into Kibybekken before the sampling point at the BØF. Samples of groundwater have been taken from three groundwater wells established in shafts at the BØF.
Highest measured concentration of PFOS in groundwater (ng/l)	154,000
Where	Brønn 5 (sampled in 2012)
Highest measured concentration of PFAS in groundwater (ng/l)	213,000
Where	Brønn 5 (sampled in 2012)
Comments/uncertainty:	Brønn 5 was analysed for 12 different PFAS compounds. In groundwater wells established in shafts, a mobilisation of PFAS compounds is expected, however, the water samples were taken one year after establishment.
Highest measured concentration of PFOS in surface water (ng/l)	515
Where	Vad-V4 (sampled in 2011)
Highest measured concentration of PFAS in surface water (ng/l)	530
Where	Vad-V4 (sampled in 2011)
Comments/uncertainty:	Vad-V4 sampled in 2011 was only analysed for PFOA and PFOS. In the sample from the same point in 2012, concentrations are lower (PFOS = 200 ng/l and PFAS = 298 ng/l).

Total annual dispersion of PFOS from the airport	Different figures are listed for two locations in the DP2 report (the text in chapter 3.1.3.5 vs. table 7). It is uncertain which figures are correct. It has therefore been decided not to report any figures here.
Total annual dispersion of PFAS from the airport	
To which recipient	Run-off of contaminated groundwater from the surveyed area at the BØF will flow into Kibybekken and from there on towards Varangerfjorden.
Calculated from water or soil concentration.	

35.6 Biota sampling

Have biota samples being taken at the airport?	No
What kind of biota?	
How many samples?	
Highest measured concentration of PFOS in biota (µg/kg wet weight)	
Where	
Highest measured concentration of PFAS in biota (µg/kg wet weight)	
Where	
Median concentration in comparable populations (e.g. in a lake)	
Comments/references	
References and concentrations in other reports.	

35.7 Uncertainty and other factors

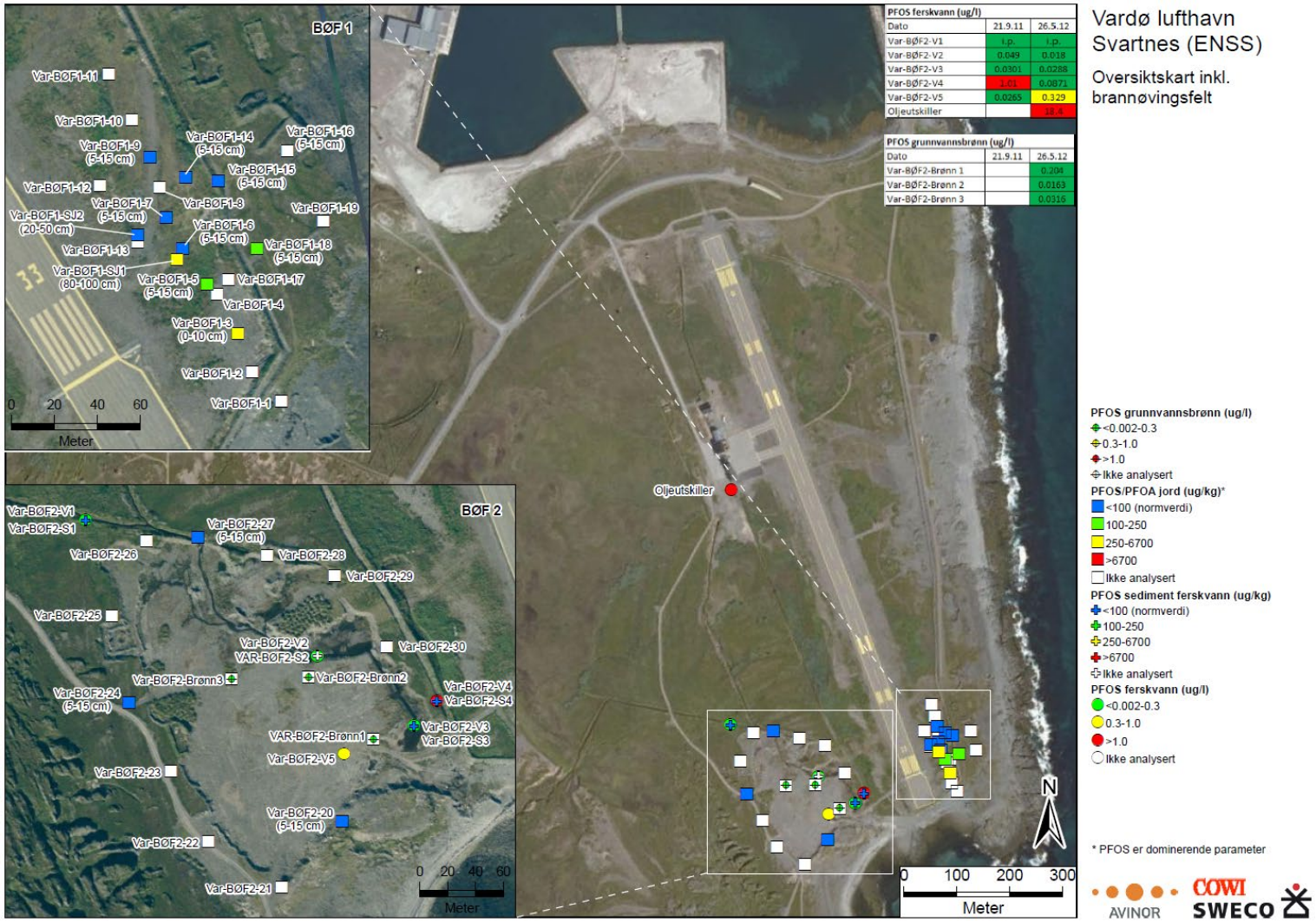
Does the estimate of the volume of PFOS in the ground correspond with the measured concentrations in water and biota?	Cannot be evaluated. Only one soil sample of deeper materials has been taken, and it is highly uncertain whether it is the sample with the highest concentration taken from 150-200 cm deep. Reference is made to two different levels for this sample in table 2 and table 4 of the DP2 report. If the sample with the highest concentration is from deeper materials, the probability that there may generally be higher concentrations in deeper materials increases, as no samples have been taken deeper than 0.5 metres at the other points. The volumes of PFOS should then be greater than that shown by the calculations, as the average concentration at each sampling point would then be higher. There are also very high concentrations in groundwater samples, which were sampled one year after establishment in shafts.

Evaluations	The water samples taken from the groundwater wells have been analysed for 12 different PFAS compounds, while the soil samples from the same points were only analysed for PFOS/PFOA. If the water samples from the groundwater wells are compared with soil samples from other sampling points analysed for 12 PFAS compounds, it can be seen that PFOS is the predominant compound in both water and soil. There are 6:2 FTS and other compounds present in both soil and groundwater samples. Concentrations in groundwater are high, and it is uncertain what the concentrations are in deeper materials at the BØF. The DP2 report assumes that there is a minor groundwater slope to the northeast (Kibybekken). It is therefore possible that PFOS is spread from the BØF to Kibybekken. In the water samples taken in the stream upstream of the BØF (Vad-V1), and upstream of other impact from the airport, no concentrations of PFOS have been detected above the detection limit. In the sample of stream water taken at/downstream of the BØF (Vad-V3), PFOS concentrations between 192 (2012) and 316 ng/l (2011) and PFAS of 285 ng/l (2012) have been detected. In the stream/ditch west of the BØF (Vad-V2), PFOS has also been detected, at approximately 145 ng/l for both measurements, and 388 ng/l PFAS (2012). Incidentally, water in this stream/ditch may come from the as it runs along the north side of the runway, and then swings north towards Kibybekken before the sampling point sampled downstream of the BØF. The water samples taken in 2011 show higher concentrations than the samples taken in 2012.

Comments/uncertainty: (Could there be any additional unknown sources of PFOS at the site with run-off to the recipient?)	The DP2 report states that: The runway is located along an east-west ridge where the centre line along the runway constitutes the water separation point for surface drainage. Drainage on the north side of the runway is to the northeast. The main drainage pattern (Kibybekken) then leads this water towards the Varangerfjord to the south. The results of analysis of surface water from Kibybekken in 2011 may indicate that there are several sources of PFOS contamination at Vadsø airport. This is because a higher concentration of PFOS was detected in the water sample Vad-V4 (515 ng/l in 2011), which is taken in Kibybekken nearer the outlet to the sea, than in the sample Vad-V3 at the BØF. Sampling point Vad-V4 is approximately 350 metres southeast of the BØF. It is uncertain whether surface water from the airport is otherwise directed to this stream, both via ditches on the north side of the runway and possibly elsewhere. The DP2 report suggests that there may have been an accidental discharge or unregistered use of foam during drills on the eastern part of the runway, or that PFOS-contaminated materials have been used during the expansion of the eastern end of the runway. Alternatively, there may be a different direction to the groundwater flow than assumed, which has led to higher concentrations further down in Kibybekken. The samples taken in 2012 do not show the same pattern; in these samples the concentrations of PFOS in all the sampling points taken of Kibybekken downstream of the BØF are approximately 200 ng/l. In 2012, a water sample was also taken at an oil separator located in the terminal area. PFOS has been identified in this water sample. In addition, high concentrations of 6:2 FTS (2,470 ng/l) and 8:2 FTS (1,060 ng/l) have been detected in this sample. The reason why PFAS compounds have been detected here is uncertain. In May 2017, an environmental survey was carried out and an action plan was drawn up in connection with the expansion of an operations building at the airport. Samples were taken from five points during this survey. This is right near the location of the sampled oil separator. The samples from four of the points were analysed for PFAS compounds. PFAS was detected in all samples, at concentrations of between 11-850 µg/kg. PFOS was the dominant PFAS compound in all the samples. An application was made to the County Governor of Finnmark for permission to temporarily store the PFAS-contaminated materials (approx. 900 m3 with concentrations of PFAS between 33-850 µg/kg) at the abandoned fire training site. The County Governor gave permission for this, and the materials were therefore stored on an impermeable covering at the old fire training site. The materials are covered with a tarpaulin to shield the materials from wind and precipitation.
Has the site been sufficiently mapped with a view to assessing the order of prioritisation?	No, the site is too poorly mapped (ref. this report for parts 1 and 2, section 2.1.1.6 and chapter 2.1.3.1). There is too much uncertainty associated with materials in deeper layers. If the sample with the highest concentration is from deeper materials, it is likely that there are higher concentrations in soil at this depth at several sampling points, as no samples have been taken deeper than 0.5 metres at the other points. In this case, the estimated volumes of PFOS should have been greater. Furthermore, no samples have been taken of the materials between 0.5-1.5 metres.
Other factors of significance to possible clean-up/implementation of	The following are recorded in Naturbase: there is a proposed protected area/nature reserve about 3 km north of the airport. Several species of high and particularly high management interest have also been recorded around the airport. The habitat

measures (for example, planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	"mountainous lime-rich areas" has been recorded at and east of the BØF. Some cultural monuments have also been registered south of the airport. The BØF is bordered by an area of cultivated land to the north. The BØF is located about 270 metres north of a built-up area along the E75. Between the built-up area and the BØF there is a marshy terrain that is used as a pasture area. Kibybekken flows close to several residential buildings. As described above, PFAS-contaminated materials from the area for the expansion of the operations building are temporarily stored at the closed fire training site.

36 Vardø Airport, Svartnes



PFOS ferskvann (ug/l)		
Dato	21.9.11	26.5.12
Var-BØF2-V1	i.p.	i.p.
Var-BØF2-V2	0.049	0.018
Var-BØF2-V3	0.0301	0.0288
Var-BØF2-V4	1.01	0.0871
Var-BØF2-V5	0.0265	0.329
Oljeutskiller		18.4

PFOS grunnvannsbrønn (ug/l)		
Dato	21.9.11	26.5.12
Var-BØF2-Brønn 1		0.204
Var-BØF2-Brønn 2		0.0163
Var-BØF2-Brønn 3		0.0316

Vardø lufthavn
Svartnes (ENSS)

Oversiktskart inkl. brannøvingsfelt

PFOS grunnvannsbrønn (ug/l)
- <0.002-0.3
- 0.3-1.0
- >1.0
- Ikke analysert

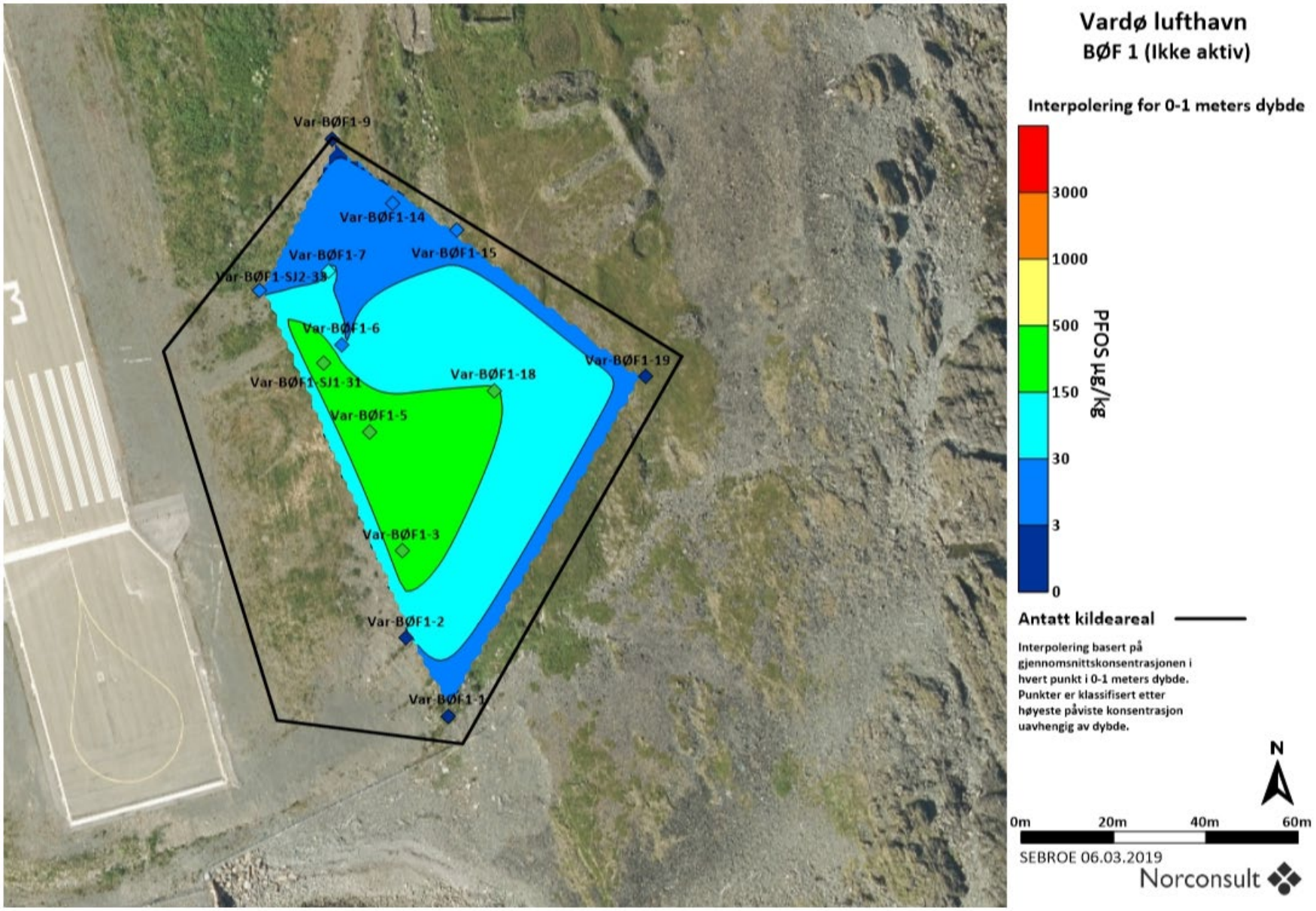
PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

PFOS sediment ferskvann (ug/kg)
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

PFOS ferskvann (ug/l)
- <0.002-0.3
- 0.3-1.0
- >1.0
- Ikke analysert

* PFOS er dominerende parameter

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Vardø lufthavn
BØF 1 (Ikke aktiv)

Interpolering for 0-1 meters dybde

PFOS µg/kg
3000
1000
500
150
30
3
0

Antatt kildeareal

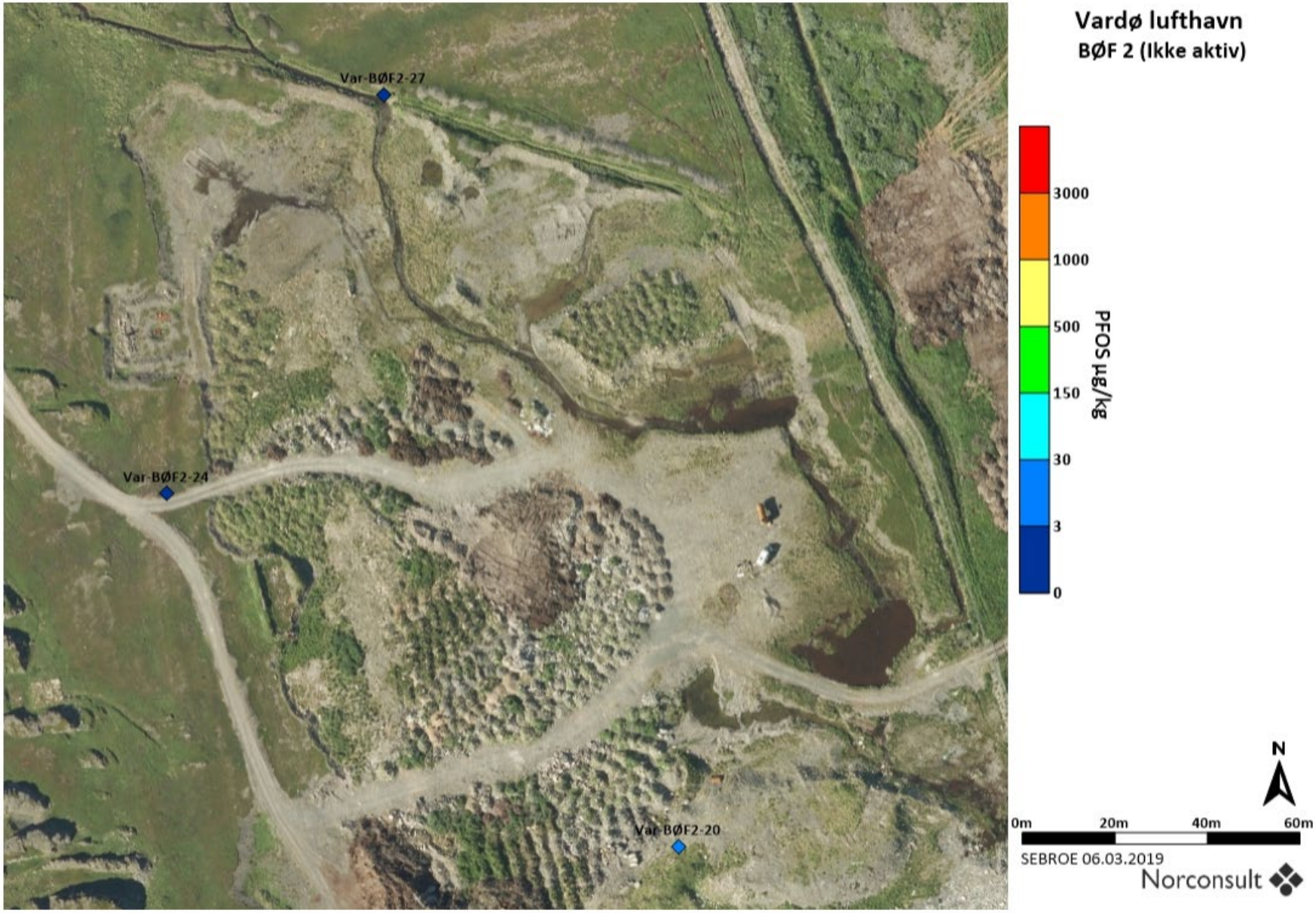
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i 0-1 meters dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.

N

0m 20m 40m 60m

SEBROE 06.03.2019

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Vardø lufthavn
BØF 2 (Ikke aktiv)
Var-BØF2-27
Var-BØF2-24
Var-BØF2-20
3000
1000
500
150
30
3
0
PFOS µg/kg
N
0m
20m
40m
60m
SEBROE 06.03.2019
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36.1 Fire training site (BØF) / contaminated site

Fire training site (BØF) / contaminated site	BØF 1 (old)	BØF 2 (oldest)
	Ramboll reports that BØF-1 was probably put into use in 1989 and was in operation until 1992. The area manager states that the site was only used a few times.	BØF 2 is located in a large gravel pit southwest of the runway. There is no information on when BØF 2 was put into use or how long drills were performed here. The airport was established during World War II, but was first used as a civilian airport in 1987. In the DP 2 report, BØF 2 is described as the oldest, but this does not correspond with the fact that there is an aircraft body at the site in aerial photos from 2012, which was not there in 2011.

36.2 The use of PFOS and other PFAS

Volume of PFOS used at the site (kg)	Not stated/described	Not stated/described
Comments/uncertainty:		
Volume of PFAS used at the site (kg)	Not stated/described	Not stated/described
Comments/uncertainty:		

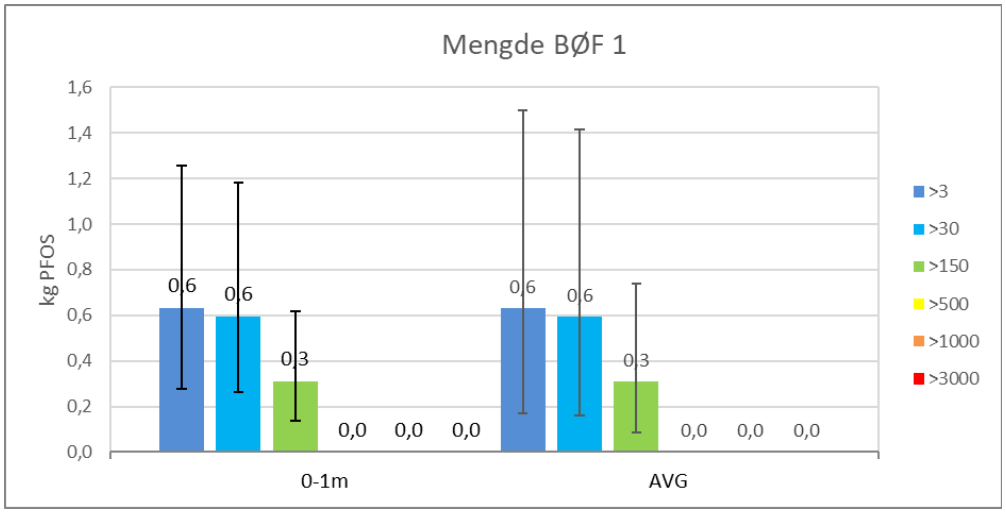
36.3 Soil sampling

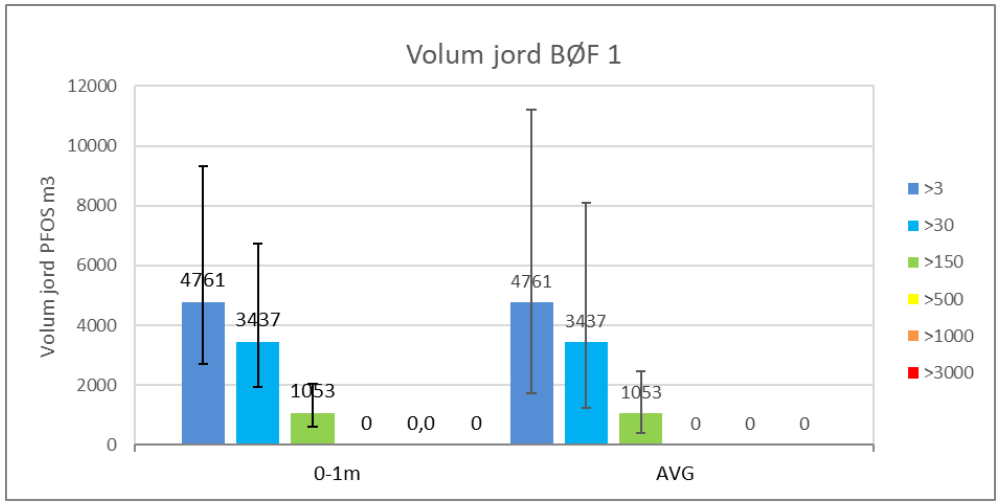
Total number of soil samples	13	3
Comments/uncertainty (e.g. 95% of the samples were taken from 0-0.1 m)	11 of the samples are surface samples taken from the layer 0-0.15 m. The last two samples are taken from 0.8-1 metres and 0.2-0.5 metres. No deeper samples have been taken due to the limited thickness of surficial deposits.	All the samples were taken from 5-15 cm deep.
Number of soil samples 0-1 m beneath the ground	13	3
Number of soil samples below 1 m	0	0
Comments/uncertainty:	The materials are stated to consist of organic soil, sandy gravel, shell sand, filler, peat soil, sand and rock.	The materials are described as sandy soil, sand and old soil on weathering layer.
Highest measured soil concentration of PFOS µg/kg	377	4
Where	Var-BØF1-SJ1-31 (0.8-1 m). The materials consist of organic matter and soil.	Var-BØF2-20 (5-15 cm). The materials consist of sandy soil.

Highest measured soil concentration of PFAS µg/kg	389	4
Where	Var-BØF1-SJ1-31 (0.8-1 m). The materials consist of organic matter and soil.	Var-BØF2-20 (5-15 cm). The materials consist of sandy soil.
Comments/uncertainty:	Sample Var-BØF1-SJ1-31 was only analysed for PFOS and PFOA. Three of the samples analysed were analysed for PFOS, PFOA and 6:2 FTS, the rest were only analysed for PFOS and PFOA. No 6:2 FTS has been detected in any of the samples. PFOA was detected in 3 of the samples, in concentrations between 3 .2-12.4 µg/kg.	The three soil samples were only analysed for PFOS and PFOA.

36.4 Volume calculation

PFOS average for all depths and points > 3 µg/kg		
Concentration (µg/kg)	92	
Area (m2)	4,761	
Volume of soil (tonnes)	7,618	
Volume of PFOS (kg)	0.6	
Uncertainty -	0.5	
Uncertainty +	0.9	
PFOS average for all depths and points > 30 µg/kg		
Concentration (µg/kg)	120	
Area (m2)	3,437	
Volume of soil (tonnes)	5,499	
Volume of PFOS (kg)	0.6	
Uncertainty -	0.4	
Uncertainty +	0.8	
PFOS average for all depths and points > 150 µg/kg		
Concentration (µg/kg)	205	
Area (m2)	1,053	
Volume of soil (tonnes)	1,685	
Volume of PFOS (kg)	0.3	
Uncertainty -	0.2	
Uncertainty +	0.4	
PFOS average for all depths and points > 500 µg/kg		
Concentration (µg/kg)		
Area (m2)		
Volume of soil (tonnes)		
Volume of PFOS (kg)		
Uncertainty -		
Uncertainty +		





PFOS average for all depths and points > 1,000 µg/kg		
Concentration (µg/kg)		
Area (m2)		
Volume of soil (tonnes)		
Volume of PFOS (kg)		
Uncertainty -		
Uncertainty +		
PFOS average for all depths and points > 3,000 µg/kg		
Concentration (µg/kg)		
Area (m2)		
Volume of soil (tonnes)		
Volume of PFOS (kg)		
Uncertainty -		
Uncertainty +		

Comments regarding calculations	The DP 2 report assumes that the PFOS-contaminated area has an area of 50*50 metres. It is written that there is considerable uncertainty associated with this estimate. The thickness of the contaminated materials is estimated to be 1 metre. With an average concentration of 80 µg/kg and a density of 1.6 tonnes/m3, this gives a residual volume of PFOS of 0.32 kg (different figures are given in Table 3 and the text in the DP2 report, it is here that the figures in the table are used). The calculation from 2019 calculates that 0.6 kg of PFOS remains in the area surveyed at BØF 1. The surveyed area is approximately 4,800 m2. The positive uncertainty for the volume of PFOS (within the estimated source area of approximately 9,100 m2) is calculated at 1.5 kg.	The DP 2 report assumes that the contaminated area extends over an area of 50*50 metres, but it is stated that it is not really possible to determine the area of the contaminated area. The thickness of the contaminated materials is estimated to be 1 metre. With an average concentration of 3.1 µg kg and a density of 1.6 tonnes/m3, this gives a residual volume of PFOS of 12.4 g. No new volume calculations have been made due to the fact that only 3 soil samples have been taken at the site.

Is the thickness of the contaminated area delimitated horizontally?	No PFOS has been detected in concentrations above the detection limit at the extreme points to the south (Var-BØF1-1 and 1-2), to the east (Var-BØF1-19) or to the north (Var-BØF1-9). The contamination at BØF 1 appears to be fairly well delimitated in all directions except to the west. However, the report describes that there is uncertainty regarding the exact location of BØF 1.	Cannot be assessed as only three soil samples have been taken. In addition, it is uncertain whether these soil samples are located in the area where the fire drills were conducted (the sampling points are located at the edge of the gravel pit). Aerial photos from 2012 show that they were not taken near where an aircraft body used for drills is located.
Is the thickness of the contaminated area delimitated vertically?	Surface samples have mainly been taken at BØF 1, with the exception of two points taken down to 0.5 and 1 metre. In the deepest sample which is from 0.8-1 metre deep, the highest concentration (377 µg/kg) was detected. Few samples have been taken in materials deeper than 0.15 metres, and the contamination is therefore not delimitated vertically.	Only surface samples were taken at BØF 2. There is no information on the degree of contamination of the deeper materials.
Comments/uncertainty:	It is described that there is the thickness of the surficial deposits is limited, and varying thickness to bedrock in the area. The BØF is approximately 6 metres above sea level. The sea is about 100 metres south of the BØF.	

36.5 Water sampling and annual dispersion

Have water samples been taken?	No	Yes
Where		In a stream and in three wells at the BØF
Highest measured concentration of PFOS in groundwater (ng/l)		204
Where		Brønn 1 sampled on 26.5.12
Highest measured concentration of PFAS in groundwater (ng/l)		308
Where		Brønn 1 sampled on 26.5.12
Comments/uncertainty:		In addition to PFOS, 8 ng/l 6:2 FTS has been detected in the sample.
Highest measured concentration of PFOS in surface water (ng/l)		1,010
Where		Var-BØF2-V4 (21.09.2011)
Highest measured concentration of PFAS in surface water (ng/l)		18,100
Where		Var-BØF2-V2 (26.05.2012)
Comments/uncertainty:		It is uncertain which PFAS compounds dominate in sample Var-BØF2-V2 (26.5.12), as the analysis report for water samples from 2012 is not available in the DP2 report. The points at which surface water samples have been taken have been sampled twice (21.9.11 and 26.5.12). The samples taken in 2011 were analysed for PFOS and PFOA. The samples taken in 2012 were also analysed for 6:2 FTS. A water sample has also been taken of an oil separator located at the southern end of the terminal area. A concentration of PFOS (18,400 ng/l), 6:2 FTS (23,100 ng/l) and PFAS (55,100 ng/l) were detected here.
Total annual dispersion of PFOS from the site (g/year)	0.02-2.5	0.4
Total annual dispersion of PFAS from the site (g/year)	Not calculated	8.5
To which recipient	Skinnstakkvika/Barentshavet	Skinnstakkvika/Barentshavet
Calculated from water or soil concentration.	Calculated groundwater concentration based on average soil concentration and a Kd of 10.	Water concentration, average of all water analyses from the site.

36.6 Biota sampling

Biota sampling		
Have biota samples being taken at the airport?	No	No
What kind of biota?		
How many samples?		
Highest measured concentration of PFOS in biota (µg/kg wet weight)		
Where		
Highest measured concentration of PFAS in biota (µg/kg wet weight)		
Where		
Median concentration in comparable populations (e.g. in a lake)		
Comments/references		
References and concentrations in other reports.		

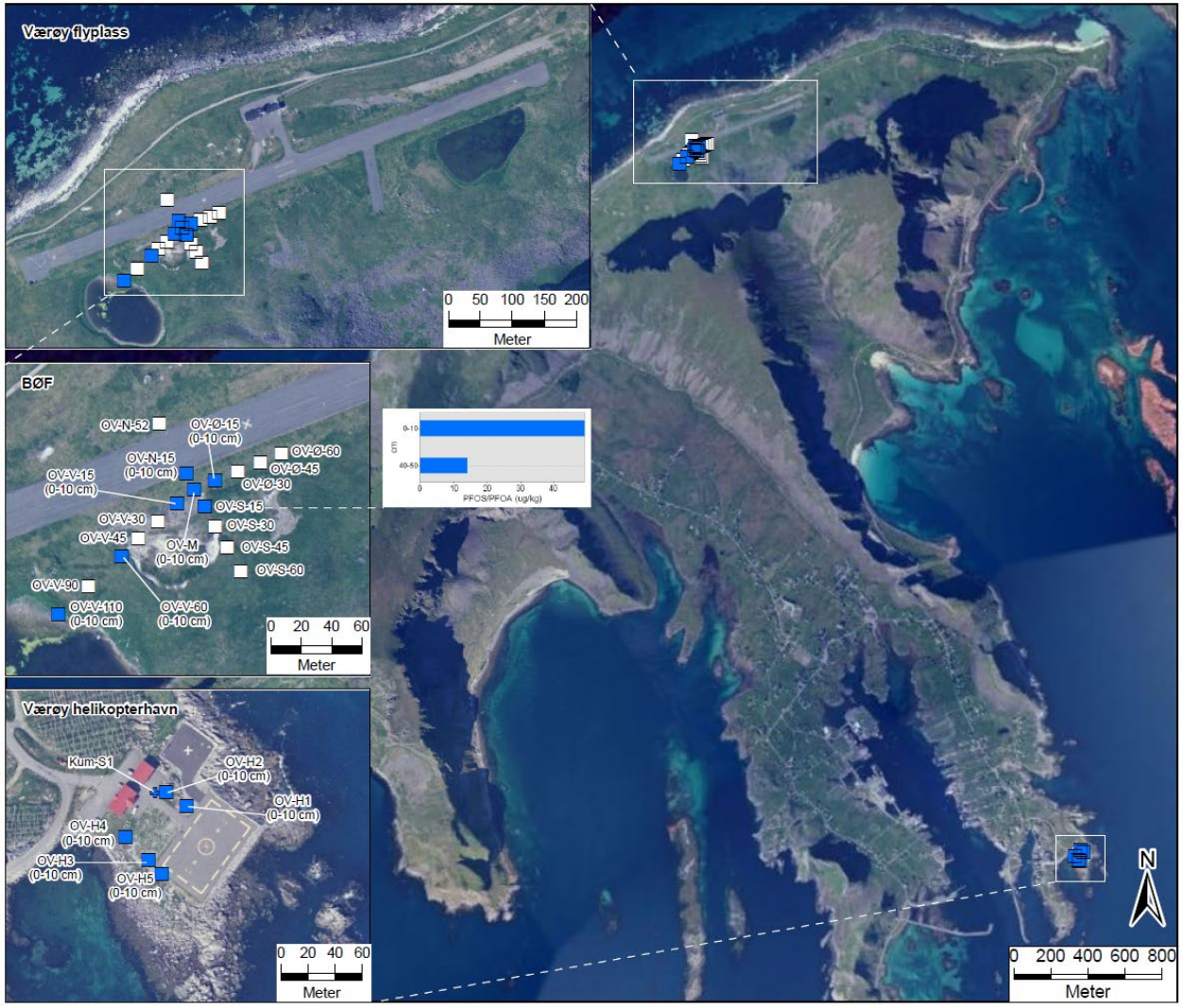
36.7 Uncertainty and other factors

Does the estimate of the volume of PFOS in the ground correspond with the measured concentrations in water and biota?	Cannot be evaluated, as no water samples or biota samples have been taken at the site.	Cannot be evaluated as no volume calculation has been performed for this site.
Evaluations	Some (four samples) high concentrations of PFOS have been detected. The rest of the samples have low concentrations (less than 33 µg/kg). The level of contamination in materials deeper than 0.15 metres is uncertain. The geology of the surficial deposits consists of permeable beach deposits consisting mainly of gravel and coarse sand. The thickness of the surficial deposits is limited; the BØF is about 6 metres above sea level. The groundwater level is assumed to be about the same level (about 0.3-0.7 metres) as at BØF2, which is in the same area, but on the other side of the runway. The site has not been used since 1992, and it was used a few times. Therefore, it is expected that there are limited volumes of PFOS in the soil at this site as the calculations show.	Very low concentrations of PFOS have been detected in the three soil samples taken at the site (below 4 µg/kg). This is inconsistent with the results of the water samples where quite high concentrations of PFOS (between 300 and 1010 ng/l) have been detected in some of the samples (Var-BØF-V4 and V5). In sample Var-BØF2-V2 (26.5.12), low concentrations of PFOS (below 50 ng/l) but a high concentration of total PFAS (18,100 ng/l) were detected. It is uncertain which PFAS compounds predominate in this sample (the analysis report is not available). 18,400 ng/l PFOS, 23,100 ng/l 6:2 FTS and 55,100 ng/l PFAS were also detected in a water sample from an oil separator at the terminal area. Sampling point V2 is at BØF 2, in a stream that runs from the area at the oil separator and towards the BØF. There are high concentrations of total PFAS in both samples, and it is possible that the contamination comes from the area at the oil separator, or that water from the oil separator is directed to the basin. It is stated in table 7 in the DP2 report that no 6:2 FTS has been detected in water from V2 such as was detected in water from oil separator. This cannot be verified as analysis attachments are not attached. An area (BØF 3) is described where fire drills have been carried out at the terminal area (north of the operational building). It is possible that there is also dispersion to this stream from this area, as the stream flows directly west of the terminal area. No soil samples have been taken at BØF 3. Sampling point V3 slightly further downstream of V2, before the stream goes into a pipe under a small road, has low concentrations of PFOS and PFAS (below 35 ng/l). 204 ng/l of PFOS, 8 ng/l of 6:2 FTS and 308 ng/l of PFAS have been detected in the sample of groundwater from brønn 1 located at the bottom of the gravel pit. This well is just downstream of the location of the aircraft body in the aerial photo from 2012. Sampling point V4 is at the end of the runway, in stagnant water in a ditch that runs along the runway east of the BØF. It is stated that the foam vehicles are tested at the end of the runway. Only water should be used during testing of equipment, but accidental spills of firefighting foam may occur during these drills. Three sediment samples have also been taken in the ditches at the same points as V2, V3

		and V4. No PFOS has been detected at V2, but at points V3 and V4 PFOS of between 50 and 90 µg/kg has been detected.

