EFTA Surveillance Authority

Technical Report on the discharge of mining waste chemicals and materials into Norwegian water bodies

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Report for

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Executive summary

This technical report describes the results of a review of technical and scientific data concerning the discharge of mining waste chemicals and materials into Norwegian water bodies, including fjords, and their impacts on the ecological and chemical status of those water bodies.

This technical report is focused on issues relating to the Water Framework Directive (WFD)[1]. Norway has implemented the Water Framework Directive since 2007 and adopted a first series of River Basin Management Plans in 2009 (as "pilots"). The first official River Basin Management Plans were published in 2016, with a second round of reporting due in 2022 (but which have not been reviewed for this report)[2].

While sea / water disposal of mining waste is banned in many countries, Norway is a notable exception to continue the practice in Europe, with approximately 10 sites being authorised to deposit mine tailings in water bodies (fjords or lakes). The discharge of mining waste to fjords is controlled by permitting that stipulates quantities, frequencies and concentrations and also requirements for monitoring.

Our analysis focuses on a number of fjords where disposal of waste has happened, is happening or has been permitted to happen in the future. The report includes the following main topics:

- a description of the chemicals and waste materials discharged into Norwegian water bodies from mining activities (chapter 2);
- a description of the hazards of and exposure to (chapter 3); risks of (chapter 4); and effects of (chapter 5) the mining waste materials and chemicals; and
- a description of the measures in place to manage those risks and effects (chapter 5).

The key findings from this report are as follows:

- Various hazardous substances and materials are (and have been) discharged during disposal of mining wastes to fjords in Norway.
- Environmental media, biota, and ultimately people, will be exposed to those substances and materials to varying degrees depending on substances and their potential bioavailability.
- In some cases, those exposure levels will clearly lead to harm to the environment, such as plants and animals being directly covered by deposition of tailings. This will have an effect over long periods, depending on the conditions in the fjord and of the discharge.
- In other cases (e.g., discharge of chemicals), the extent to which harm will be caused is very situation-dependent and is affected by the specific chemicals used or present in the tailings; discharge parameters; and local environments. Several of the chemicals that are known to be used can have both short-term and long-term effects on aquatic organisms, and some of the most harmful (e.g., CMR substances) can have serious effects on humans. Some of those chemicals are naturally present in the source rock, so their discharge is in effect inevitable (so long as deposition to sea is permitted); others are deliberately added during the mining process but are still

[1] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, OJ L 327, 22.12.2000, p. 1–73.
[2] The technical work on this report was undertaken in 2022. It has been revised in 2024 to update bibliographic references.

relevant if the wider tailings materials are discharged. The extent to which these substances are able to cause harm in practice is also highly situation dependent. However, information reviewed suggests that acute toxic effects may be expected, near to the discharge points, at concentration levels expected during discharge.

- Pressures from mining disposal are recognised in the river basin management plans covering several of the fjords considered. However, it is noticeable that the measures identified to address the pressures are focused on increasing the understanding of possible impacts of the discharges rather than more ambitious measures looking at stopping the discharges or reducing their impacts.
- The fact that sea disposal is presented as unavoidable due to lack of space and topography of the Norwegian environment is becoming less relevant as an example from industry shows that a 'no sea disposal' approach is possible. For example, the mining project by Arctic Mineral Resources AS includes a plan for a 'no waste' approach, without any sea disposal or land disposal and all tailings either sold, reused or backfilled into the mine.
- Disposal of mining waste is an activity regulated by permitting. A review of the permits has shown that, while they contain a range of obligations to prevent pollution and minimise impacts, they do not contain requirements to actively seek to reduce impacts and recycle waste where possible (although they do include a requirement to reduce pollution as far as possible considering technical and economic feasibility). Based on both the precautionary principle, but also the waste hierarchy, looking at reusing waste should be encouraged or at least reviewed.
- Results following monitoring of fjords appear to include acknowledgement by the authorities that ongoing disposal of materials from mining activities contribute to the negative or moderate conditions (in the context of the water framework directive) in certain fjords.
- Article 4(8) of the WFD provides that an EEA State must ensure that the application of the Article 4(7) WFD exemption "does not permanently exclude or compromise the achievement of the objectives of [the] Directive in other bodies of water within the same river basin district and is consistent with the implementation of other Community environmental legislation". The permitting of submarine tailings disposal activities in fjords covered by exemptions calls into question whether the long-term achievement of environmental objectives is being compromised by additional industrial activities in water bodies which are failing to achieve good status.

Contents

1. Introduction

1.1 This report

The aim of this report is to present the findings from a project on 'Gathering and assessing data concerning environmental issues in Norway'. Concerns have been raised by NGOs and members of the public on the fact that mining companies are discharging waste into water bodies and that this is threatening the chemical status of the water bodies and also the non-deterioration principle as expressed under the Water Framework Directive (WFD).

This report is a technical report[3] that describes our conclusions from the review of technical and scientific data concerning the discharge of mining waste chemicals and materials into Norwegian water bodies and fjords. It contains an overview of the available data used to determine the chemical and ecological statuses of Norwegian fjords impacted by mining operations. As such our analysis focuses on a number of fjords where disposal of waste has happened, is happening or has been permitted to happen in future. The methodology used in the data gathering and data analysis phases is set out in Appendix C. This report also details data gaps encountered and limitations in Appendix B.

This report has been compiled following direct and indirect exchanges with stakeholders, including an open invitation for stakeholders and third parties to provide information to ESA as set out in a Call for Information from the EFTA Surveillance Authority (ESA, 2022). This report reviewed and analysed a series of published and non-published information provided to ESA by stakeholders.

A bibliography of sources directly quoted in this report is presented in Appendix A. Multiple other sources of information were provided by stakeholders in response to the call for evidence, and these were also taken into account in the project[4]. Information submitted through the call for information has been used and cited in this report, while ensuring that intellectual property rights, trade secrets and personal data rights are respected.

1.2 Objectives of the project

The core objective of this was to identify, obtain and review technical and scientific information and evidence which may clarify or substantiate, amongst other things:

(i) what mining chemicals and materials are discharged into Norwegian water bodies;

(ii) what effect those chemicals and materials have on the respective water bodies;

(iii) whether there is technical and scientific data supporting the view that mining waste negatively impacts and/or harms the water bodies where they are discharged;

(iv) whether there are risk management measures in place to ensure there is no unacceptable risk of a breach of the WFD requirements concerning, for example, non-deterioration; and

[3] This report reviewed a series of sources and information to perform a technical analysis and as such does not constitute a legal analysis.
[4] The technical work on this report was undertaken in 2022. It has been revised in 2024 to update bibliographic references. However, it has not been updated to take into account any information made available after the call for information and associated stakeholder consultations in 2022. It does not, therefore, take into account the most recent river basin management plans published for Norway.

(v) whether, by allowing mining companies to dispose of mining waste chemicals and materials into Norwegian water bodies under the current Norwegian legislative framework, Norway is or might be acting in breach of the WFD and related EEA legal requirements.[5]

The project has taken into account, amongst other things, the effects of mining waste on water bodies vis-à-vis chemical/ecological status, including effects on vulnerable or 'at risk' areas of the environment such as benthic organisms. The focus of the project is on disposal of mining waste, including chemicals of concerns, after 1 May 2018[6] and/or where there is current and ongoing disposal of mining waste including chemicals of concern.

1.3 Background and context

Water Framework Directive

Directive 2000/60/EC ("Water Framework Directive" or "WFD") was adopted in October 2000 and entered into force in December 2000. The WFD is a broad piece of legislation that covers the protection of inland surface waters, transitional waters, coastal waters, and groundwater. At the heart of the Directive are the aims to avoid deterioration of water quality and impacts, both for aquatic life and humans exposed via the environment. The WFD includes the requirement for Member States (and EFTA Members) to develop river basin management plans (RBMPs) and to report of both ecological status and chemical status of water, biota, and sediment. The development of RBMPs also requires the identification of anthropogenic pressures (Annex II of the Directive) which need to be managed. Furthermore, as part of chemical status, the WFD identifies a set of priority and priority hazardous substances which present a Europe-wide risk to water; this requires monitoring and reporting under the WFD RBMPs. These substances are further regulated through the Environmental Quality Standards Directive, a so-called daughter Directive of the WFD.

Article 4 of the WFD presents the two main objectives of the legislation: on the one hand to prevent deterioration of the status of all surface and groundwater bodies, and to protect, enhance and restore all water bodies in order to achieve 'good water status', originally by the end of 2015 and with full implementation by 2027 to be achieved in all surface and groundwater bodies, i.e., good status or good potential (for heavily modified and artificial water bodies).

The Directive, however, envisages a number of exemptions to the general objectives that are possible under certain conditions. These include:

- Article 4(4) allows for an extension of the deadline beyond 2015.
- Article 4(5) allows for the achievement of less stringent objectives.
- Article 4(6) allows a temporary deterioration of the status of water bodies as a result of circumstances of natural cause or force majeure.
- Article 4(7) sets out conditions in which deterioration of status or failure to achieve certain WFD objectives may be permitted. This includes failure to achieve the objectives due to new modifications to the physical characteristics of surface water bodies or alterations in the level of groundwater, and failure to prevent deterioration from high to good status due to new sustainable human development activities.

Thus, the WFD leaves a considerable degree of flexibility and discretion to the Member States when implementing the Directive. On the other hand, the Court of Justice of the European Union

[5] Including those set out at Point A1 of Annex 1 of the Consultancy Agreement.
[6] Date from which the WFD requirements apply in Norway

('CJEU') has clarified in the Weser ruling[7] that the environmental objectives, including the non-deterioration objective also apply to individual projects. Its scope is therefore widely applicable.