Comments/uncertainty: (Could there be any additional unknown sources of PFOS at the site with run-off to the recipient?)	Samples of water from the oil separator and water at point V2 in the stream downstream of the terminal area indicate other possible sources. Drills have been carried out in an area at the northwest corner of the generator building which is north of the operational building (this was not perceived as the BØF by the area manager and it is unclear if foam was used in the area, but is referred to as BØF 3 in the DP 2 report). Tests were performed with foam vehicles, but not for hot drills at BØF 3. During the tests with foam vehicles, only water was used. Surveys have previously been carried out at BØF 3 by Ramboll. No PFOS was detected in the soils during these surveys. The foam vehicles are tested at the ends of the runway. Only water should be used during testing of equipment, but accidental spills of firefighting foam may occur during these drills. Samples from stagnant water in a ditch at the end of the runway (V4) have a relatively high content of PFOS (1,010 ng/l).	See description under BØF 1
Has the site been sufficiently mapped with a view to assessing the order of prioritisation?	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the volume of PFOS in the soil with the stipulated level of uncertainty.	No, not enough soil samples have been taken. The site is not well enough mapped with a view to assessing the order of prioritisation (see this report for parts 1 and 2, chapter 2.1.1.6 and chapter 2.1.3.1).
Comments/uncertainty:	The precise location of this site is not known. The area may have been excavated and flattened in connection with the relocation of fencing and probably also in connection with the S&L project.	The exact location and direction of drills are unknown.
General information about the airport		
Other factors of significance to possible clean-up/implementation of measures (for example, planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	Several species of high and particularly high management interest have been recorded in the airport area (plants and birds). Just east of the runway is an area recorded as the habitat "mountainous lime-rich areas". A number of cultural monuments have also been recorded in the area around the airport.	

37 Værøy Airport/Værøy Heliport



Værøy helikopterhavn (ENVR)

Oversiktskart inkl. brannøvingsfelt

PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

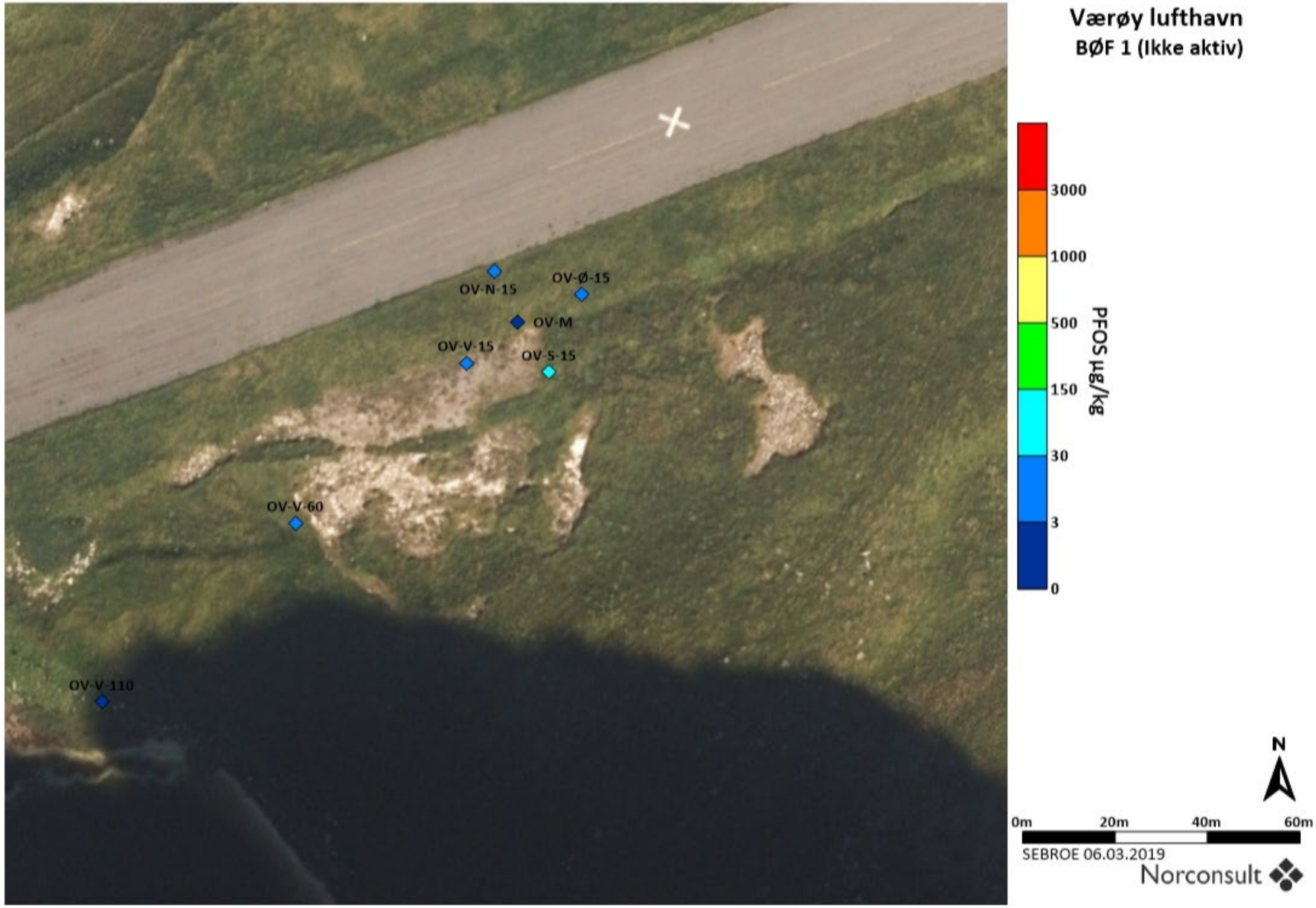
PFOS sediment ferskvann (ug/kg)
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

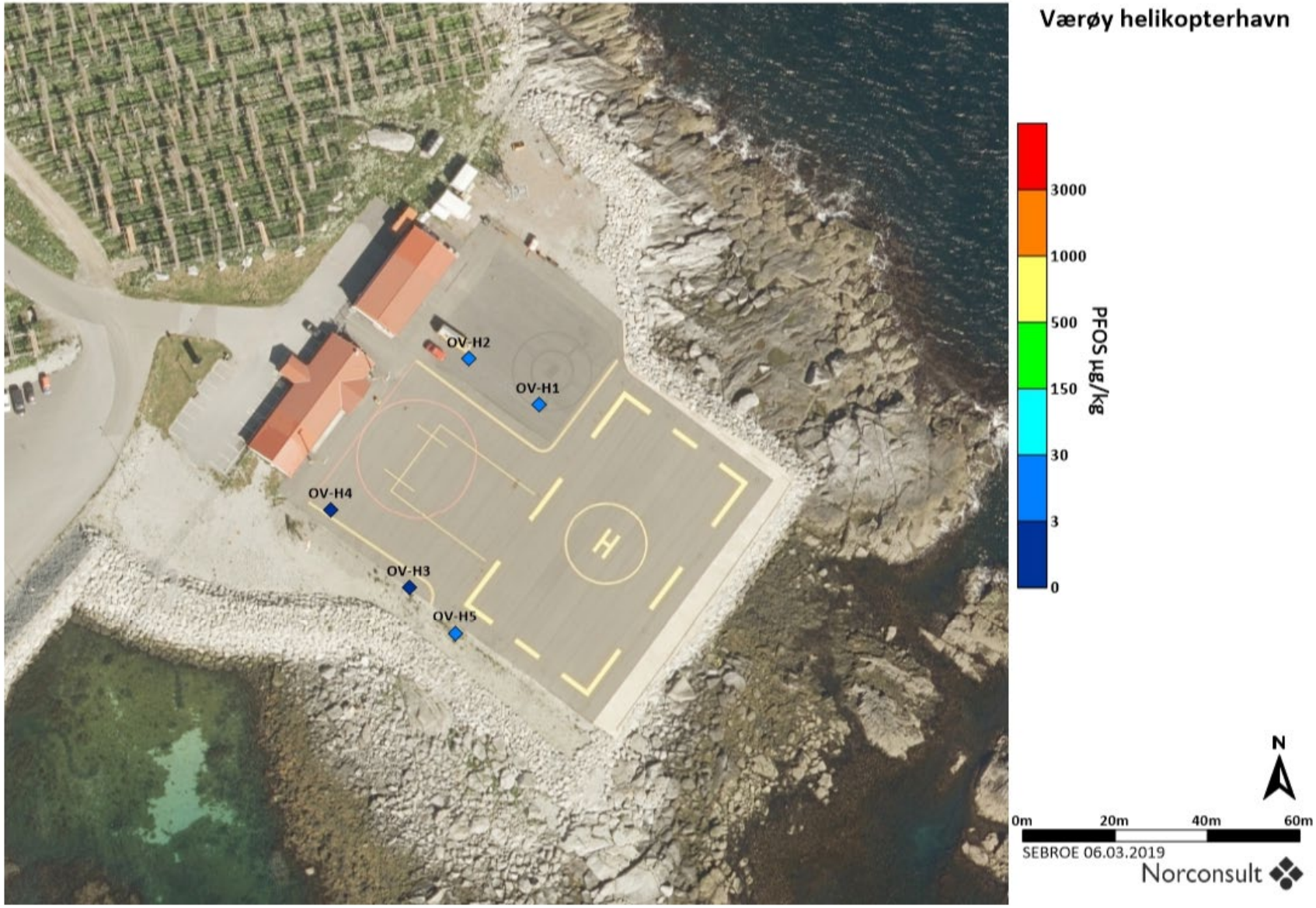
Mrk. varierende skala for x-aksen i diagrammene

* PFOS er dominerende parameter

ip = ikke påvist

AVINOR COWI SWECO


Værøy lufthavn
BØF 1 (Ikke aktiv)
OV-N-15
OV-Ø-15
OV-M
OV-V-15
OV-S-15
OV-V-60
OV-V-110
3000
1000
500
150
30
3
0
PFOS µg/kg
N
0m
20m
40m
60m
SEBROE 06.03.2019
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Værøy helikopterhavn
OV-H2
OV-H1
OV-H4
OV-H3
OV-H5
H
3000
1000
500
150
30
3
0
PFOS µg/kg
N
0m
20m
40m
60m
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37.1 Fire training site (BØF) / contaminated site

Fire training site (BØF) / contaminated site	BØF 1 (inactive)	At the terminal area
	Værøy Airport was opened in 1986, but was closed to public traffic in 1990 after a plane crash. One old fire training site has been registered at Værøy Airport. This was only in use by Avinor from when the airport was opened in 1986 until it was shut down in 1990.	Værøy heliport, located on the other side of Værøy, to the south, is used for public transport today (which takes place by helicopter). No fire training site has been established at Værøy heliport. Hot drills are performed at Trondheim Airport, Værnes. Functional tests of fire engines are performed at various locations at the heliport from time to time.

37.2 The use of PFOS and other PFAS

Volume of PFOS used at the site (kg)	Not stated/calculated	Not stated/calculated
Comments/uncertainty:	The BØF was only used for about four years when the airport was in operation, and it is thus assumed that small volumes of foam were used in total at this site.	
Volume of PFAS used at the site (kg)	Not stated/calculated	Not stated/calculated
Comments/uncertainty:		

37.3 Soil sampling

Total number of soil samples	8	5
Comments/uncertainty (for example, 95% of the samples were taken from 0–0.1 m)	7 of the 8 samples were taken from 0.0.1 m. One sample was taken from 0.4-0.5 m.	Surface samples.
Number of soil samples 0-1 m beneath the ground	8	5
Number of soil samples below 1 m	0	0
Comments/uncertainty:	The materials are described as sand or sandy soil.	
Highest measured soil concentration of PFOS µg/kg	49.5	14.3
Where	OV-S-15-6 (0-0.1 m). The materials consist of sand	H1 - material type not specified
Highest measured soil concentration of PFAS µg/kg	49.5	14.3
Where	OV-S-15-6 (0-0.1 m). The materials consist of sand	H1 - material type not specified

Comments/uncertainty:	All samples were only analysed for PFOA and PFOS. No PFOA has been detected in any of the samples.	Only concentrations of PFOS are stated in the report, analysis attachments are not included, so it is unknown whether analysis for multiple compounds was carried out.

37.4 Volume calculation

No volumes have been calculated for any of these sites.	BØF 1 (inactive)	At the terminal area
Comments	The DP2 report assumes that the most contaminated area is situated within an area of 60*60 metres. It is assumed that the thickness of the contaminated materials is 0.5 metres, and that the average concentration of PFOS in this area is 17 µg/kg. On this basis it is calculated that approximately 0,05 kg of PFOS remains at the BØF.	There are no previously calculated volumes of PFOS in the ground at Værøy heliport.
Is the extent of the contaminated area delimitated horizontally?	No, even though relatively low concentrations of PFOS have been detected throughout the BØF, it is only at an extreme point to the southwest where no PFOS has been detected above the detection limit (OV-V-110, which is a sediment sample from Sandtjønna). At the other extreme points, PFOS has been detected at concentrations between 5.4-49.5 µg/kg. The centre of the BØF is believed to be at OV-S-15 where a bonfire site was observed, and this soil sample had the highest PFOS concentration.	No. No specific area is suspected of being contaminated with PFAS at Værøy Heliport. Sampling was thus carried out at a few points apparently only to get an indication of whether the ground is contaminated by PFAS after, for example, the functional test of a fire engine. The sampling detected PFOS in three out of five samples, and in low concentrations.
Is the extent of the contaminated area delimitated vertically?	No, the contamination is not delimitated vertically. Only surface samples were taken at the BØF, with the exception of one point where a sample of the materials from 0.4-0.5 m was taken. In this sample a PFOS concentration of 14 µg/kg was detected. How deep the contamination extends is therefore uncertain. It was stated that there are relatively permeable materials (sand) in the area.	No. No specimens were taken of deeper materials, only of surface materials.
Comments/uncertainty:	The BØF was only used for about four years when the airport was in operation, and it is thus assumed that small volumes of foam were used in total at this site.	Værøy heliport is right at the sea edge, and there is bare bedrock around the site. It is assumed that there is a thin cover of surficial deposits.

37.5 Water sampling and annual dispersion

Have water samples been taken?	No	No
Where		
Highest measured concentration of PFOS in groundwater (ng/l)		
Where		
Highest measured concentration of PFAS in groundwater (ng/l)		
Where		
Comments/uncertainty:		
Highest measured concentration of PFOS in surface water (ng/l)		
Where		
Highest measured concentration of PFAS in surface water (ng/l)		
Where		
Comments/uncertainty:		
Total annual dispersion of PFOS from the site (g/year)	Not calculated; in the DP2 report it is assumed that there are no substance discharges of environmental significance.	Not calculated
Total annual dispersion of PFAS from the site (g/year)	Not calculated	Not calculated
To which recipient	The runoff is expected to go towards the sea to the northwest, and/or towards Sandtjønna which is to the southwest. PFOS was not detected in sediment samples (OV-V-110) taken of Sandtjønna.	Håkjerringvika to the southwest, Røssnesvågen to the east.
Calculated from water or soil concentration.		

37.6 Biota sampling

Have biota samples being taken at the airport?	No	No

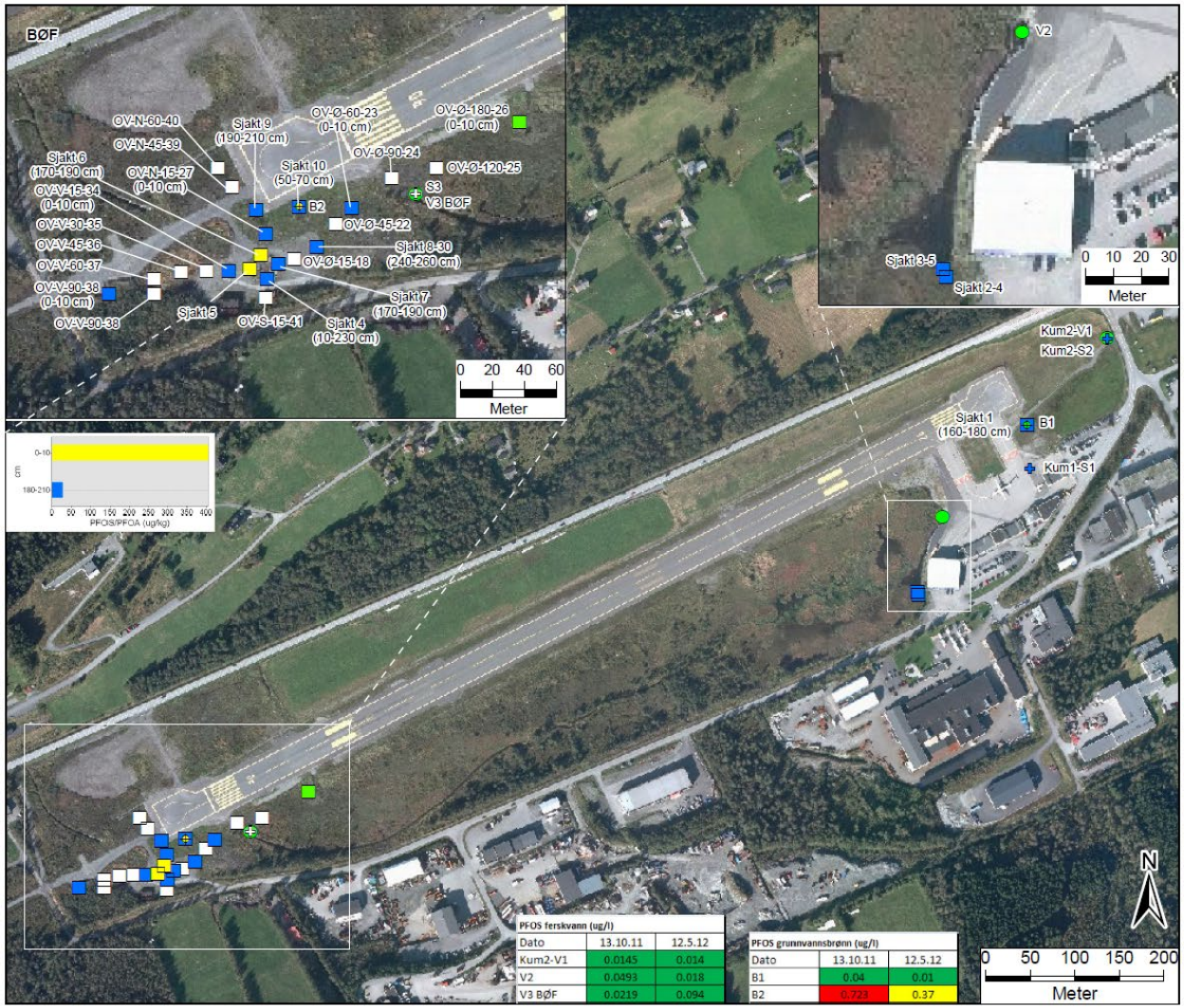
What kind of biota?		
How many samples?		
Highest measured concentration of PFOS in biota (µg/kg wet weight)		
Where		
Highest measured concentration of PFAS in biota (µg/kg wet weight)		
Where		
Median concentration in comparable populations (e.g. in a lake)		
Comments/references		
References and concentrations in other reports.		

37.7 Uncertainty and other factors

Does the estimate of the volume of PFOS in the ground correspond with the measured concentrations in water and biota?	Cannot be evaluated. The volume of PFOS remaining in the ground at this site was not calculated, as there is only one sample with PFOS exceeding 20 ug/kg. No samples of water or biota have been collected.	Cannot be evaluated as there are no calculated volumes of PFOS in the ground at this site, or samples of water or biota.
Evaluations		
Comments/uncertainty: (Could there be any additional unknown sources of PFOS at the site with run-off to the recipient?)	It is not stated that there are additional sources of PFOS at the site or elsewhere at the airport, but the possibility cannot be ruled out.	
Has the site been sufficiently mapped with a view to assessing the order of prioritisation?	The site is considered sufficiently surveyed with a view to assessing the order of prioritisation, but will not be prioritised for measures based on a cost/benefit perspective (ref. this report for parts 1 and 2, chapter. 2.1.1.6 and chapter 2.1.3.1).	No specific area is suspected of being contaminated with PFAS at Værøy Heliport. The sampling detected PFOS in three out of five samples, and in low concentrations (<15 ug/kg). It is assumed that there is a thin cover of surficial deposits, and it is likely that there are low volumes in the soil. The site will not be prioritised for measures based on a cost/benefit perspective (ref. this report for parts 1 and 2, chap. 2.1.1.6 and chapter 2.1.3.1).

Comments/uncertainty:	Low concentrations of PFOS have been detected at Værøy Airport. PFOS was detected in 6 of 8 samples, in concentrations between 5.4-49.5 g/kg. PFOS has not been detected in the remaining two samples. Only one sample shows concentrations above 20 µg/kg. The low concentrations of PFOS are probably due to the fact that the airport was only in operation for about four years, and that it is over 20 years since regular traffic was closed when the survey was carried out. Værøy Airport is exposed to the weather, and there are sandy and permeable materials at the BØF, which may have contributed to the leaching of PFOS from the soil. It is not expected that there are large undiscovered volumes of PFOS in soil at this site. There were no visible installations at BØF, but the remains of a "bonfire area" with burnt metal were found in the area. The delimitation of the BØF was therefore not clearly defined.	
Other factors of significance to possible clean-up/implementation of measures (for example, planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	From Naturbase: Two protected areas/nature reserves are recorded about 3 km from the airport; at Hundholmen, located east of Værøy, as well as the southwestern part of Værøy. There are also several areas of high and particularly high management interest at Værøy Airport, as well as in the marine area outside the airport. The habitats sandy and gravel beach, sand dunes and ponds are right next to the airport. The area around the airport is also registered as an important outdoor recreation area; "Nordlandshagen". Some cultural monuments have also been recorded around the airport. THC in environmental condition class 3 has been detected at the sampling point (OV-S-15) which is believed to be at the centre of BØF.	From Naturbase: Two protected areas/nature reserves are recorded about 2 km from the heliport; at Hundholmen, located east of Værøy, as well as the southwestern part of Værøy. There are also several areas of high and particularly high management interest at Værøy Heliport, as well as in the marine area outside. The habitat shell sand is registered in the sea just outside the heliport. In addition, a particularly outdoor recreation area has been recorded in the sea to the east, Skjersvika, as well as a pier and a lighthouse to the south and west.

38 Ørsta/Volda Airport, Hovden



Ørsta/Volda lufthavn
Hovden (ENOV)

Oversiktskart inkl.
brannøvingsfelt

PFOS grunnvannsbrønn (ug/l)
- <0.002-0.3
- 0.3-1.0
- >1.0
- Ikke analysert

PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

PFOS sediment ferskvann (ug/kg)
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

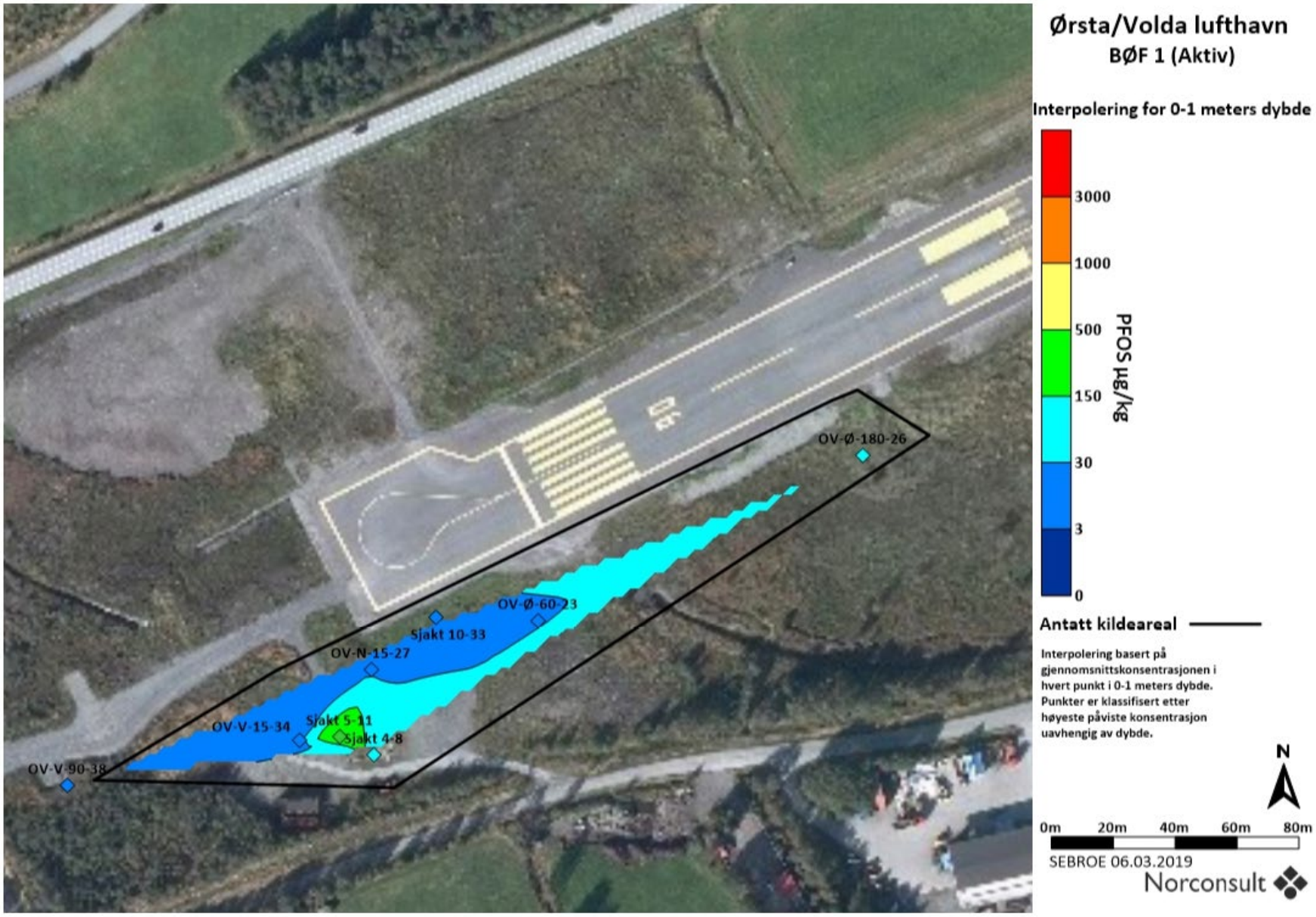
PFOS ferskvann (ug/l)
- <0.002-0.3
- 0.3-1.0
- >1.0
- Ikke analysert

Mrk. varierende skala for x-aksen i diagrammene

* PFOS er dominerende parameter

ip = ikke påvist

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Ørsta/Volda lufthavn
BØF 1 (Aktiv)

Interpolering for 0-1 meters dybde

PFOS µg/kg
3000
1000
500
150
30
3
0

Antatt kildeareal

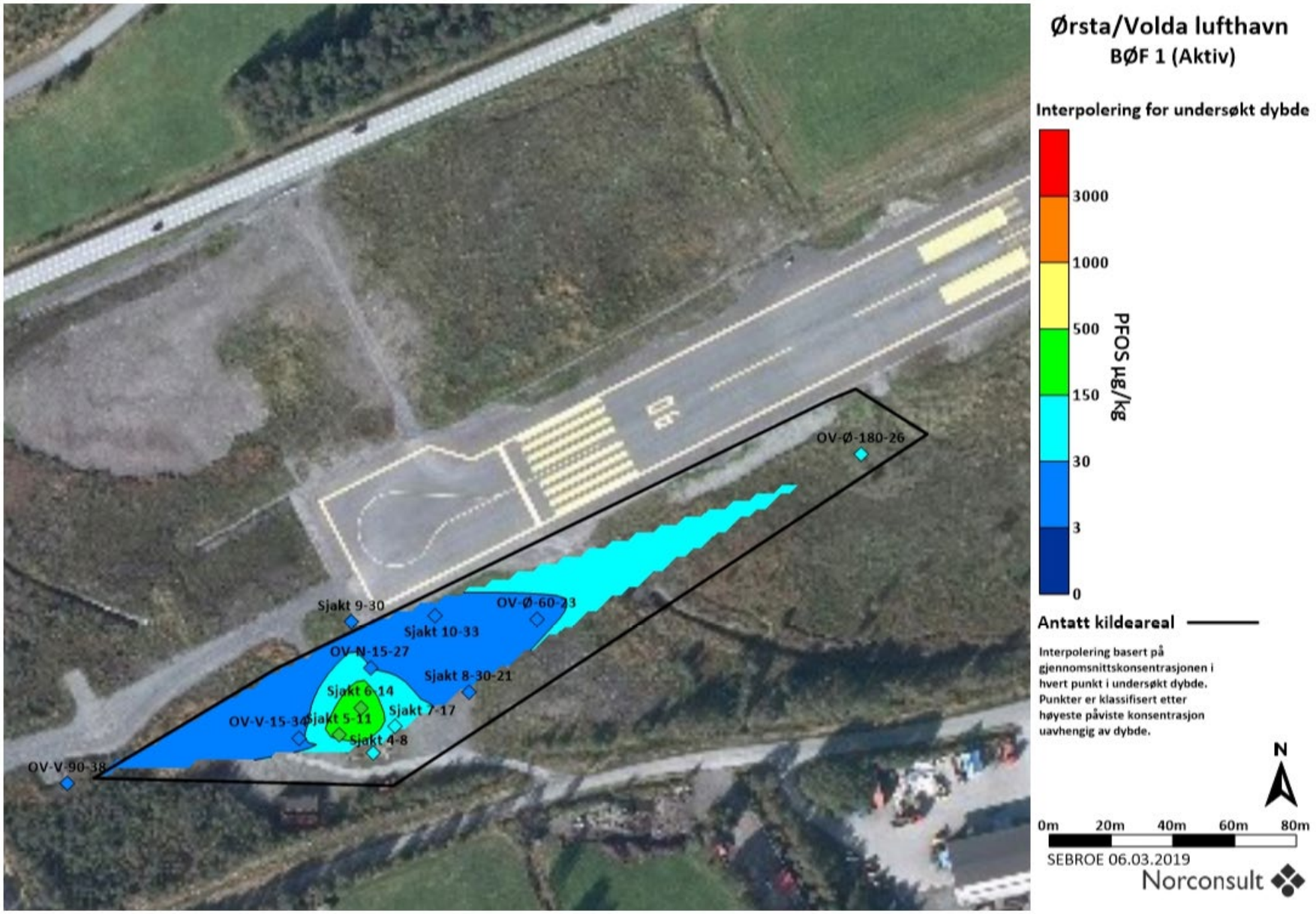
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i 0-1 meters dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.

N

0m 20m 40m 60m 80m

SEBROE 06.03.2019

Norconsult


Ørsta/Volda lufthavn
BØF 1 (Aktiv)
Interpolering for undersøkt dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m 20m 40m 60m 80m
SEBROE 06.03.2019
Norconsult
OV-Ø-180-26
Sjakt 9-30
OV-Ø-60-23
Sjakt 10-33
OV-N-15-27
Sjakt 8-30-21
Sjakt 6-14
Sjakt 7-17
OV-V-15-34
Sjakt 5-11
Sjakt 4-8
OV-V-90-38

38.1 Fire training site (BØF) / contaminated site

Fire training site (BØF) / contaminated site	**BØF 1 (old)**
	It is unclear how long the site has been in use. Ørsta/Volda Airport has been in operation since 1971. The fire training site were in use approximately twice per year until 2012. No other fire drills have been carried out elsewhere at the airport. The plant was closed during the 2012 surveys. The platform consists of a concrete base with approximately 10 cm high edges. Drainage from the site is led to a sand trap foam before an oil separator. Drainage from the oil separator goes to the ditch/ground.

38.2 The use of PFOS and other PFAS

Volume of PFOS used at the site (kg)	Not stated/calculated
Comments/uncertainty:	
Volume of PFAS used at the site (kg)	Not stated/calculated
Comments/uncertainty:	

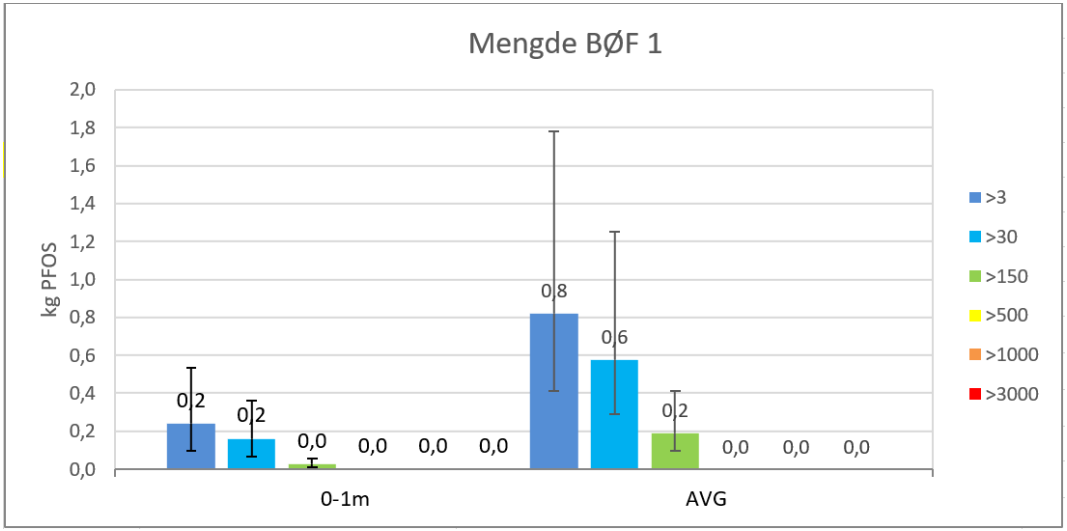
38.3 Soil sampling

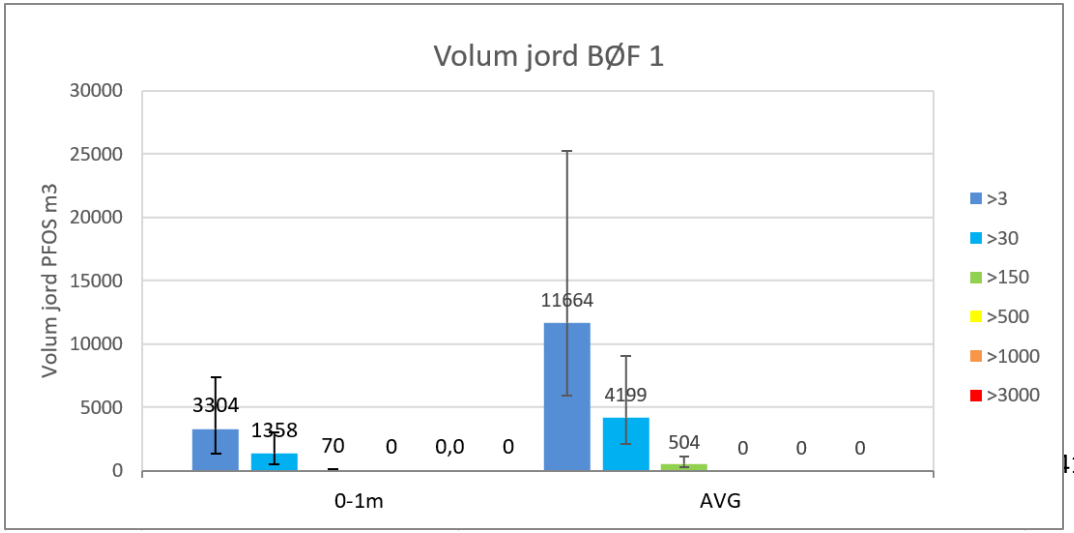
Total number of soil samples	13
Comments/uncertainty (for example, 95% of the samples were taken from 0–0.1 m)	6 of the samples (approximately 50%) are surface samples, taken from 0-0.1 metres. The materials are stated to consist of sandy soil with organic material in surface samples from 0-0.1 metres deep, and sand in the remaining samples.
Number of soil samples 0-1 m beneath the ground	8
Number of soil samples below 1 m	6
Comments/uncertainty:	A total of 14 samples when splitting the samples taken between 0-1 metres and > 1 metre.
Highest measured soil concentration of PFOS µg/kg	455
Where	Sjakt 6-14 (1.7-1.9 metres). The materials consist of sand.
Highest measured soil concentration of PFAS µg/kg	455
Where	Sjakt 6-14 (1.7-1.9 metres). The materials consist of sand.

Comments/uncertainty:	Sample "sjakt 6-14" was only analysed for PFOS and PFOA. Of the 13 samples analysed, 10 of the samples have been analysed for PFOS/PFOA, and 3 of the samples have been analysed for 12 different PFAS compounds. Of compounds other than PFOS, only 6:2 FTS has been detected in two of the samples from the surface, and not in the last analysed sample from 1.8-2.1 m deep.

38.4 Volume calculation

PFOS average for all depths and points > 3 µg/kg	
Concentration (µg/kg)	44
Area (m2)	4,486
Volume of soil (tonnes)	18,662
Volume of PFOS (kg)	0.8
Uncertainty -	0.4
Uncertainty +	1.0
PFOS average for all depths and points > 30 µg/kg	
Concentration (µg/kg)	86
Area (m2)	1,615
Volume of soil (tonnes)	6,718
Volume of PFOS (kg)	0.6
Uncertainty -	0.3
Uncertainty +	0.7
PFOS average for all depths and points > 150 µg/kg	
Concentration (µg/kg)	235
Area (m2)	194
Volume of soil (tonnes)	807
Volume of PFOS (kg)	0.2
Uncertainty -	0.1
Uncertainty +	0.2
PFOS average for all depths and points > 500 µg/kg	
Concentration (µg/kg)	





Area (m2)	
Volume of soil (tonnes)	
Volume of PFOS (kg)	
Uncertainty -	
Uncertainty +	
PFOS average for all depths and points > 1,000 µg/kg	
Concentration (µg/kg)	
Area (m2)	
Volume of soil (tonnes)	
Volume of PFOS (kg)	
Uncertainty -	
Uncertainty +	
PFOS average for all depths and points > 3,000 µg/kg	
Concentration (µg/kg)	
Area (m2)	
Volume of soil (tonnes)	
Volume of PFOS (kg)	
Uncertainty -	
Uncertainty +	

Comments regarding calculations	In the DP2 report, it is calculated that 272 g of PFOS remains at the BØF. This assumes that the most contaminated area lies within an area of 20x20 metres, the average concentration of PFOS is 200 µg/kg and that the thickness of the contaminated materials is 2 metres. The calculation from 2019 calculates that approximately 800 kg of PFOS remains in the area surveyed at the BØF. It is then assumed that for the area surveyed (approx. 4,500 m2), the thickness of the contaminated materials is 2.6 metres and that the average concentration in this area is 44 µg/kg.
Is the extent of the contaminated area delimitated horizontally?	No. The extreme point to the west (surface test OV-V-90-38) and to the north (sjakt 9-30 from 1.9-2.1 m) have concentrations of <8 µg/kg. The extreme point to the east (surface sample OV-Ø-180-26) and south (sample sjakt 4-8 from 0.1-2.3 metres) have

	concentrations of 139 and 60.2 µg/kg respectively. The contamination is therefore least delimitated in a southerly and easterly direction. Sampling point OV-Ø-180-26 is located approximately 180 metres northeast of the platform where the fire drills were performed.
Is the extent of the contaminated area delimitated vertically?	No. In the sample "sjakt 6-14", a concentration of PFOS of 455 µg/kg was detected at a depth of 1.7-1.9 metres. It is uncertain how much deeper this contamination extends. In the other samples of deeper materials, PFOS was also detected, but at lower concentrations (7.2-51.9 µg/kg). The deepest sample was taken at a depth of 2.6 metres.
Comments/uncertainty:	The sample from 1.7-1.9 metres deep in sjakt 6-14 was taken below groundwater level. It is assumed that concentrations will decrease relatively rapidly with depth below groundwater level due to horizontal dispersion with groundwater.

38.5 Water sampling and annual dispersion

Have water samples been taken?	Yes
Where	Groundwater samples have been taken from a well located east of the BØF (B2), and in a well at the terminal area (B1). Samples of surface water have been taken from a culvert/ditch system east of the BØF, as well as from a ditch and a manhole on the eastern side of the runway.
Highest measured concentration of PFOS in groundwater (ng/l)	684
Where	B2 (13.10.11)
Highest measured concentration of PFAS in groundwater (ng/l)	1,030
Where	B2 (12.5.12)
Comments/uncertainty:	The sample taken on 13.10.11 was only analysed for PFOS/PFOA. The sample taken on 12.5.12 was analysed for 12 PFAS compounds. In this sample, PFOS dominates, but there is also evidence of part 6:2 FTS, PFHxA and PFPeA. In the overview map in the DP2 report, total PFOS and PFOA are stated in the table that should show PFOS in the groundwater well, which is why the figures are not the same.
Highest measured concentration of PFOS in surface water (ng/l)	94
Where	V3 BØF (12.05.12)
Highest measured concentration of PFAS in surface water (ng/l)	143
Where	V3 BØF (12.05.12)

Comments/uncertainty:	Samples of surface water were taken on two occasions. The samples which were tested on 9.9.11, were only analysed for PFOS/PFOA. The samples taken on 12.5.12 were analysed for 12 PFAS compounds. PFOS is the predominant compound in all samples. In the sample V3 BØF taken 12.5.2012, PFHxS, PFHxA and PFPeA were also detected.
Total annual dispersion of PFOS from the site (g/year)	7
Total annual dispersion of PFAS from the site (g/year)	Not calculated
To which recipient	Between the runway and an industrial area (including an environmental station) and industry located south of the runway, there is an marshland area. Run-off from the environmental station and other industry in the area will drain towards the marshland on the south side of the runway and then further to the northeast. From the airport, the water is led to the Mos-Ola river and then on to Ørstafjorden
Calculated from water or soil concentration.	Water concentration. Table 8 in the DP2 report states that average values have been used for surface water.

38.6 Biota sampling

Have biota samples being taken at the airport?	No
What kind of biota?	
How many samples?	
Highest measured concentration of PFOS in biota (µg/kg wet weight)	
Where	
Highest measured concentration of PFAS in biota (µg/kg wet weight)	
Where	
Median concentration in comparable populations (e.g. in a lake)	
Comments/references	
References and concentrations in other reports.	

38.7 Uncertainty and other factors

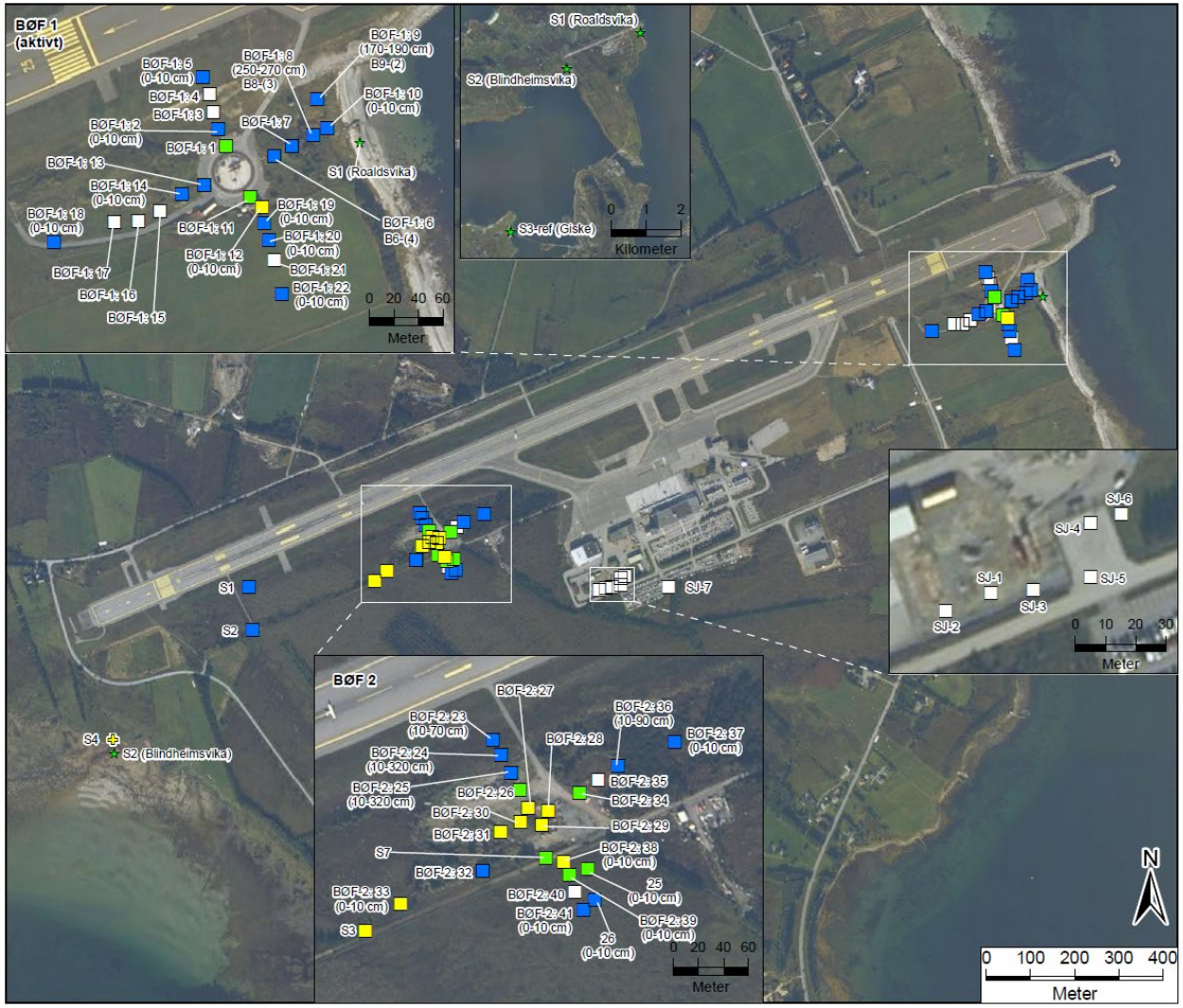
Does the estimate of the volume of PFOS in the ground correspond with the measured concentrations in water and biota?	Cannot be evaluated for biota, as no biota samples have been taken. Cannot be reliably evaluated for water. It is calculated that relatively low volumes of PFOS remain in the ground in the surveyed area (0.8 kg). Moderate concentrations have been detected in groundwater, which is consistent with permeable materials of sand with relatively low bonding capacity for PFOS. There are low concentrations of PFOS in water in the ditch east of the BØF. Groundwater flow direction is somewhat uncertain, and groundwater samples have not been taken in several directions around the BØF to clarify the dispersion direction(s), and also in the ditch northwest of the BØF.
Evaluations	Low to moderate concentrations of PFOS have been detected in the soil materials at the BØF. Two samples of the top soil that were analysed for 12 PFAS compounds also contain 6:2 FTS, in addition to PFOS. PFOS contamination of over 100 µg/kg has been detected at three of the sampling points, two of which are directly on the training platform (concrete base). One point is located about 180 metres east of the platform. The contamination at this point may be due to the testing of foam cannons over the terrain, or other activity. The groundwater well is located northeast of the platform, close to the runway, and at a sampling point (sjakt 10) where only samples of deeper materials have been analysed, and a low concentration of PFOS (8.8 ug/kg) was detected in the soil. No other compounds have been analysed in the soil sample. There are moderate concentrations of PFOS in the groundwater samples from this well (370 and 684 ng/l), but some 6:2 FTS, PFHxA and PFPeA (sum PFAS 1,030 ng/l) have also been detected. The highest concentration of PFOS in soil has been detected in deeper materials below groundwater level at the platform, and although the DP2 report states that B1 should be downstream of the platform, it is uncertain whether the direction of groundwater flow from the BØF is actually to the northeast, and that the well B1 will capture dispersion from this area. From an aerial photo it appears that there is a ditch system east of the BØF, along the marsh on the south side of the runway in the direction of the terminal area. This may be a possible dispersion path for PFOS contamination, both from the platform area and from contamination detected at sampling point 180 metres northeast of the platform. Low concentrations of PFOS (21-94 ng/l) and PFAS (143 ng/l) have been detected in water from the ditch east of the BØF (V3). This indicates that part of the dispersion of contamination of PFOS is to the marsh area to the east. The DP2 report states that groundwater will be directed towards the Mos Ola river, and then into the Ørstafjord.
Calculation	The groundwater well B2 has the same location as sjakt 10. Viewing the average concentration of PFOS in the groundwater samples at this point in isolation, (which is 527 ng/l in four samples from 2011 and 2012), and the average concentration detected in soil (sand) in sjakt 10 which is 8.8 µg/kg in a sample from 50-70 cm deep), a Kd of 17 l/kg can be calculated. Kd based on this calculation is relatively similar to Kd values from laboratory experiments in sand (Master's theses Nygård, 2017; Nordskog, 2013). However, Kd will vary, among other things, with the level of contamination relative to the groundwater level (Nygård, 2017), and since only one soil sample has been taken at a depth interval of 20 cm in the shaft, there is also considerable uncertainty in the calculation.

Comments/uncertainty: (Could there be any additional unknown sources of PFOS at the site with run-off to the recipient?)	Approximately 35 µg/kg PFOS has been detected in two surface samples (sjakt 2 and 3) of materials mixed in filler southwest of the Widerøe hangar, near the terminal area. In water samples at point V2, which is a ditch slightly north of these shafts, 18 to 50 ng/l PFOS has been detected. 13.6 and 24.3 ng/l of PFOS have also been detected in water from groundwater well B1 at the terminal area; no PFOS was detected in soil (1.6-1.8 metres deep) taken from the same place the well is located. PFOS has also been detected in water samples from a manhole and a ditch just east of the eastern end of the runway; these samples have about 14 ng/l PFOS. There are many different activities south of the airport, and it cannot be ruled out that some of these could be sources of ground or water contamination in the marshland south of the runway.
Has the site been sufficiently mapped with a view to assessing the order of prioritisation?	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the volume of PFOS in the soil with the stipulated level of uncertainty.
Comments/uncertainty:	
Other factors of significance to possible clean-up/implementation of measures (for example, planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	There is a protected forest area north of the airport, but it is on the other side of the Ørstafjord. Otherwise, several species of high and particularly high management interest have been recorded in the airport area. There are some cultural monuments north of the airport, on the other side of the E39. The wetland area bordering the south side of the runway and fire training site constitutes an important habitat (oceanic ombrotrophic bog) and several endangered bird species have been observed in the area. There are several energy wells registered on plot 55/27 300 m east of the fire training site area, but the nearest well (bedrock) registered with water supply is 1 km west of the fire training site.

39 Ålesund Airport:

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APPENDIX A



Ålesund lufthavn
Vigra (ENAL)

Oversiktskart inkl. brannøvingsfelt

Jord og sediment

PFOS/PFOA jord (ug/kg)*
- <100 (normverdi)
- 100-250
- 250-6700
- >6700
- Ikke analysert

PFOS sediment ferskvann (ug/kg)
- 0
- <LOQ
- LOQ-63
- 63-6300
- >6300
- Ikke analysert

PFOS sediment marint (ug/kg)
- 0
- <LOQ
- LOQ-63
- 63-6300
- >6300
- Ikke analysert

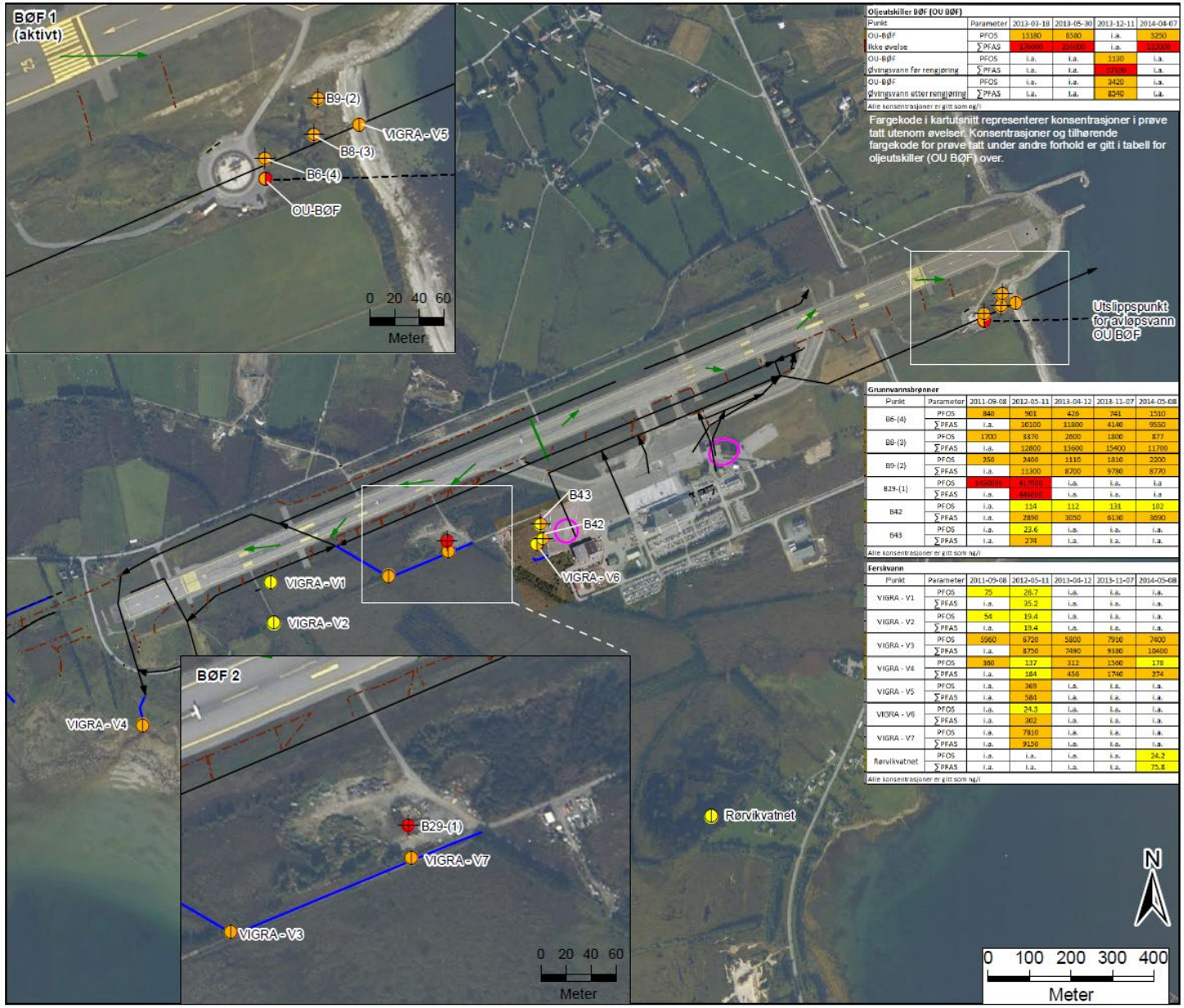
* PFOS er dominerende parameter

LOQ = rapporteringsgrense
i.a. = ikke analysert

AVINOR Norconsult COWI SWECO

Norconsult

APPENDIX A



Oljeutskiller BØF (OU BØF)

Punkt	Parameter	2013-03-18	2013-05-30	2013-12-11	2014-04-07
OU-BØF Ikke øvelse	PFOS	15180	8580	i.a.	3250
	∑PFAS	176000	220000	i.a.	112000
OU-BØF øvingsvann før rengjøring	PFOS	i.a.	i.a.	1130	i.a.
	∑PFAS	i.a.	i.a.	57100	i.a.
OU-BØF øvingsvann etter rengjøring	PFOS	i.a.	i.a.	3420	i.a.
	∑PFAS	i.a.	i.a.	8340	i.a.

Alle konsentrasjoner er gitt som ng/l

Fargekode i kartutsnitt representerer konsentrasjoner i prøve tatt utenom øvelser. Konsentrasjoner og tilhørende fargekode for prøve tatt under andre forhold er gitt i tabell for oljeutskiller (OU BØF) over.

Grunnvannsbrønner

Punkt	Parameter	2011-09-08	2012-05-11	2013-04-12	2013-11-07	2014-05-08
B6-(4)	PFOS	840	901	426	741	1510
	∑PFAS	i.a.	16100	11800	4140	9550
B8-(3)	PFOS	1700	3870	2600	1800	877
	∑PFAS	i.a.	12800	13600	15400	11700
B9-(2)	PFOS	250	2400	1110	1810	2200
	∑PFAS	i.a.	11300	8700	9780	8770
B29-(1)	PFOS	3490000	417000	i.a.	i.a.	i.a
	∑PFAS	i.a.	466000	i.a.	i.a.	i.a
B42	PFOS	i.a.	114	112	131	102
	∑PFAS	i.a.	2890	3050	6130	3690
B43	PFOS	i.a.	23.6	i.a.	i.a.	i.a.
	∑PFAS	i.a.	274	i.a.	i.a.	i.a.

Alle konsentrasjoner er gitt som ng/l

Ferskvann

Punkt	Parameter	2011-09-08	2012-05-11	2013-04-12	2013-11-07	2014-05-08
VIGRA - V1	PFOS	75	26.7	i.a.	i.a.	i.a.
	∑PFAS	i.a.	35.2	i.a.	i.a.	i.a.
VIGRA - V2	PFOS	54	19.4	i.a.	i.a.	i.a.
	∑PFAS	i.a.	19.4	i.a.	i.a.	i.a.
VIGRA - V3	PFOS	5960	6720	5800	7910	7400
	∑PFAS	i.a.	8750	7490	9180	10400
VIGRA - V4	PFOS	360	137	312	1360	178
	∑PFAS	i.a.	184	456	1740	274
VIGRA - V5	PFOS	i.a.	369	i.a.	i.a.	i.a.
	∑PFAS	i.a.	584	i.a.	i.a.	i.a.
VIGRA - V6	PFOS	i.a.	24.3	i.a.	i.a.	i.a.
	∑PFAS	i.a.	302	i.a.	i.a.	i.a.
VIGRA - V7	PFOS	i.a.	7810	i.a.	i.a.	i.a.
	∑PFAS	i.a.	9150	i.a.	i.a.	i.a.
Rørvikvatnet	PFOS	i.a.	i.a.	i.a.	i.a.	24.2
	∑PFAS	i.a.	i.a.	i.a.	i.a.	75.8

Alle konsentrasjoner er gitt som ng/l

Ålesund lufthavn Vigra (ENAL)

Oversiktskart inkl. brannøvingsfelt

Vann

PFOS / ∑ PFAS grunnvannsbrønn (ng/l) *
- Ikke analysert
- 0
- <LOQ
- LOQ-230
- 230-36 000
- >36 000

PFOS / ∑ PFAS ferskvann (ng/l) *
- Ikke analysert
- 0
- <LOQ
- LOQ-230
- 230-36 000
- >36 000

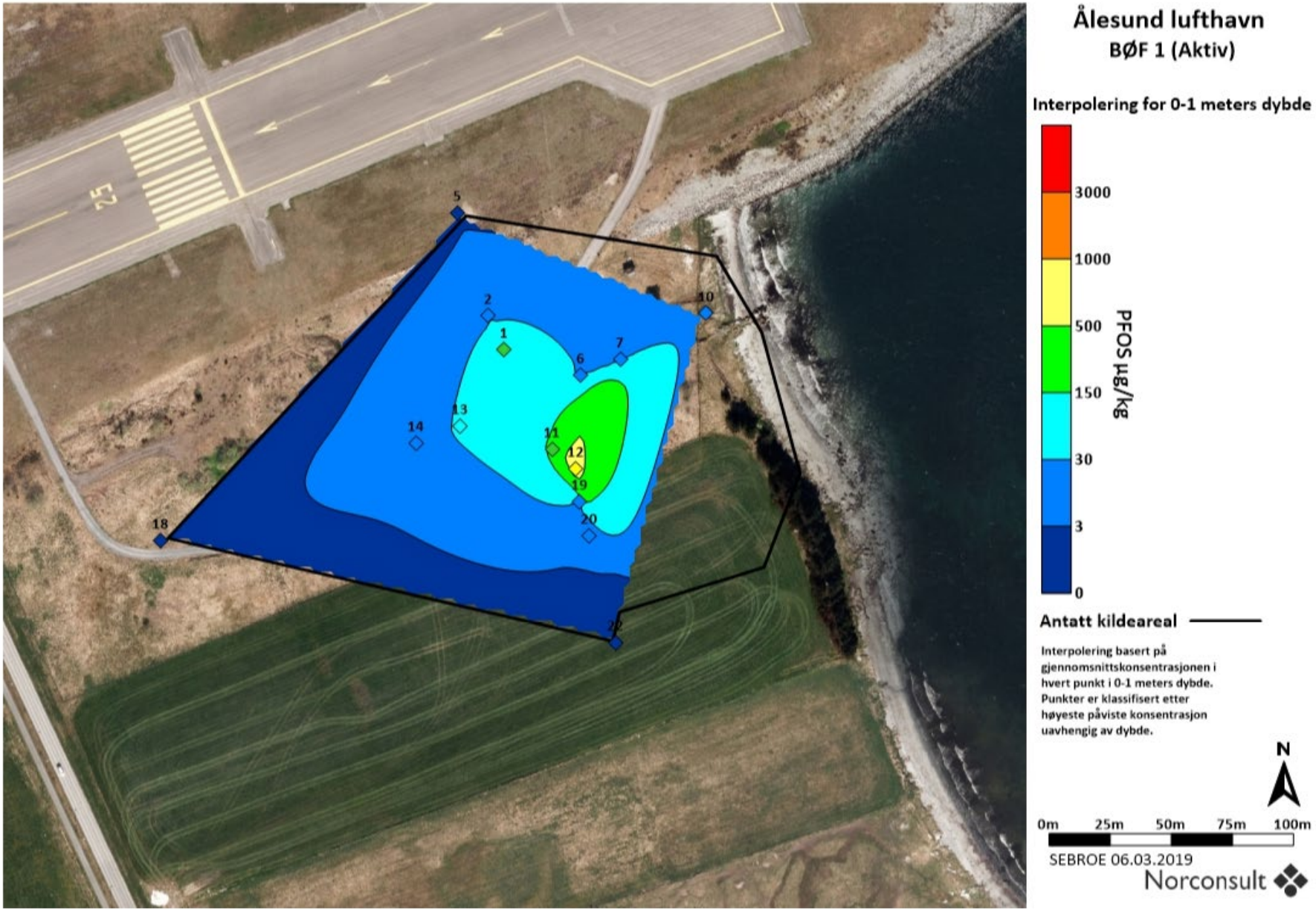
Avlopsledning
- Avløp annet
- Avløp Felles
- Drensvann
- Glykolholdig overvann
- Glykolholdig spillvann
- Overvann
- Pumpespillvannsledning
- Spillvann

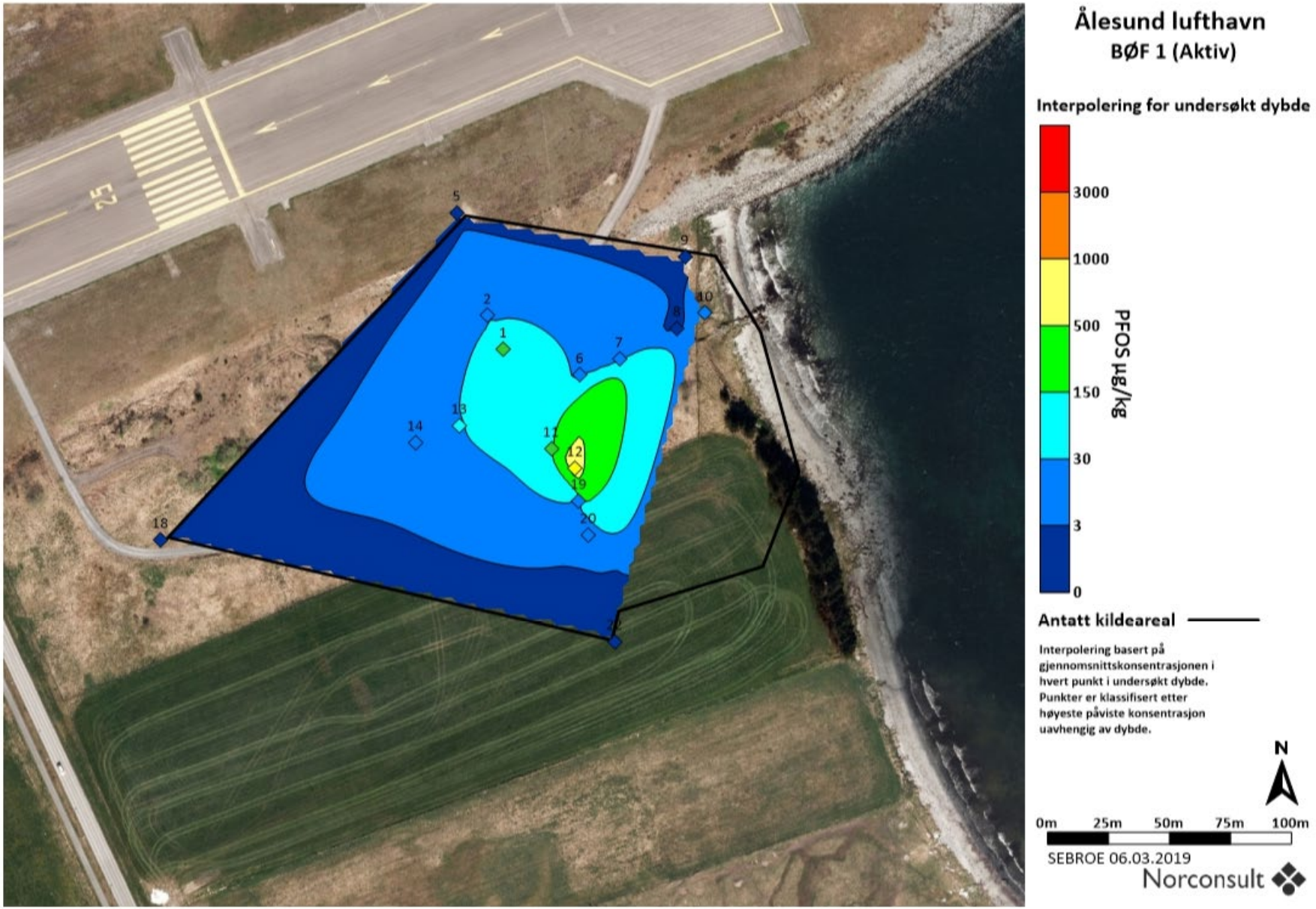
Avrenning
- Deponi glykolforurenset snø
- Overvannsledning
- Avrenningsveg glykol
- Bekkeresipient
- Overvannsystem
- Vannskille rullebane
- Antatt avrenningsveg baneavising

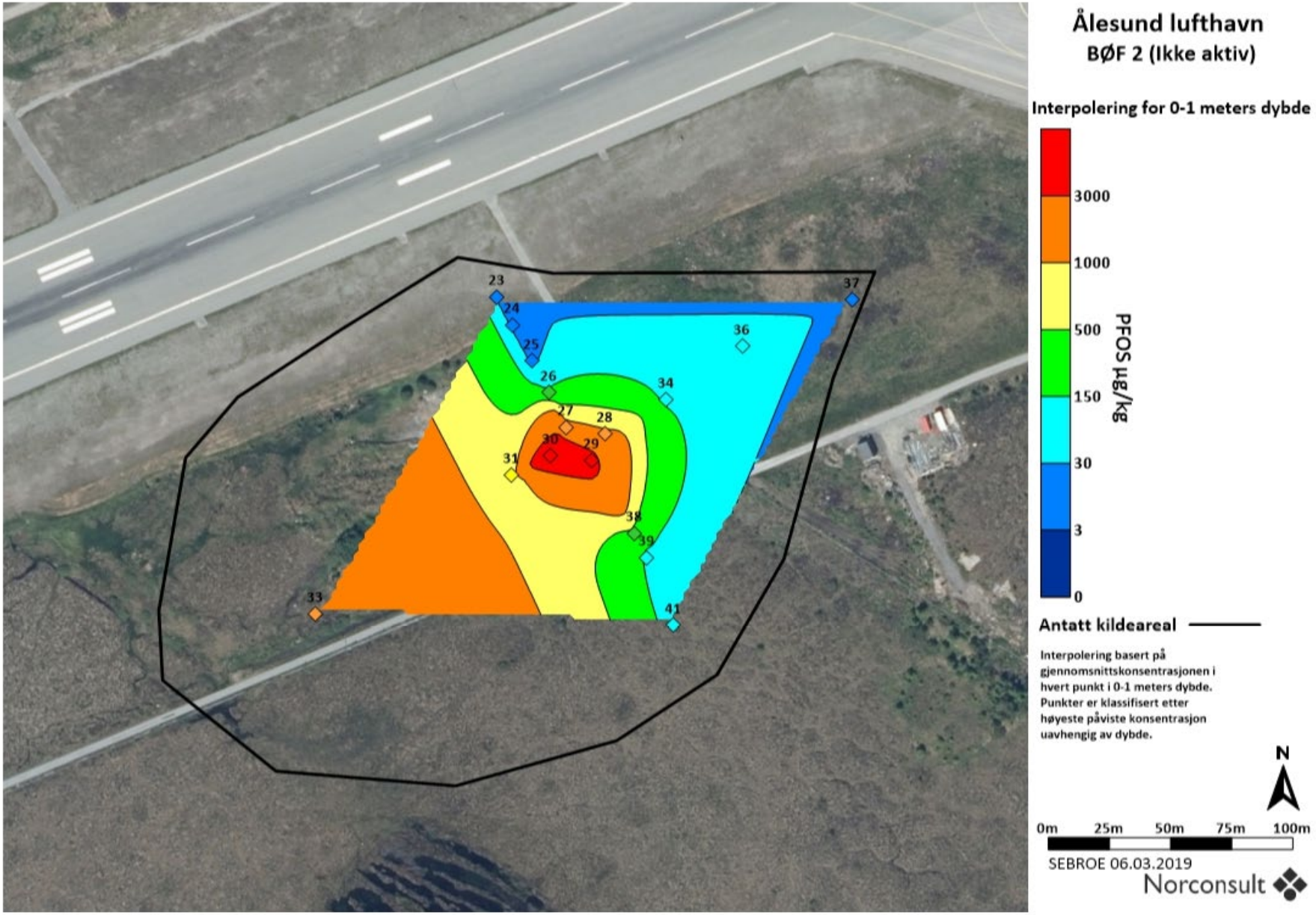
* Venstre halvdel = PFOS
Høyre halvdel = ∑PFAS

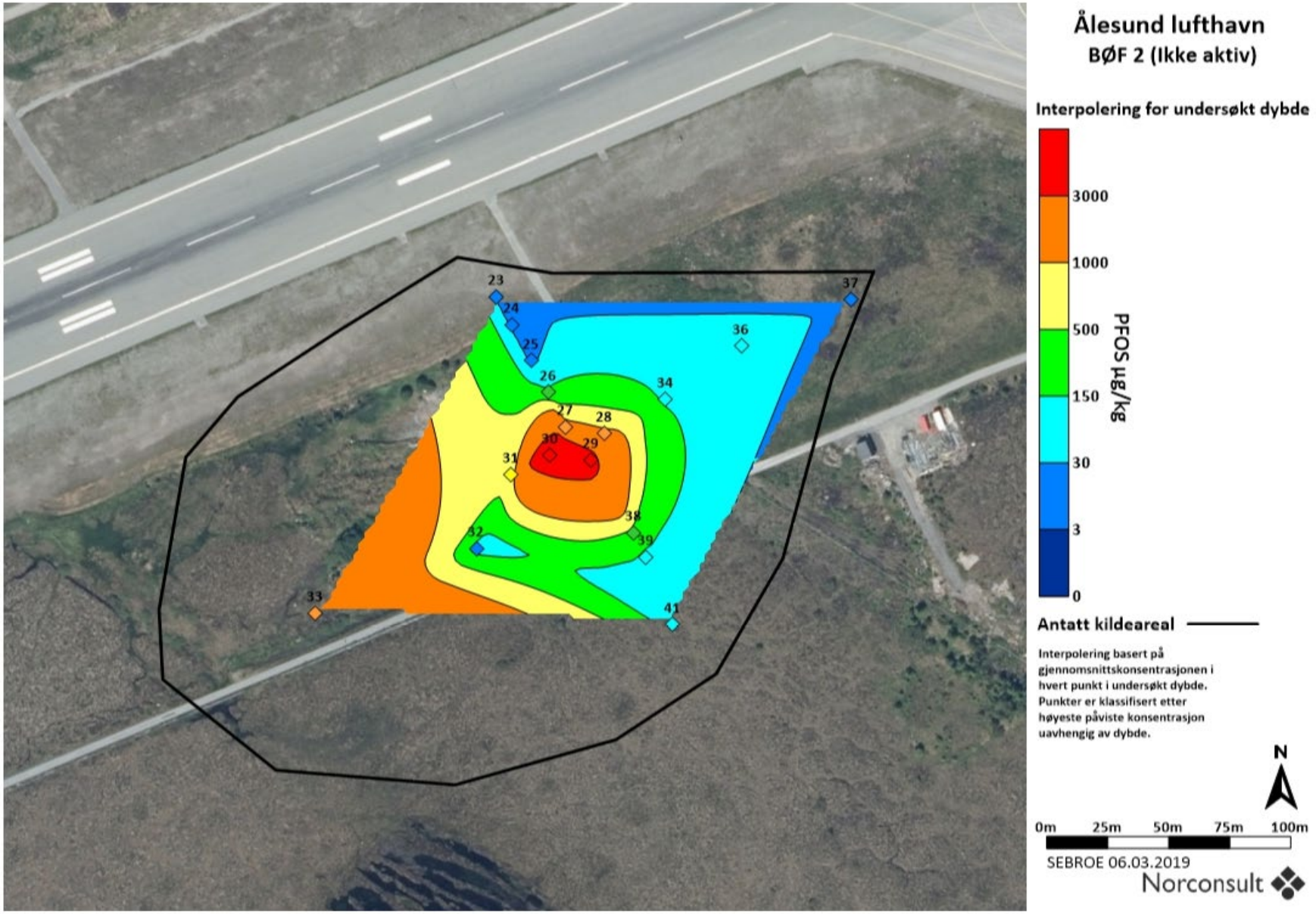
i.a. = ikke analysert
LOQ = rapporteringsgrense (tilsv. ikke påvist for ∑PFAS)

AVINOR Norconsult COWI SWECO


Ålesund lufthavn
BØF 1 (Aktiv)
Interpolering for 0-1 meters dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i 0-1 meters dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m 25m 50m 75m 100m
SEBROE 06.03.2019
Norconsult
E2
1
2
5
6
7
10
11
12
13
14
18
19
20
22


Ålesund lufthavn
BØF 1 (Aktiv)
Interpolering for undersøkt dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m 25m 50m 75m 100m
SEBROE 06.03.2019
Norconsult


Ålesund lufthavn
BØF 2 (Ikke aktiv)
Interpolering for 0-1 meters dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i 0-1 meters dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m 25m 50m 75m 100m
SEBROE 06.03.2019
Norconsult
23
24
25
26
27
28
29
30
31
33
34
36
37
38
39
41


Ålesund lufthavn
BØF 2 (Ikke aktiv)
Interpolering for undersøkt dybde
3000
1000
500
150
30
3
0
PFOS µg/kg
Antatt kildeareal
Interpolering basert på gjennomsnittskonsentrasjonen i hvert punkt i undersøkt dybde. Punkter er klassifisert etter høyeste påviste konsentrasjon uavhengig av dybde.
N
0m 25m 50m 75m 100m
SEBROE 06.03.2019
Norconsult
23
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36
37
38
39
41

39.1 Fire training site (BØF) / contaminated site

Fire training site (BØF) / contaminated site	**BØF 1 (active)**	**BØF 2 (old)**
	BØF 1 is located approximately 4 metres above sea level and has been in use since 1997. There is an impermeable covering on the site itself, with collection of seepage water to an oil separator and discharge of wastewater via a pipe to Roaldsleira. Foam containing both PFOS and 6:2 FTS has been used at BØF 1. The airport fence is located directly south of the BØF, and beyond this is cultivated land. Avinor has decided that the active fire training site at Ålesund will be closed after the 2019 training season.	BØF 2 is approximately 15 metres above sea level. It is uncertain when BØF 2 was put into use, but it is believed that it was around 1978. BØF 2 was taken out of service in 1997, when BØF 1 was established. The area west of BØF 2 was filled up with materials from excavation work elsewhere at the airport. These materials are above the surface as they were was when BØF 2 was active. Directly south of BØF 2 is the airport fence, and beyond this is a soft marshland.