Weser ruling (C-461/13)

The court case concerned the planning decision to deepen the Weser river in northern Germany. Despite significant negative effects, the authorities concluded that deterioration of the water body status was not expected because the overall ecological status class would not decrease. The ruling contradicted this interpretation and the Court ruled that:

- **Member States must not authorise projects which may cause a deterioration of the status of a surface water body unless it is possible to grant a derogation under Article 4(7) of the Directive.**
- **There is deterioration as soon as the status of at least one of the quality elements determining the status of the water body falls by one class, even if that fall does not result in a fall in classification of the body of surface water as a whole.**

Implementation of the WFD in Norway

Norway is linked to the European Union as an EFTA country through the Agreement on the European Economic Area (EEA), signed in 1992 and established in 1994. As an EEA EFTA State, Norway is required to comply with the requirements of the WFD and related law. With some amendments, the WFD was formally introduced into the EEA agreement in 2009 (decision 125/2007 of the EEA Joint Committee[8]), giving EFTA countries extended deadlines for its implementation. Norway transposed the WFD into national legislation (the Norwegian Regulation on a Framework for Water Management in 2007, also known as Vannforskriften, the Water Regulation) in 2007.

Norway voluntarily implemented the WFD in selected sub-districts from 2007 until 2009, and in 2009 adopted a series of River Basin Management Plans for these sub-districts, allowing the country to gain experience in river basin management planning and participate in the Common Implementation Strategy (CIS) (Halleraker et al, 2013).

The Pilot RBMPs were adopted in 2009, then approved in 2010. In September 2010, Norway's Pilot RBMPs was reported to ESA, which considered that it adequately followed the approach of, and the requirements specified in Annex VII of the WFD (European Commission, 2012). These pilot RBMPs did not cover the fjords that were further analysed as part of this technical report (NEA and KLD, 2022).

The first official River Basin Management Plans were approved by the Norwegian Government in July 2016; these cover the 2016-2021 period and represent the first cycle under formal WFD obligations[9]. The second cycle, updating RBMPs for the 2022-2027 period, was, at the time of production of this report, pending approval by the Norwegian government.

[7] CJEU Judgment of 1 July 2014, C-461/13, ECLI:EU:C:2015:433.
[8] Decision of the EEA Joint Committee No 125/2007 of 28 September 2007 amending Annex XX (Environment) to the EEA Agreement, OJ L 47, 21.2.2008, p. 53–56, available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A22007D0125.
[9] Planning documents applicable to water for 2016 to 2021 available at: https://www.vannportalen.no/plansyklus/planperioden-2016---2021/.

Water bodies in Norway

According to the 2016 RBMPs[10], Norway has a total count of 33,970 registered water bodies, of which 2,283 are coastal, 1,401 groundwaters, 6,803 lakes, and 23,303 rivers.[11] These are distributed across 15 national River Basin Districts (RBDs) responsible for compiling data and developing the corresponding regional water management plans and actions. As seen in the table below, out of these, 10 are "international sharing water courses" (IRBDs) with Sweden and Finland and five are only on Norwegian territory.

Table 1-1 Norwegian River Basin Districts

Type	RBDs	Territory
IRBD	Troms og Finnmark	Mainly Norwegian
IRBD	Finnish-Norwegian	Shared with Finland
IRBD	Kemijoki	Mainly Finnish
IRBD	Tornionjoki/Torneälven	Mainly Finnish and Swedish
IRBD	Nordland og Jan Mayen	Mainly Norwegian
IRBD	Bottenviken	Mainly Swedish
IRBD	Trøndelag	Mainly Norwegian
IRBD	Bottenhavet	Mainly Swedish
RBD	Møre and Romsdal.	Norway
RBD	Vestland	Norway
RBD	Rogaland	Norway
RBD	Agder	Norway
RBD	Vestfold og Telemark	Norway
IRBD	Innlandet og Viken	Mainly Norwegian
IRBD	Västerhavet	Mainly Swedish

Note: IBRD = International River Basin District, RBD = River Basin District

Mining in Norway

Norway is a mineral-rich country and is a producer of industrial minerals. Norway is the largest source of olivine and of ground marble for use as a filler in paper and other applications. The most relevant industrial minerals and deposits in Norway include (NGU, 2020):

[10] Note that further adjustments could have occurred in the latest RBMPs, in the grouping of river basin sub-districts and on the delineation of water bodies (resulting in possibly higher or lower number of waterbodies).
[11] Based on Norway's Vann-Nett portal, available at: https://vann-nett.no/portal/#/area/1/all.

- Carbonates, which can be found in Brønnøy municipality (white calcite marble), Verdal (limestone), Tysfjord (limestone), Hammerfall (dolomite), Hekkelstrand (dolomite), Seljeli (dolomite), and Brevik (limestone).
- Feldspar, anorthosite and nepheline syenite, which can be found in Sogn (anorthosite), Stjernøy (nepheline syenite) and Glamsland (feldspar, not in operation).
- Graphite, in Skaland.
- Quartz and quartzite, which can be found in Gamasfjell (Quartzite), Kragerø (quartzite), Melkfjell (quartzite), Nasafjell (hydrothermal quartz), Rana (hydrothermal quartz), Drag (hydrothermal quartz) and Svanvik (hydrothermal quartz).
- Olivine, in Åheim.
- Talc, in Bårstad and Linnajavri.
- Titanium minerals, which can be found in Tellnes (ilmenite), Engebøfjellet (rutile) and Bjerkreim-Sokndal (ilmenite).
- Apatite, vanadium and magnetite, which can be found in Bjerkreim-Sokndal (all three), and Misvær (apatite)

Disposal of mining waste in water

At a global scale, the majority of mining waste is disposed of on land. In 2013, the International Mining Organisation estimated that fewer than 15 out of the 2,500 industrial scale mines in the world were using sea disposal, representing less than 1% of the extractive waste from mineral processing (European Commission, 2018). Sea or water disposal of mining waste is banned in many countries, and Norway is the notable exception in Western Europe to continue the practice.

A resolution from the International Union for Conservation of Nature from 2016 (IUCN, 2016) called for stopping sea disposal of extractive waste. It was signed by 51 out of the 53 participants, and was only opposed by Norway and Turkey (Guardian, 2016). While the resolution is not binding, the signatories (including the EU countries, China and Russia among others) agreed that 'the dumping of mining waste on the sea floor (submarine tailings disposal, STD), and the marine and coastal depositing of mining-related wastes may significantly harm the marine environment. The resolution included examples of harm which are contamination of water and air by heavy metals; distribution of contaminants through submarine currents; destruction of marine and coastal habitat and biodiversity; modification of the coastline; loss of natural and cultural heritage; and sedimentation of bays and ports. Mining waste disposal in water may also negatively affect human health and activities (IUCN, 2016).

Most of Norway's significant mines and quarries are located along the coast where, in some instances, there are concerns that some disposal activities involving mining waste are responsible for deterioration of water quality (in particular biological and chemical elements). According to the MWEI BREF (European Commission, 2018), sea disposal of extractive waste is currently actively applied in approximately 10 sites in Norway.

The regulation of emissions from submarine tailings disposal sites in Norway is achieved through permitting.

Disposal of waste rock and tailings can take place either in lakes or artificial dams on land and in shallow or deep-sea locations. The Norwegian Environment Agency (NEA, 2019a) notes that 'the most severe environmental problems are found in relation to mining for sulphide minerals. This is due to the weathering properties of the sulphide minerals, which cause release of metals'. Examples of metals include nickel, copper, lead and zinc. On the other hand, non-sulphide mines

related to the extraction of minerals such as ilmenite, rutile, marble, olivine, graphite, or quartz have lower content of metals. Thus, the main environmental challenge relates mainly to the disposal of residual materials in the form of tailings of waste rocks.

1.4 Other issues

Other issues have been raised in the evidence submitted by stakeholders, including uncertainties on the Environmental Impact Assessment Procedure in Norway (Planning and Building Act); and permitted landfill sites that are viewed to threaten water quality.

These issues are not directly related to the scope of this project and have not been investigated.

2. General description of the chemicals and waste materials discharged into Norwegian water bodies from mining activities

2.1 Introduction

This section presents information on substances used as part of the mining activities, mining organisation, location of mining waste and practices related to disposal of mining waste for a number of selected fjords in Norway. The fjords selected are as below.

Table 2-1 Overview of fjords selected

Name of water body / fjord	Reasons for being selected
Jøssingfjord / ID 0240000100-C	Historical and new land or sea deposit under assessment.
Førdefjorden-ytre / ID 0281010202-C	New mining waste disposal approved
Elnesvågen/ ID 0302012400-2-C	Mining waste disposal ongoing
Tosen-ytre/ ID 0360011100-2-C **Tosen-indre / ID 0360011100-2-C**	New mining waste disposal being considered
Ranfjorden – Mo / 0362011000-2-C	Mining waste disposal ongoing
Tysfjorden / ID 0364020100-6-C	Mining waste disposal ongoing
Bergsfjorden / ID 0401011400-C	Mining waste disposal ongoing
Lillebukta - Ytre Simavik (Stjernsunden) / 0420030200-1-C	Mining waste disposal ongoing
Repparfjorden ytre / ID 0421010500-1-C	Old Mining waste disposal and new activity planned
Bøkfjorden-ytre/ 0424030500-3-C	Mining waste disposal in the past and new activity planned

2.2 Overview of substances being discharged as part of mining disposal

Information on chemical substances involved

The table in Appendix E presents an overview of the information identified with regard to substances being used as part of mining activities in a number of selected fjords in Norway. The level of detail of the information presented varies, based on the information identified. The table has been compiled relying on a range of sources, including permits and publicly available reports.

Nanomaterials and microplastics were raised as relevant topics by NGOs, in particular nanomaterials and microplastics being contained in tailings disposed of in water.