39.2 The use of PFOS and other PFAS

Volume of PFOS used at the site (kg)	370	1,750
Comments/uncertainty:	Estimated consumption from 1997 to 2001.	Estimated consumption from 1978 to 1997. Foam containing PFOS should only have been used at BØF 2.
Volume of PFAS used at the site (kg)	405	
Comments/uncertainty:	Estimated consumption from 2001 to 2012.	Not calculated

39.3 Soil sampling

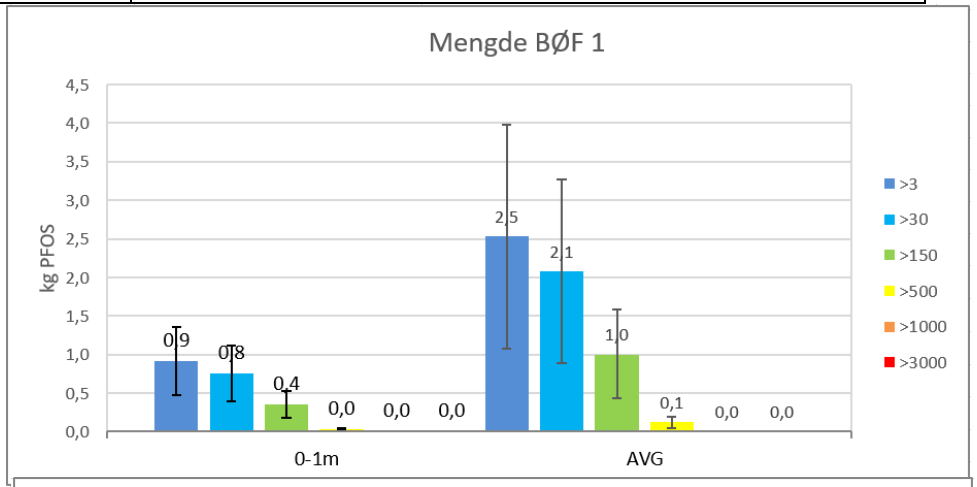
Fire training site (BØF) / contaminated site	BØF 1 (active)	BØF 2 (old)
Total number of soil samples	26	32

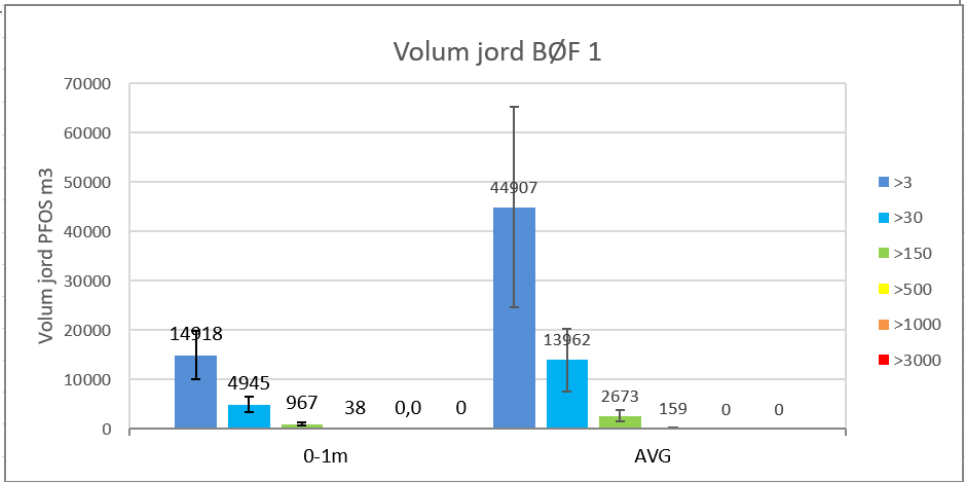
Comments/uncertainty (for example, 95% of the samples were taken from 0–0.1 m)	14 of the samples are surface samples taken from 0-0.2 metres under terrain. Five of the samples were taken at intervals between 0.1-2.8 metres deep, four of these samples represent large depth intervals (1 sample of over 2 metres layer thickness). Seven of the samples are of only deeper materials at intervals between 1.7-3 metres deep. The materials are stated to consist of gravel, sand, soil, silty sand, shell sand and filler.	10 of the samples are surface samples taken from 0-0.1 m below terrain. 12 of the samples were taken at intervals between 0-3.2 metres deep, seven of these samples represent large depth intervals (1 sample of over 2 metres layer thickness). Nine of the samples are of only deeper materials at intervals between 1.5-4.1 metres deep. No sampling depth is given in the table in the report for sample BØF 2:36, but it is shown as 10-90 cm in the overview map, so this value is used here. The materials are stated as consisting of sandy soil, sandy gravel, gravel, sand, fill and soil. The area where the BØF is located has been filled in; it can be seen from an aerial photo from 1968 that it was originally a marshland, an aerial photo from 2006 shows that materials have also been filled west of the BØF. The filled area is 14-15 metres above sea level, and the marshland west of this is about 11 metres above sea level, and the marshland south of the BØF is about 12 metres above sea level.
Number of soil samples 0-1 m beneath the ground	19	23
Number of soil samples below 1 m	12	19
Comments/uncertainty:	The samples that go over both the intervals 0-1 m and > 1 m are counted both as top samples (0-1 m) and deeper samples (> 1 m). By splitting up these samples, the total number of samples will be 31 samples.	The samples that go over both the intervals 0-1 m and > 1 m are counted both as top samples (0-1 m) and deeper samples (> 1 m). By splitting up these samples, the total number of samples will be 42 samples.
Highest measured soil concentration of PFOS µg/kg	846	6,390
Where	BØF-1: 12 (0-0.1 m). The materials consist of sand and rock.	BØF-2: 30 (10-160 m). The materials consist of filler
Highest measured soil concentration of PFAS µg/kg	860	6,390
Where	BØF-1: 12 (0-0.1 m). The materials consist of sand and rock.	BØF-2: 30 (10-160). The materials consist of filler

Comments/uncertainty:	Brønn 1:12 was analysed for 12 different PFAS compounds. In addition to PFOS, 6:2 FTS and PFDA have been detected in the sample. Only one more sample has been analysed for 12 PFAS compounds, and only PFOS and PFPeA were detected in the sample.	BØF-2:30 was only analysed for PFOS and PFOA. No PFOA was detected in the sample. A total of six samples have been analysed for multiple 12 PFAS compounds; PFOS is the predominant compound.

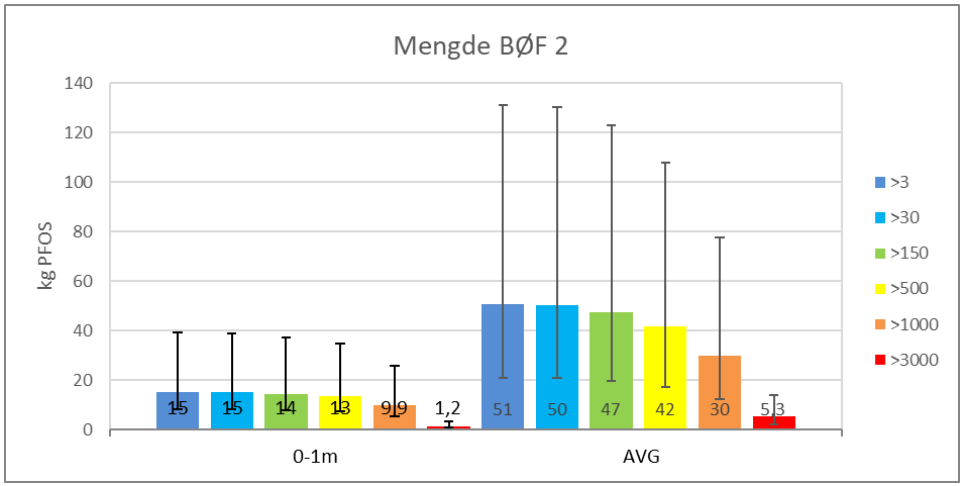
39.4 Volume calculation

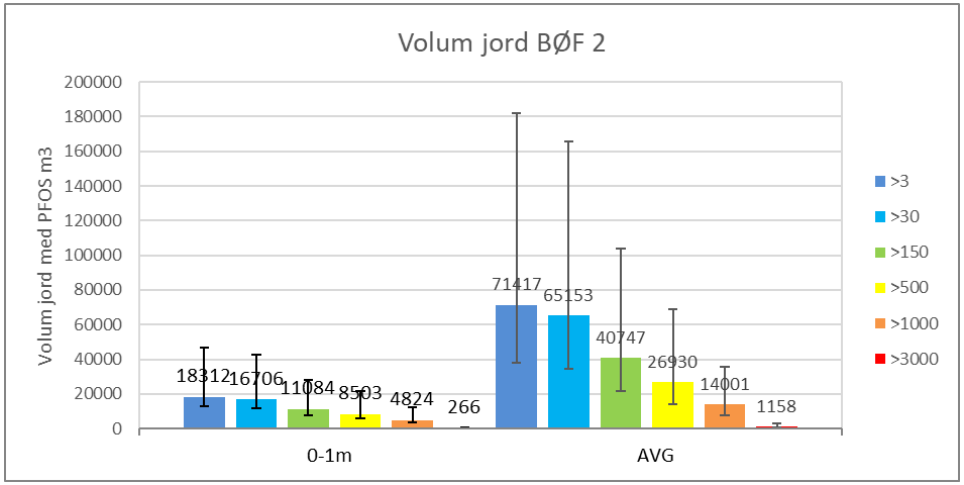
PFOS average for all depths and points > 3 µg/kg	BØF 1	BØF 2
Concentration (µg/kg)	44	604
Area (m2)	14,969	18,312
Volume of soil (tonnes)	71,851	104,983
Volume of PFOS (kg)	2.5	51
Uncertainty -	1.5	30
Uncertainty +	1.5	81
PFOS average for all depths and points > 30 µg/kg		
Concentration (µg/kg)	116	658
Area (m2)	4,654	16,706
Volume of soil (tonnes)	22,339	95,775
Volume of PFOS (kg)	2.1	50
Uncertainty -	1.2	30
Uncertainty +	1.2	80
PFOS average for all depths and points > 150 µg/kg		
Concentration (µg/kg)	293	990
Area (m2)	891	10,448
Volume of soil (tonnes)	4,277	59,898
Volume of PFOS (kg)	1.0	47
Uncertainty -	0.6	28
Uncertainty +	0.6	75





PFOS average for all depths and points > 500 µg/kg		
Concentration (µg/kg)	590	1,317
Area (m2)	53	6,905
Volume of soil (tonnes)	254	39,586
Volume of PFOS (kg)	0.1	42
Uncertainty -	0.1	25
Uncertainty +	0.1	66
PFOS average for all depths and points > 1,000 µg/kg		
Concentration (µg/kg)		1,817
Area (m2)		3,590
Volume of soil (tonnes)		20,581
Volume of PFOS (kg)		30
Uncertainty -		18
Uncertainty +		47
PFOS average for all depths and points > 3,000 µg/kg		
Concentration (µg/kg)		3,910
Area (m2)		297
Volume of soil (tonnes)		1,703
Volume of PFOS (kg)		5.3
Uncertainty -		3.1
Uncertainty +		8.5





Fire training site (BØF) / contaminated site	BØF 1 (active)	BØF 2 (old)
Comments regarding calculations	The DP2 report assumes that the most contaminated area is situated within an area of 30*50 metres, and that the thickness of the contaminated materials is approximately 2 metres. With an average concentration of PFOS of 159 µg/kg, it is calculated that approximately 763 g PFOS remains in the soil at BØF 1. Furthermore, it is estimated that 221 g PFOA and 1,238 g total PFC remains. The risk assessment report assumes that the contaminated area has an extent of 18,000 ± 5,000 m2, and the thickness of the contaminated materials is 2.5 ± 0.5 m. With an average concentration of PFOS in the materials of 31 µg/kg it is calculated that 2 ± 1 kg PFOS µg/kg remains in the ground at BØF 1. The calculation made in 2019 assumes that the contaminated area extends over an area of up to 28,000 m2 (to delimitate contamination down to <3 µg/kg), and that the average concentration in this area is 44 µg/kg.	The DP2 report assumes that the most contaminated area is situated within an area of 50*50 metres, and that the thickness of the contaminated materials is approximately 2.5 metres. With an average concentration of PFOS in the materials of 1032 µg/kg it is calculated that 10.32 kg of PFOS and 56 g remains in the ground at BØF 2. In the risk assessment report, it is assumed that the contaminated area has an extent of 19,000 ± 5,000 m2, and that the thickness of the contaminated materials is 3 ± 0.5 metres as an average. With an average concentration of PFOS of 433 µg/kg, and a density of the materials of 0.5±0.25 kg/dm3, it is calculated that 12 ± 7 kg of PFOS remains at the site. The calculation made in 2019 assumes that the contaminated area extends over an area of up to 50,000 m2 (to delimitate contamination down to <3 µg/kg), and that the average concentration of PFOS in this area is 604 µg/kg. This gives an estimate of the remaining volume of PFOS at BØF 2 of about 50 kg. One of the reasons why the calculation carried out in 2019 gives a much higher figure than in the 2016 risk assessment report is that the calculation carried out in 2019 assumes a density of the materials of 1,470 kg/m3. This figure is the result of a weighting of the volume of contaminated materials consisting of filler and the volume of contaminated materials consisting of peat/bog soil.
Is the extent of the contaminated area delimitated horizontally?	No concentrations of PFOS above the detection limit have been detected three of the extreme points (points 5, 18 and 22). The contamination is therefore delimitated in the western direction. The contamination is not delimited in an easterly direction, towards Roaldsleira.	No, the area is not delimitated horizontally. Concentrations of PFOS above the norm value have been detected at all extreme points. The extremes to the north and northeast (surface samples at points 37 and 23) have the lowest concentrations (<15 µg kg). The extreme point to the southeast (surface sample at point 41) has about 40 ug/kg. Marsh soil at the extreme sampling point towards the southwest (surface sample at point 33) has very high concentrations (2,690 µg/kg).

Is the extent of the contaminated area delimitated vertically?	At five of the sampling points at BØF 1 (points 1, 6, 7, 11 and 13) samples were analysed from top layers (0-0.2 metres deep), intermediate layers (0.1-2.5) and below groundwater level which is approximately 2 metres deep. The highest concentrations of PFOS are found in the top layer and down to groundwater level. At four of these sampling points (points 6, 7, 11 and 13), the lowest concentration is in the deepest sample. At the same time, relatively high concentrations of PFOS have been found in groundwater water samples. Concentrations of PFOS below the detection limit have been detected at three sampling points (points 8, 9 and 13) with samples of deeper materials. There is PFOS above the detection limit, but <20 µg/kg in the deepest samples at three of the sampling points (points 6, 7 and 11), and at sampling point BØF-1-1 there is a concentration of 101 µg/kg in the deepest sample. It is uncertain how much deeper this contamination extends. The contamination is therefore not delimitated vertically.	No, concentrations above the detection limit have been detected in four of the deepest samples. It is uncertain how much deeper this contamination extends.
Comments/uncertainty:		Samples of marsh soil at sampling point 32 which is to the west have low concentrations (3.5-4.1 metres deep), but no surface samples have been taken at this point.

39.5 Water sampling and annual dispersion

Fire training site (BØF) / contaminated site	BØF 1 (active)	BØF 2 (old)
Have water samples been taken?	Yes	Yes
Where	Samples from 3 groundwater wells have been taken downstream of the platform at BØF 1 (B6, B8 and B9). A sample of surface water that comes out into the sea off the beach in Roaldsleira (Vigra V5) was also taken. The pipe drains large areas, including the operations area, the aircraft stand, parking areas and the terminal area. The pipe goes under BØF 1 and out into Roaldsleira. The condition of the pipe is unknown. Samples of water have also been taken from an oil separator established at BØF 1. The oil separator receives the water from the impermeable covering centrally at BØF 1, and flows into a separate pipe into Roaldsleira.	A sample was also taken from a groundwater well that was established in a shaft at BØF 2 in 2011 (B29). Samples of surface water have also been taken from a ditch that runs from BØF 2 in the direction of Blindheimsvika, as well as from a ditch that drains water away from the shoulder of the road, and from a manhole at another surface water pipeline. Water samples have also been taken at the outlet in Blindheimsvika.
Highest measured concentration of PFOS in groundwater (ng/l)	3,370	1,450,000
Where	B8 (11-05-2012)	Groundwater B29 (08-09-2011)
Highest measured concentration of PFAS in groundwater (ng/l)	15,400	1,461,500
Where	B8 (07-11-2013)	Groundwater B29 (08-09-2011)
Comments/uncertainty:	In sample B8 taken on 7.11.13, high concentrations of 6:2 FTS, PFHxA, PFPeA were detected in addition to PFOS. In all of the groundwater samples taken at BØF 1, higher concentrations of 6:2 FTS were detected than those of PFOS, as well as high concentrations of PFHxA and PFPeA.	The well has been established in a shaft, and the concentration of PFOS in the sample from 2011 may have been increased due to mobilisation by excavation. The sample taken on 8.9.11 was only analysed for PFOS and PFOA. The sample taken on 11.5.12 has much lower concentrations and has been analysed for 11 PFAS compounds. This sample shows high concentrations of PFHxS, PFHxA and PFOA in addition to PFOS. PFOS is the dominant PFAS compound in both groundwater samples.
Highest measured concentration of PFOS in surface water (ng/l)	369	7,910
Where	V5 (11.05.12)	V3 (07-11-2013)

Highest measured concentration of PFAS in surface water (ng/l)	584	10,400
Where	V5 (11.05.12)	V3 (08-05-2014)
Comments/uncertainty:	PFOS is the predominant PFAS compound in sample V5, but 6:2 FTS, PFBA, PFHxS, PFHxA, PFHpA, PFOA and PFPeA were also detected. Water samples from the oil separator are not considered to be representative of the surface water in the area, but are directed to discharge into the sea. Very high concentrations of PFAS have been detected in the water from the oil separator tested five times in the period 2013-2014. 6:2 FTS in particular stands out with high concentrations (between 3,290 to 212,000 ng/l). The concentration of total PFAS during this period is between 8,540-236,000 ng/l. Avinor has not used PFAS foam at its airports since 2012 and the oil separators are emptied and cleaned once a year (unless they produce < 1kg oil during the course of a year), or more often if necessary. In six measurements from the oil separator carried out between April 2014 and August 2018, concentrations of total PFAS are lowest in 2015 and then show an upward trend with a concentration of almost 100,000 ng/l in August 2018 (taken from figure 18 in Avinor's letter to the County Governor of Møre og Romsdal on 20.2.2019).	PFOS is the predominant PFAS compound in sample V3 sampled on 8.5.14, but high concentrations of PFHxS and PFHxA were also detected in the sample.
Total annual dispersion of PFOS from the site (g/year)	70 g [8.4 g]. The total annual dispersion is given without parentheses, and the total annual dispersion volume of PFOS from the oil separator is given in square brackets [].	140 g
Total annual dispersion of PFAS from the site (g/year)	Not calculated [155 g] The total annual dispersion of PFAS from the oil separator is given in square brackets [].	Not calculated

To which recipient	To Roaldsleira	To Blindheimsvika. Any groundwater transport will be limited and take place in marshlands with high adsorption of PFOS, leading to a slow transport. PFOS is likely to leak out to the greatest extent in pulses caused by high rainfall and snowmelt.
Calculated from water or soil concentration.	Water concentration	Water concentration

39.6 Biota sampling

Fire training site (BØF) / contaminated site	BØF 1 (active)	BØF 2 (old)
Have biota samples being taken at the airport?	Yes	Yes
What kind of biota?	Fore grass, common limpet, polychaete, murex, sea lettuce, green weed	Grass species, tree/pussy willow, polychaete, "small mussel", heart urchin, common cockle, Baltic prawn, common seaweed flea, mussel, common periwinkle, flounder, plaice, cod, common dab
How many samples?	8	60
Highest measured concentration of PFOS in biota (µg/kg wet weight)	5.8	110
Where	Murex, Active BØF (BØF-1, Roaldstranda)	8. Polychaete, outer Blindheimsvika, and the same concentration in flounder, inner Blindheimsvika.
Highest measured concentration of PFAS in biota (µg/kg wet weight)	6.4	121.9
Where	Polychaete, Active BØF (BØF-1, Roaldstranda)	8. Polychaete, outer Blindheimsvika
Median concentration in comparable populations (e.g. in a lake)	It is was not possible to find a reported content of PFAS in murex from another survey. Common limpet has therefore been used. Median concentration of total PFAS in common limpet (n=6) in a bay just outside the BØF at Statoil Mongstad in 2015 was 33.75 ug/kg ww.. The median concentration of PFOS in the same samples was 7.2 µg/kg. Retrieved from Statoil Petroleum report; "Environmental contaminants in biota at Statoil Mongstad 2015, SAM e-report no: 35-2015.	The average concentration of PFOS in three composite samples of polychaete in the inner Oslo fjord was 1.35 ug/kg ww. Source: Norwegian Environment Agency report M-812, 2017. In three mixed samples of bristle worm taken in the sea just outside the BØF at Alta Airport, the median concentration of PFOS was 26 µg/kg and PFAS 29.4 µg/kg. Extracted from an Avinor report in 2016, Alta Airport: Surveys of PFAS in soil, water and biota.

	The average concentration of PFOS in a sample of 500 g of common limpet taken at Fonnesflaket in Northern Hordaland was 0.229 ng/g vv. Source: Uni Research Miljø Sam-Marlin "Undersøkelse av miljøgifter i sediment og albuesnegl ved Fonnesflaket i Lindås 2016 ("Survey of environmental contaminants in sediment and common limpet at Fonnesflaket in Lindås 2016")	
Comments/references	PFAS has not been detected in the sample of fore grass taken outside BØF 1. In the biota samples taken from Roaldstranda, PFOS has been detected above the detection limit in common limpet, polychaete and murex. No PFOS has been detected above the detection limit in sea lettuce or green weed. All of the biota samples where PFOS has been detected at Roaldstranda have concentrations below the EQS value for PFOS.	Low concentrations of PFAS have been detected in muscle from fish (cod, plaice and common dab) fished in Blindheimsvika. Concentrations above the EQS value were detected in 2 out of a total of 32 samples of fish (in plaice and cod). The highest concentrations of PFOS/PFAS have been detected in the beach biota. Here, PFOS/PFAS has been detected in all biota samples, and concentrations above the EQS value in a total of 7 of 14 samples. The species where concentrations have been detected above the EQS value are polychaete, Baltic prawn, common seaweed flea, common limpet, common periwinkle and flounder. PFOS is the dominant PFAS compound in the samples taken of beach biota. In the samples taken from vegetation at BØF 2, concentrations above the EQS value have been detected in both composite samples (grass and willow).
References and concentrations in other reports.	The EQS value in the Water Regulations for PFOS in biota is 9.1 µg/kg wet weight. In a risk assessment from 13 December 2018, EFSA changed the tolerability limit (TDI - tolerable daily intake) for PFOS and PFOA, so these are now far lower than the TDI values set in 2008. This may cause EQS for biota to also be lower in the future.	The EQS value in the Water Regulations for PFOS in biota is 9.1 ng/g wet weight. In a risk assessment from 13 December 2018, EFSA changed the tolerability limit (TDI - tolerable daily intake) for PFOS and PFOA, so these are now far lower than the TDI values set in 2008. This may cause EQS for biota to also be lower in the future.

39.7 Uncertainty and other factors

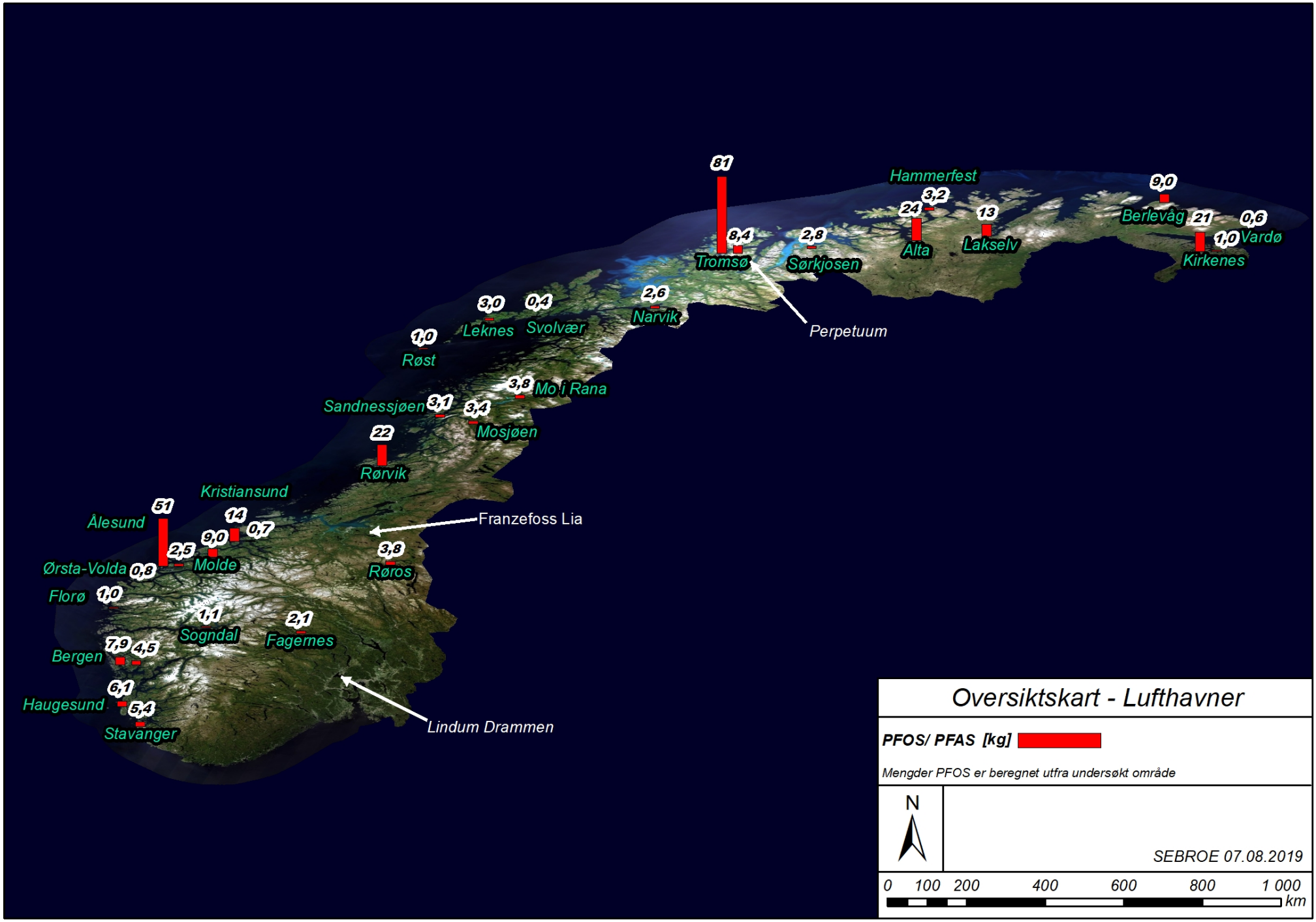
Fire training site (BØF) / contaminated site	BØF 1 (active)	BØF 2 (old)
Does the estimate of the volume of PFOS in the ground correspond with the measured concentrations in water and biota?	Cannot be reliably evaluated.	Cannot be reliably evaluated.

Evaluations	It is estimated that approximately 2.5 kg of PFOS remains in the ground at BØF 1. It is estimated that approximately 370 kg of PFOS has been used. This shows that much of the PFOS volume has probably already been leached out to the recipient. According to NGU, the deposits between the BØF and the sea are wind and marine beach deposits. These are sandy materials which usually have good hydraulic conductivity. Relatively low concentrations of PFOS have been detected in soil samples at BØF 1, which is probably due to the fact that PFOS was phased out of firefighting foam a few years after BØF 1 was put into use. Although relatively low concentrations of PFOS/PFAS have been detected in soil, high and varying concentrations of PFOS/PFAS have been detected in groundwater. This may indicate vertical dispersal with little adsorption of PFOS in the sand at groundwater level. Relatively low concentrations of PFOS/PFAS have been demonstrated in the biota samples taken at Roaldstranda. This is in line with the relatively low concentrations in the soil samples. In some of the biota samples, higher concentrations of 6:2 FTS have been detected than of PFOS. This corresponds to the fact that 6:2 FTS is associated with newer foam products and the proven concentrations of the compound in the water samples. High concentrations of PFAS have been detected in the wastewater discharged from the oil separator at the BØF. Discharges from the oil separator (155 g) to Roaldsleira therefore constitute a significant proportion of the annual dispersion of PFAS to the recipient.	It is calculated that approximately 58 kg of PFOS remains at BØF 2. It is estimated that approximately 1,750 kg of PFOS has been used at the site. This shows that much of the PFOS volume has already been leached out to the recipient. This may be consistent with the fact that it is over 20 years since BØF 2 was used. Relatively high concentrations of PFOS have been detected in soil, groundwater (B6, B8 and B9) and surface water (V7, V3 and V4), which may indicate that relatively large volumes of PFOS are still leaching from BØF 2.

Comments/uncertainty: (Could there be any additional unknown sources of PFOS at the site with run-off to the recipient?)	It cannot be ruled out that there are additional sources of PFAS at Ålesund Airport: The airport reports that accident drills have been carried out in various areas inside and outside the airport fence. Foam should not have been used in connection with the snow depots, but washing of the fire engines' pumps can take place at the workshop area. Testing of the cannons and foam cannon sight adjustment is carried out regularly both at the west end and northeast end of the runway. It cannot be ruled out that this activity has previously been carried out at the old fire training site in the direction of the marshland, and that foam may then have been used.	It cannot be ruled out that there are additional sources of PFAS at Ålesund Airport: The airport reports that accident drills have been carried out in various areas inside and outside the airport fence. Testing of the cannons and foam cannon sight adjustment is carried out regularly both at the west end and northeast end of the runway. It cannot be ruled out that this activity has previously been carried out at the old fire training site in the direction of the marshland, and that foam may then have been used. Samples have also been taken from two wells located at a snow depot east of BØF 2 (B42 and B43). B42 was sampled 4 times and B43 was sampled once. Significant concentrations of PFAS have been detected in well B42, with a concentration between approximately 2,900-6,100 ng/l. The compounds 6:2 FTS, PFHxA and PFPeA dominate the PFAS concentration. The cause of the high concentrations in this well is uncertain. The airport reports that no foam has been used in connection with the snow landfills, but that washing of the fire engine's pumps may occur at the workshop area. Washing takes place in a paved area with drainage to a closed surface water system. In theory, this washing should therefore not have been able to supply large quantities of water containing PFAS to the groundwater.
Has the site been sufficiently mapped with a view to assessing the order of prioritisation?	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the volume of PFOS in the soil with the stipulated level of uncertainty.	Yes, in accordance with the criteria (in this report for part 1 and part 2, chapter 2.1.3.1), sampling points and soil samples are sufficient to calculate the volume of PFOS in the soil with the stipulated level of uncertainty.

Comments/uncertainty:		There is particular uncertainty associated with contamination in the marshland to the west, where only one sample was taken of surface materials at point 33 which has a high concentration of PFAS. Also, no samples have been taken showing the state of marsh materials deeper than 0.1 metre in this area. Samples of marsh between 350-410 m deep at point 32 have low concentrations and PFAS has not been detected in the deepest sample.
General information about the airport		
Other factors of significance to possible clean-up/implementation of measures (for example, planned rebuilding works at the airport, commercial and/or extensive angling, tourism or similar in proximity to the recipient, potable water deposits, protected areas, etc.)	From Naturbase: Several species of high and particularly high management interest have been registered in Vigra, in the sea areas around Vigra, and around Vigra Airport. Blindheimsvika, Roaldsleira and the area around Rørvikvatnet/Myrane are registered Ramsar protected areas. Blindheimsvika and Roaldsleira are registered wildlife protection areas and Rørvikvatnet is a registered nature reserve. A water sample has been taken at Rørvikvatnet, which shows the dispersion of PFAS here as well. There is no clear inlet or outlet from Rørvikvatnet, and it is believed that PFAS is supplied via groundwater. Blindheimsvika is home to a sea meadow and mudflats habitat, Roaldsleira home to a sand dunes habitat and Rørvikvatnet home to an intact lowland marshland habitat. The selected habitat type 'hayfield' is found along the runway. There are also sites with cultural monuments at Rognodden which is located southwest of the airport. Several red-listed plant and bird species have been recorded at the airport area and in the surrounding area. The risk assessment report states that much of the area is registered as resting, grazing and spawning areas for ducks, waders, gulls and auks, as well as a grazing area for deer. The airport is registered with Avinor's vulnerability class 3, which means vulnerable recipients, highest priority and highest level at the facility. Directly south of BØF 1 and beyond this is cultivated land. At BØF 2, THC in environmental condition class 2-3 has been detected in 10 of the soil samples analysed at BØF 2.	

APPENDIX B - Map of Norway with calculated quantities of PFOS/ΣPFAS in soil


81
Tromsø
8,4
Hammerfest
3,2
24
Alta
13
Lakselv
2,8
Sørkjosen
9,0
Berlevåg
21
Kirkenes
1,0
0,6
Vardø
Perpetuum
2,6
Narvik
3,0
Leknes
0,4
Svolvær
1,0
Røst
3,8
Mo i Rana
Sandnessjøen
3,1
3,4
Mosjøen
22
Rørvik
Kristiansund
51
Ålesund
14
0,7
9,0
2,5
Molde
Ørsta-Volda
0,8
Florø
1,0
Franzefoss Lia
3,8
Røros
1,1
Sogndal
2,1
Fagernes
7,9
4,5
Bergen
6,1
Haugesund
5,4
Stavanger
Lindum Drammen
Oversiktskart - Lufthavner
PFOS/ PFAS [kg]
Mengder PFOS er beregnet utfra undersøkt område
N
SEBROE 07.08.2019
0 100 200 400 600 800 1 000
km

APPENDIX C - Remedial action methods

Remedial action methods for soil - p. 1 - 2

Remedial action methods for water treatment - p.3

Method			Description	Advantages and disadvantages	Development level with documented long-term effect 1 - lab 2 - pilot 3 - in use	Reference
In situ solutions	Unsaturated zone	Capping/screening	Capping or encapsulation of contaminated material in order to prevent/reduce infiltration and dispersal via groundwater.	Neither removes nor breaks down PFAS. May require monitoring over an extended period time after the measures have been implemented in order to document the effect and determine any need for the replacement of barriers. Restrictions on post-use.	3	Ross et al., 2018
		Stabilisation	Addition and mixing of sorbents in soil (active carbon, organo-clay, mixture of active carbon/clay/Al hydroxides, etc.).	Neither removes nor breaks down PFAS. Long-term fixing has not been documented. Potential continuing restrictions on post-use.	2	Ross et al., 2018 Yao et al., 2015
		Chemical oxidation	Chemical oxidation with peroxydisulphate.	Uncertainty related to the effect on precursors and the formation of intermediate products. Potential continuing restrictions on post-use.	2	Yao et al., 2015, 2016
		Washing	Flushing of material *in situ* with water, possible addition of solvent or other chemicals, with subsequent treatment of (ground)water.	Presupposes monitoring of dispersal. Any solvents/chemicals which are used should be of low toxicity and recyclable.	2*	Yao et al., 2015 NGI/OSL Avinor, 2018
	Saturated zone	Pump and treat	Pumping groundwater with subsequent water treatment and reinfiltration.	Reduces dispersal via groundwater. Although tests show a good effect in terms of reductions in concentrations in the water that is treated, it can take a long time to remove significant quantities if the permeability of the material is low. Depends on site-specific conditions and soil/water concentrations.	3*	Yao et al., 2015 Banzhaf et al., 2017
		Active barrier	Establishment of active barriers in the groundwater zone/ditch in order to reduce dispersal via groundwater. Three main types of barriers for adsorption, precipitation and physical/chemical breakdown of contamination respectively.	Reduces dispersal via groundwater. Barriers with sorbent materials (for adsorption) are assumed to be most suitable for PFAS. Long-term effect has not been documented. May require monitoring over an extended period time after the measures have been implemented in order to document the effect and determine any need for the replacement of barriers. Potential continuing restrictions on post-use.	2	Yao et al., 2015
		Chemical oxidation	Chemical oxidation with peroxydisulphate.	Uncertainty related to the effect on precursors and the formation of intermediate products. Potential continuing restrictions on post-use.	2	Yao et al., 2015, 2016
		Stabilisation ("trap and treat")	Injection of particulate carbon into saturated zone to reduce PFAS mobility.	Assumes homogeneous distribution of particulate carbon in material in the saturated zone is achieved. Less effective for PFOA and short-chain PFAS (<C7). Cannot be replaced with new sorbent material in the event of unsatisfactory effect or saturation of sorbent.	1	Ross et al., 2018

		Foam fractionation	Compressed air is fed down into the borehole, so that foam containing concentrated PFAS is formed in the well. The foam can then be extracted.	Only works for PFAS in the well and within the immediate area of influence of the well. Potential for uncontrolled dispersal and contamination of groundwater outside the contaminated area.	1	Ross et al., 2018

* must be combined with water treatment

Method		Description	Advantages and disadvantages	Development level with documented long-term effect 1 - lab 2 - pilot 3 - in use	Reference
***Ex situ* solutions**	Incineration	Thermal treatment at high temperature (1,600-2,000°C) in order to destroy PFAS *ex situ*. Based on electrical, thermal or plasma-based processes. Electrical process (with graphite electrode) can be carried out *in situ*.	Little formation of by-products anticipated. Requires availability of suitable incineration plants. Requires removal of coarse fraction, as well as analyses of mineral content and TOC. High mineral soil content is less suitable due to high level of residual ash. Energy-intensive and anticipated high cost.	3	Yao et al., 2015 Ross et al., 2018
	Thermal desorption	Thermal treatment of PFAS-contaminated material (400-500 °C), followed by the treatment of flue gases at 900-1000°C.	Requires lower temperatures compared with combustion, but uncertain as to whether the measure will have the desired effect as regards PFAS. Requires higher temperatures (>500°C) for the effective removal of PFOS and other long-chain PFAS compounds. No full-scale trials have been carried out.	2	Ross et al., 2018
	Washing	Washing of material ex *situ* with water, with possible addition of solvent or other chemicals, and subsequent water treatment. Often involves the separation of fine and coarse fractions, with the fine fraction then being treated. Relevant methods for treating the fine fraction include incineration, landfill disposal, extraction, etc.	Separating out the fine fraction reduces the volume of material which must be treated. Often has to be used in combination with other methods, especially if the material contains a high proportion of fine material (see Yao et al., 2015 p. 325).	2*	Yao et al., 2015 Ross et al., 2018
	Supercritical fluid extraction	Extraction of PFAS using supercritical CO_2, methanol and nitric acid (HNO_3).	Could potentially be an effective, environmentally friendly and low-cost method for removing PFAS. No full-scale trials have been carried out.	1	Yao et al., 2015
	High-energy electron radiation	The use of an electron accelerator to generate a large number of high-energy electrons, which generate a form of ionizing radiation.	Avoids the use of chemicals Little understanding as to whether any by-products are formed during the process	1	Ross et al., 2018
	Steam generator	Steam treatment of contaminated material (1100°C).	High temperatures (1100°C) would be expected to remove all long-chain and short-chain PFAS, including precursors. Assumed to be low cost compared with other measures. No full-scale trials have been carried out. Small-scale trials with planned start-up in 2018.	1	Ross et al., 2018

	Crushing ("ball milling")	Crushing and milling of contaminated material using steel balls (5-10 mm in diameter). The process entails the deformation of soil particles and increased temperature on the surface of particles, with subsequent thermal destruction of PFAS.	Physical destruction without the use of chemicals. No full-scale trials have been carried out.	1	Ross et al., 2018
	External disposal	Excavation with external disposal of material May include material from the unsaturated and saturated zones.	Contamination is removed and the potential for further dispersal at the site is eliminated. Limited reception capacity. No destruction of PFAS. Potentially long transport distance. Excavation of material from the saturated zone will require groundwater treatment during the construction phase.	3	Ross et al., 2018 Yao et al., 2015

* must be combined with water treatment

APPENDIX D – Assessment of the suitability of the sites

Assessment of the suitability of the sites for pump and treat and capping/screening - p. 1-2