Information on nanomaterials

Nanomaterials are defined by the European Commission (2011) as follows: ’Nanomaterial’ means a natural, incidental or manufactured material containing particles, in an unbound state or as an aggregate or as an agglomerate and where, for 50 % or more of the particles in the number size distribution, one or more external dimensions is in the size range 1 nm-100 nm. In specific cases and where warranted by concerns for the environment, health, safety or competitiveness the number size distribution threshold of 50 % may be replaced by a threshold between 1 and 50%’.

There is very little literature published on impacts of nanomaterials, either natural or engineered, on the water environment. With regard to chemicals, nanomaterials are covered by the same regulatory framework that ensures the safe use of all chemicals and mixtures: the REACH ((EC) No 1907/2006) and CLP ((EC) No 1272/2008) Regulations. This means that hazardous properties of nanoforms of substances have to be assessed and their safe use needs to be ensured. There are also specific provisions for nanomaterials in sector-specific legislation such as that covering food, biocides and cosmetics (EUON, nd).

On 3 December 2018 the Commission adopted Commission Regulation (EU) 2018/1881 to modify REACH Annexes I, III and VI-XII, introducing nano-specific clarifications and new provisions in the chemical safety assessment (Annex I), registration information requirements (Annex III and VI-XI) and downstream user obligations (Annex XII). The amendments have applied since 1 January 2020.

Under the REACH Regulation, companies are required to assess risks of nanoforms of the chemicals they manufacture or import and ensure those risks are adequately controlled through risk management measures. However the main concern relates to the presence of nanomaterials in the tailings rather than the use of nanomaterial chemicals in the mining process. REACH applies to substances, including the product being mined and then placed on the market, as well as to chemicals used in the mining process (and which may be discharged to fjords with the tailings).

Concerning the WFD more specifically, there is no mention made of nanomaterials. For chemical substances, 'good chemical status' is defined as compliance with all the quality standards established for chemical substances at European level. These are specified in the Environmental Quality Standards Directive for 45 priority and priority hazardous substances including heavy metals, industrial chemicals, pesticides and unintentionally formed substances. A proposal for the revision of these substances was published by the European Commission in November 2022

(European Commission, 2022a)[12]. To date, nanomaterials have not been considered as such, although some discussions in the Working Group on Chemicals have been held on silver in its nano form.

More specifically, nanomaterials have been raised as being of concern by the Norwegian Institute of Marine Research (IMR) in its responses to permit consultation hearings for Tosenfjord, Førdefjord and the Bøkfjord.

- For the Tosenfjord and mining of Bindalen Kolsvik, IMR found that the environmental impact assessment performed as part of the permitting activities did not sufficiently consider that mining waste will be finely ground, and that the dispersion of fine particulate matter, nanoparticles and microplastics is not sufficiently assessed (IMR, 2020a). The IMR response also raises the importance of investigating plastic waste from wear and tear of pipes and other activities (see also below on microplastics) (Naturvernforbundet, 2022a).
- For the Bøkfjord, planned mining activities at an iron mine that has been inactive since 2015 have been approved. The IMR concern is that nanoparticles are not sufficiently considered as part of the environmental impact assessment study.
- For the Førdefjord, an environmental assessment for Nordic Mining ASA (Nordic Rutile AS) indicated that 100 tonnes of nanomaterial from titanium oxide will be released in the fjord every year as part of the current permit. It was noted by IMR that no information was requested of the permit applicant (i.e., mining operator) by the Norwegian Environmental Agency (NEA) nor the Ministry of Climate and Environment on nanoparticle characterisation of the mine tailings (IMR, 2020b and 2009).

A review of the permits for the fjords selected has found no mention of nanomaterials. Environmental permits for discharges to water in other industrial sectors do not typically include nanomaterial-specific condition.

Information on microplastics

Microplastics have been on the regulatory agenda with the increased awareness of the challenges and risks they pose to the environment.

The current EU water legislation (i.e., the UWWTD, WFD and EQSD) does not include requirements for monitoring or removal of microplastics (MP)[13]. In water, brake and tyre wear is the single largest source of microplastics, accounting for 500,000 tonnes per annum in the EU entering sewers through run-off. This is a source of 'unintentional' release of microplastics.

In 2020, the Committee for Socio-economic Analysis (SEAC) adopted its opinion on a restriction proposal to ban 'intentionally used' microplastics in a range of products, including fertilisers, cosmetics and detergents. It estimated that this would prevent the release of 500,000 tonnes of microplastics into the environment over a 20-year period (ECHA, 2020). This has now been formalised in the European Commission legislative proposal to ban intentionally added microplastics from products including toothpastes, cosmetics and artificial turf sports fields (European Commission, 2022b).

[12] For surface water the proposal currently propose adding 24 individual substances to the list of priority substances: pesticides, pharmaceuticals and industrial chemicals as well as a group of 24 PFAS substances; changing the environmental quality standard (EQS) for 16 substances: more stringent in 14 cases and less stringent in two cases; developing a methodology for the measurement and monitoring of microplastics and antimicrobial resistance genes in surface water and groundwater, with a view to listing them as a pollutant in future; removing 4 substances from the list (3 pesticides and 1 industrial chemical) as they no longer pose an EU-wide threat.

[13] It is noteworthy that the Commission's proposal for a revised Urban Waste Water Treatment Directive include a requirement to monitor microplastics in sewage sludge for agglomerations above 100,000 p.e.

Microplastics are not considered in the permits that have been reviewed as part of this project and are not explicitly required to be considered under the Water Framework Directive. However, it is worth noting that the on-going review of the Environmental Quality Standards Directive might include future requirements to consider microplastics and consider future options to set environmental quality standards for microplastics.

Concerns about microplastics have been raised by NGOs and also research organisations such as the Institute of Marine Research. For example, in response to changes in the permit for Sydvaranger Drift AS, the IMR (2020c) pointed out that microplastics from wear and tear of pipelines have not been considered in the environmental impact assessment.

2.3 Location of disposal of mining waste

This section presents information on the locations where disposal of mining waste takes place in Norway.

Table 2-2 Information on water body location

Name of water body / fjord	Name of River Basin District	Status of mining waste disposal (IMR, 2022)[14]	Information on amount of mining waste deposited / to be deposited	Indication of amount of mining waste to be deposited in future
Jøssingfjord / ID 0240000100-C	RBD: Rogaland Sub-Unit: Dalane /	Historical and new land or sea deposit under assessment.	Approximately 2.5 millions of tonnes of tailings have been deposited in Jøssingfjorden from 1960 to 1984 (NEA, 2019a). In 1994 a land deposit was established, and since then there has not been any direct discharge of tailings to the fjord. The fjord nevertheless receives drainage water and effluent including suspended material from the opencast mine and the land deposit (ESA, 2021a). Titania AS has permission for disposal at Tellenes of an amount of up to 3.6 million tonnes of effluent (NEA, 2002).[15] The deposit has capacity for a total of 65 million tonnes of tailings (NEA, 2002).	Suspended substance: - 912,500 kg per year or 2500 kg per day until 31.07.2023. - 292,000 kg per year or 800 kg per day from 01.08.2023 Additional requirements will be assessed after monitoring in 2024 Nickel: - 6 kg per day (or 2190 kg per year) until 31.07.2023. - 3.5 kg per day (or 1277.5 kg per year) from 01.08.2025 to 31.12.2024 - 1.5 kg per day (or 547.5 kg per year) from 01.01.2025 Additional requirements will be assessed after monitoring in 2024.

[14] IMR, 2022d.
[15] Permit 2002.0072.T, process effluent and decanting water from the landfill "is permitted to be discharged into the Tellenes watercourse with an outlet in Jøssingfjord via stream and power plant tunnel. Overflow from magnetite filter is also allowed to lead Jøssingfjord. Drainage water from the open pit is allowed to be carried out to the fjord through its own tunnel".

Name of water body / fjord	Name of River Basin District	Status of mining waste disposal (IMR, 2022)[14]	Information on amount of mining waste deposited / to be deposited	Indication of amount of mining waste to be deposited in future
Førdefjorden-ytre / ID 0281010202-C	RBD: Vestland Sub-unit: Sunnfjord	Not yet started (approved)	The mine has not started to operate yet. The discharge permit was granted in June 2015 and the operating permit in June 2020. The Ministry of Climate and Environment denied the administrative appeal for the discharge permit in 2016. In May 2022, the Ministry of Trade, Industry and Fisheries denied the administrative appeal for the license (Naturvernforbundet, 2022b).	The marine deposit (sea landfill) is on the seabed outside Engjabøneset. A maximum of 4 million tonnes of effluent per year can be disposed (NEA, 2015a).
Elnesvågen/ ID 0302012400-2-C Frænfjorden	RBD: Møre og Romsdal Sub-unit: Romsdal	Currently ongoing	Tailings have been deposited since 1982. Disposal in 2008 totalled approximately 0.46 million tonnes (Helgelands Blad, 2019) (IMR, 2022d).	Permission for an annual marine deposit (sea landfill) in Frænfjorden of an amount of up to 0.7 million tonnes of departure mass and 300 litres of exhaust mass oil (NEA, 2015b).
Tosen-ytre/ ID 0360011100-2-C **Tosen-indre / ID 0360011100-2-C**	RBD: Nordland og Jan Mayen Sub-unit: Bindalsfjorden-Velfjorden	Not yet started (awaiting approval)	The Directorate for Mineral Management was processing the permit in 2020 (Helgelands Blad, 2019). No information has been identified to confirm that it has been approved yet.	Plan to deposit 200,000 tonnes per year for 10 to 15 years (IMR, 2022d).
Ranfjorden – Mo / 0362011000-2-C	RBD: Nordland og Jan Mayen Sub-unit: Ranfjorden	Currently ongoing	Total production of iron ore since 1902 has been around 100 million tonnes. During this time, 50-70 million	A maximum of 3 million tonnes of effluent per year can be deposited in the marine deposit in Ranfjorden.