Colour codes	
	Unsuitable
	Suitable
	Uncertain
	Information missing

Airport and site	PFOS in soil	Type of material	Approx. depth to groundwater	Depth for calculation in soil without uncertainty	Depth for PFOS in soil below groundwater level	Depth of highest concentrations in soil	Concentrations ∑PFAS in ground	Mean concentrations ∑PFAS in groundwater	Comments	Suitable for pump and treat - ref.section 3.2.2 of the report	Suitability for capping/screening - ref.section 3.2.2 of the report
	kg		m	m	m	m	ng/l	ng/l			
Tromsø lufthavn Langnes - BØF 2 (gammelt)	81	Gravel at the surface, then stone, coarse sand, soil, sand over marsh and/or clay.	2	3,35	1,4	1-2.4	48,500-261,000	135850	Samples from two wells taken in May 2012, upon establishment, and in 2014. In samples from 2014, the concentration ranges from 48,000-175,000.	No, due to marsh material.	No, contamination in contact with groundwater.
Ålesund lufthavn Vigra - BØF 2 (gammelt)	51	The material is stated as consisting of sandy soil, sandy gravel, gravel, sand, fill and soil. Marsh area west and south.	2	3,9	1,9	0-3.2	446,000-1,450,000	948 000	Two samples taken in the same well, highest cons. on establishment and measured only for PFOS. Lower conc. for total PFAS one year after.	May be suitable, but uncertain due to marshland material in the area just west and south of the BØF. Should analyse for TOC in groundwater.	No, contamination in contact with groundwater.
Alta lufthavn - BØF1 (aktivt)	24	The area is situated on alluvial deposits and primarily comprises sandy material.	1,75	2,3	0,55	1-2.3, probably not much deeper			No samples of groundwater.	No, the groundwater here is believed to be seawater.	No, contamination in contact with seawater.
Rørvik lufthavn Ryum - BØF 2 (yngre, men ikke aktivt)	22	Limited description, but described as marine deposits from fine sand to clay for the airport in general.	0,5	1,1	0,6	approx. 1, but bedrock at 1.1 m	527	527	One sample from shaft.	No, bedrock at approx. 1.1 m.	No, contamination in contact with groundwater. It is likely that leaching is taking place due to tidal impact.
Kirkenes lufthavn Høybuktmoen - BØF 1 (gammelt)	21	Glacial stream deposits with sand, gravel and stones.	6	2,6	-	0-2.6, maybe deeper (6 m)	i.p.-5500	2018	The depth to groundwater is only assumed in the DP2 report. Ten samples have been taken from four groundwater wells about 200 m northwest of the BØF. Nine with PFAS detected, and one sample with nothing detected.	No information available about depth to groundwater or the depth of the contamination.	No information available about depth to groundwater or the depth of the contamination.
Kristiansund lufthavn Kvernberget - BØF B (gammelt)	14	Stone, gravel, sand, marsh, boulders.	1	2,5	1,5	0-2.5, maybe deeper (4 m)	7,610-45,000	29737	Three samples from three wells, all taken shortly after establishment in shaft.	No, due to marsh material.	No, contamination in contact with groundwater.
Lakselv lufthavn Banak - BØF 3 (aktivt)	13	Sand. Medium sand, coarse sand, fine sand and silt.	2,5	3,2	0,7	0.1-3	640-67,500	17118	Nine samples from three wells sampled in 2012 and 2013.	Presumed to be suitable when combined with measures in material in the unsaturated zone.	Presumed to be suitable when combined with pump and treat (the contamination in contact with groundwater).
Berlevåg lufthavn - BØF 1 (gammelt)	9,4	Sand, thin layer of peat and beach deposits (round pebbles and shell sand). Elements of building waste.	-	1,2	-	0-1.2, probably not much deeper			No samples of groundwater and surface water.	No, groundwater not encountered during sampling. Groundwater depth not known.	No groundwater encountered during sampling. May be suitable, but the contaminated area must be delimited vertically, and groundwater levels must be examined.
Molde lufthavn Årø - BØF 1 (aktivt og gammelt)	9,3	Crushed stone, stone, gravel, sand, clay, organic sand. In topsoil in the new part, there is crushed stone, sand and gravel.	1,7	1,7	0	0-1.7, average depth to bedrock 1.7 m	23900	23900	One sample from shaft.	No. Unsaturated zone down to bedrock/clay/groundwater of approx. 1.7 meters.	No, likely that leaching is taking place due to tidal impact.
Tromsø lufthavn Langnes - BØF 1 (aktivt)	8,4	The material is stated as mainly consisting of a layer of stone, gravel and sand over shell sand, clay and silt.	2	2	0	0-1.6	298-49,500	13078	5 samples. Three samples from two wells, and two were taken from a shaft when establishing the wells in the shaft.	May be suitable, but is very close to the sea.	No, likely that leaching is taking place due to tidal impact.
Bergen lufthavn Flesland - BØF 1 (yngst, ikke aktivt)	7,9	Soil with a lot of organic material and assumed gravel material in the centre of the BØF.	-	0,4	-	0-0.4	5,750-14,200	9975	Two samples from an environmental well about 50 m southwest of the BØF - below the hill where the BØF is located. Established before the DP2 investigations. The well is 3 metres deep, drilled through unconsolidated material and down into bedrock.	No. The bedrock is located on a rounded hill with thin unconsolidated material cover. It is not known whether there is any groundwater above the bedrock in the area of the BØF.	No. Very undulating forest terrain around the platform.
Haugesund lufthavn Karmøy - BØF B (gammelt)	6,1	The unconsolidated material generally consists of fill material consisting of boulders, rubble, sand and gravel.	0,5	1,8	1,3	0-1.8, maybe deeper (3 m)	49800	49 800	Groundwater in a shaft near/at the BØF. There is a well at the BØF, but it is believed to be upstream of the BØF.	May be suitable. But very little sample basis for groundwater.	No, contamination in contact with groundwater.
Stavanger lufthavn Sola - BØF 2 (gammelt)	5,4	There is mainly fine sand, as well as some soil, aggregate and gravel in the description of samples.	2,5	2 (3.5)	1	1,4-3.1 m, but added material 0-1.5 m (deducted from the calculation)	12,800-86,600	45400	Four samples from one well.	Presumed to be suitable when combined with measures in material in the unsaturated zone.	Presumed to be suitable when combined with pump and treat (the contamination in contact with groundwater).
Bergen lufthavn Flesland - BØF 2 (gammelt)	4,5	Rubble, stone and gravel.	< 2.5 m	2,5	-	0-1.3	87-1,080	516	Tree samples from three wells.	No. Relatively low concentrations in groundwater will have little effect.	May be suitable, but do not know the exact groundwater level other than that it is less than 2.5 m below ground level.
Mo i Rana lufthavn Røssvoll - BØF 1 (gammelt)	3,8	BØF on a thick deposit of unconsolidated material comprising sand and gravel.	> 5 m	3,6	-	0-3.6, maybe deeper (6 m)			No samples of groundwater.	No information available about depth to groundwater or the depth of the contamination.	No information available about depth to groundwater or the depth of the contamination.
Røros lufthavn - BØF 1 (ikke aktivt)	3,8	Sand, gravel and silt as well as some peat (0 - 50 cm below ground level)	1,35	1,1	-	0-1 not in deeper material (investigated to 1.6 m)	624-33,200	6217	Six samples from four wells at the BØF (they have mean conc. PFAS 7672 ng/l), and seven samples from four wells in the terminal area.	Presumed to be suitable when combined with measures in material in the unsaturated zone.	Presumed to be suitable.
Mosjøen lufthavn Kjærstad - BØF 1 (gammelt)	3,4	Sand/gravel/rock over rubble to the south, and more sandy material over soil material and solid bedrock to the north.	> 5 m	4	-	1.5-4, maybe deeper (6.5 m)			No samples of groundwater.	No information available about depth to groundwater or the depth of the contamination.	No information available about depth to groundwater or the depth of the contamination.
Hammerfest lufthavn - BØF 1 (gammelt)	3,2	Gravel, clay and sand.	2,5	1,2	-	0-1.9, mean depth to bedrock 1.2 m			No samples of groundwater. But high conc. in ditch with leachate (11,000 ng/L) immediately downstream of the BØF.	No, mean depth to bedrock of 1.2 metres.	May be suitable, but mapping must be carried out to determine whether contaminated leachate is due to water flowing through the BØF from the ditch on the east side. Could prevent water throughflow.
Sandnessjøen lufthavn Stokka - BØF 1 (gammelt)	3,1	Mix of topsoil, crushed stone, spreading sand, block and bedrock. Marsh to the west.	1,2	1,3	0,1	0-1.25, maybe deeper (2.3 m)	1,100-72,000	31275	Four samples. One sample of water in shaft (taken in 2011), and three samples from three wells (taken in 2012).	No, due to marsh material.	No, contamination in contact with groundwater.
Leknes lufthavn - BØF 1 (ikke aktivt)	3,0	Peat, shell sand and soil.	1,7	2	0,3	0-2, maybe deeper (2.7 m)	1,620-11,600	6033	Two samples from two wells (taken in 2012).	No, due to peat.	No, contamination in contact with groundwater.

Sørkjosen lufthavn - BØF 1 (gammelt)	2,8	Mainly sandy material, with a layer of stone, gravel and crushed stone on top.	2,5	2,5	0	0-2.5, maybe deeper (3.5 m)			No samples of groundwater.	No information available concerning concentrations in groundwater.	No, contamination in contact with groundwater.
Narvik lufthavn Framnes - BØF nord (ikke aktivt) og fylling	2,6	Thin gravel and crushed stone layer with soil. Over the beach deposits with layers of medium to fine and coarse sand.	-	1,9	-	0-1.8, probably not much deeper	910	910	No water seepage in shafts at the BØF or fill described. Sample of water in a shaft about 50 metres north of the fill material (located just north of the BØF).	No, bedrock at between 0.7-2 metres.	Presumed to be suitable.
Ålesund lufthavn Vigra - BØF 1 (aktivt)	2,5	The material is stated as consisting of gravel, sand, soil, silty sand, shell sand and fill.	2	3	1	0-2.7, maybe deeper (4 m)	4,140-15,400	10637	12 samples from three wells (taken in 2012 to 2014). Significant concentrations of PFAS other than PFOS have been detected; three samples of PFOS only from 2011 have therefore not been included.	May be suitable, but is very close to the sea.	No, contamination in contact with groundwater. It is likely that leaching is taking place due to tidal impact.
Fagernes lufthavn Leirin - BØF A (ikke aktivt)	2,1	Gravel and blasted rock.	1,5	2,2	0,7	0-2.1			No samples of groundwater.	No information available concerning concentrations in groundwater.	No, contamination in contact with groundwater.
Sogndal lufthavn Haukåsen - BØF1 (ikke aktivt)	1,1	Mixture of moraine, organic soil, stone, sand, clay, rubble with fine material, marsh soil.	1,4	3	1,6	1-3, maybe deeper (4 m)	275-658	467	Groundwater wells in two shafts at BØF, one year after establishment.	No. Relatively low concentrations in groundwater will have little effect.	No, contamination in contact with groundwater.
Røst lufthavn - BØF1 (ikke aktivt)	1,0	Gravel over bedrock.	0,55	1,2	0,65	0-0.5 lower conc. in deeper material (investigated to 1.2 m)			No samples of groundwater.	No information available concerning concentrations in groundwater.	No, contamination in contact with groundwater.
Kirkenes lufthavn Høybuktmoen - Driftsområdet	1,0	Sand, gravel, stone, boulders, gravel, coarse sand.	> 30 m	2,5	-	0-2.5, maybe deeper (6 m)			No samples of groundwater.	No information available about depth to groundwater or the depth of the contamination.	No information available about depth to groundwater or the depth of the contamination.
Florø lufthamn - BØF1 (aktivt)	1,0	Blasted rock and some organic soil over bedrock outside the BØF.	< 3 m	1,6	-	0-1.5	102	102	One sample from shaft.	No. Relatively low concentrations in groundwater will have little effect.	No, likely that leaching is taking place due to tidal impact. Groundwater level unknown.
Ørsta-Volda lufthamn Hovden - BØF 1 (gammelt)	0,8	Sand	1,8	2,6	0,8	0-2.3	1030	1 030	Groundwater from well in shaft one year after establishment. The well is probably slightly upstream of the most heavily polluted area.	No. Relatively low concentrations in groundwater will have little effect.	No, contamination in contact with groundwater.
Kristiansund lufthavn Kvernberget - BØF A (aktivt)	0,7	Stone, gravel, sand, boulders, and one sampling point SJ5 in marsh just outside the BØF.	2,5	4	1,5	0.4-4, maybe deeper (5 m)			No samples of groundwater.	No information available concerning concentrations in groundwater.	No, contamination in contact with groundwater.
Vardø lufthavn Svartnes - BØF 1 (gammelt)	0,6	Sand, gravel, soil and peat and some rock.	0,5	1	0,5	0-1, maybe deeper (1.7 m)	16-308	122	Samples from three wells. Uncertain whether it was in connection with establishment. Low concentrations, very permeable material.	No. Relatively low concentrations in groundwater will have little effect.	No, likely that leaching is taking place due to tidal impact.
Svolvær lufthavn Helle - BØF B (Ikke aktivt)	0,5	Gravel, stone and sand.	-	0,7	-	0-1.3, mean depth to bedrock 0.7 m			No samples of groundwater.	No information available concerning depth to groundwater or concentrations in groundwater.	No information available concerning depth to groundwater. Situated close to the sea, likely that leaching is taking place due to tidal impact.

APPENDIX E – Limits of remedial action

Cost calculations "pump and treat" - p. 1-3

Limits of remedial action, capping - p. 4-8

Limits of remedial action, excavation and external disposal - p. 9-26

Site-specific remedial action limits for "pump and treat" for the three site which are presumed to be suitable (n=3)

Table 1 This appendix presented estimated quantities of ∑PFAS removed over different operating times for pump and treat remedial action in order to remove pollution in the saturated zone at the sites Lakselv BØF 3, Stavanger BØF 2 and Røros Airport. Pump and treat remedial action in the saturated zone is only considered to be suitable in combination with measures in the unsaturated zone.

With the existing mapping basis, the cost/effect calculations are only considered to be a feasibility study. No site-specific limits have been set for pump and treat measures, but highlighted in yellow in Table 1 are the scope of the measures and the estimated operating time required for 100% clean-up of the saturated zone/groundwater (assuming no new flow from the unsaturated zone).

Table 1: Overview of estimated quantities ∑PFAS (kg) in the groundwater/saturated zone, proportion of the total removed from the saturated zone over the number of years during which the remedial action is carried out, cost/effect (NOK per kg removed) over the number of years during which the remedial action is carried out.

Airport and site		**Lakselv Airport Banak - BØF 3 (active)**	**Stavanger Airport - BØF 2 (old)**	**Røros Airport**
Estimated quantity of ∑PFAS in the saturated zone (kg)		1.1	3.0	1.2
When pumping 1 well				
PFAS removed over one year	kg	0.40	0.21	0.003
Proportion of total in groundwater/saturated zone	%	37%	7%	0.3%
Cost/effect over one year	NOK/kg	6,892,680	13,368,401	936,350,809
PFAS removed over two years	kg	0.80	0.43	0.01
Proportion of total in groundwater/saturated zone	%	74%	14%	0.5%
Cost/effect over two years	NOK/kg	3,616,560	7,000,833	491,299,376
PFAS removed over three years	kg	1.20	0.64	0.01
Proportion of total in groundwater/saturated zone	%	100%	21%	1%
Cost/effect over three years	NOK/kg	2,524,521	4,878,310	342,948,898
PFAS removed over ten years	kg		2.15	0.03
Proportion of total in groundwater/saturated zone	%		70%	3%
Cost/effect over ten years	NOK/kg		1,906,778	135,258,229
PFAS removed over twenty years	kg		4.30	0.06
Proportion of total in groundwater/saturated zone	%		141%	5%
Cost/effect over twenty years	NOK/kg		1,270,021	90,753,086
When pumping 3 wells				
PFAS removed over one year	kg	1.20	0.64	0.01
Proportion of total in groundwater/saturated zone	%	100%	21%	1%
Cost/effect over one year	NOK/kg	3,221,048	4,841,059	340,228,431
PFAS removed over three years	kg		1.93	0.03
Proportion of total in groundwater/saturated zone	%		63%	2%
Cost/effect over three years	NOK/kg		1,804,080	127,314,087
PFAS removed over five years	kg		3.22	0.04
Proportion of total in groundwater/saturated zone	%		100%	4%
Cost/effect over five years	NOK/kg		1,196,684	84,731,218
PFAS removed over ten years	kg			0.09
Proportion of total in groundwater/saturated zone	%			8%
Cost/effect over ten years	NOK/kg			52,794,067
PFAS removed over twenty years	kg			0.18
Proportion of total in groundwater/saturated zone	%			15%
Cost/effect over twenty years	NOK/kg			36,825,491

When pumping 6 wells				
PFAS removed over one year	kg		1.29	0.02
Proportion of total in groundwater/saturated zone	%		42%	2%
Cost/effect over one year	NOK/kg		2,690,598	189,837,603
PFAS removed over three years	kg		3.87	0.05
Proportion of total in groundwater/saturated zone	%		100%	5%
Cost/effect over three years	NOK/kg		1,016,897	72,045,151
PFAS removed over ten years	kg			0.18
Proportion of total in groundwater/saturated zone	%			15%
Cost/effect over ten years	NOK/kg			30,817,793
PFAS removed over twenty years	kg			0.35
Proportion of total in groundwater/saturated zone	%			30%
Cost/effect over twenty years	NOK/kg			21,983,359

When pumping 9 wells				
PFAS removed over one year	kg		1.93	0.03
Proportion of total in groundwater/saturated zone	%		63%	2%
Cost/effect over one year	NOK/kg		1,998,612	141,520,971
PFAS removed over two years	kg		3.87	0.05
Proportion of total in groundwater/saturated zone	%		100%	5%
Cost/effect over two years	NOK/kg		1,084,155	76,957,105
PFAS removed over three years	kg			0.08
Proportion of total in groundwater/saturated zone	%			7%
Cost/effect over three years	NOK/kg			55,435,817
PFAS removed over ten years	kg			0.26
Proportion of total in groundwater/saturated zone	%			23%
Cost/effect over ten years	NOK/kg			25,306,013
PFAS removed over twenty years	kg			0.53
Proportion of total in groundwater/saturated zone	%			46%
Cost/effect over twenty years	NOK/kg			18,849,626

Site-specific limits of remedial action for capping/screening for the four sites which are considered to be suitable (n=4)

Table 2 shows estimated costs, effectiveness of remedial actions, cost/effect and limits of remedial action (indicated in yellow) for capping measures at the four sites which are considered to be suitable. Lakselv BØF 3 and Stavanger BØF 2 are only considered as suitable for capping in combination with pump and treat remedial measures in the saturated zone. Costs are also shown for measures relating to the total quantity, including positive uncertainty (shaded blue in the table), but as described in section 3.2.4.2 of the report, this was not included in the assessment of site-specific limits on action limits. Comments are presented in Table 2 regarding the sites where 20% has been added to the quantity of PFOS due to evidence of significant contamination by other PFAS compounds. Figure 1 to Figure 4 show NOK per kg ∑PFAS capped and kg ∑PFAS capped at the four sites. The black line indicates where the action limit is set.

Table 2: Estimated costs, effectiveness of remedial actions, cost/effect and limits of remedial action (indicated in yellow) for capping measures at the four sites which are considered to be suitable. Lakselv BØF 3 and Stavanger BØF 2 are only considered as suitable for capping in combination with pump and treat remedial measures in the saturated zone.

Airport and site		**Lakselv Airport Banak - BØF 3 (active)**	**Stavanger Airport Sola - BØF 2 (old)**	**Røros Airport - BØF 1 (inactive)**	**Narvik Airport Framnes - BØF North (inactive) and fill**
Comments regarding the calculation		Platform area has been deducted	Quantity in unsaturated zone	Added PFAS	Added PFAS
Quantity of PFOS/∑PFAS, including positive uncertainty	kg	26	9	8.6	5.5
Area around BØF with elevated PFOS/∑PFAS	m^2	22,300	28,230	47,100	24,500
Circumference of area	m	590	660	868	809
Depth with PFOS/∑PFAS	m	3.2	2	1.1	1.9
Effectiveness of remedial action	g/m^3	0.3	0.2	0.2	0.2
Levelling of terrain prior to membrane	NOK	735,900	931,590	4,710,000	2,450,000
Levelling material, including transport and laying out	NOK	3,166,600	4,008,660	11,398,200	5,929,000
Cost of ditches	NOK	1,321,600	924,000	668,360	1,075,970
Cost of membrane	NOK	4,460,000	5,646,000	9,420,000	4,900,000
Cost for capping of all PFOSΣPFAS	NOK	9,684,100	11,510,250	26,196,560	14,354,970
Cost-effect	NOK/kg	370,690	1,235,177	3,046,112	2,609,995
Quantity of PFOS/ΣPFAS > 3 µg/kg	kg	13	3.8	4.5	3.2
Area around BØF with elevated PFOS/∑PFAS	m^2	12,115	12,172	27,705	8,190
Circumference of area	m	453	475	738	757
Depth with PFOS/∑PFAS	m	3.2	2	1.1	1.9
Effectiveness of remedial action	g/m^3	0.3	0.2	0.1	0.2
Proportion of total quantity of PFOSΣPFAS	%	100%	70%	100%	100%
Levelling of terrain prior to membrane	NOK	399,795	401,676	2,770,500	819,000
Levelling material, including transport and laying out	NOK	1,720,330	1,728,424	6,704,610	1,981,980
Cost of ditches	NOK	1,014,720	665,000	568,260	1,006,810
Cost of membrane	NOK	2,423,000	2,434,400	5,541,000	1,638,000
Cost of capping	NOK	5,557,845	5,229,500	15,584,370	5,445,790

Cost-effect	NOK/kg	429,373	1,393,900	3,433,882	1,724,436

Airport and site		**Lakselv Airport Banak - BØF 3 (active)**	**Stavanger Airport Sola - BØF 2 (old)**	**Røros Airport - BØF 1 (inactive)**	**Narvik Airport Framnes - BØF North (inactive) and fill**
Quantity of PFOS/ΣPFAS > 30 µg/kg	kg	13	3.7	4.0	2.9
Area around BØF with elevated PFOS/∑PFAS	m^2	7,771	10,257	13,505	4,376
Circumference of area		390	431	520	573
Depth with PFOS/∑PFAS	m	3.2	2	1.1	1.9
Effectiveness of remedial action	g/m^3	0.4	0.2	0.3	0.4
Proportion of total quantity of PFOSΣPFAS	%	97%	69%	89%	92%
Levelling of terrain prior to membrane	NOK	256,443	338,481	1,350,500	437,600
Levelling material, including transport and laying out	NOK	1,103,482	1,456,494	3,268,210	1,058,992
Cost of ditches	NOK	873,600	603,400	400,400	762,090
Cost of membrane	NOK	1,554,200	2,051,400	2,701,000	875,200
Cost of capping	NOK	3,787,725	4,449,775	7,720,110	3,133,882
Cost-effect	NOK/kg	300,427	1,210,458	1,915,378	1,074,514

Quantity of PFOS/ΣPFAS > 150 µg/kg	kg	11	2.9	2.5	2.1
Area around BØF with elevated PFOS/∑PFAS	m^2	4,582	4,575	3,596	1,553
Circumference of area		309	262	278	303
Depth with PFOS/∑PFAS	m	3.2	2	1.1	1.9
Effectiveness of remedial action	g/m^3	0.6	0.3	0.6	0.7
Proportion of total quantity of PFOSΣPFAS	%	84%	54%	56%	67%
Levelling of terrain prior to membrane	NOK	151,206	150,975	359,600	155,300
Levelling material, including transport and laying out	NOK	650,644	649,650	870,232	375,826
Cost of ditches	NOK	692,160	366,800	214,060	402,990
Cost of membrane	NOK	916,400	915,000	719,200	310,600
Cost of capping	NOK	2,410,410	2,082,425	2,163,092	1,244,716
Cost-effect	NOK/kg	216,970	717,525	850,985	584,483

Quantity of PFOS/ΣPFAS > 500 µg/kg	kg	4.2	0.8	0.4	1.5
Area around BØF with elevated PFOS/∑PFAS	m^2	1,118	733	290	668
Circumference of area		129	160	169	127
Depth with PFOS/∑PFAS	m	3.2	2	1.1	1.9
Effectiveness of remedial action	g/m^3	1.1	0.5	1.2	1.2
Proportion of total quantity of PFOSΣPFAS	%	32%	15%	9%	47%
Levelling of terrain prior to membrane	NOK	36,894	24,189	29,000	66,800
Levelling material, including transport and laying out	NOK	158,756	104,086	70,180	161,656
Cost of ditches	NOK	288,960	224,000	130,130	168,910
Cost of membrane	NOK	223,600	146,600	58,000	133,600
Cost of capping	NOK	708,210	498,875	287,310	530,966
Cost-effect	NOK/kg	169,975	623,638	744,518	357,782

Airport and site		Lakselv Airport Banak - BØF 3 (active)	Stavanger Airport Sola - BØF 2 (old)	Røros Airport - BØF 1 (inactive)	Narvik Airport Framnes - BØF North (inactive) and fill
Quantity of PFOS/ΣPFAS > 1000 µg/kg	kg	0.2			0.7
Area around BØF with elevated PFOS/∑PFAS	m^2	35			237
Circumference of area		33			80
Depth with PFOS/∑PFAS	m	3.2			1.9
Effectiveness of remedial action	g/m^3	1.7			1.6
Proportion of total quantity of PFOSΣPFAS	%	1%			23%
Levelling of terrain prior to membrane	NOK	1,155			23,700
Levelling material, including transport and laying out	NOK	4,970			57,354
Cost of ditches	NOK	73.920			106,400
Cost of membrane	NOK	7,000			47,400
Cost of capping	NOK	87,045			234,854
Cost-effect	NOK/kg	455,241			323,922

Quantity of PFOS/ΣPFAS > 3000 µg/kg	kg				
Area around BØF with elevated PFOS/∑PFAS	m^2				
Depth with PFOS/∑PFAS	m				
Effectiveness of remedial action	g/m^3				
Proportion of total quantity of PFOSΣPFAS	%				
Levelling of terrain prior to membrane	NOK				
Levelling material, including transport and laying out	NOK				
Cost of ditches	NOK				
Cost of membrane	NOK				
Cost of capping	NOK				
Cost-effect	NOK/kg				

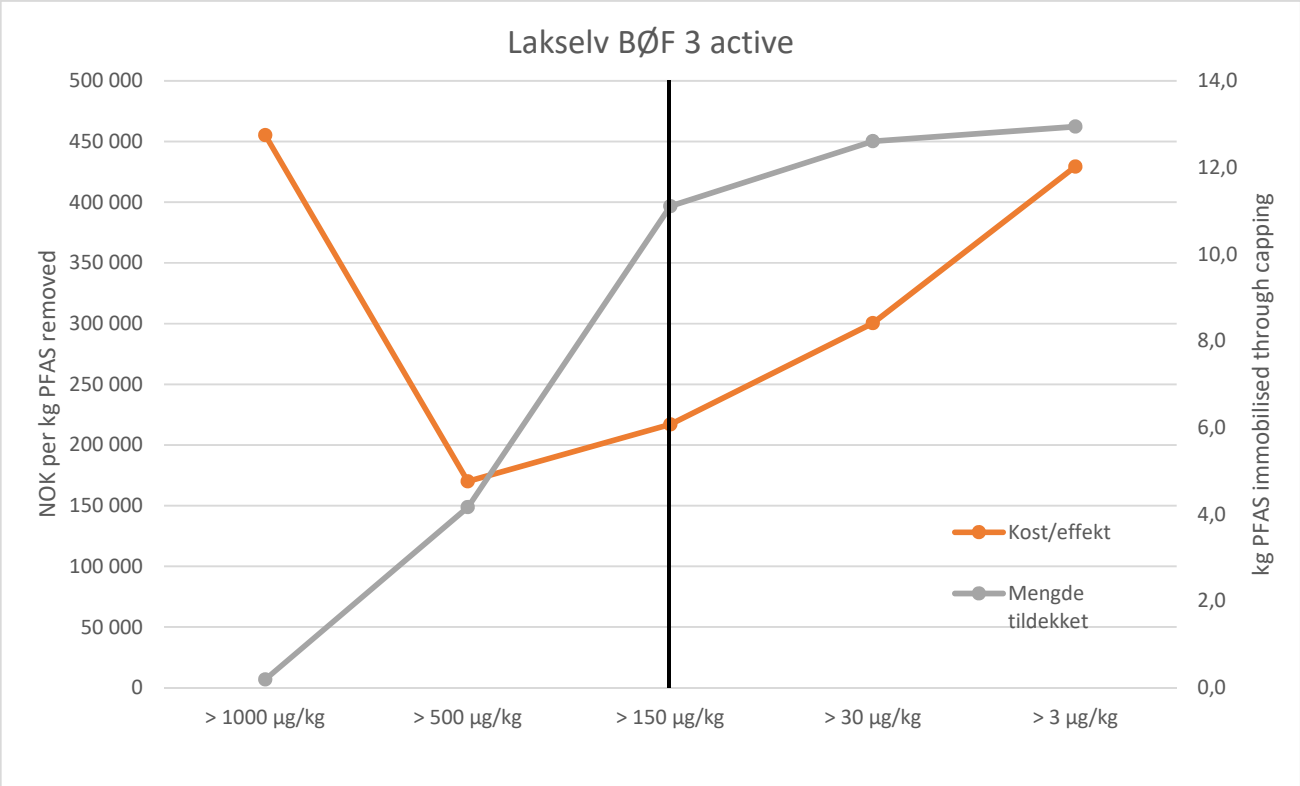


Figure 1: At Lakselv BØF 3, the action limit is set to concentrations of ∑PFAS >150 µg/kg, which immobilises 84% of the contamination.

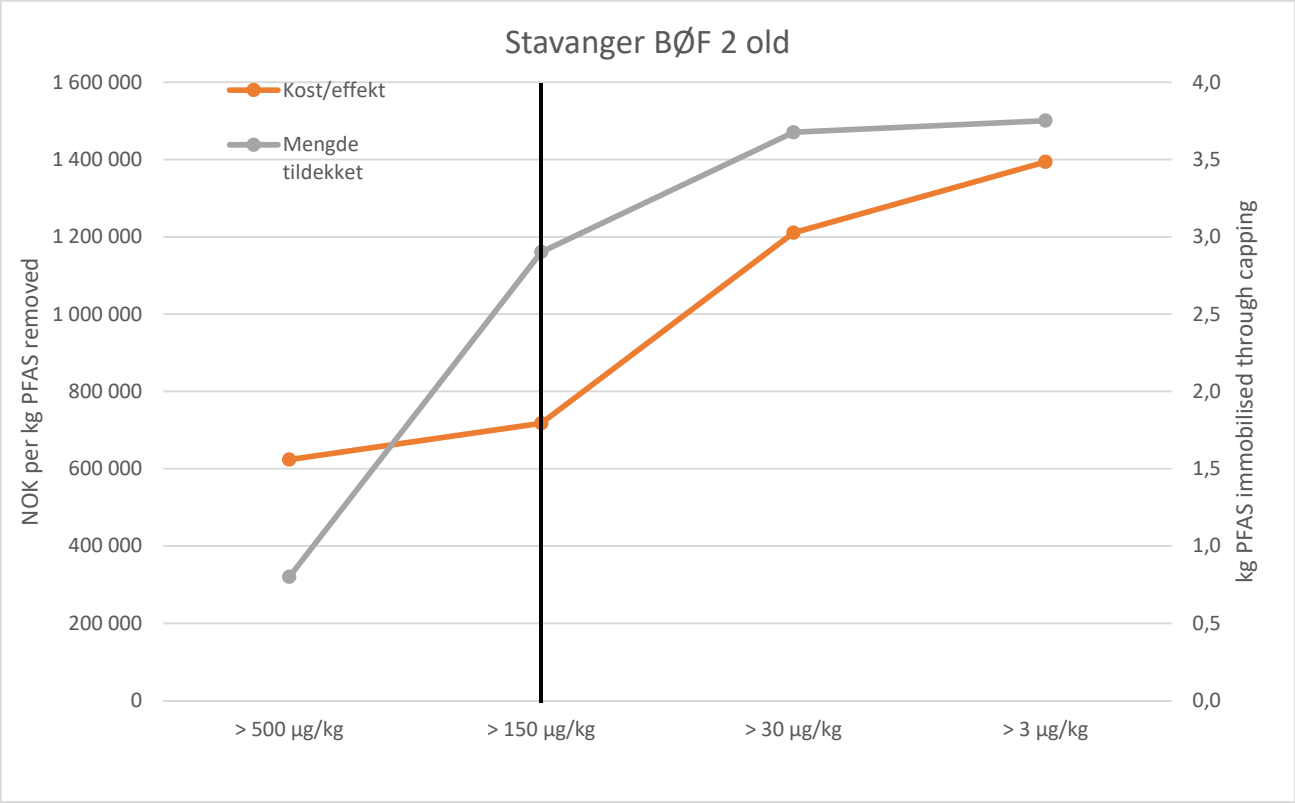


Figure 2: At Lakselv BØF 2, the action limit is set to concentrations of ∑PFAS >150 µg/kg, which immobilises 54% of the contamination.

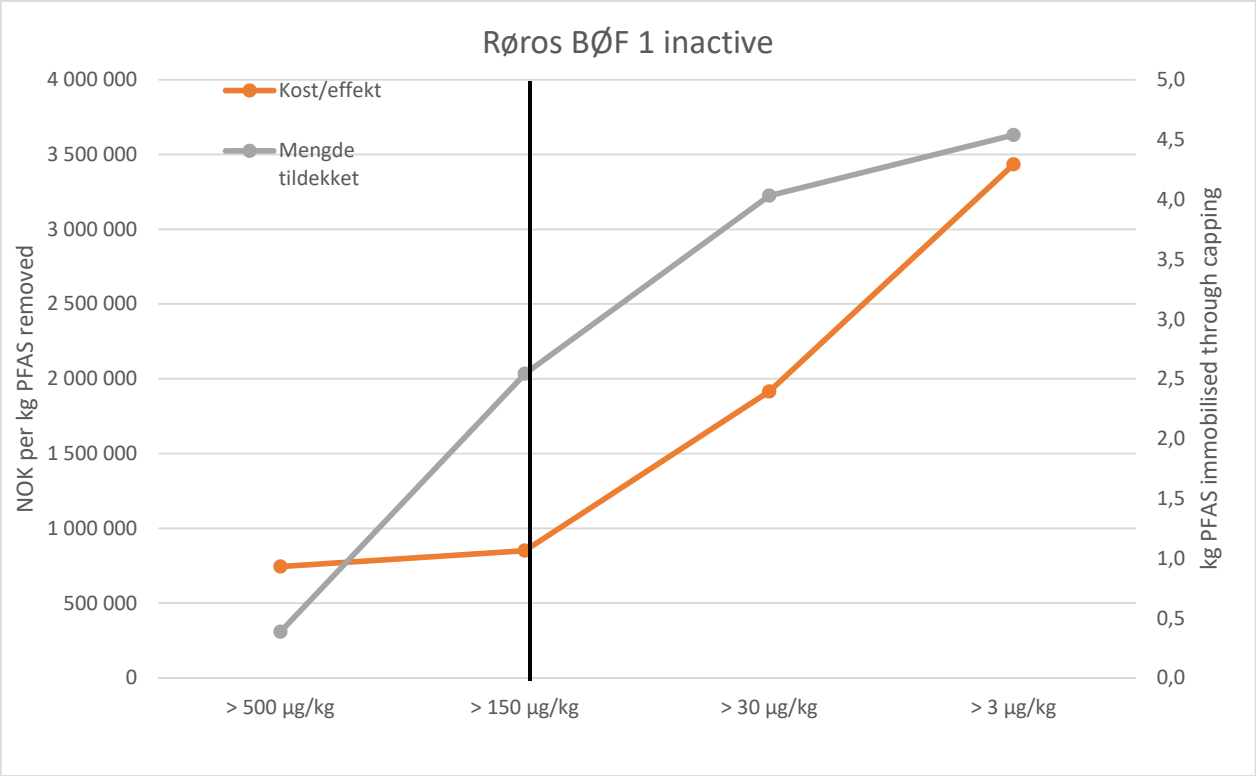


Figure 3: At Røros BØF 1, the action limit is set to concentrations of ∑PFAS >150 µg/kg, which immobilises 56% of the contamination.

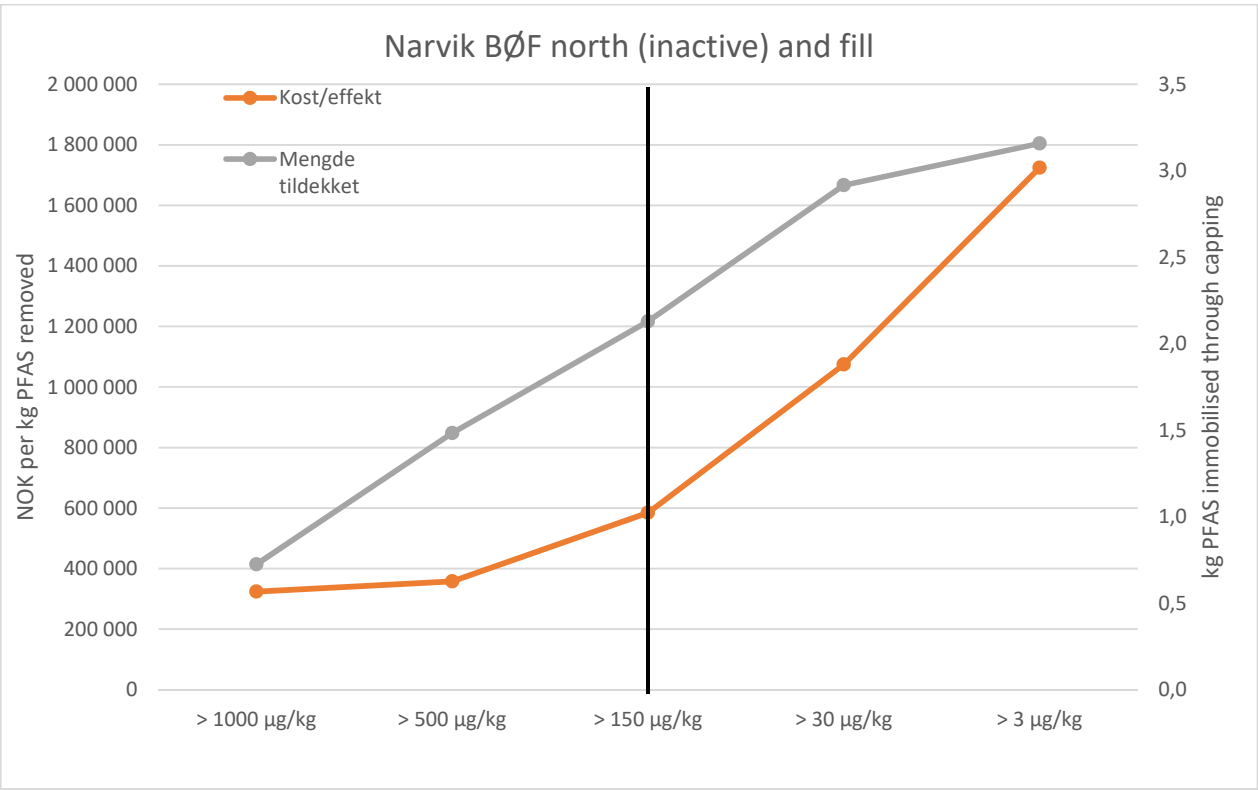


Figure 4: At Narvik BØF north and fill, the action limit is set to concentrations of ∑PFAS >150 µg/kg, which immobilises 67% of the contamination.

Site-specific measures for excavation measures at all sites in Part 2 (n= 32)

Table 3 of this appendix shows the estimated cost of excavation measures for the quantity of PFOS/ΣPFAS above the various concentration limits for the 32 sites for which quantities have been estimated. The table provides an overview of quantities of PFOS/ΣPFAS (kg), volume of material (m^3), measure effectiveness (g/m^3), cost of removing contamination and cost/effect (NOK per kg removed) above the various concentration limits, as well as the cost of remedial action (total cost). Costs are also shown for measures relating to the total quantity, including positive uncertainty (shaded blue in the table), but as described in section 3.2.4.2 of the report, this was not included in the assessment of site-specific limits on action limits.

Comments have been added to Table 3 for those sites where 20% has been added to the amount of PFOS due to evidence of significant contamination by other PFAS compounds. Comments have also been added for those sites where costs have been added for the treatment of water in excavation pits below groundwater level and additional costs for active fire training sites (except for Tromsø, Ålesund and Alta which are to be closed from 2020).

Figure 5 to Figure 34 shows NOK per kg ∑PFAS removed and kg ∑PFAS removed from 30 of the 32 sites, along with a brief description for each figure. For the last two sites, Kirkenes operations area and Kristiansund BØF A, the estimates indicate that there are no quantities above the concentration limit of 150 µg/kg. The limit of measures is set to the concentration limit where the amount of PFOS/∑PFAS removed is significantly reduced, and/or cost per kg removed rises significantly. The description for each figure specifies the proposed concentration for the action limit, and the proportion of ∑PFAS removed at this limit. The description also specifies an increase in NOK per kg removed and total action costs by setting the action limit to a lower concentration limit (ref. the cost calculations given in the table in this appendix), as well as the difference in the quantity of ∑PFAS removed. The sequence of the sites is the same as in Table 3, which shows the cost calculations and in Figure 5 to Figure 34 .