Name of water body / fjord	Name of River Basin District	Status of mining waste disposal (IMR, 2022)[14]	Information on amount of mining waste deposited / to be deposited	Indication of amount of mining waste to be deposited in future
			tonnes of waste have been disposed of to Ranfjorden (NEA, 2012). Rana Gruber AS has had a permit to dispose mining waste from the iron ore mine into Ranfjorden since 1979. In 2012 the permit was amended to increase the disposal of waste from around 2 million tonnes to 3 million tonnes each year (ESA, 2021b).	
Tysfjorden / ID 0364020100-6-C	RBD: Nordland og Jan Mayen Sub-unit: Ofotfjorden	Currently ongoing	The Quartz Corp AS has permission to discharge 37,000 tons per year of suspended matter (NEA, 2011).	The permit requires the company to study how quantities of tailings can be reduced by 31 December 2020. No information identified on whether this was done.
Bergsfjorden / ID 0401011400-C	RBD: Troms og Finnmark Sub-unit: Senja	Currently ongoing	Skaland Graphite AS has permission to discharge 40,000 tonnes of waste per year (Troms and Finnmark County Governors, 1989).	A maximum of 225,000 tonnes of rock can be deposited over a period of 15 years (Troms and Finnmark County Governors, 1989).
Lillebukta - Ytre Simavik (Stjernsunden) / 0420030200-1-C	RBD: Troms og Finnmark Sub-unit: Alta, Kautokeino, Loppa og Stjernøya	Currently ongoing	Sibelco Nordic AS has permission to discharge 300,000 tonnes per year.	No indication for future.

Name of water body / fjord	Name of River Basin District	Status of mining waste disposal (IMR, 2022)[14]	Information on amount of mining waste deposited / to be deposited	Indication of amount of mining waste to be deposited in future
Repparfjorden ytre / ID 0421010500-1-C	RBD: Troms og Finnmark Sub-unit: Sørøya/Seiland/Kvaløya med inland	Currently ongoing and new deposit planned.	Nussir ASA has permission to discharge 2 million tonnes of tailings annually into Repparfjorden in Northern Norway (NEA, 2019a).	In total a maximum of 25 million m+ / 30 million tonnes of effluent can be deposited in the marine deposit (NEA, 2016).
Bøkfjorden-ytre/ 0424030500-3-C	RBD: Norsk-finsk Sub-unit: Neiden	Currently ongoing and new activity planned.	The permit (NEA, 2008) applies to an annual amount of effluents / suspended matter (SS) of 4 million tonnes and an annual amount of water treatment chemicals of a total of 65 tonnes calculated as active substance.	No information

2.4 Companies permitted to dispose of mining waste in water

The table below presents an overview of the mining companies that have obtained permits, including information on the date that permits were granted.

Table 2-3 Information on companies permitted to dispose mining waste in water

Water body / fjord	Mining companies/ entities	Mining activity	(1) date permits were granted; and (2) duration/time-period permits endure	Points of discharge	General description of mining waste	Emission limits	Applies from	Applies to
Jøssingfjord	Titania AS	Until 1960, the ore was extracted from the company's ilmenite mines in Sandbekk, before the company started open-pit mining at the plant at Tellnes, which from 1965 is the company's only plant in operation. In 1989, Titania AS became part of Kronos Worldwide Inc. The current permit allows mining, preparation and drying of an annual production of up to 1,2 million tonnes of ilmenite concentrate, 60,000 tonnes of magnetite and 20,000 tonnes of sulphide concentrate.	Number: 2002.0072.T First granted: 9.04.2002 Last modified: 04.02.2021	Jøssingfjorden	Nickel	6 kg/day	dd	31.07.2023
						3.5 kg/day	01.08.2023	31.12.2024
						1.5 kg/day	2025	
					Suspended solids (SS)	2500 kg/day	present	31.07.2023
						800 kg/day	01.08.2023	n/a
					Tall oil		present	n/a
					Organic solvents		present	n/a
					Till-N	160 kg/day	present	n/a
Førdefjorden-ytre	Nordic Rutile AS	The Engebo rutile and garnet mining project is an open pit mine being developed by Nordic Mining's	Number: - First granted: 05.06.2015	Førdefjorden	Suspended substance (SS)	4 million tonnes per year	Start-up	n/a

Water body / fjord	Mining companies/ entities	Mining activity	(1) date permits were granted; and (2) duration/time-period permits endure	Points of discharge	General description of mining waste	Emission limits	Applies from	Applies to
		subsidiary Nordic Rutile in the Vestland County of Norway. Nordic Mining acquired the rights to the Engebø deposit in 2006. The zoning plan and environmental permits were granted in April 2015 and the Updated Definitive Feasibility Study (UDFS) of the Engebø Project was published in May 2021.	Last modified: 18.01.2019		Magnafloc 5250	4 tonnes per year	Start-up	n/a
					Sodium isobutyl xanthate (SIBX)	2 tonnes per year	Start-up	n/a
					Dow Froth 400	3 tonnes per year	Start-up	n/a
Elnesvågen	Omya Hustadmarmor AS	Brønnøy Kalk AS is the company that extracts approximately 2 million tonnes of calcite marble every year. The calcite marble is then shipped from Velfjord to Omya Hustadmarmor's. The extraction of calcite marble from Akselberg open pit mine in Velfjord started in 1997.	Number: 1994.0092.T First granted: 20.11.2015 Last modified:28.06.2018	Frænfjorden	Fatty acids, C14–18 and C16–18 unsaturated products with adipic acid and triethanolamine, dimethyl sulphate quaternised	2320 tonnes per year	20.11.2015	n/a
					Polyacrylamide	12.5 tonnes per year	20.11.2015	n/a
					Process departure mass	0.7 million tonnes	20.11.2015	n/a

Water body / fjord	Mining companies/ entities	Mining activity	(1) date permits were granted; and (2) duration/time-period permits endure	Points of discharge	General description of mining waste	Emission limits	Applies from	Applies to
					Exhaust mass Oil	300 litres	20.11.2015	n/a
Ranfjorden – Mo	Rana Gruber AS	Rana Gruber AS operates mines of iron ore deposits. The mines are located in Storforshei and Ørtfjell in the Dunderland Valley, located 35 kilometres north-east of the city of Mo i Rana. The iron ore production takes place at the company's iron ore deposits at Ørtfjel.	Number: 2012.305.T First granted: 20.12.2012 Last modified: 26.06.2015	Ranfjord	Exit mass, suspended solids (ss)	3 million tonnes per year	01.01.2014	n/a
					Flotation chemicals (diamine/diamine acetate)	40 tonnes per year	present	n/a
Tysfjorden	Quartz Corp AS	Production of right-handed quartz of up to 30,000 tonnes of finished product per years of which everything can be acid washed and up to 3000 tonnes can be chlorinated	Number: 2010.0161.T First granted: 05.12.2011 Last modified: 23.06.2020	Tysfjord	Departure mass, suspended substance (ss)	78,000 kg/day 37,000 tonnes/year	present	n/a
					Diamine	13 kg/day 6 tonnes/year	present	n/a
					Fluorosilicic acid (100%)	23175 kg/day	present	n/a

Water body / fjord	Mining companies/ entities	Mining activity	(1) date permits were granted; and (2) duration/time-period permits endure	Points of discharge	General description of mining waste	Emission limits	Applies from	Applies to
						8500 tonnes/year		
					Petroleum sulfonate	160 kg/day 25 tonnes/year	present	n/a
					Sodium chloride NaCl	800 kg/day 230 tonnes/year	present	n/a
Bergsfjorden	Skaland Graphites AS	Production of graphite concentrate (90-94% carbon). The permit applies for production of up to 16,000 tonnes per year.	Number: 1989.0061.T First granted: 09.22.1989 Last modified: 24.01.2002	Bergsfjorden	Chromium	1.37 g/day 500 g/year	present	n/a
					Copper	2.74 g/day 1000 g/year	present	n/a
					Departure mass, suspended fabric (ss)	40,000 tonnes/year	present	n/a
					MIBC	30,000 litres/year	present	n/a

Water body / fjord	Mining companies/ entities	Mining activity	(1) date permits were granted; and (2) duration/time-period permits endure	Points of discharge	General description of mining waste	Emission limits	Applies from	Applies to
					Nickel	14.25 g/day 5200 g/year	present	n/a
					Oil	50 mg/l/year	present	n/a
					Sepco CE 3040 LH	5000 litres/year	present	n/a
					Zinc	4.11 g/day 1500 g/year	present	n/a
Repparfjorden ytre	Nussir AS	Mining of copper-containing ore[1]	Number: 2016.0051.T Permit granted: 15.01.2016	Repparfjorden		Daily annual average	present	n/a
					Burnt lime	600 kg/day 500 kg/day	Start-up	n/a
					Carboxylmethyl cellulose	350 kg/day 300 kg/day	Start-up	n/a

Water body / fjord	Mining companies/ entities	Mining activity	(1) date permits were granted; and (2) duration/time-period permits endure	Points of discharge	General description of mining waste	Emission limits	Applies from	Applies to
					Exit mass, suspended solids	6500 tonnes/day	Start-up	n/a
					Magnafloc 10	240 kg/day	Start-up	n/a
					Methyl Isobutyl Carbinol	350 kg/day	Start-up	n/a
					Sodium Isopyl Xanthate	Awaiting investigation	n/a	n/a
Bøkfjorden-ytre	Sydvaranger Gruver AS	Quarrying of iron ore for the extraction of mineral ores with an annual production of up to 3 million tonnes of iron ore concentrate. The open pit operations will mainly take place within the areas for previous mass extraction, and the permit applies to temporary storage of oil-contaminated masses in this area	Number: 2008.190.T Granted: 23.06.2008 Last modified: 08.10.2014	Bøkfjorden	Departure compound, suspended solids (SS)	4 million tonnes/year	present	n/a
					Water treatment chemicals (accordance with section 1.2 of the permit)	65 tonnes/ year	present	n/a

2.5 Information on practices surrounding disposal of mining waste

This section details information identified related to practices surrounding disposal of mining waste. The information has been gathered from the permits and the Vann-Nett platform.

In this section we summarise the available information on:

i. how the mining waste is transported to/discharged at the deposit sites;

ii. whether there is a treatment/pre-treatment of mining waste (and whether there is removal of certain chemicals/materials);

iii. where deposit sites are generally located in fjords;

iv. at what depth mining waste is deposited;

v. whether the fjords are salt/fresh water, and the general ecology of the fjords;

vi. whether the conditions regulating the disposal of waste by mining companies are set out exclusively in licences and/or in other legal requirements;

vii. information contained within the permits regarding chemicals, in particular whether the permits identify or list chemicals of concern which are covered by the permits including the limits on amounts and disposal conditions;

viii. whether penalties have been imposed on mining companies for breach of the conditions concerning disposal of mining waste (and, if so, what penalties have been imposed);

ix. whether any risk management measures are imposed on mining companies to reduce or eliminate exposure; and

x. whether, after chemicals/materials are deposited into fjords, there are requirements for companies to cover-up, treat, monitor and/or take any other action to return the fjord/fjord bed to its original/natural state.

The information identified from the permits is presented in the table below. Note that the information reflects the latest information identified; there might be more recent information that is not freely available or that was not identified by our team as part of the research.

Table 2-4 Information on practices for mining waste disposal

Water body	Company	Disposal conditions
Jøssingfjord	Titania AS	The following analysis is based on Permit 2002.0072.T ('the permit'), first granted in April 2002 and last updated in February 2021. As stated in the permit, waste materials from extraction plants and drying plants are permitted to be deposited in an existing deposit. The deposit may contain up to 65 million tonnes of tailings. 3.6 million tonnes / year is the maximum tonnage of effluent that can be deposited each year. The total amount of effluent to the deposit shall not exceed the abovementioned limit of 3.6 million tonnes per year. i) According to the permit, process effluent from extraction plants, drying plants and leachate from dam 5 at the landfill and decanting water from the landfill is permitted to be discharged into the Tellenes watercourse with an outlet in Jøssingfjord via stream and power plant tunnel. Overflow from magnetite filter is also allowed to lead

Water body	Company	Disposal conditions
		to Jøssingfjord. Drainage water from the open pit is allowed to be carried out to the fjord through its own tunnel. ii) According to the permit, any oily wastewater from workshops or the like must be treated satisfactorily in an oil separator or equivalent treatment unit so that the emission limits are complied with. iii and iv) According to the Norwegian Environment Agency (NEA, 2019a), from 1960 to 1984, the mining company Titania deposited 2.5 million tonnes of mine tailings in Jøssingfjord every year. The Jøssingfjord was filled from a basin depth of 70 metres to a threshold depth of 20 metres. After 24 years, the water depth was significantly reduced, and the discharge point had to be extended to further in the fjord. From 1984 to 1994, the mine tailings were released in a basin just outside of Jøssingfjorden, Dyngadjupet. The basin depth in this area was 170 metres, and outfall depth was 113 metres. The basin depth was reduced to 140 metres during this period. v) The following parameters are described in Vann-nett: Water type - Water type name: protected coast/fjord - Ecoregion: North Sea South - Salinity: Euhaline (> 30). Normal sea water. - Tide: small (<1 m) - Wave exposure: protected. Protected area - Name: Kysten Jæren-Dalane - Reason: Lakse- og innlandsfiskloven § 7 (The Salmon and Inland Fish Act) vi) In licences and legal requirements (Pollution Control Act, Product Control Act, Internal Control Regulations, Water Regulations, Waste Regulations on hazardous waste, Regulations on notification of acute pollution or danger of acute pollution) vii) Yes. See section 2.3 viii) No. ix) According to the permit, the company has the following general terms and conditions: - to restrict their emissions - to comply with limit values - to reduce pollution as far as possible - to replace equipment and change of discharge point - to have preventive maintenance to keep ordinary emissions at the lowest possible level and to avoid unintentional emissions - to take action in the event of an increased risk of pollution The company must establish preventive and emergency measures against acute pollution, including environmental risk analysis, preventive measures, a contingency plan, a contingency organisation, an exercise of emergency preparedness, and must notify risk of or acute pollution to the pollution authorities as soon as possible.

Water body	Company	Disposal conditions
		Of relevance to water disposal specifically, the company must: - Investigate the location of the discharge point out into Jøssingfjord by 1 June 2021 - Propose an action plan by 31 December 2021 for Sandbekk to achieve the goal of good chemical and ecological condition in Sandbekkelva. - By 01.01.2025, emissions of nickel to the Sandbekkelva must be reduced so that they do not exceed 0.75 kg / day. x) The company must have a plan for closure and post-operation of the deposit. The plan shall include necessary measures to bring the deposit area back to a state that is in the greatest possible harmony with the surrounding nature, as well as measures to ensure against pollution of the surroundings after the deposit has been closed. The plan must be updated regularly and must be anchored in the company's internal control. The plan shall also include a financial guarantee or equivalent security to ensure that the obligations arising from the permit and / or relevant regulations can be fulfilled even after the closure of the business. The guaranteed amount shall cover expected costs for closure and after-sales for a minimum of 30 years. The company also has obligations to: a) perform emission control and reporting to the pollution authority, including map emissions to air and water, to control and document the emissions by carrying out measurements, to manage the quality assurance of the measurements, to have an emission control programme included in its internal control and to report to the pollution authority by 1 March each year b) perform environmental monitoring, including monitoring of the receiving environment and monitoring in accordance with the water regulations
Førdefjorden-ytre	Nordic Rutile	Since 2011, the permits have been held by Nordic Mining's wholly owned subsidiary Nordic Rutile AS.[16] The following analysis is based on Permit 2016.0721.T ('the permit'), first granted in June 2015 and last updated in January 2019. (i) According to Nordic Mining, the process plant area will be accessed from the county road Fv611 via a ramp road. A tailings disposal system will transfer tailings from the process plant via a subsea pipeline to a dedicated subsea deposition area.[17] (ii) According to Nordic Mining, the process plant sewage treatment plant includes a sludge separator unit used for sewage treatment. Sewage from the mine complex will also be routed to the sludge separator.[18] As explained in the permit, for the recovery of fresh water and to optimise the deposition of effluents, Magnafloc 5250 (polyacrylamide) can be used as a flocculant, and SIBX and Dow Froth 400 for flotation. (iii and iv) The Fjord is up to 330m deep. The sea landfill is on the seabed outside Engjabøneset. As pointed out by the permit, at the end of the open pit operation, the landfill shall have a maximum height corresponding to the threshold level, approx. 220 meters water depth. After completion of operation, the landfill shall have a maximum height of approx. 150 meters water depth. Drainage pipes for effluent masses shall be led out into the Førdefjord through discharge arrangements to maximum 50 meters above the fjord bottom.

[16] https://d2zbxcnktjvvs5.cloudfront.net/1620730209/updated-definitive-feasibility-study-executive-summary.pdf, p. 10
[17] https://d2zbxcnktjvvs5.cloudfront.net/1620730209/updated-definitive-feasibility-study-executive-summary.pdf, p. 38 and 39.
[18] https://d2zbxcnktjvvs5.cloudfront.net/1620730209/updated-definitive-feasibility-study-executive-summary.pdf, p. 39

Water body	Company	Disposal conditions
		(v) The following parameters are described in Vann-nett: Water type - Water type name: Fjord influenced by freshwater - Ecoregion: North Sea North - Salinity: Polyhaline (18 - 30). - Tide: Medium (1-5 m) - Wave exposure: protected. Protected area - Name: Førdefjorden - Reason: Lakse- og innlandsfiskloven § 7 (The Salmon and Inland Fish Act) (vi) In licences and legal requirements (Pollution Control Act, Product Control Act, Internal Control Regulations, Water Regulations, Waste Regulations on hazardous waste, Regulations on notification of acute pollution or danger of acute pollution). (vii) Yes. See section 2.3 (viii) No. (ix) General terms and conditions. The company must establish preventive and emergency measures against acute pollution. The company must perform investigations and create reports regarding water quality of the affected water body. (x) The company must perform environmental monitoring of receiving areas. Nordic Rutile AS shall establish a satisfactory financial security as described including closure and monitoring of the sea landfill in for a minimum of 15 years after the landfill has been closed, If a facility is shut down or a business stops for an extended period of time, the owner or user must do what is necessary at all times to counteract the risk of contamination.
Elnesvågen / Frænfjorden	Omya Hustadmarmor AS	Frænfjorden is a narrow and shallow fjord in north-western Norway. It extends east–west about 7 km and is about 1 km wide and depths are mostly less than ~70m (75% of the fjord has a depth shallower than 50m). From 1980 to 2003, the discharge permit regulated the quantity of tailings deposited per hour. From 2003, the company changed its focus to manage the STD on the basis of environmental monitoring results and social feedback (Jensen and Hylland, 2019). The following analysis is based on Permit 1994.0092.T ('the permit'), granted in November 2015 and last updated in June 2018. This permit applies to pollution from the production of calcium carbonate based on an annual production of 4.5 million tonnes. 0.7 million tonnes per year of solid mass and 300 litres of exhaust mass oil per year can be discharged to the water. i. No information ii. According to the permit, any oily wastewater from workshops or the like must be treated satisfactorily in an oil separator or equivalent treatment unit and in accordance with the Pollution regulation. iii. According to the permit, departure from the production process is permitted to be deposited in the deep channel in Frænfjorden within an area limited by the line Løsetneset - Ålvora - Langøya - Nordøya - Furøya - Elnestangen. Deposit outside this area is not permitted