For sites with active fire training sites which are to continue to be used after any measures have been implemented, a cost of NOK 80 million has been added to the total cost of the measures at each concentration limit. In the figures for these sites, measures regarding quantities above the concentration limits of 3,000 µg/kg and 1000 µg/kg will be associated with a higher cost per kg PFAS removed than the lower concentration limits (e.g. Lakselv BØF 3 and Molde BØF 1). The lowest point on the curve for cost per kg PFAS removed occurs at >150 µg/kg.

Airport and site		Tromsø lufthavn Langnes - BØF 2 (gammelt)	Ålesund lufthavn Vigra - BØF 2 (gammelt)	Alta lufthavn - BØF1 (aktivt)	Rørvik lufthavn Ryum - BØF 2 (yngre, men ikke aktivt)	Kirkenes lufthavn Høybuktmoen - BØF 1 (gammelt)	Kristiansund lufthavn Kvernberget - BØF B (gammelt)	Lakselv lufthavn Banak - BØF 3 (aktivt)	Berlevåg lufthavn - BØF 1 (gammelt)	Molde lufthavn Årø - BØF 1 (aktivt og gammelt)	Tromsø lufthavn Langnes - BØF 1 (aktivt)	Bergen lufthavn Flesland - BØF 1 (yngst, ikke aktivt)	Haugesund lufthavn Karmøy - BØF B (gammelt)	Stavanger lufthavn Sola - BØF 2 (gammelt)	Bergen lufthavn Flesland - BØF 2 (gammelt)	Mo i Rana lufthavn Røssvoll - BØF 1 (gammelt)	Røros lufthavn - BØF 1 (ikke aktivt)
Comments regarding calculations		Added PFAS and water treatment	Added water treatment	Added water treatment	Added water treatment		Added PFAS and water treatment	Added water treatment and cost for active		Calculated for PFAS (in part 1 of the order), added cost for active	Added PFAS	Added PFAS	Added water treatment	Added relocation of added material 0-1.5 m at the BØF.			Added PFAS
Quantity of PFOS/ΣPFAS, including positive uncertainty	kg	223	131	36	55	68	89	26	27	20	27	37	15	13	8,2	8	8,6
Volume of material	m^3	75 849	181 920	37 428	10 610	148 039	33 614	87 621	42 801	26 684	21 399	13 860	20 588	59 427	83 111	33 118	56 897
Effectiveness of remedial action	g/m3	2,9	0,7	1,0	5,2	0,5	2,7	0,3	0,6	0,8	1,2	2,7	0,7	0,2	0,1	0,3	0,2
Cost of remedial action	NOK/m^3	kr 2 313	kr 2 122	kr 1 901	kr 2 377	kr 2 573	kr 2 156	kr 1 966	kr 2 261	kr 2 161	kr 1 987	kr 1 909	kr 1 675	kr 1 893	kr 1 611	kr 2 228	kr 3 040
Cost for removal of all PFOSΣPFAS	NOK	kr 176 049 092	kr 387 615 626	kr 71 767 438	kr 25 821 024	kr 380 967 907	kr 73 087 962	kr 252 854 309	kr 96 774 769	kr 137 651 702	kr 42 514 690	kr 26 457 984	kr 35 091 294	kr 120 105 024	kr 133 866 318	kr 73 801 881	kr 172 953 232
Cost-effect	NOK/kg	kr 789 727	kr 2 953 452	kr 2 016 884	kr 470 073	kr 5 628 976	kr 820 313	kr 9 678 798	kr 3 551 108	kr 6 841 655	kr 1 597 321	kr 718 979	kr 2 400 314	kr 9 022 019	kr 16 421 201	kr 8 812 606	kr 20 032 936
Quantity of PFOS/ΣPFAS > 3 µg/kg	kg	97	51	24	22	21	17	13	9,4	9,3	10	9,4	6,1	5,4	4,5	3,8	4,5
Volume of material	m^3	33 902	71 417	26 340	4 365	45 287	6 508	44 208	14 858	12 714	8 228	3 565	8 759	24 344	47 045	15 134	30 476
Total weight of soil in investigated volume	tonnes	54 243	104 983	42 143	6 984	76 988	11 714	70 733	25 259	22 886	13 988	5 347	15 766	38 950	79 977	25 728	51 808
Effectiveness of remedial action	g/m^3	2,9	0,7	0,9	5,1	0,5	2,6	0,3	0,6	0,7	1,2	2,6	0,7	0,2	0,1	0,2	0,1
Proportion of total quantity of PFOSΣPFAS	%	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
Cost of remedial action	NOK/m^3	kr 2 313	kr 2 122	kr 1 901	kr 2 377	kr 2 573	kr 2 156	kr 1 966	kr 2 261	kr 2 161	kr 1 987	kr 1 909	kr 1 675	kr 1 893	kr 1 611	kr 2 228	kr 3 040
Cost of removal	NOK	kr 79 021 819	kr 153 178 018	kr 50 684 858	kr 10 977 397	kr 116 542 049	kr 14 636 585	kr 167 510 630	kr 33 595 206	kr 107 469 788	kr 16 347 137	kr 6 805 203	kr 15 275 751	kr 49 364 763	kr 75 775 382	kr 33 726 270	kr 92 637 954
Cost-effect	NOK/kg	kr 810 634	kr 3 019 617	kr 2 136 194	kr 490 135	kr 5 661 098	kr 851 006	kr 12 941 077	kr 3 591 721	kr 11 506 807	kr 1 621 016	kr 720 976	kr 2 503 655	kr 9 210 574	kr 16 919 118	kr 8 917 371	kr 20 411 978
Quantity of PFOS/ΣPFAS > 30 µg/kg	kg	97	50	24	22	20	17	13	9,2	9,2	10	9,4	6,0	5,3	4,3	3,7	4,0
Volume of material	m^3	29 792	65 153	23 863	4 365	40 342	6 508	30 307	12 570	11 127	5 884	3 564	7 753	20 514	35 055	13 158	14 856
Effectiveness of remedial action	g/m^3	3,3	0,8	1,0	5,1	0,5	2,6	0,4	0,7	0,8	1,7	2,6	0,8	0,3	0,1	0,3	0,3
Proportion of total quantity of PFOSΣPFAS	%	100 %	99 %	100 %	100 %	99 %	100 %	97 %	99 %	98 %	99 %	100 %	99 %	98 %	95 %	98 %	89 %
Cost of remedial action	NOK/m^3	kr 2 313	kr 2 122	kr 1 901	kr 2 377	kr 2 573	kr 2 156	kr 1 966	kr 2 261	kr 2 161	kr 1 987	kr 1 909	kr 1 675	kr 1 893	kr 1 611	kr 2 228	kr 3 040
Cost of removal	NOK	kr 69 514 032	kr 139 889 941	kr 45 975 008	kr 10 977 397	kr 103 815 962	kr 14 636 585	kr 140 183 601	kr 28 421 078	kr 104 039 278	kr 11 690 150	kr 6 804 440	kr 13 590 265	kr 41 598 289	kr 56 463 089	kr 29 321 959	kr 45 157 032
Cost-effect	NOK/kg	kr 715 210	kr 2 774 701	kr 1 945 339	kr 490 135	kr 5 088 328	kr 851 006	kr 11 118 804	kr 3 079 450	kr 11 347 246	kr 1 173 947	kr 720 976	kr 2 251 239	kr 7 921 094	kr 13 251 337	kr 7 896 708	kr 11 203 567
Amount of PFOS/ΣPFAS > 150 µg/kg	kg	96	47	23	22	19	17	11	8,4	8,9	9,7	9,4	5,8	4,1	2,4	2,6	2,5
Volume of material	m^3	21 835	40 747	17 910	3 644	33 311	6 423	18 182	4 225	8 486	3 786	3 487	5 184	9 150	9 653	5 792	3 956
Effectiveness of remedial action	g/m^3	4,4	1,2	1,3	6,0	0,6	2,7	0,6	2,0	1,0	2,6	2,7	1,1	0,5	0,2	0,5	0,6
Proportion of total quantity of PFOSΣPFAS	%	98 %	94 %	96 %	98 %	94 %	99 %	84 %	90 %	95 %	96 %	100 %	95 %	77 %	53 %	70 %	56 %
Cost of remedial action	NOK/m^3	kr 2 313	kr 2 122	kr 1 901	kr 2 377	kr 2 573	kr 2 156	kr 1 966	kr 2 261	kr 2 161	kr 1 987	kr 1 909	kr 1 675	kr 1 893	kr 1 611	kr 2 228	kr 3 040
Cost of removal	NOK	kr 51 110 614	kr 88 111 121	kr 34 657 373	kr 9 265 035	kr 85 723 776	kr 14 453 292	kr 116 347 940	kr 9 553 281	kr 98 335 229	kr 7 521 908	kr 6 656 301	kr 9 287 603	kr 18 554 370	kr 15 547 282	kr 12 908 080	kr 12 024 042
Cost-effect	NOK/kg	kr 533 210	kr 1 857 336	kr 1 525 122	kr 420 582	kr 4 422 371	kr 847 109	kr 10 472 890	kr 1 132 313	kr 11 106 693	kr 778 876	kr 707 037	kr 1 596 612	kr 4 475 194	kr 6 534 280	kr 4 891 245	kr 4 730 395
Quantity of PFOS/ΣPFAS > 500 µg/kg	kg	94	42	19	21	11	15	4,2	7,7	6,9	9,1	8,9	5,0	1,1	0,5		0,4
Volume of material	m^3	18 810	26 930	9 400	2 915	13 663	3 103	3 802	2 482	4 282	2 838	2 739	2 830	1 466	983		319
Effectiveness of remedial action	g/m^3	5,0	1,5	2,0	7,2	0,8	4,9	1,1	3,1	1,6	3,2	3,3	1,8	0,8	0,5		1,2
Proportion of total quantity of PFOSΣPFAS	%	97 %	82 %	78 %	94 %	56 %	88 %	32 %	82 %	74 %	90 %	94 %	82 %	21 %	11 %		9 %
Cost of remedial action	NOK/m^3	kr 2 313	kr 2 122	kr 1 901	kr 2 377	kr 2 573	kr 2 156	kr 1 966	kr 2 261	kr 2 161	kr 1 987	kr 1 909	kr 1 675	kr 1 893	kr 1 611		kr 3 040
Cost of removal	NOK	kr 44 113 440	kr 58 796 266	kr 18 476 828	kr 7 531 760	kr 35 160 665	kr 7 294 081	kr 88 077 299	kr 5 610 958	kr 89 252 092	kr 5 638 451	kr 5 229 133	kr 5 343 748	kr 2 972 755	kr 1 582 513		kr 969 681
Cost-effect	NOK/kg	kr 467 916	kr 1 409 705	kr 994 736	kr 356 957	kr 3 067 432	kr 481 846	kr 21 139 125	kr 728 535	kr 12 892 707	kr 619 218	kr 586 266	kr 1 068 190	kr 2 601 344	kr 3 116 680		kr 2 512 773
Quantity of PFOS/ΣPFAS > 1000 µg/kg	kg	91	30	13	16	0,9	15	0,2	6,8	4,6	8,1	7,7	3,8				
Volume of material	m^3	16 261	14 001	4 938	1 329	650	2 725	112	1 564	1 698	2 050	1 854	1 435				
Effectiveness of remedial action	g/m^3	5,6	2,1	2,7	12,2	1,4	5,5	1,7	4,4	2,7	3,9	4,1	2,7				
Proportion of total quantity of PFOSΣPFAS	%	94 %	59 %	56 %	73 %	4 %	87 %	1 %	73 %	50 %	80 %	81 %	62 %				
Cost of remedial action	NOK/m^3	kr 2 313	kr 2 122	kr 1 901	kr 2 377	kr 2 573	kr 2 156	kr 1 966	kr 2 261	kr 2 161	kr 1 987	kr 1 909	kr 1 675				
Cost of removal	NOK	kr 38 216 598	kr 31 367 888	kr 9 992 974	kr 3 761 950	kr 1 672 724	kr 6 480 045	kr 80 824 061	kr 3 535 338	kr 83 669 250	kr 4 072 877	kr 3 539 286	kr 3 006 983				
Cost-effect	NOK/kg	kr 419 202	kr 1 048 489	kr 757 807	kr 231 147	kr 1 901 970	kr 431 245	kr 422 705 837	kr 517 717	kr 18 068 565	kr 503 051	kr 460 510	kr 789 899				
Quantity of PFOS/ΣPFAS > 3000 µg/kg	kg	68	5,3		16		10,6		4,6	1,4	3,4	3,5	1,8				
Volume of material	m^3	8 680	1 158		1 329		1 278		598	284	526	423	385				
Effectiveness of remedial action	g/m^3	7,8	4,6		12,2		8,3		7,8	4,9	6,5	8,2	4,7				
Proportion of total quantity of PFOSΣPFAS	%	70 %	10 %		73 %		61 %		50 %	15 %	34 %	37 %	30 %				
Cost of remedial action	NOK/m^3	kr 2 313	kr 2 122		kr 2 377		kr 2 156		kr 2 261	kr 2 161	kr 1 987	kr 1 909	kr 1 675				
Cost of removal	NOK	kr 20 681 046	kr 4 121 539		kr 3 761 950		kr 3 358 672		kr 1 351 188	kr 80 613 378	kr 1 045 041	kr 807 889	kr 1 249 134				
Cost-effect	NOK/kg	kr 304 098	kr 773 846		kr 231 147		kr 317 593		kr 291 370	kr 58 171 675	kr 307 187	kr 234 067	kr 688 672				

Airport and site		Mosjøen lufthavn Kjærstad - BØF 1 (gammelt)	Hammerfest lufthavn - BØF 1 (gammelt)	Sandnessjøen lufthavn Stokka - BØF 1 (gammelt)	Leknes lufthavn - BØF 1 (ikke aktivt)	Sørkjosen lufthavn - BØF 1 (gammelt)	Narvik lufthavn Framnes - BØF nord (ikke aktivt) og fylling	Ålesund lufthavn Vigra - BØF 1 (aktivt)	Fagernes lufthavn Leirin - BØF A (ikke aktivt)	Sogndal lufthavn Haukåsen - BØF1 (ikke aktivt)	Røst lufthavn - BØF1 (ikke aktivt)	Kirkenes lufthavn Høybuktmoen - Driftsområdet	Florø lufthamn - BØF1 (aktivt)	Ørsta-Volda lufthamn Hovden - BØF 1 (gammelt)	Kristiansund lufthavn Kvernberget - BØF A (aktivt)	Vardø lufthavn Svartnes - BØF 1 (gammelt)	Svolvær lufthavn Helle - BØF B (Ikke aktivt)	Summary for all sites Part 2 (n= 32)
Comments regarding calculations							Added PFAS	Added water treatment	Added water treatment	Added water treatment	Added water treatment		Added PFAS and cost for active	Added water treatment	Added water treatment	Added water treatment		
Quantity of PFOS/ΣPFAS, including positive uncertainty	kg	12	6,5	6,7	7,1	12	5,5	4,0	5,2	2,9	4,6	2,8	2,3	1,8	1,4	1,5	1,1	869
Volume of material	m^3	41 164	20 295	19 061	71 035	10 219	25 826	65 220	24 674	38 081	17 508	154 906	18 489	25 263	16 559	9 302	4 974	1 495 542
Effectiveness of remedial action	g/m3	0,3	0,3	0,4	0,1	1,2	0,2	0,1	0,2	0,1	0,3	0,02	0,1	0,1	0,1	0,2	0,2	0,7
Cost of remedial action	NOK/m^3	kr 2 326	kr 2 159	kr 2 334	kr 2 190	kr 2 306	kr 2 186	kr 2 256	kr 2 249	kr 2 326	kr 1 663	kr 1 908	kr 1 952	kr 2 430	kr 1 913	kr 2 361	kr 2 268	
Cost for removal of all PFOSΣPFAS	NOK	kr 95 746 305	kr 43 820 505	kr 44 481 281	kr 155 583 350	kr 23 564 476	kr 56 447 923	kr 147 722 742	kr 56 090 779	kr 89 168 868	kr 29 710 874	kr 295 594 053	kr 116 091 078	kr 62 002 323	kr 112 284 935	kr 22 568 870	kr 11 282 784	kr 3 569 541 399
Cost-effect	NOK/kg	kr 7 831 917	kr 6 782 943	kr 6 663 525	kr 21 995 528	kr 1 900 644	kr 10 223 152	kr 37 105 369	kr 10 743 471	kr 30 287 596	kr 6 474 448	kr 105 622 526	kr 50 945 886	kr 34 844 516	kr 81 761 808	kr 15 031 939	kr 10 728 627	kr 16 584 383
Quantity of PFOS/ΣPFAS > 3 µg/kg	kg	3,4	3,2	3,1	3,0	2,8	3,2	2,5	2,1	1,1	1,0	1,0	1,1	0,8	0,7	0,6	0,5	338
Volume of material	m^3	11 436	10 244	9 075	30 428	2 283	15 561	44 907	10 168	14 748	3 811	55 035	9 581	11 664	8 096	4 761	2 360	641 307
Total weight of soil in investigated volume	tonnes	18 298	15 367	14 520	42 599	3 652	24 898	71 851	18 303	23 597	6 098	93 560	17 245	18 662	14 573	7 618	4 013	1 042 348
Effectiveness of remedial action	g/m^3	0,3	0,3	0,3	0,1	1,2	0,2	0,1	0,2	0,1	0,3	0,02	0,1	0,1	0,1	0,1	0,2	0,7
Proportion of total quantity of PFOSΣPFAS	%	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
Cost of remedial action	NOK/m^3	kr 2 326	kr 2 159	kr 2 334	kr 2 190	kr 2 306	kr 2 186	kr 2 256	kr 2 249	kr 2 326	kr 1 663	kr 1 908	kr 1 952	kr 2 430	kr 1 913	kr 2 361	kr 2 268	
Cost of removal	NOK	kr 26 599 816	kr 22 119 422	kr 21 178 704	kr 66 644 023	kr 5 263 381	kr 34 011 689	kr 101 902 772	kr 23 470 796	kr 34 903 401	kr 6 940 008	kr 105 018 730	kr 98 701 665	kr 28 950 674	kr 96 093 062	kr 11 845 771	kr 5 354 457	kr 1 712 547 179
Cost-effect	NOK/kg	kr 7 858 014	kr 6 994 402	kr 6 752 501	kr 22 429 291	kr 1 901 864	kr 10 769 970	kr 40 291 117	kr 11 102 498	kr 31 074 753	kr 6 973 617	kr 106 902 921	kr 86 403 209	kr 35 257 654	kr 147 187 528	kr 18 780 833	kr 10 892 932	kr 20 402 690
Quantity of PFOS/ΣPFAS > 30 µg/kg	kg	3,0	3,1	3,1	2,8	2,8	2,9	2,1	2,1	1,0	1,0	0,3	1,1	0,6	0,6	0,6	0,5	332
Volume of material	m^3	5 624	6 791	6 936	20 520	2 283	8 314	13 962	8 395	6 576	3 752	10 495	6 136	4 199	7 108	3 437	2 246	441 582
Effectiveness of remedial action	g/m^3	0,5	0,5	0,4	0,1	1,2	0,4	0,1	0,3	0,1	0,3	0,03	0,2	0,1	0,1	0,2	0,2	0,8
Proportion of total quantity of PFOSΣPFAS	%	90 %	97 %	98 %	94 %	100 %	92 %	82 %	99 %	87 %	100 %	33 %	95 %	70 %	96 %	94 %	99 %	94 %
Cost of remedial action	NOK/m^3	kr 2 326	kr 2 159	kr 2 334	kr 2 190	kr 2 306	kr 2 186	kr 2 256	kr 2 249	kr 2 326	kr 1 663	kr 1 908	kr 1 952	kr 2 430	kr 1 913	kr 2 361	kr 2 268	
Cost of removal	NOK	kr 13 081 267	kr 14 662 505	kr 16 185 129	kr 44 943 320	kr 5 263 381	kr 18 172 790	kr 32 098 642	kr 19 483 187	kr 15 897 730	kr 6 842 253	kr 20 026 739	kr 91 977 436	kr 10 808 982	kr 94 202 831	kr 8 719 483	kr 5 094 038	kr 1 279 537 818
Cost-effect	NOK/kg	kr 4 300 984	kr 4 779 044	kr 5 292 236	kr 16 169 954	kr 1 901 864	kr 6 230 902	kr 15 483 569	kr 9 275 592	kr 16 229 444	kr 6 881 921	kr 62 360 037	kr 85 045 636	kr 18 707 704	kr 150 261 580	kr 14 681 400	kr 10 416 739	kr 15 932 740
Amount of PFOS/ΣPFAS > 150 µg/kg	kg	2,7	2,8	2,6	1,6	2,7	2,1	1,0	1,9	0,6	0,8		0,7	0,2		0,3	0,3	310
Volume of material	m^3	3 140	3 000	2 941	6 910	2 160	2 951	2 673	5 537	2 034	1 786		2 138	504		1 053	879	233 477
Effectiveness of remedial action	g/m^3	0,9	0,9	0,9	0,2	1,3	0,7	0,4	0,3	0,3	0,5		0,3	0,4		0,3	0,4	1,2
Proportion of total quantity of PFOSΣPFAS	%	81 %	88 %	82 %	53 %	99 %	67 %	40 %	88 %	53 %	82 %		58 %	23 %		49 %	67 %	78 %
Cost of remedial action	NOK/m^3	kr 2 326	kr 2 159	kr 2 334	kr 2 190	kr 2 306	kr 2 186	kr 2 256	kr 2 249	kr 2 326	kr 1 663		kr 1 952	kr 2 430		kr 2 361	kr 2 268	
Cost of removal	NOK	kr 7 303 552	kr 6 477 516	kr 6 862 373	kr 15 134 422	kr 4 980 900	kr 6 449 347	kr 6 633 500	kr 13 056 506	kr 5 334 372	kr 3 572 446		kr 84 172 582	kr 1 829 760		kr 3 090 276	kr 1 994 424	kr 756 949 224
Cost-effect	NOK/kg	kr 2 677 224	kr 2 315 714	kr 2 656 722	kr 9 701 972	kr 1 817 672	kr 3 028 427	kr 6 617 077	kr 6 986 301	kr 9 006 187	kr 4 396 752		kr 127 662 179	kr 9 647 867		kr 9 941 513	kr 6 090 298	kr 8 619 239
Quantity of PFOS/ΣPFAS > 500 µg/kg	kg	1,8	2,4	1,8		2,4	1,5	0,1	0,7	0,003	0,5						0,1	257
Volume of material	m^3	1 364	1 673	1 218		1 400	1 269	159	1 261	5	572						106	105 586
Effectiveness of remedial action	g/m^3	1,3	1,4	1,5		1,7	1,2	0,8	0,6	0,6	0,9						0,7	1,9
Proportion of total quantity of PFOSΣPFAS	%	53 %	75 %	57 %		86 %	47 %	5 %	33 %	0 %	50 %						16 %	57 %
Cost of remedial action	NOK/m^3	kr 2 326	kr 2 159	kr 2 334		kr 2 306	kr 2 186	kr 2 256	kr 2 249	kr 2 326	kr 1 663						kr 2 268	
Cost of removal	NOK	kr 3 172 626	kr 3 611 863	kr 2 842 637		kr 3 228 361	kr 2 774 091	kr 962 549	kr 3 438 749	kr 614 351	kr 1 555 500						kr 239 775	kr 398 490 171
Cost-effect	NOK/kg	kr 1 757 839	kr 1 528 076	kr 1 594 033		kr 1 364 029	kr 1 869 271	kr 8 016 111	kr 4 952 554	kr 239 009 757	kr 3 124 432						kr 3 025 815	kr 12 731 414
Quantity of PFOS/ΣPFAS > 1000 µg/kg	kg	0,5	1,9	0,9		1,7	0,7				0,2							204
Volume of material	m^3	256	953	429		800	450				198							51 702
Effectiveness of remedial action	g/m^3	1,9	2,0	2,0		2,1	1,6				1,1							3,3
Proportion of total quantity of PFOSΣPFAS	%	14 %	59 %	27 %		62 %	23 %				23 %							52 %
Cost of remedial action	NOK/m^3	kr 2 326	kr 2 159	kr 2 334		kr 2 306	kr 2 186				kr 1 663							
Cost of removal	NOK	kr 595 449	kr 2 057 259	kr 1 001 142		kr 1 844 778	kr 984 221				kr 933 060							kr 277 555 883
Cost-effect	NOK/kg	kr 1 215 495	kr 1 102 518	kr 1 175 294		kr 1 076 913	kr 1 357 484				kr 4 107 762							kr 25 437 273
Quantity of PFOS/ΣPFAS > 3000 µg/kg	kg		0,6															115
Volume of material	m^3		182															14 843
Effectiveness of remedial action	g/m^3		3,3															6,8
Proportion of total quantity of PFOSΣPFAS	%		19 %															40 %
Cost of remedial action	NOK/m^3		kr 2 159															
Cost of removal	NOK		kr 393 833															kr 117 383 669
Cost-effect	NOK/kg		kr 645 261															kr 6 196 491



Figure 5: At Tromsø BØF 2, the action limit is set to concentrations of ∑PFAS >150 µg/kg, which removes 98% of the contamination. If the action limit is reduced from >150µg/kg to >30µg/kg, the cost per kg of∑PFAS removed increases by approximately NOK 180,000, which represents an increase in the total cost of approximately NOK 18.4 million. The increase in effect is only 1 kg more (from 96 to 97 kg).

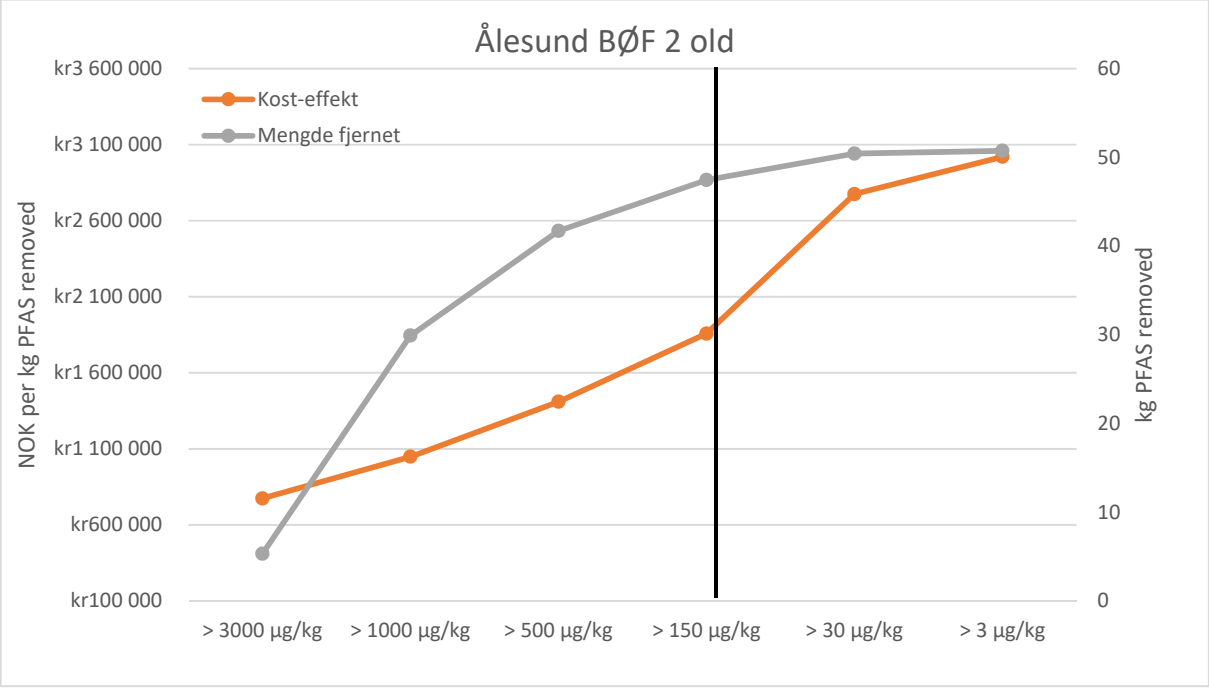


Figure 6: At Ålesund BØF 2, the action limit is set to concentrations of ∑PFAS >150 µg/kg, which removes 94% of the contamination. If the action limit is reduced from >150µg/kg to >30 µg/kg, the cost per kg of ∑ PFAS removed increases by approximately NOK 917,000, which represents an increase in the total cost of approximately NOK 51.8 million. The increase in effect is 3 kg more (from 47 to 50 kg).

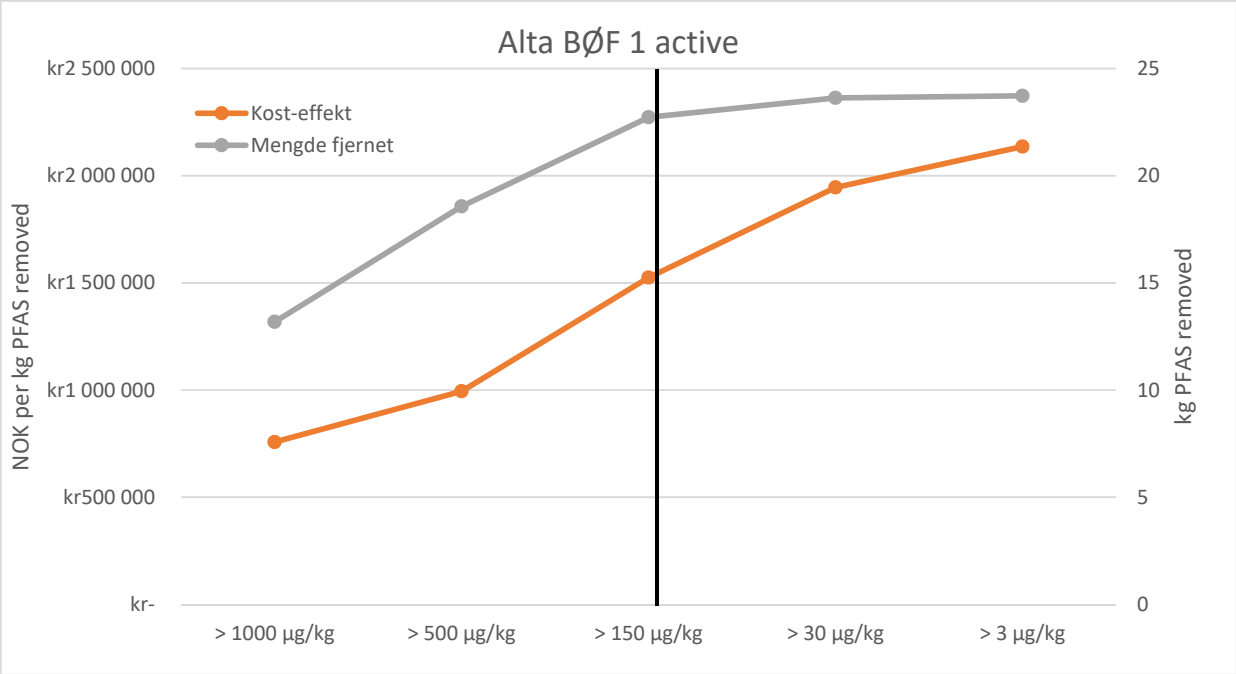


Figure 7: At Alta BØF 1, the action limit is set to concentrations of ∑PFAS > 150 µg/kg, which removes 96% of the contamination. If the action limit is reduced from >150 µg/kg to >30 µg/kg, the cost per kg of ∑PFAS removed increases by approximately NOK 420,000, which represents an increase in the total cost of approximately NOK 11 million. The increase in effect is 1 kg more (from 23 to 24 kg).

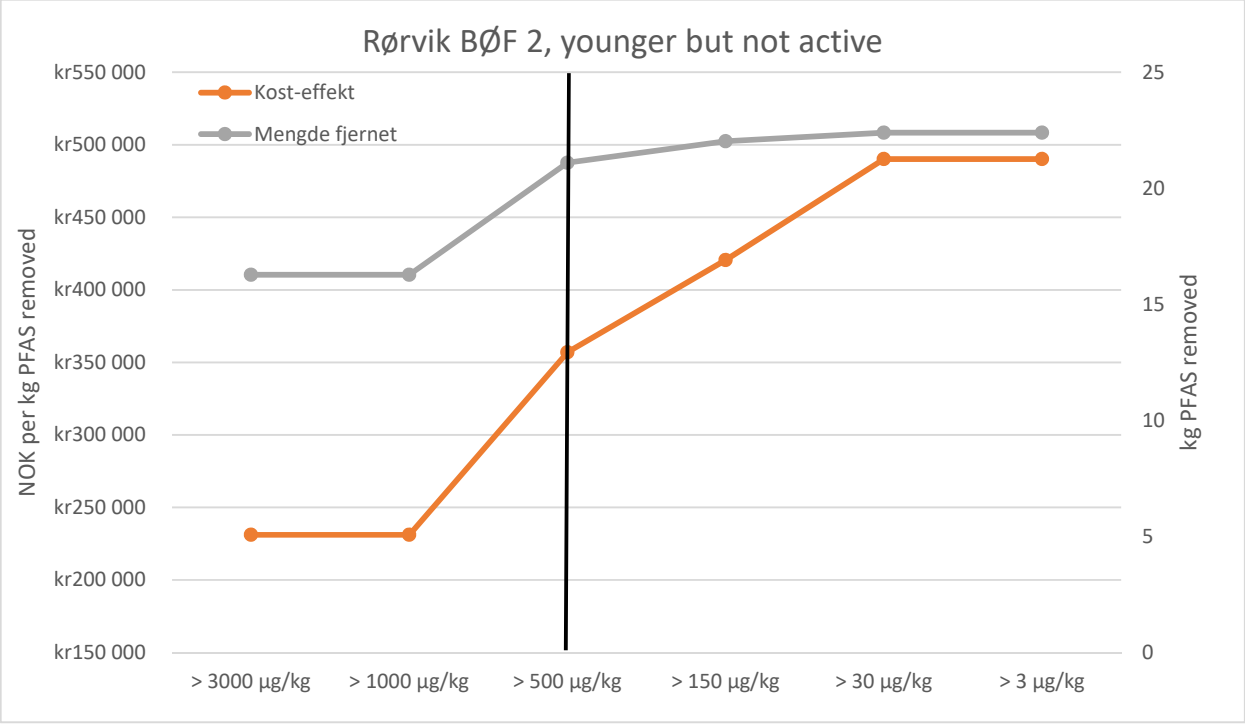


Figure 8: At Rørvik BØF 2, the action limit is set to concentrations of ∑PFAS > 500 µg/kg, which removes 94% of the contamination. If the action limit is reduced from >500 µg/kg to >150 µg/kg, the cost per kg of ∑PFAS removed increases by approximately NOK 63,000, which represents an increase in the total cost of approximately NOK 1.7 million. The increase in effect is 1 kg more (from 21 to 22 kg).

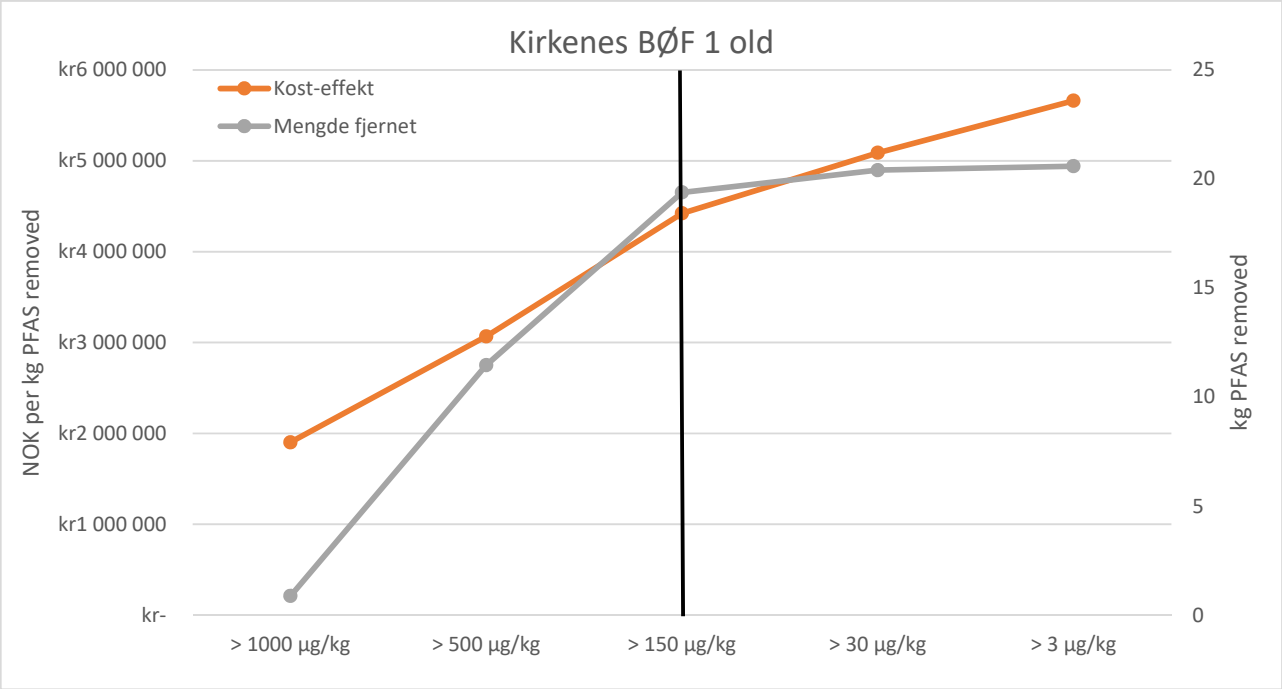


Figure 9: At Kirkenes BØF 1, the action limit is set to concentrations of ∑PFAS > 150 µg/kg, which removes 94% of the contamination. If the action limit is reduced from >150 µg/kg to >30 µg/kg, the cost per kg of ∑PFAS removed increases by approximately NOK 670,000, which represents an increase in the total cost of approximately NOK 18 million. The increase in effect is 1 kg more (from 19 to 20 kg).