Water body	Company	Disposal conditions
		The effluent line for process effluent and the cooling water is permitted to be discharged here too. iv. Disposal is only permitted in those parts of the area that are deeper than 30m. Disposal that results in the build-up of masses up to a level above 30m is not permitted. The cooling water must be discharged into Elnesvågen at an approximate distance of 20m from land and to a depth of approx. 8m. It shall not exceed 2,000m^3 per hour and not entail significant temperature changes in the water body. The use of antifouling agents shall be limited as far as possible without unreasonable costs or inconveniences. v. The following parameters are described in Vann-nett: Water type - Water type name: Protected coast/fjord - Ecoregion: Norwegian Sea South - Salinity: Euhaline (> 30) - Tide: Medium (1-5 m) - Wave exposure: protected. Protected area - Name: Elnesvågen badeplass - Reason: Lov om kommunale helse- og omsorgstjenester m.m. (Act on municipal health and care services, etc.) vi. In licences and legal requirements (Pollution Control Act, Product Control Act, Internal Control Regulations, Water Regulations, Waste Regulations on hazardous waste, Regulations on notification of acute pollution or danger of acute pollution) vii. Yes. See section 2.3. viii. No. Under the last identified control in 2017 (2017.050.I.miljodir), there were no deviations found from the permit, only some notes: - Note 1. Verification of whether the acceptance criterion for turbidity at or outside the boundaries of the sea landfill is complied with is carried out through measurements of turbidity within the boundaries of the sea landfill. - Note 2. Routines follow-up of the preventive maintenance have some points for improvement. - Note 3. Routines for unloading dispersants are not fully laid down in the internal control. ix. General terms and conditions apply. The company must establish preventive and emergency measures against acute pollution. The company must perform investigations and create reports regarding long term effects of effluent and of the degradation of flotation and flocculation chemicals. The company must perform emission control and reporting to the Norwegian Environment Agency. The company must have a waste management plan that describes waste from the disposal, monitoring and control of the deposit, alternative use of disposal and termination of the deposit / rehabilitation. Surveys of the receiving environment must be carried out at least every 3 years in Frænfjorden to get an overall overview of the environmental condition and to document any changes over time. The investigations shall include sampling and measurements both within and outside the landfill area.

Water body	Company	Disposal conditions
		x. Omya Hustadmarmor AS shall have financial security for the closure and monitoring of the sea landfill in Frænfjorden for 10 years after the landfill has been closed. The security, together with the return on interest, must be sufficient to cover all costs of closing the sea landfill and monitoring.
Tosen-ytre / Tosen-indre	Bindal Gruver AS	Permit not granted yet according to information identified. In 2020 Bindal municipality proposed to permit an area of 460,000 m^2 at a depth of 300m in the Tosenfjorden as a marine landfill for a planned gold mine. According to the proposal, 200,000 tonnes a year for 10 to 15 years would be discharged in the Tosenfjord,[19]
Ranfjorden – Mo	Rana Gruber AS	The following analysis is based on Permit 2012.305.T ('the permit'), granted in December 2012 and last updated in June 2015. This permit is based on an annual extraction of up to 4.5 million tonnes of ore and the preparation of up to 85,000 tonnes of imported ore for the production of magnetite concentrate. (i) According to the permit, from 2014 all waste is deposited via a drainage pipe for process sewage at a depth of 125m, 980m from the beach. (ii) The permit states that any oily wastewater from workshops or the like must be treated in an oil separator or equivalent cleaning unit. Water should be recycled in a plant so that residues from flotation chemicals that follow the water flow to the sea landfill are reduced as far as possible. (iii) Ranfjord (iv) 125m. (v) The following parameters are described in Vann-nett: Water type - Water type name: Fjord influenced by freshwater - Ecoregion: North Sea South - Salinity: Polyhaline (18 - 30). - Tide: Medium (1-5 m) - Wave exposure: protected. Protected area - Name: Ranafjorden - Reason: Lakse- og innlandsfiskloven § 7 (The Salmon and Inland Fish Act) (vi) In licences and legal requirements (Pollution Control Act, Product Control Act, Internal Control Regulations, Water Regulations, Waste Regulations on hazardous waste, Regulations on notification of acute pollution or danger of acute pollution) (vii) Yes. See section 2.3 (viii) No (ix) no information (x) no information

[19] https://www.hi.no/hi/nyheter/2020/mars/raar-mot-gullgruvedeponi-i-tosenfjorden

Water body	Company	Disposal conditions
Tysfjorden	Quartz Corp AS	The following analysis is based on Permit 2010.0161.T ('the permit'), first granted in December 2011 and last updated in June 2020. (i) As the permit describes discharge pipes for process wastewater must be led to the water body at a minimum depth of 30m. The discharge must take place in such a way (e.g., through the use of a diffuser, pipe design and discharge rate) so that the best mixing possible in the water body is achieved. (ii) Any oily wastewater from workshops or the like must be treated satisfactorily in oil separator or equivalent cleaning unit. (iii) Not specified (iv) Minimum depth of 30m. (v) The following parameters are described in Vann-nett: Water type - Water type name: Fjord Protected coast/fjord - Ecoregion: Norwegian Sea North - Salinity: Euhaline (> 30) - Tide: Medium (1-5 m) - Wave exposure: protected. Protected area The water body has no protected areas (vi) In licences and legal requirements (Pollution Control Act, Product Control Act, Internal Control Regulations, Water Regulations, Waste Regulations on hazardous waste, Regulations on notification of acute pollution or danger of acute pollution) (vii) Yes. See section 2.3 (viii) No, but the permit noted some deviations: the company used non-declared chemicals, and placed the buoy that measures pH 180m away from the outlet, when the maximum stipulated in the permit is 30m. Moreover, the permit indicates that the company must have investigated: - How to reduce tailing mass by 31 December 2020. - Water - whether the discharges have resulted in a concentration of the substance in the sediments in the area, and whether this can have a detrimental effect on sediment-living organisms and the aquatic environment in the area. (ix) No information (ix) General terms and conditions apply. The company must perform emission control and reporting to the pollution authority. The company must establish preventive and emergency measures against acute pollution. (x) The company must perform environmental monitoring of the receiving environment. In case of closure of a facility for an extended period of time, the owner or user must do what is necessary at all times to counteract the risk of contamination.
Bergsfjorden	Skaland Graphites AS	The following analysis is based on Permit 1989.0061.T ('the permit'), first granted in September 1989 and last updated in January 2002

Water body	Company	Disposal conditions
		(i) According to the permit, the process wastewater must be discharged into the Bergsfjord at least 180m from land and to a depth of 30m below the lowest water level. The distance from land is calculated as the horizontal distance from the shoreline at medium water level. The discharge shall take place in such a manner that the interference in the water masses is as small as possible. (ii) According to the permit, any oily wastewater from workshops or the like must be treated satisfactorily in oil separator or equivalent treatment unit. MIBC (methyl-isobutyl-carbinol) is used to help graphite bind to the air bubbles on the surface / foam in the flotation process. Fresh water is recycled in a thickener where a polymer, Sepco CE 3040 LH, is added, which compresses suspended fabric and increases reuse of the water. (iii) The process wastewater must be discharged into the Bergsfjord at least 180m from land and to a depth of 30m below the lowest water level (iv) 30m (v) The following parameters are described in Vann-nett: Water type - Water type name: Moderately exposed coast - Ecoregion: Norwegian Sea North - Salinity: Euhaline (> 30) - Tide: Medium (1-5 m) - Wave exposure: Moderately exposed. Protected area - Name: Bøværstranda - Reason: Lov om kommunale helse- og omsorgstjenester m.m. (Act on municipal health and care services, etc.) (vi) In licences and legal requirements (Pollution Control Act, Product Control Act, Internal Control Regulations, Water Regulations, Waste Regulations on hazardous waste, Regulations on notification of acute pollution or danger of acute pollution). (vii) Yes. See section 2.3. (viii) No. According to the permit the company must: - Investigate emissions of environmental toxins (arsenic, barium, copper, nickel, zinc and chromium) by 30 June 2020. - Investigate long term effects and decomposition of flotation chemicals in the sea deposit by 30 June 2020. - Investigate diffuse emissions by 30 June 2020. (ix) General terms and conditions apply. The company must perform emission control and reporting to the to the county governor. The company must establish preventive and emergency measures against acute pollution. (x) The company must perform environmental monitoring of the receiving environment which should have been submitted by 30 June 2020. If a facility is closed or a business stops for an extended period, the owner or the user must do what is necessary at all times to prevent any pollution.

Water body	Company	Disposal conditions
Repparfjorden ytre	Nussir AS	According to Nussir, production is set to start in 2024 in two ores that comprise the copper project, Nussir and Ulveryggen. These are about 4km apart from each other. Both are located in Hammerfest municipality, adjacent to the regional road and the Repparfjord (Nussir, 2022). The following analysis is based on Permit 2016.0051.T ('the permit'), granted in January 2016 and not yet updated. i) According to the permit, drainage pipes for effluent shall be led out into the Repparfjord through discharge arrangements to a maximum of 30m above the fjord bottom. (ii) The permit approves the use of flotation chemicals and flocculation chemicals from the preparation process together with the effluents to the sea deposit. Magnafloc 10 can be used as a flocculant and for adjusting the process (including pH), burnt lime must be used. (iii) The discharge arrangement must be flexible to ensure a construction of the sea landfill that minimises the potential for dispersal of particles. The choice of solution for the discharge must be submitted to the Norwegian Environment Agency for approval. (iv) Maximum of 30m above the fjord bottom (v) The following parameters are described in Vann-nett: Water type - Water type name: Protected coast/fjord - Ecoregion: Barents Sea - Salinity: Euhaline (> 30) - Tide: Medium (1-5 m) - Wave exposure: Protected. Protected area - Name: Repparfjorden - Reason: : Lakse- og innlandsfiskloven § 7 (The Salmon and Inland Fish Act) (vi) In licences and legal requirements (Pollution Control Act, Product Control Act, Internal Control Regulations, Water Regulations, Waste Regulations on hazardous waste, Regulations on notification of acute pollution or danger of acute pollution). (vii) Yes. See section 2.3. (viii) No, but the permit states that the company must: - Prepare a proposal for investigating possible long-term effects and degradation of process chemicals in the water deposit; and - Examine the quality elements in the water body that can be directly or indirectly affected by the company's emissions, including the company's discharge, and impact in the water body. (ix) General terms and conditions apply. The company must perform emission control and reporting to the to the Norwegian Environment Agency. The company must establish preventive and emergency measures against acute pollution. (x) Nussir ASA shall have a waste management plan that describes waste from extraction and preparation processes, monitoring and control of waste, alternative

Water body	Company	Disposal conditions
		use of waste materials and closure / after-treatment of waste deposit and rehabilitation. The plan must also contain a characterisation of the waste. The company will work continuously to reduce the amount of waste / waste rock that must be deposited by finding alternative uses for the waste. (x) The company shall have a financial security including closure and monitoring of the waste deposit. The monitoring shall take place for a minimum of 15 years after the waste deposit has ceased to be used. If a facility is shut down or a business stops for an extended period of time, the owner or user must do what is necessary at all times to counteract the risk of contamination.
Bøkfjorden-ytre	Sydvaranger Drift AS	According to control 2015.012.U.miljodir, Sydvaranger Gruve AS (SVG) was declared bankrupt on 18 November 2015. At the opening of the bankruptcy, SVG was given 48 hours to shut down production. During these 48 hours, the preparation plant was emptied of ore and shut down. 20 people worked as of 2 December 2015 for the bankruptcy estate at the plant, 12 of these work in the mine at Bjørnevatn. In April 2016, the Tschudi Group acquired the Sydvaranger assets, and 100,000 tonnes of high-grade iron ore concentrate were produced. In 2018, the Tschudi Group entered into a partnership with the US-based fund Orion Mine Finance. In January 2021 Sydvaranger was merged with Tacora Resources Inc. [20] The following analysis is based on Permit 2008.190.T ('the permit'), granted in April 2008 and last updated in October 2014. Thus, it is previous to the acquisition of Sydvaranger by the Tschudi group in 2016 and its later merger with Tacora Resources Inc. This permit gave permission to Sydvaranger to emit pollution from mining activities in Bjørnevatn. It allows an annual production of 3 million tonnes of iron ore concentrate in the open pits at Bjørnevann west, north and east, Hyttemalmen, Kjellmannsåsen, Grundtjern, Søstervann, Bjørnefjell, Fisketind, Jerntoppen, Tverrdalen. No more recent permit was identified. (ii) The permit allows the use of an annual amount of 65 tonnes of water treatment chemicals, named Magnafloc 10, 155, 1707, LT37 and LT 38. For the use of other water treatment chemicals, the company must apply to the Norwegian Environment Agency for a permit. Any oily wastewater from workshops or the like must be treated satisfactorily in an oil separator or equivalent treatment unit. (iii) The permit applies to the disposal of waste materials from the separation process in Kirkenes to a sea landfill in Bøkfjorden, which is a continuation of the existing sea landfill from the former Sydvaranger ASA. (iv) The drainage pipe for process drainage shall be laid out in Bøkfjorden at least 450m from land and to a depth of at least 25m. (v) The following parameters are described in Vann-nett: Water type - Water type name: Protected coast/fjord - Ecoregion: Barents Sea - Salinity: Euhaline (> 30) - Tide: Medium (1-5 m) - Wave exposure: Protected. Protected area

[20] https://www.sydvarangergruve.no/history

Water body	Company	Disposal conditions
		- Name: Neidenfjorden-Bøkefjorden - Reason: : Lakse- og innlandsfiskloven § 7 (The Salmon and Inland Fish Act) (vi) In licences and legal requirements (Pollution Control Act, Product Control Act, Internal Control Regulations, Water Regulations, Waste Regulations on hazardous waste, Regulations on notification of acute pollution or danger of acute pollution). (vii) Yes. See section 2.3. (viii) No, but the permit states that the company must carry out an investigation of possible long-term effects and degradation of water treatment chemicals on the water deposit. (ix) General terms and conditions apply. The company must perform emission control and reporting to the to the to the Climate and Pollution Agency (KLIF, now the NEA). The company must establish preventive and emergency measures against acute pollution. (x) Sydvaranger mine shall have a waste management plan that describes waste from the separation process (disposal), monitoring and control of the landfill, alternative use of disposal and termination of the landfill / rehabilitation. The company is obliged to keep the plan up to date in the event of any changes in the operating situation and continuously. Sydvaranger shall have financial security for monitoring the sea landfill in Bøkfjorden for 15 years after the landfill has been closed. If a facility is shut down or a business stops for an extended period of time, the owner or user must do what is necessary at all times to counteract the risk of contamination.

2.6 Proximity of STDs to aquaculture

A review of the other uses of the fjords where STD is permitted / in activity was conducted focusing on aquaculture activities which could be negatively affected by the disposal activities. Aquaculture locations were identified from the Norwegian fisheries portal (Directorate of Fisheries, nd), and an approximate estimation of distance was used on the portal to get the best estimate of distance.

Table 2-5 Description of aquaculture activities in fjords of concern

Fjord	Proximity to aquaculture
Jøssingfjord	The closest aquaculture site is 15.5km SE, along the coast. There is no aquaculture labelled upstream or downstream in Jøssingfjord. The closest aquaculture is labelled as NAPP in FLEKKEFJORD, this includes food fish (salmon, trout, rainbow trout) (Olsgard Iiasle, 1993).
Førdefjorden-ytre	The deposit site is located West off the coast of Gryta. The nearest aquaculture site found is 4.3km downstream, West of the mining site, it is named as DYVIKA and is in VESTLAND and includes food fish (salmon, trout, rainbow trout).
Tysfjorden (Kjøpsviksundet)	Using Kjøpsviksundet as a reference, the closest aquaculture site identified was 2.24km upstream, South of the reference point.
Indre Tysfjorden	The waste disposal site is located East of Nordnes as well as near Drag. The nearest aquaculture sites (all including food fish) are 4.7km East labelled as HULLØYHAMN Ø in NORDLAND, located adjacent to the site; 3.2km South East named BJØRKVIK

	in NORDLAND, upstream of the site; 6.0km South East called RAHKASLUOKTA in NORDLAND, upstream of the site; and 7.1km East named SALALUOKTA in NORDLAND, upstream of the site. See Naturvernforbundet, 2015.
Stjernsundet	Closest aquaculture site identified is called DAVATLUFT in TROMS OG FINNMARK located 9.8km upstream East of the site. This contains salmon, trout and rainbow trout (Ramirez-Llodra et al., 2022).
Repparfjorden ytre	The closest aquaculture site is located 10.7km downstream, Northwest of the site called ENKENESET; this contains salmon, trout and rainbow trout.
Bøkfjorden-ytre	The discharge point is located North of the town of Kirkenes; there are no aquaculture sites near the discharge point. There is a 'slaughter cage' located 2.6km East and adjacent to the site, called BLÅSENBORGNESET, for which the activities are unclear.

3. General description of the hazards and exposures relating to mining waste chemicals and materials

3.1 Overview

This section provides an overview of the inherent *hazards* associated with the chemicals and materials that are (or have been) discharged into Norwegian fjords through disposal of tailings. It also includes reflections on the likely *exposures*, including exposure routes and exposure levels. The next chapter then goes on to discuss the *risks* of these chemicals and materials.

KEMI (2020) provides the following descriptions of some key terms, in the context of risk assessment of chemicals:

- The **hazard** of a chemical depends on its intrinsic properties, its capacity to interfere with normal biological processes in living organisms, or its capacity to burn, explode, corrode, etc.
- **Exposure** assessment determines the nature and extent of exposure for humans and organisms in the environment to chemicals under different conditions.
- **Risk** characterisation combines the results of a hazard assessment (hazard identification and dose-response assessment) with an exposure assessment. Substance-specific toxicity information is compared against measured or estimated exposure levels to determine whether concentrations associated with an exposure are of concern and triggers risk reduction measures.

These definitions are important in terms of understanding how chemicals and other materials in mining waste may cause harm to people and the environment.

3.2 Hazards

Chapter 2 identified a number of materials and chemicals that have been identified as being discharged during disposal of mining waste. The table below provides information on the hazards of a (non-exhaustive) selection of these substances, as an illustration of the *potential* of discharges to cause harm. Note that some of the chemicals previously used may no longer be permitted for use, and the table below may not exclusively include substances that are used today.

Note that the table is not exhaustive: additional chemicals will be relevant for some mines and not all chemicals will be relevant for all mines. There is information on other chemicals included in the appendices to this report.

The table is separated into (a) materials; (b) chemicals present in tailings from source rock; and (c) chemicals used in the mining process (e.g., flocculants and flotation chemicals).