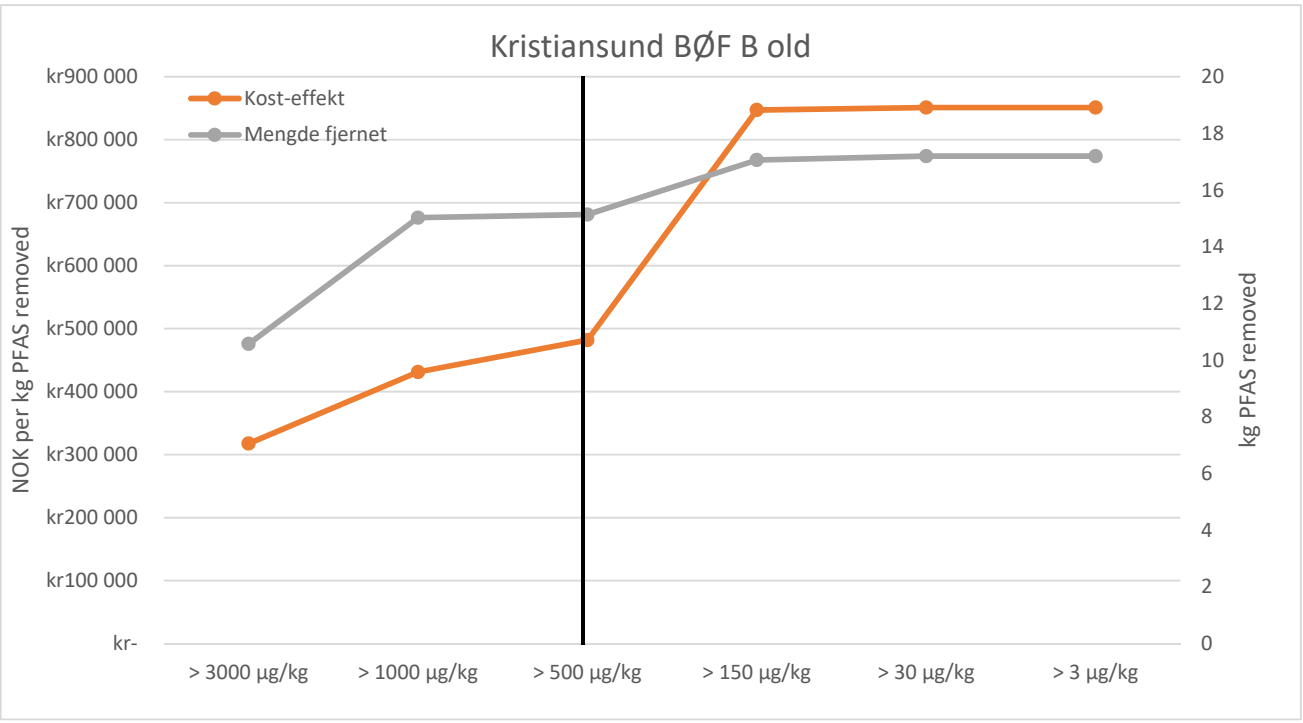


Figure 10: At Kristiansund BØF B, the action limit is set to concentrations of ∑PFAS > 500 µg/kg, which removes 88% of the contamination. If the action limit is reduced from >500 µg/kg to >150 µg/kg, the cost per kg of ∑PFAS removed increases by approximately NOK 370 000, which represents an increase in the total cost of approximately NOK 7 million. The increase in effect is 2 kg more (from 15 to 17 kg).

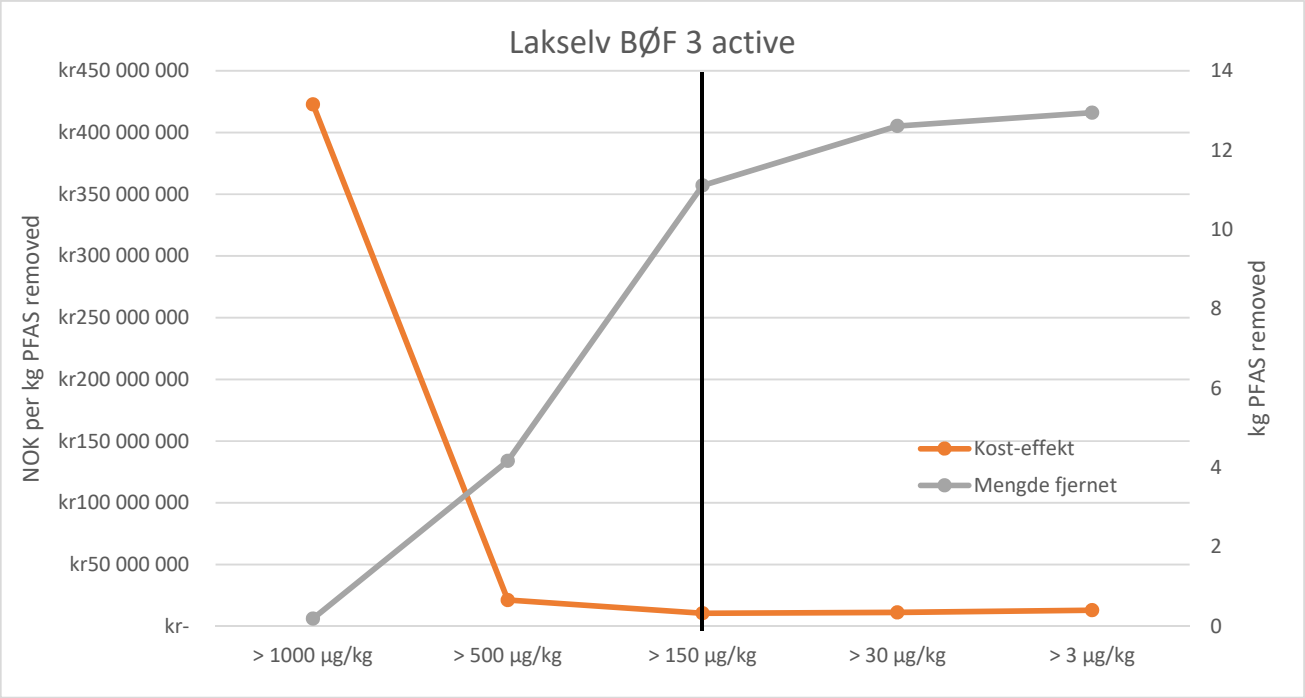


Figure 11: At Lakselv BØF 3, the action limit is set to concentrations of ∑PFAS > 150 µg/kg, which removes 84% of the contamination. If the action limit is reduced from >150 µg/kg to >30 µg/kg, the cost per kg of ∑PFAS removed increases by approximately NOK 650,000, which represents an increase in the total cost of approximately NOK 24 million. The increase in effect is 2 kg more (from 11 to 13 kg).

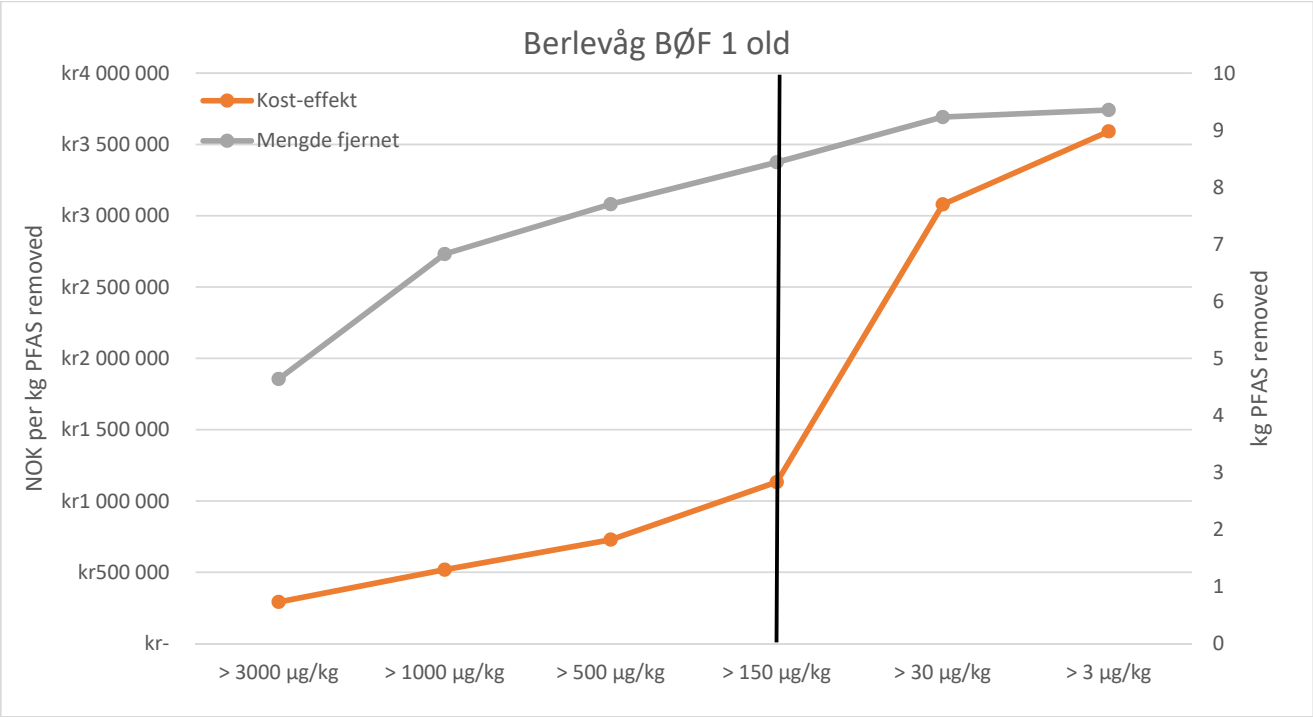


Figure 12: At Berlevåg BØF 1, the action limit is set to concentrations of ∑PFAS > 150 µg/kg, which removes 90% of the contamination. If the action limit is reduced from >150 µg/kg to >30 µg/kg, the cost per kg of ∑PFAS removed increases by approximately NOK 1.9 million, which represents an increase in the total cost of approximately NOK 18.9 million. The increase in effect is 0.8 kg more (from 8.4 to 9.2 kg).

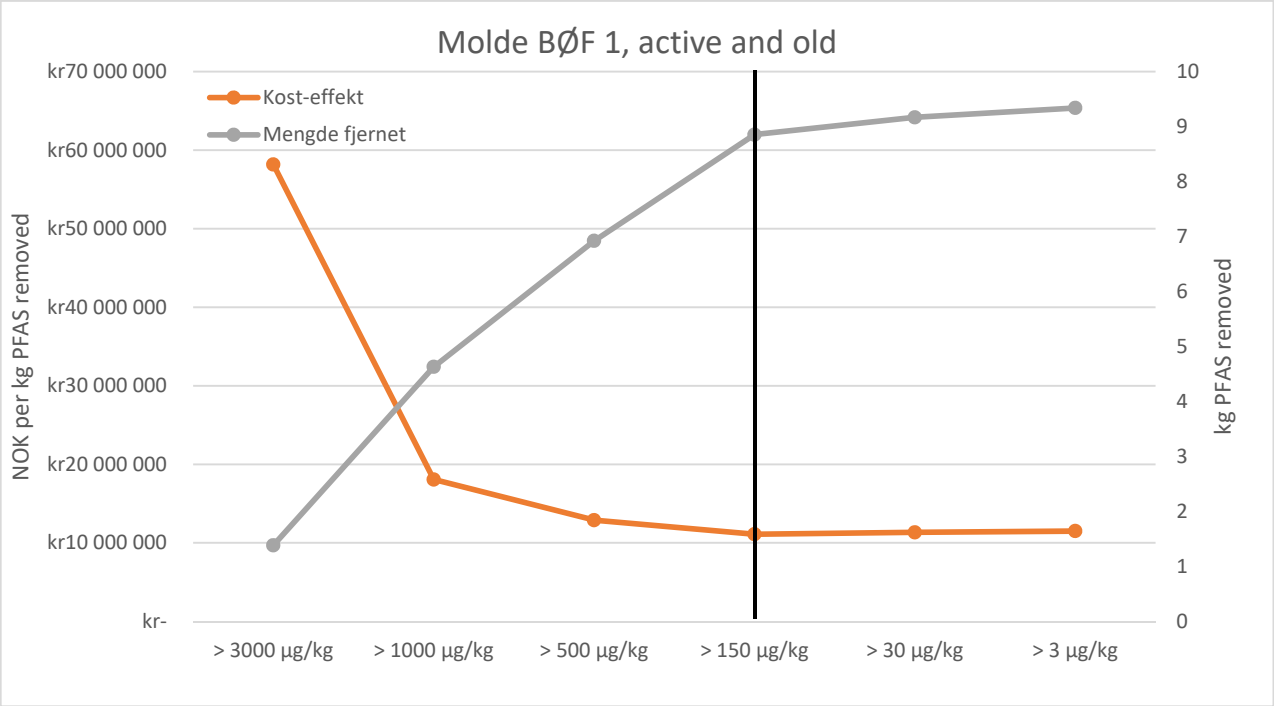


Figure 13: At Molde BØF 1, the action limit is set to concentrations of ∑PFAS > 150 µg/kg, which removes 95% of the contamination. If the action limit is reduced from >150 µg/kg to >30 µg/kg, the cost per kg of ∑PFAS removed increases by approximately NOK 240,000, which represents an increase in the total cost of approximately NOK 5.7 million. The increase in effect is 0.3 kg more (from 8.9 to 9.2 kg).

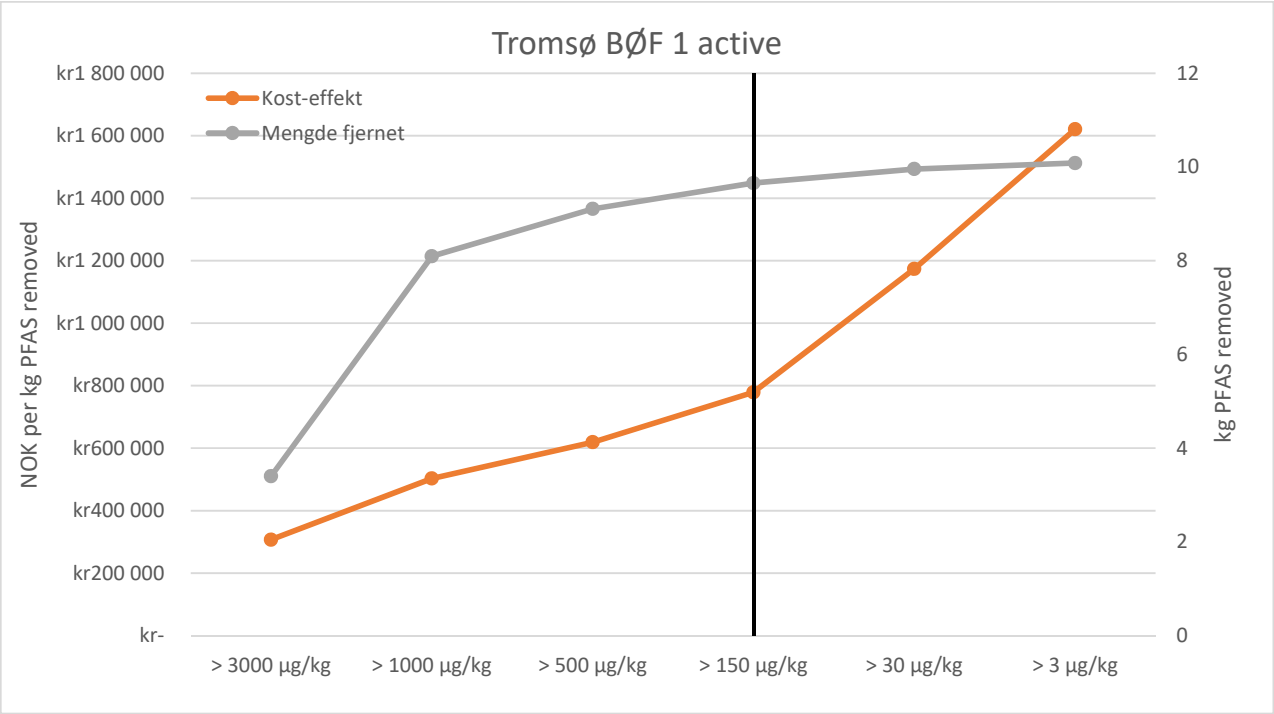


Figure 14: At Tromsø BØF 1, the action limit is set to concentrations of ∑PFAS > 150 µg/kg, which removes 96% of the contamination. If the action limit is reduced from >150 µg/kg to >30 µg/kg, the cost per kg of ∑PFAS removed increases by approximately NOK 400,000, which represents an increase in the total cost of approximately NOK 4.2 million. The increase in effect is 0.3 kg more (from 9.7 to 10 kg).

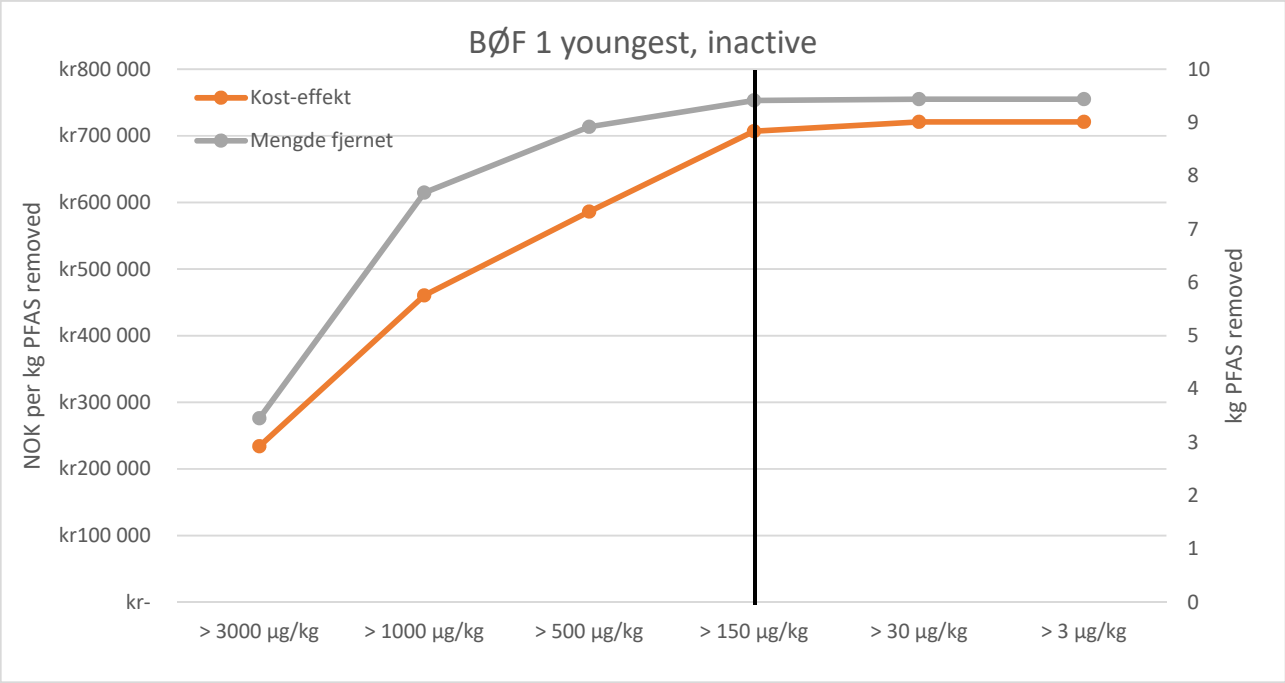


Figure 15: At Bergen BØF 1, the action limit is set to concentrations of ∑PFAS > 150 µg/kg, which removes 100% of the contamination. If the action limit is reduced from >150 µg/kg to >30 µg/kg, the cost per kg of ∑PFAS removed increases by approximately NOK 14,000, which represents an increase in the total cost of approximately NOK 150,000 million, even though the effect is no higher.

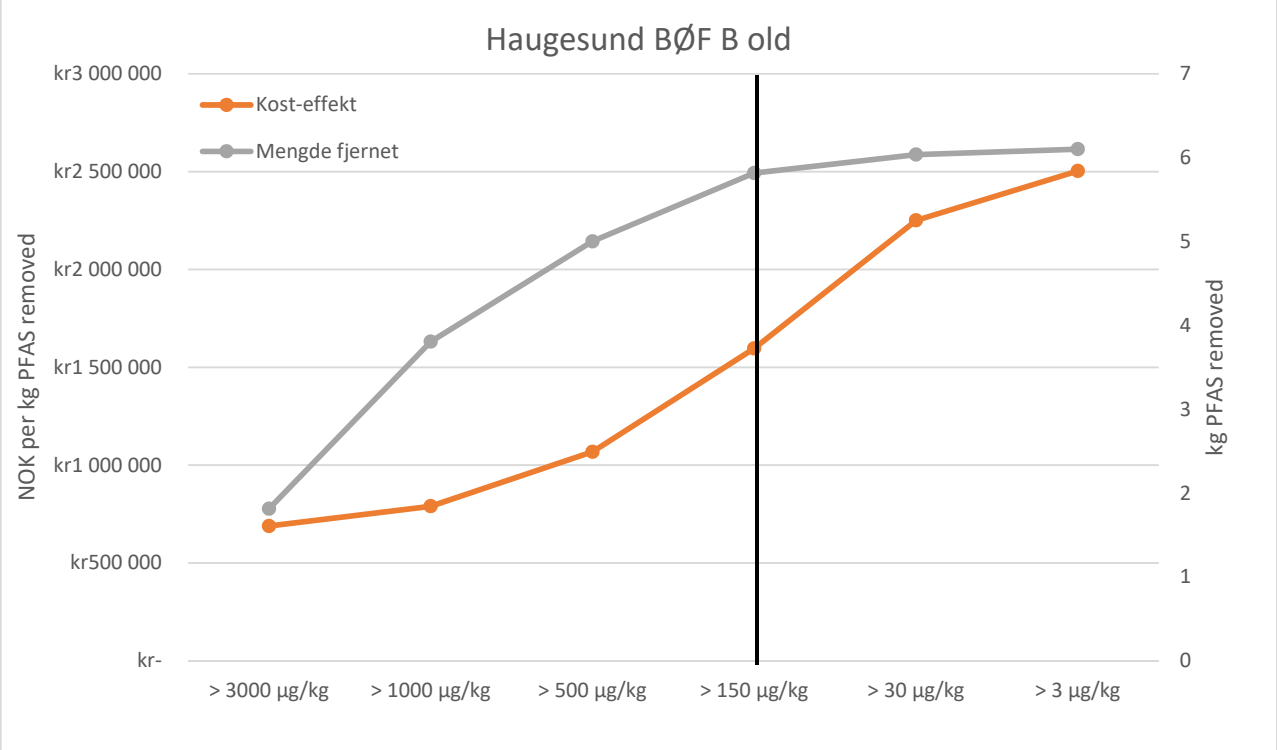


Figure 16: At Haugesund BØF B, the action limit is set to concentrations of ∑PFAS > 150 µg/kg, which removes 95% of the contamination. If the action limit is reduced from >150 µg/kg to >30 µg/kg, the cost per kg of ∑PFAS removed increases by approximately NOK 650,000, which represents an increase in the total cost of approximately NOK 4.3 million. The increase in effect is 0.2 kg more (from 5.8 to 6 kg).

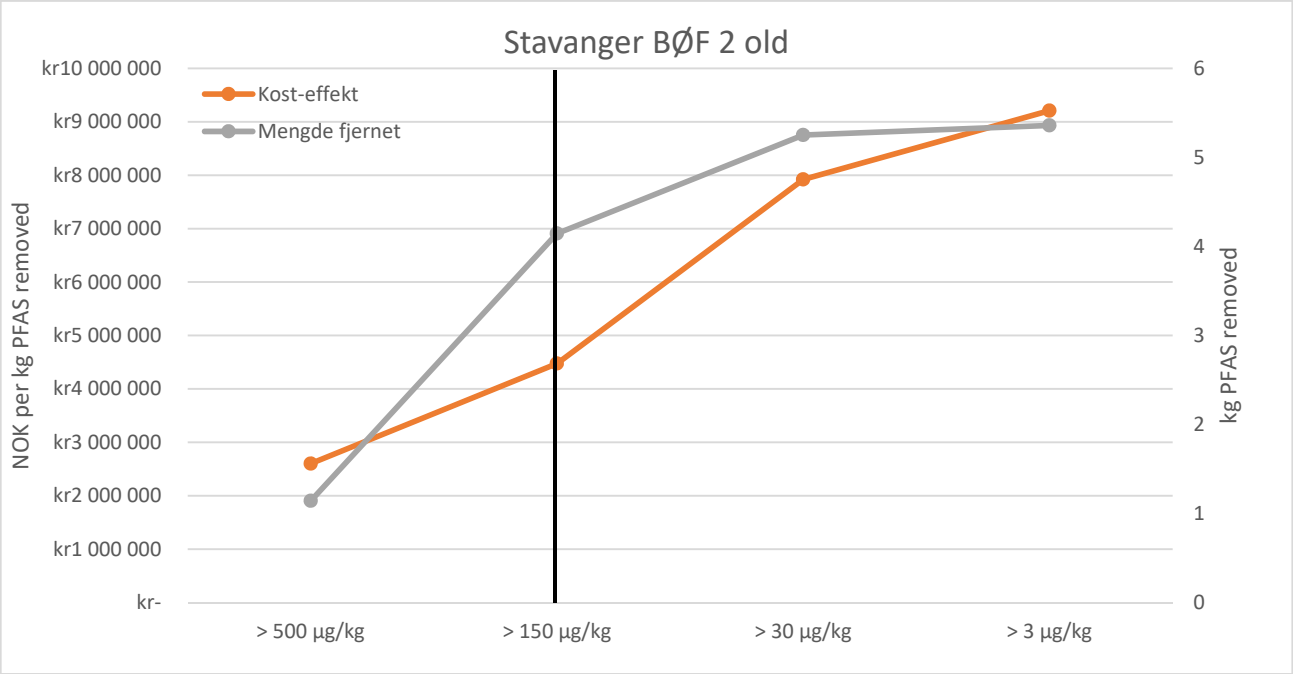


Figure 17: At Stavanger BØF 2, the action limit is set to concentrations of ∑PFAS > 150 µg/kg, which removes 77% of the contamination. If the action limit is reduced from >150 µg/kg to >30 µg/kg, the cost per kg of ∑PFAS removed increases by approximately NOK 3.4 million, which represents an increase in the total cost of approximately NOK 23 million. The increase in effect is 1.3 kg more (from 4.1 to 5.3 kg).

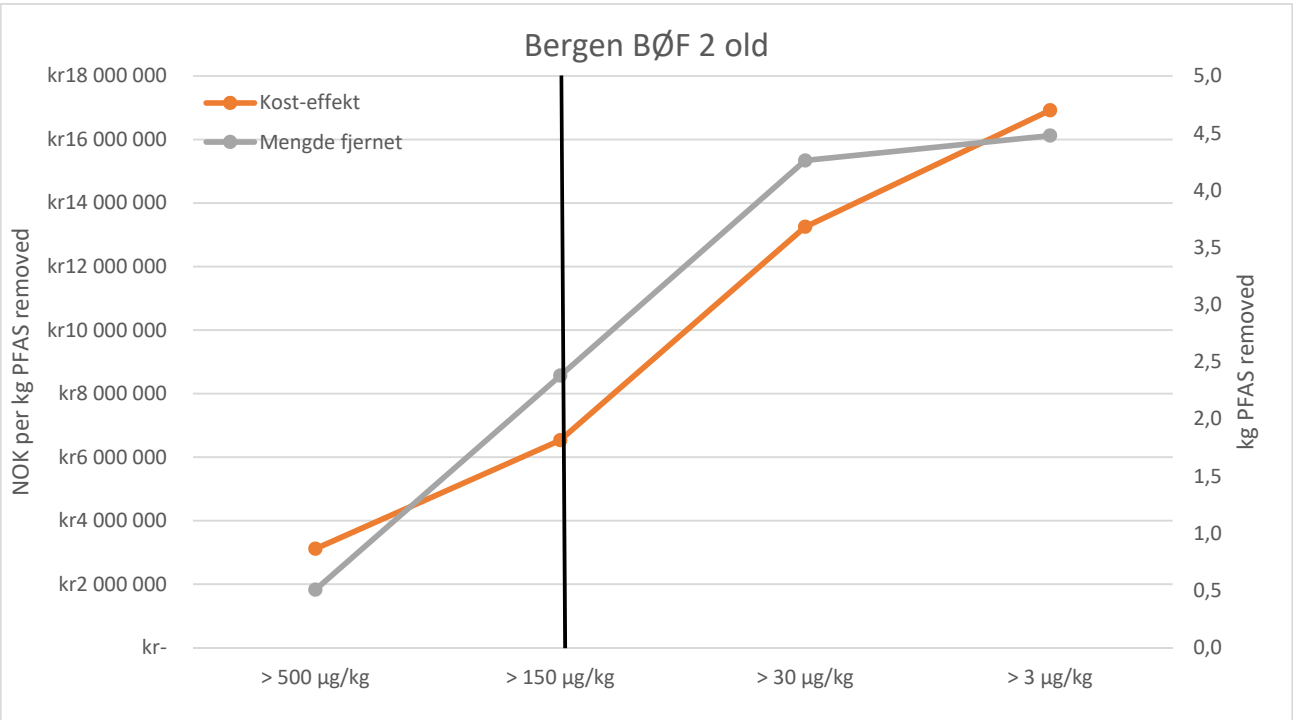


Figure 18: At Bergen BØF 2, the action limit is set to concentrations of ∑PFAS > 150 µg/kg, which removes 53% of the contamination. If the action limit is reduced from >150 µg/kg to >30 µg/kg, the cost per kg of ∑PFAS removed increases by approximately NOK 6.7 million, which represents an increase in the total cost of approximately NOK 41 million. The increase in effect is 1.9 kg more (from 2.4 to 4.3 kg).

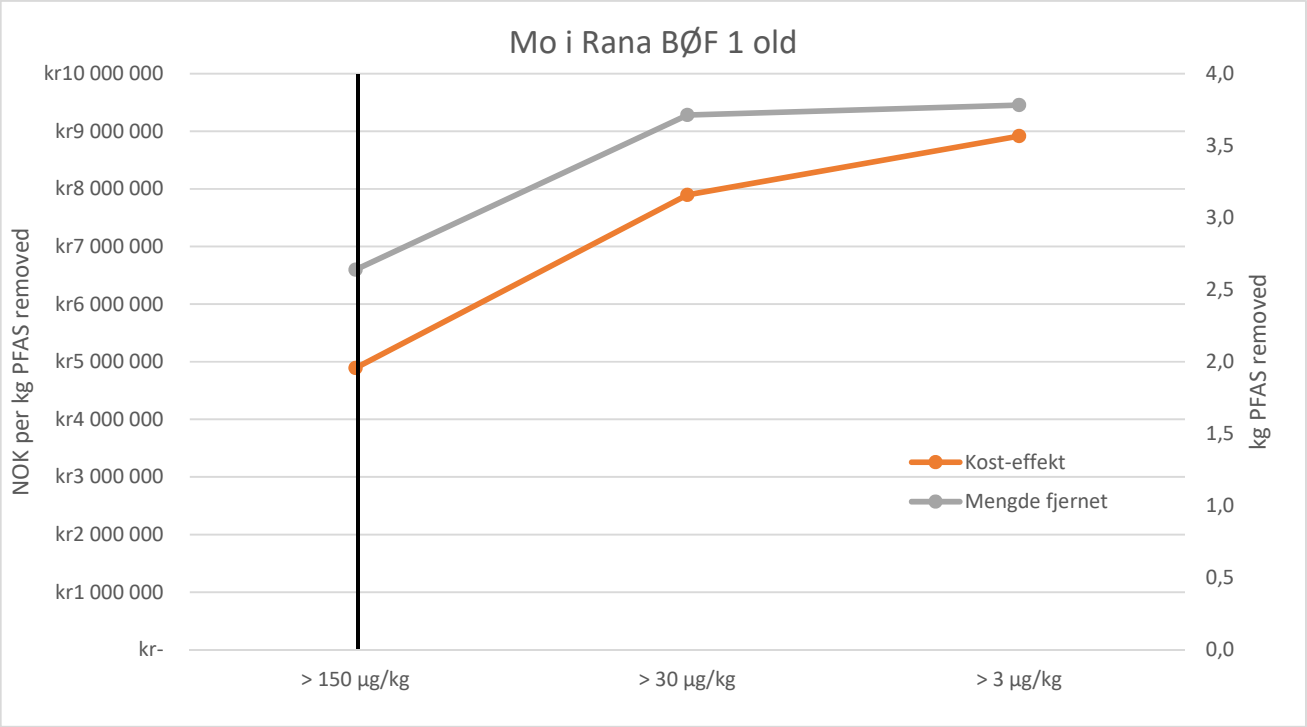


Figure 19: At Mo i Rana BØF 1, the action limit is set to concentrations of ∑PFAS > 150 µg/kg, which removes 70% of the contamination. If the action limit is reduced from >150 µg/kg to >30 µg/kg, the cost per kg of ∑PFAS removed increases by approximately NOK 3 million, which represents an increase in the total cost of approximately NOK 16 million. The increase in effect is 1.1 kg more (from 2.6 to 3.7 kg).



Figure 20: At Røros BØF 1, the action limit is set to concentrations of ∑PFAS > 150 µg/kg, which removes 56% of the contamination. If the action limit is reduced from >150 µg/kg to >30 µg/kg, the cost per kg of ∑PFAS removed increases by approximately NOK 6.4 million, which represents an increase in the total cost of approximately NOK 33 million. The increase in effect is 1.5 kg more (from 2.5 to 4 kg).

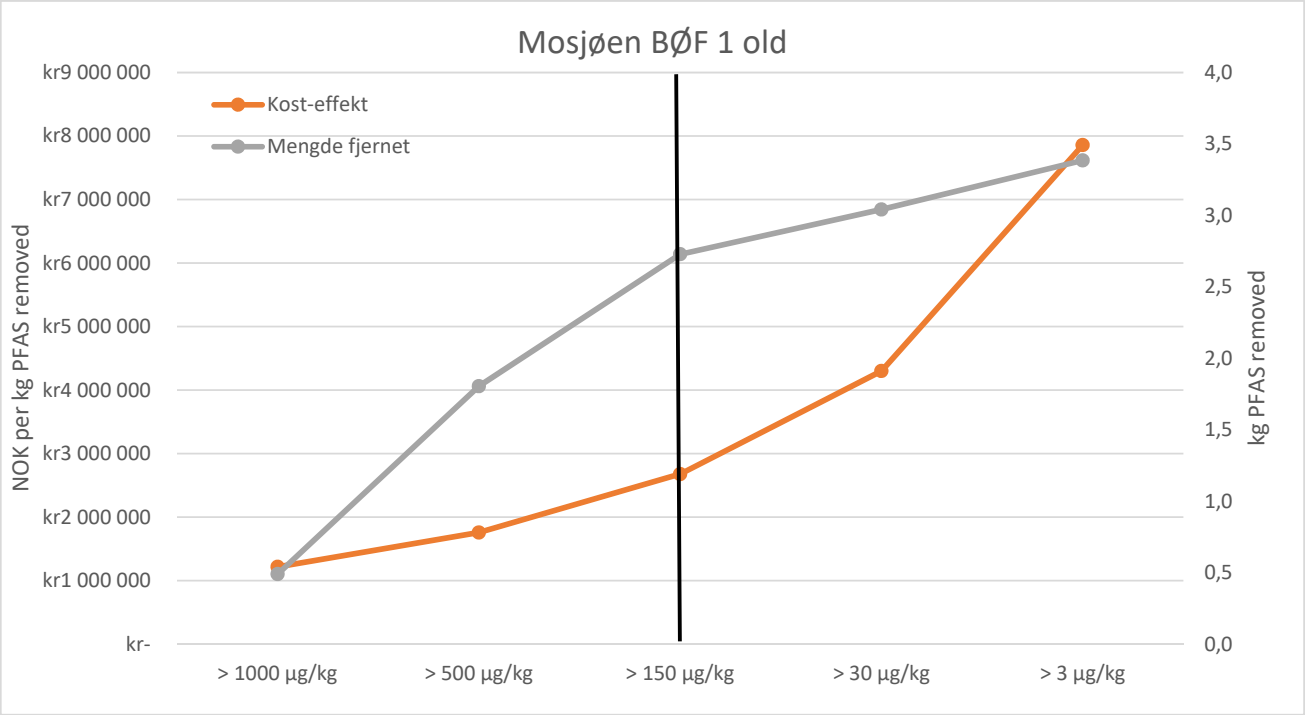


Figure 21: At Mosjøen BØF 1, the action limit is set to concentrations of ∑PFAS > 150 µg/kg, which removes 81% of the contamination. If the action limit is reduced from >150 µg/kg to >30 µg/kg, the cost per kg of ∑PFAS removed increases by approximately NOK 1,6 million, which represents an increase in the total cost of approximately NOK 5.8 million. The increase in effect is 0.3 kg more (from 2.7 to 3 kg).

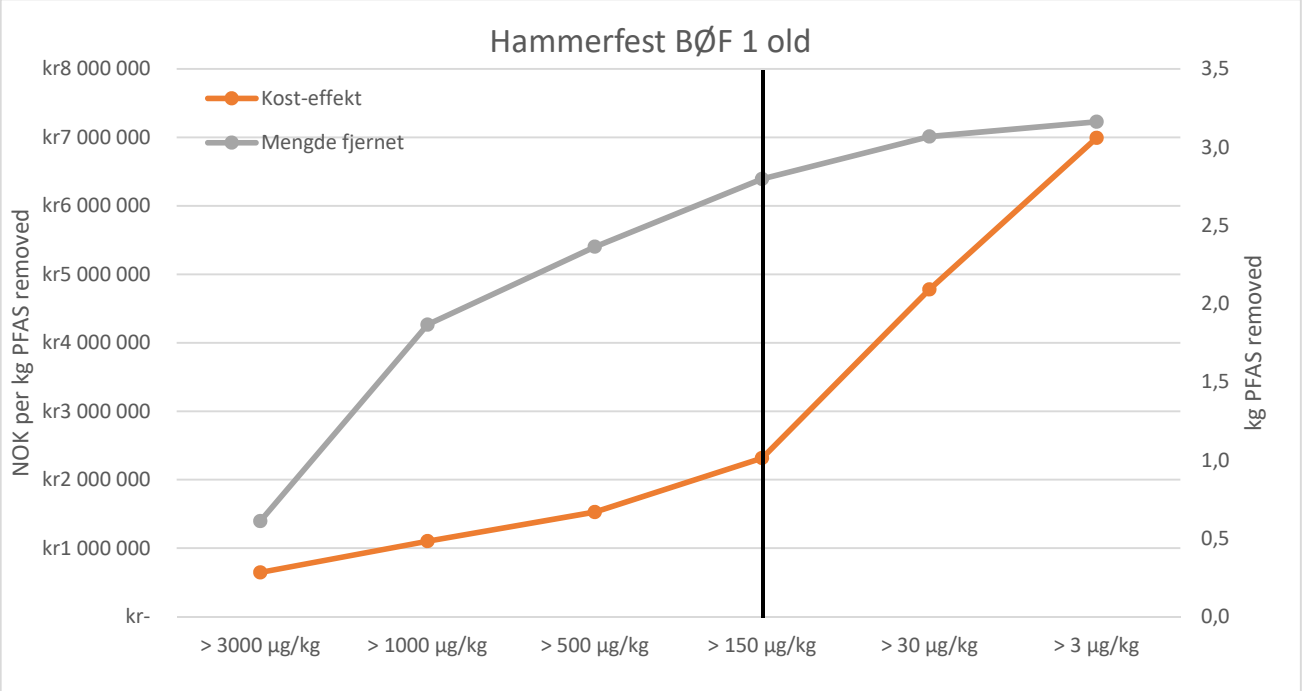


Figure 22: At Hammerfest BØF 1, the action limit is set to concentrations of ∑PFAS > 150 µg/kg, which removes 88% of the contamination. If the action limit is reduced from >150 µg/kg to >30 µg/kg, the cost per kg of ∑PFAS removed increases by approximately NOK 2.5 million, which represents an increase in the total cost of approximately NOK 8 million. The increase in effect is 0.3 kg more (from 2.8 to 3.1 kg).

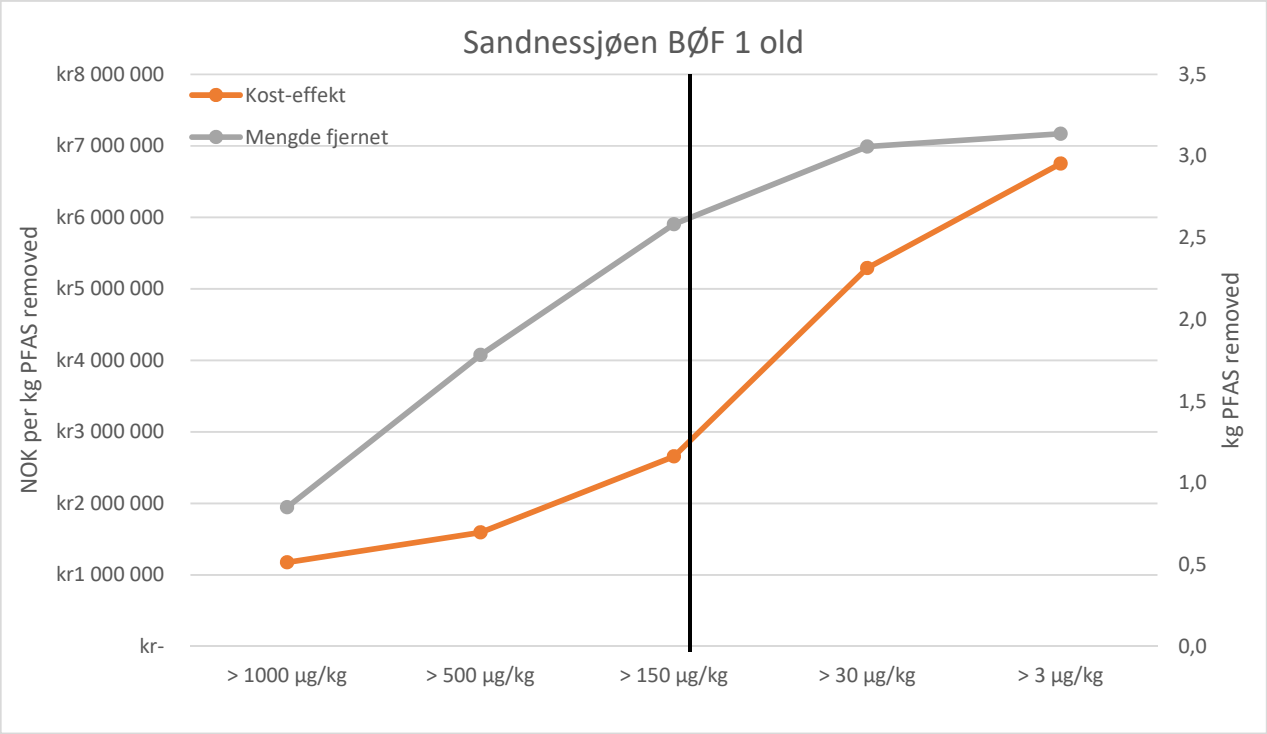


Figure 23: At Sandnessjøen BØF 1, the action limit is set to concentrations of ∑PFAS > 150 µg/kg, which removes 82% of the contamination. If the action limit is reduced from >150 µg/kg to >30 µg/kg, the cost per kg of ∑PFAS removed increases by approximately NOK 2.6 million, which represents an increase in the total cost of approximately NOK 9 million. The increase in effect is 0.5 kg more (from 2.6 to 3.1 kg).

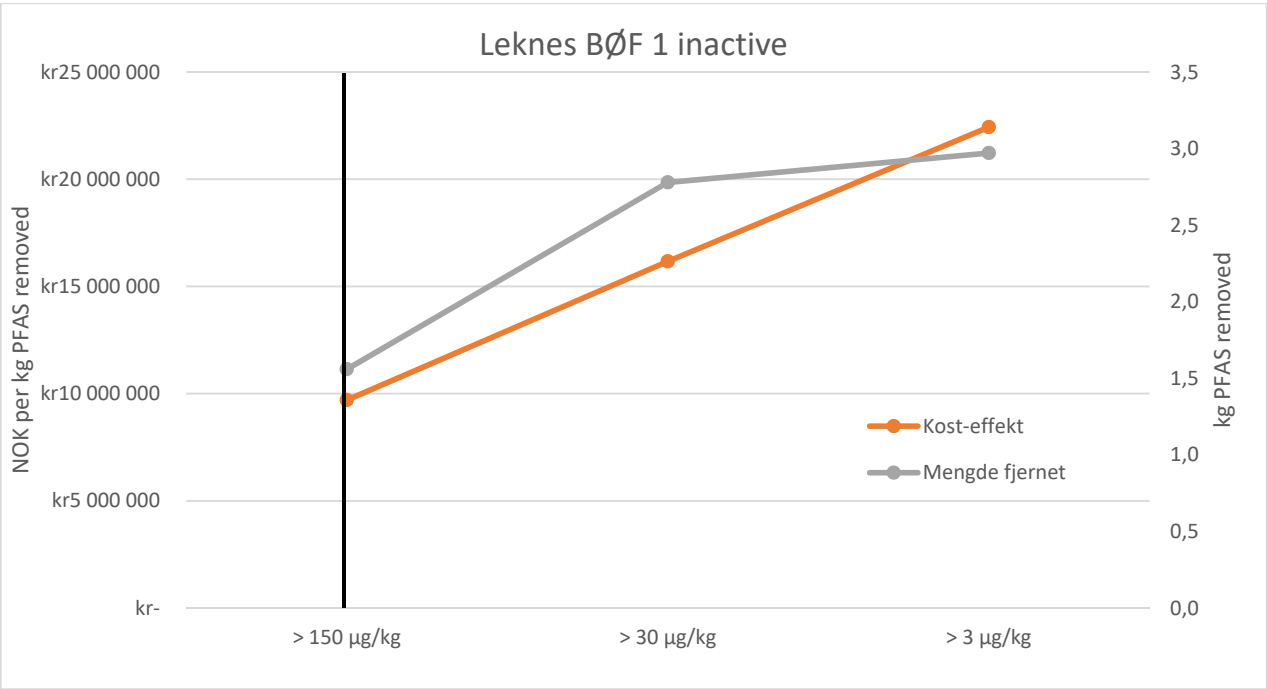


Figure 24: At Leknes BØF 1, the action limit is set to concentrations of ∑PFAS > 150 µg/kg, which removes 53% of the contamination. If the action limit is reduced from >150 µg/kg to >30 µg/kg, the cost per kg of ∑PFAS removed increases by approximately NOK 6.5 million, which represents an increase in the total cost of approximately NOK 30 million. The increase in effect is 1.2 kg more (from 1.6 to 2.8 kg).

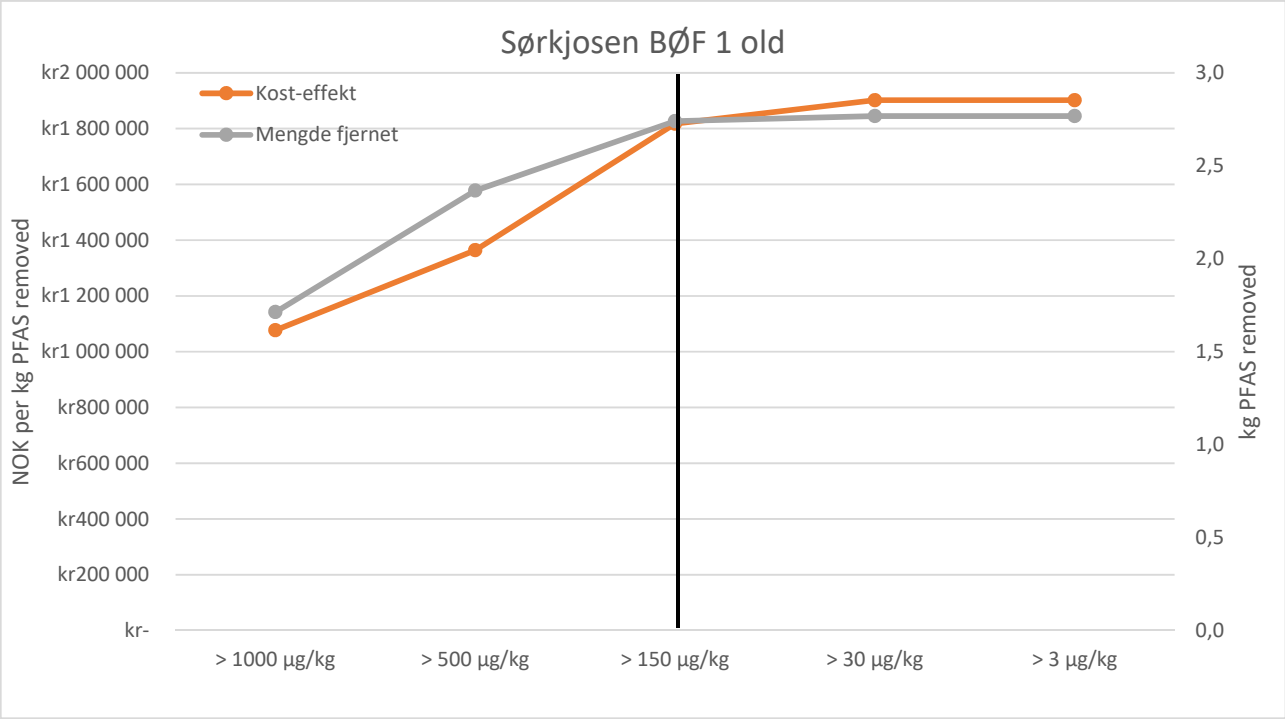


Figure 25: At Sørkjosen BØF 1, the action limit is set to concentrations of ∑PFAS > 150 µg/kg, which removes 53% of the contamination. If the action limit is reduced from >150 µg/kg to >30 µg/kg, the cost per kg of ∑PFAS removed increases by approximately NOK 84,000, which represents an increase in the total cost of approximately NOK 282,000. The increase in effect is 0.1 kg more (from 2.7 to 2.8 kg).

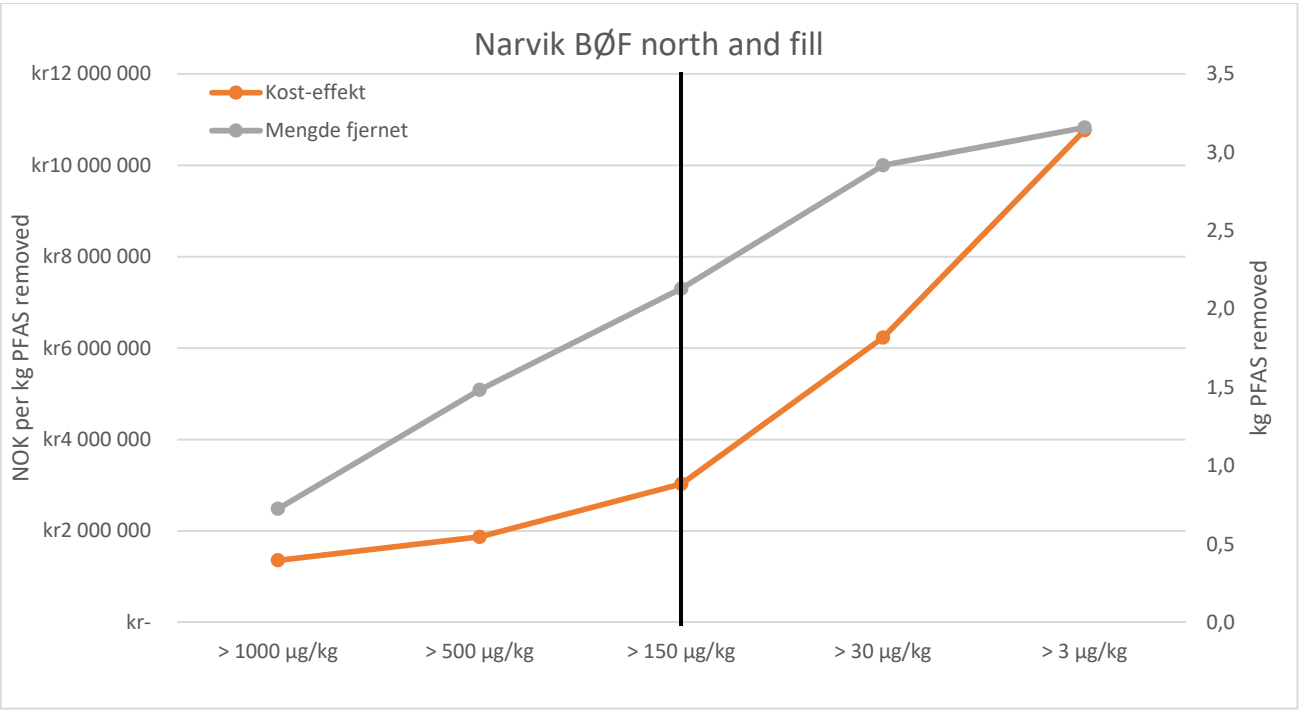


Figure 26: At Narvik BØF north and fill, the action limit is set to concentrations of ∑PFAS > 150 µg/kg, which removes 67% of the contamination. If the action limit is reduced from >150 µg/kg to >30 µg/kg, the cost per kg of ∑PFAS removed increases by approximately NOK 3.2 million, which represents an increase in the total cost of approximately NOK 11.7 million. The increase in effect is 0.8 kg more (from 2.1 to 2.9 kg).

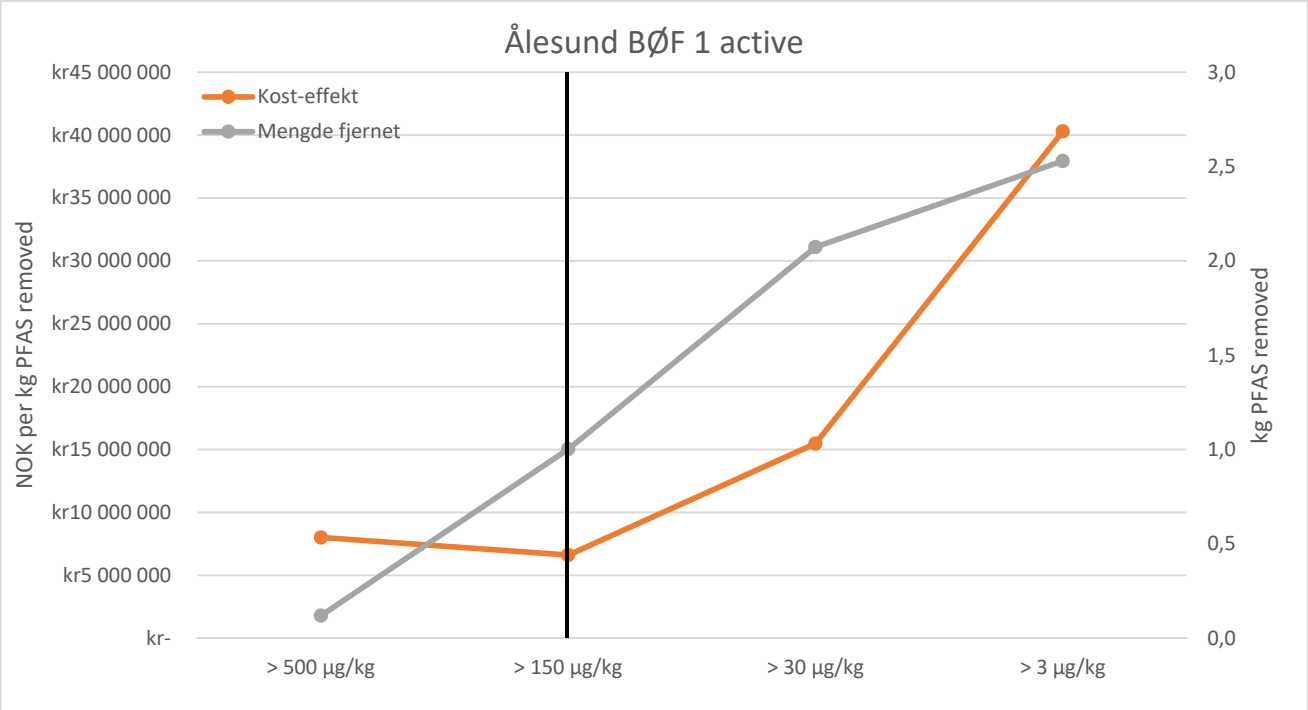


Figure 27: At Ålesund BØF 1, the action limit is set to concentrations of ∑PFAS > 150 µg/kg, which removes 40% of the contamination. If the action limit is reduced from >150 µg/kg to >30 µg/kg, the cost per kg of ∑PFAS removed increases by approximately NOK 8.9 million, which represents an increase in the total cost of approximately NOK 25 million. The increase in effect is 1.1 kg more (from 1 to 2.1 kg).

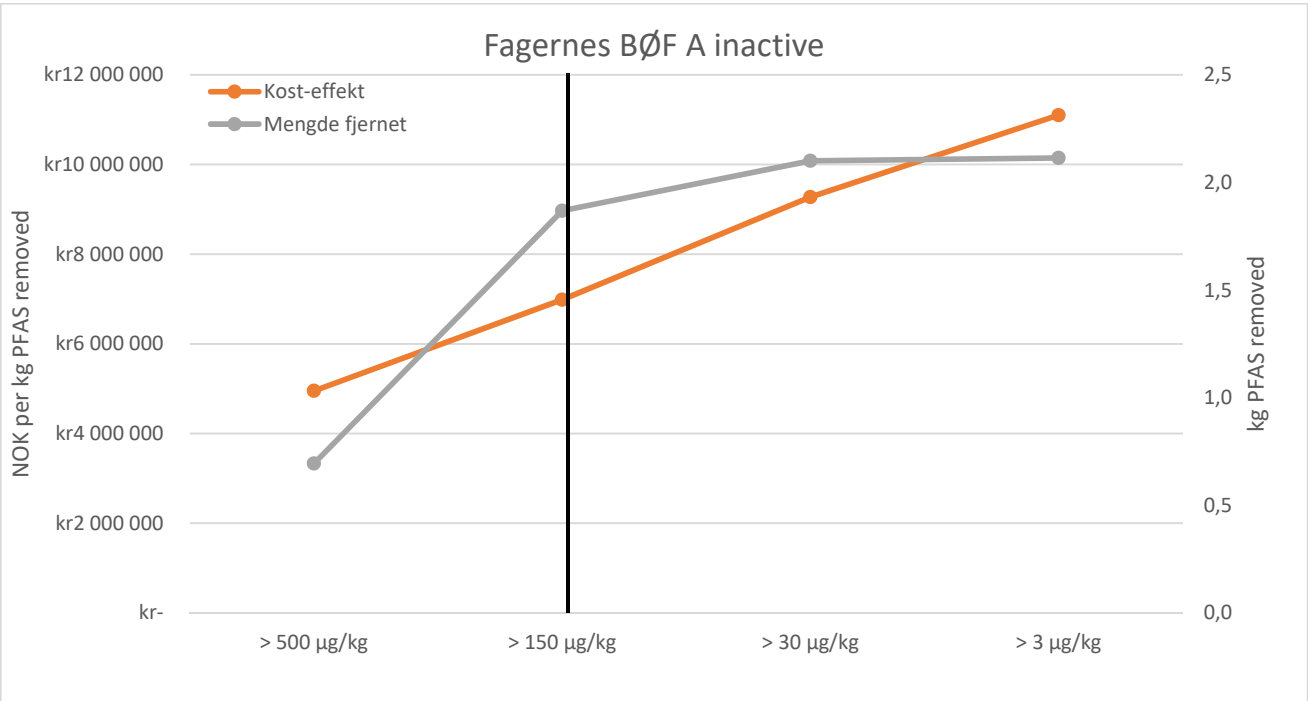


Figure 28: At Fagernes BØF A, the action limit is set to concentrations of ∑PFAS > 150 µg/kg, which removes 88% of the contamination. If the action limit is reduced from >150 µg/kg to >30 µg/kg, the cost per kg of ∑ PFAS removed increases by approximately NOK 2.3 million, which represents an increase in the total cost of approximately NOK 6.4 million. The increase in effect is 0.2 kg more (from 1.9 to 2.1 kg).

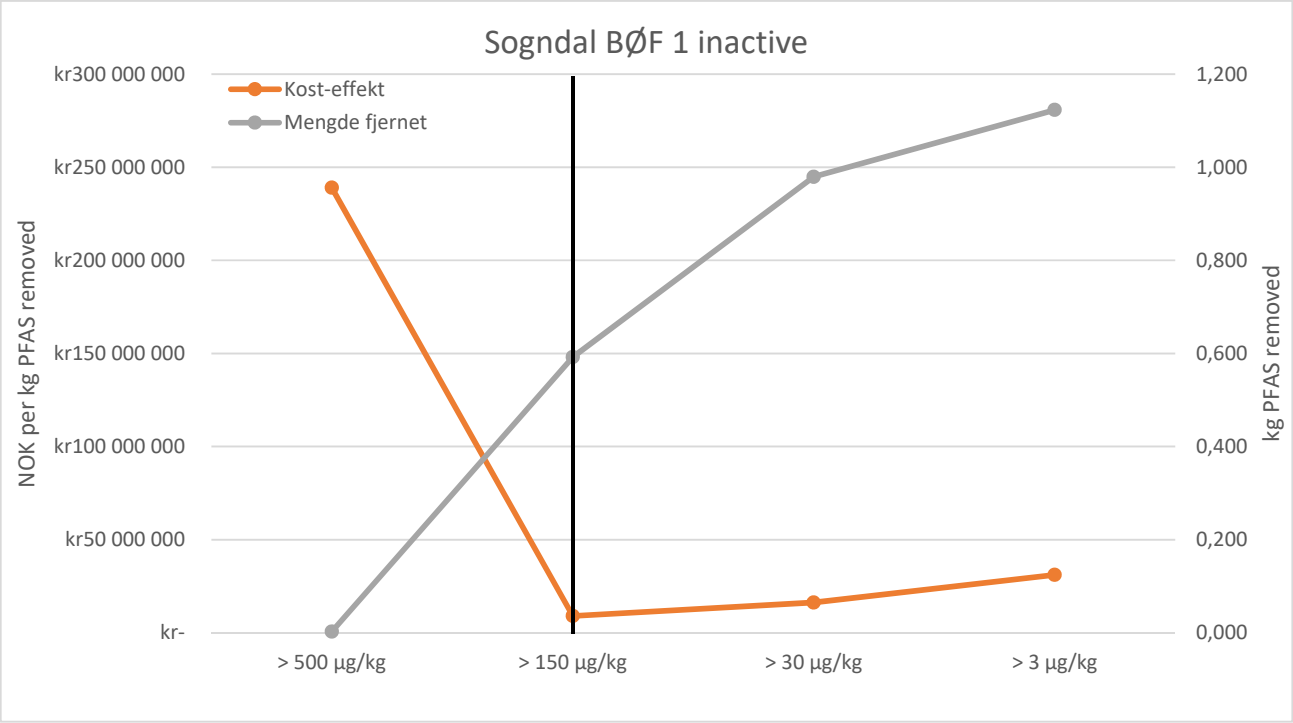


Figure 29: At Sogndal BØF 1, the action limit is set to concentrations of ∑PFAS > 150 µg/kg, which removes 53% of the contamination. If the action limit is reduced from >150 µg/kg to >30 µg/kg, the cost per kg of ∑PFAS removed increases by approximately NOK 7.2 million, which represents an increase in the total cost of approximately NOK 10.6 million. The increase in effect is 0.4 kg more (from 0.6 to 1 kg).

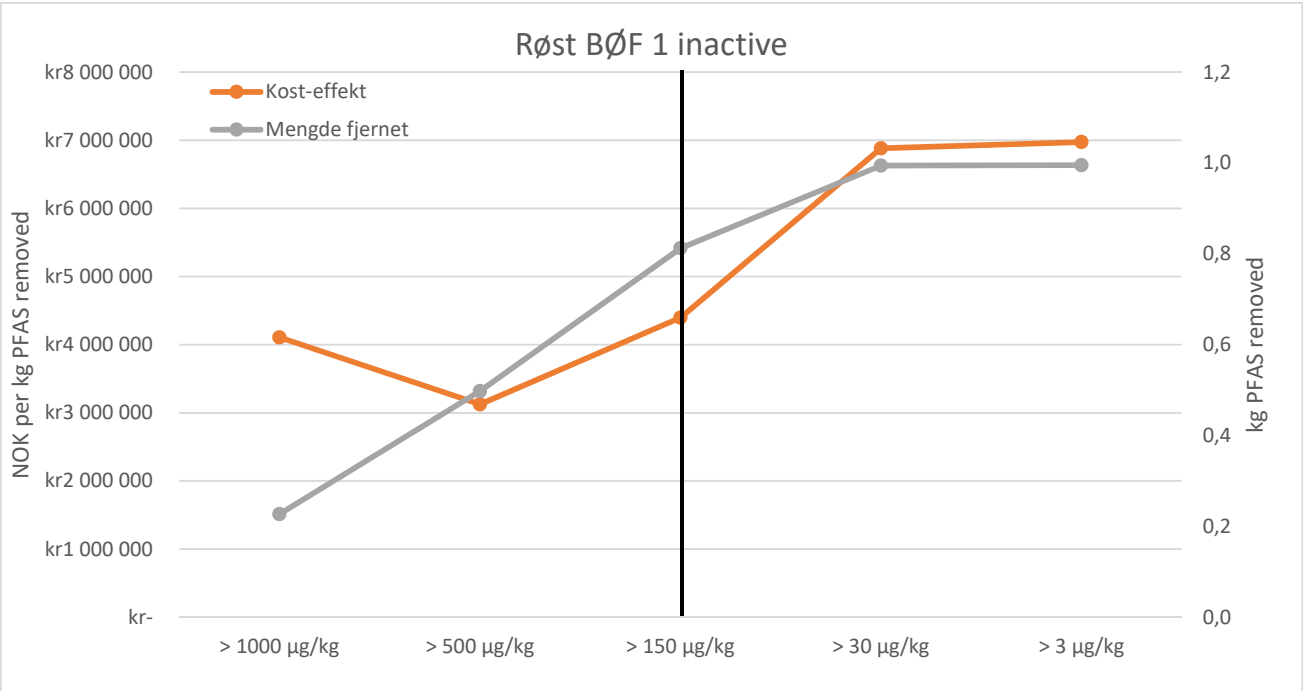


Figure 30: At Røst BØF 1, the action limit is set to concentrations of ∑PFAS >150 µg/kg, which removes 82% of the contamination. If the action limit is reduced from >150 µg/kg til >30 µg/kg, the cost per kg of ∑PFAS removed increases by approximately NOK 2.5 million, which represents an increase in the total cost of approximately NOK 3.3 million. The increase in effect is 0.2 kg more (from 0.8 to 1 kg).

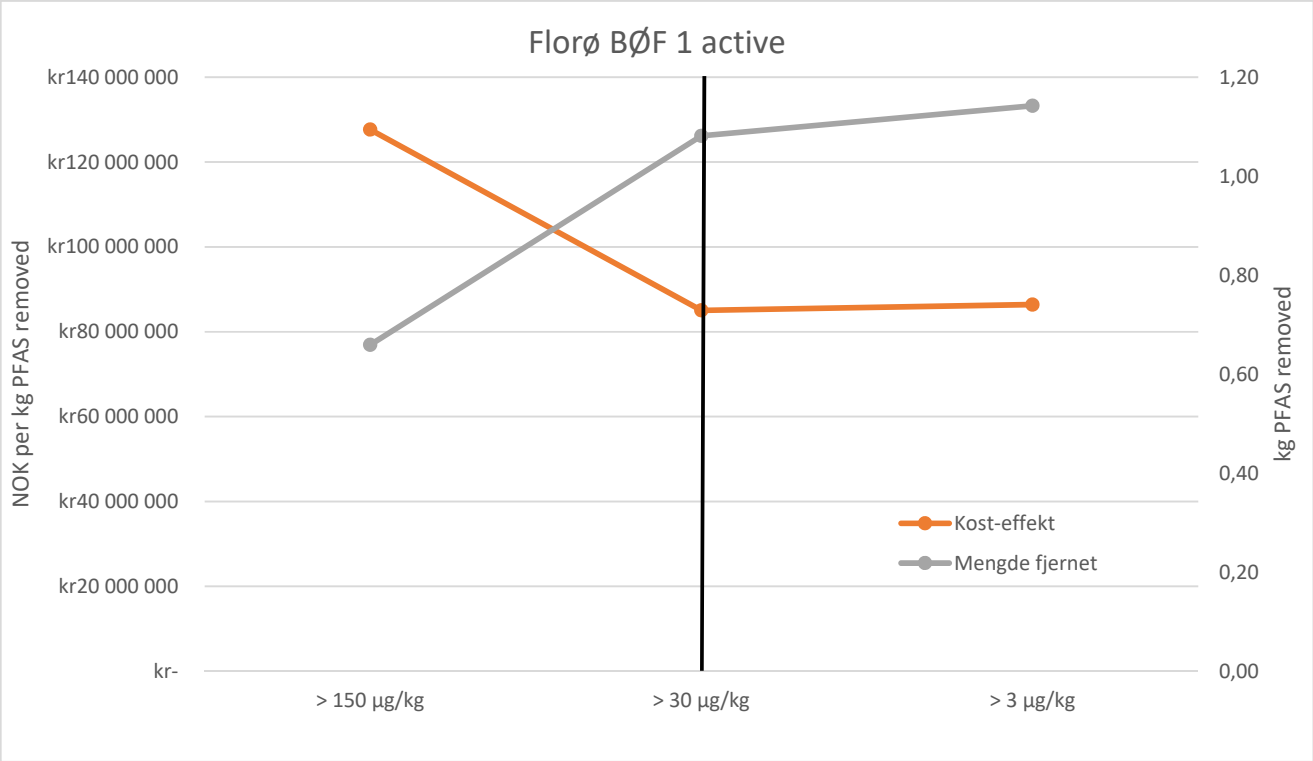


Figure 31: At Florø BØF 1, the action limit is set to concentrations of ∑PFAS > 30 µg/kg, which removes 95% of the contamination (1.1 kg). If the action limit is reduced from >30 µg/kg to >3 µg/kg, the cost per kg of ∑PFAS removed increases by approximately NOK 1.4 million, which represents an increase in the total cost of approximately NOK 6.7 million. The increase in effect is less than 0.1 kg more.

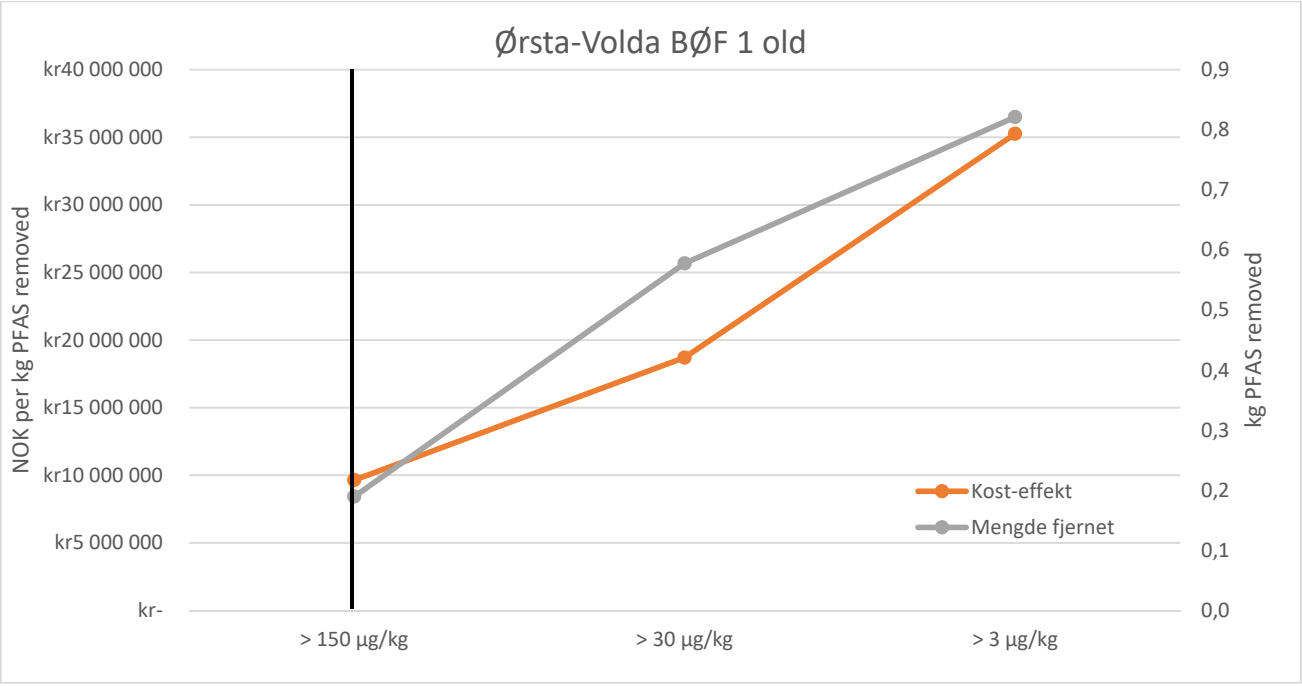


Figure 32: At Ørsta-Volda BØF 1, the action limit is set to concentrations of ∑PFAS > 150 µg/kg, which removes 23% of the contamination. If the action limit is reduced from >150µg/kg to >30µg/kg, the cost per kg of ∑PFAS removed increases by approximately NOK 9 million, which represents an increase in the total cost of approximately NOK 9 million. The increase in effect is 0.4 kg more (from 0.2 to 0.6 kg).

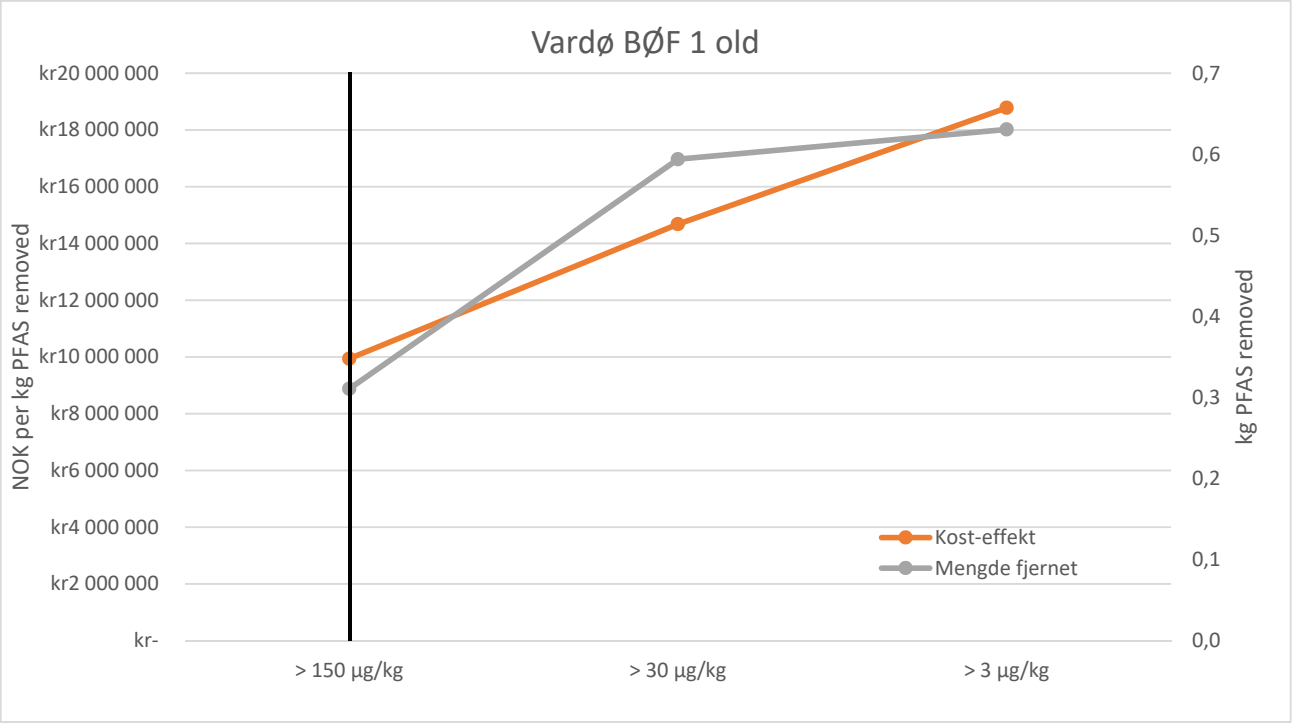


Figure 33: At Vardø BØF 1, the action limit is set to concentrations of ∑PFAS > 150 µg/kg, which removes 49% of the contamination. If the action limit is reduced from >150 µg/kg to >30µg/kg, the cost per kg of ∑PFAS removed increases by approximately NOK 4.7 million, which represents an increase in the total cost of approximately NOK 5.6 million. The increase in effect is 0.3 kg more (from 0.3 to 0.6 kg).

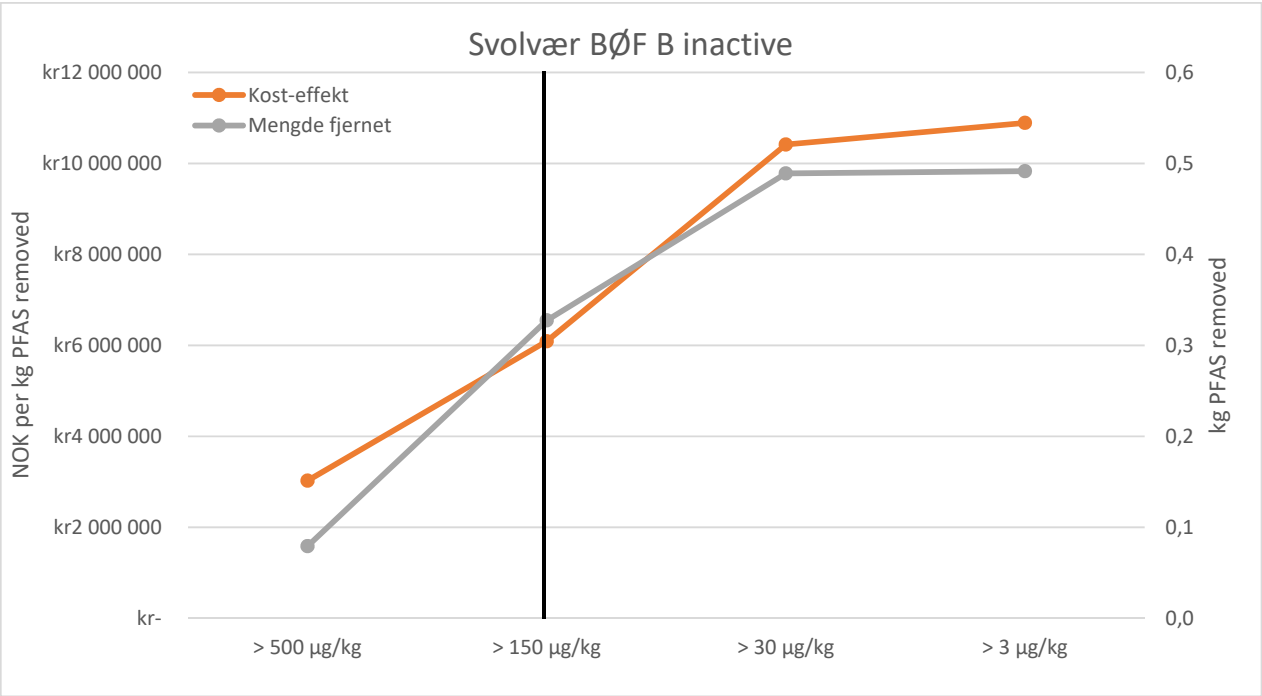


Figure 34: At Svolvær BØF B, the action limit is set to concentrations of ∑PFAS >150 µg/kg, which removes 67% of the contamination. If the action limit is reduced from >150 µg/kg to >30µg/kg, the cost per kg of ∑PFAS removed increases by approximately NOK 4.3 million, which represents an increase in the total cost of approximately NOK 3 million. The increase in effect is 0.2 kg more (from 0.3 to 0.5 kg).