Table 3-1 Overview of hazards of some chemicals and materials relevant to mining wastes (not exhaustive)

Substance / material	Information on hazards (examples) (ECHA, 2022)
Materials (waste rock and tailings)	
General solid materials	Physical impacts on ecosystems e.g. through coverage by tailings
Suspended solids / particulate material	Can cause physical damage to fish and other aquatic life For example, reduced visibility and damage to gills in fish (NEA, 2019a).
Chemicals present in tailings (examples)	
Arsenic	Acutely toxic (cat. 3) if inhaled or swallowed Very toxic to aquatic life with long term effects (aquatic acute 1, aquatic chronic 1) SVHC status: Carcinogenic (arsenic acid)
Cadmium	Carcinogenic (cat. 1B), mutagenic (cat. 2) and toxic to reproduction (cat. 2) Very toxic to aquatic life with long term effects (aquatic acute 1, aquatic chronic 1) WFD priority hazardous substance SVHC status: Carcinogenic, STOT (various cadmium compounds also identified as mutagenic and/or toxic for reproduction)
Copper	Toxic to aquatic life with long lasting effects (aquatic chronic 2) SVHC status: Not SVHC
Lead	May damage fertility; may damage the unborn child (toxic to reproduction cat. 1A) Very toxic to aquatic life with long term effects (aquatic acute 1, aquatic chronic 1) WFD priority substance SVHC status: Toxic for reproduction
Mercury	May damage the unborn child (toxic to reproduction cat. 1A) Fatal if inhaled (acute toxic cat. 2) Very toxic to aquatic life with long term effects (aquatic acute 1, aquatic chronic 1) WFD priority hazardous substance SVHC status: Not SVHC
Nickel	Carcinogenic (cat. 2) WFD priority substance SVHC status: Not SVHC
Zinc (powder)	Very toxic to aquatic life with long term effects (aquatic acute 1, aquatic chronic 1) SVHC status: Not SVHC
Chemicals used in the mining process (examples)	

Substance / material	Information on hazards (examples) (ECHA, 2022)
Carboxymethyl cellulose (CMC)	Not classified.
Dow Froth 400	[No hazard information identified]
Fluorosilicic acid (reacted from hydrofluoric acid before discharge)	Skin corrosion (cat. 1B)
Lilaflot D817M	Takes a very long time to biologically degrade, has high fat-solubility and therefore potential for bioaccumulation. Meets all criteria for inclusion on the list of substances prohibited for use or discharge to nature in Norway. Chemicals with similar properties to Lilaflot D817M were used by the offshore industry in the mid-1990s, but have now been phased out (NEA, 2019a).
MIBC (methyl-isobutyl-carbinol)	May cause respiratory irritation (STOT SE 3)
Microplastics	Insoluble in water, degrade very slowly and can easily be ingested by living organisms, raises concerns about their general impact on the environment and, potentially, on human health (European Commission, 2022b)
Polyacrylamide [Note 1]	[No hazard information identified]
Sepco CE 3040 LH	Proprietary polymer. No hazard data identified.
SIBX	Possibly: • Acutely toxic if swallowed, in contact with skin • Respiratory sensitiser • Very toxic to aquatic life, with long-lasting effects [Note 2] Note that additional data generation has been requested by ECHA under the REACH regulation [Note 3]

Notes: (1) For example, in water treatment chemicals such as Magnafloc 10, 155, LT37 and LT38 as mentioned in the previous chapter. (2) "Possibly" because there is no EU harmonised classification, only various "notified" classifications which vary by company (https://echa.europa.eu/information-on-chemicals/cl-inventory-database/-/discli/details/58533). (3) Additional information was requested during dossier compliance check, expected by 16 September 2022 (https://echa.europa.eu/documents/10162/07002bda-4792-1bda-f179-976358a4e3e5).

Note that the above are examples of chemicals and materials that have been identified as being discharged during mining waste disposal into fjords; most of the substances are also included in permit discharge limits for some mining operations (where they are used). It is relevant to note that some concerns have been expressed regarding degradation products for some of these substances, for example, concerns that SIBX may degrade to carbon disulphide in the environment. These degradation products are not typically included in permits[21], but have, for example, been included in the context of inputs to environmental risk assessments used to inform setting of permit conditions[22].

It is also worth noting that some of the data and literature reviewed refers to substances that may be of concern, and which have been monitored as part of programmes relevant to discharge of mining wastes, but which may not be directly relevant. For example, some studies have

[21] The permits reviewed generally include emission limits for the substances used in or present in the mining process. The permits themselves do not include degradation products, which is in keeping with the approaches in setting permit conditions in other environmental permitting regimes.
[22] See for example, IFE (2020, In this study, a maximum theoretical CS_2 concentration based on laboratory-based experiments was 1.98 mg/l in marine water, which compares to the PNEC for this substance of 0.001 mg/l. However, it is not known whether such high concentrations could occur in the real world.

investigated pollution by PCBs, which are not directly identified as having been used or discharged to fjords from mining activities.

Based on the above, it is clear that various hazardous substances can be discharged during disposal of mining wastes into fjords, and this is reflected in permit conditions setting quantitative limits for maximum allowable discharges of these substances. The fact that permits allow discharge of hazardous chemicals is, on its own, not unusual, and is typical of many industries that are covered by environmental permitting requirements. There is, however, an expectation that permit conditions should be set such that exposure is controlled, so as to ensure that risks to health and the environment are tolerable.

3.3 Exposure

The extent to which material or chemical substances discharged into fjords from mining activities pose risks to the environment and people depends not only on the inherent hazards, but also the extent to which the environment and people are exposed to those hazards.

In the case of tailing materials in general, for example, disposal on the seabed can have major consequences on flora and fauna that are covered by that material, with the magnitude of impacts depending on factors such as: composition of tailings; distribution of fine material; volume of the tailings discharged in a given time; depth of discharge and disposal; current (e.g. related to periodic water exchange); duration; and biodiversity in the fjord (NEA, 2019a). As set out in chapter 2, releases in some fjords are permitted to be as much as several million tonnes per year, and such exposure levels will clearly have negative consequences on any flora and fauna covered by the discharges.

In the case of chemicals – either those present naturally in the rock/tailings or those used in the mining process – biota, and ultimately humans, will be exposed to these chemicals to some degree. The extent of this exposure will depend on many factors such as:

- Quantities released, and duration of those releases.
- Extent to which the substances are bound within the tailings. Several of the substances will be part of the source rock and will thus *tend to* be less bioavailable, though this is not always the case. Chemicals used (added) in the mining process will *tend to* be more readily available.
- The physicochemical properties of the chemicals, which affects the extent to which they are distributed across environmental compartments (water, sediment, air, etc.), as well as how widely they will be transported.
- Degradation, through biodegradation or abiotic processes. This could lead to exposure to degradation products which are either more or less hazardous than the original substances.
- Uptake and absorption, distribution, metabolism and excretion by organisms in the fjords, including any potential bioaccumulation.
- Properties of water in the fjords, such as pH, currents, temperature and other parameters.

Appendix D of this report includes information on the potential extent of the risks and impacts associated with such exposures. In principle, permit conditions – for disposal of mining wastes and for other industrial activities – should be set such that discharge limits lead to those risks/impacts being controlled.

The permits reviewed for the current study (see chapter 2) generally include provisions on quantities that can be discharged to water bodies (as well as e.g. air, land), but do not typically include measures to reduce or eliminate the potential for those chemicals to be bioavailable once discharged. However, they do include measures such as requirements to continuously seek substances that are environmentally better than those listed in the permits and to further limit emissions below those limits set in the permits (e.g. as far as possible without unreasonable costs). This is typical of permitting regimes in similar industries in other European countries. (However, Norway is the only EFTA country where submarine disposal of mining tailings is allowed, so such discharge of mining wastes is of course not covered in permits elsewhere.)

It is also relevant to note that there may be various other sources of some of the chemicals listed in the tables above, both other industrial sources, and in some cases natural sources (e.g. for the metals present in the tailings/rock itself). It is not known whether the emission limit values included in permits are set taking into account those other sources of the chemical substances.

Nonetheless, it is clear that there will be at least some exposure, in the near vicinity of discharge, to all of the chemicals, and – depending on their properties, and the conditions of discharge and those of the fjords themselves – also in locations more remote from the immediate discharge point. The extent of this exposure will vary location-by-location, and chemical-by-chemical, as well as on the form of the chemical and the discharge; it is only though effective monitoring and modelling of environmental fate and behaviour that the actual extent of exposure can be determined. Available monitoring data is described in chapter 2[23].

It should also be noted that the concentrations of some of the chemicals are likely to increase over time, particularly those that are persistent, so effective monitoring over appropriate time periods is also critical to understanding exposure levels.

[23] Note, however, that no information was available/reviewed on whether the "emission limit" values set in permits are being exceeded. Elsewhere in this report, however, information is available (e.g. from Vann-Nett) on whether the chemical EQS values or BQE are being exceeded, feeding into the Norwegian conclusions on water body status.

4. General description of risks relating to mining waste chemicals and materials

4.1 Overview

The previous chapter considered the hazards of, and exposure to, chemicals and materials present in discharges from mining activities into fjords.

The present chapter focuses on the risks associated with this disposal of mining wastes, and how those risks are assessed in the context of setting conditions for mining waste disposal.

Specifically, the chapter covers:

- Risks (and benefits) of sea-based mining waste disposal compared to land-based disposal.
- Considerations on the risks of and potential damage from discharges to fjords, building on the information in the previous chapter.
- Considerations based on permitting requirements for assessment and management of risks.
- Emerging policies that may require more stringent risk management for mining waste disposal in the future.

4.2 Risks of sea-based mining waste disposal

Mining waste is one of the largest waste streams in the EU (European Commission, nd1). Its management is governed, in part, by the Extractive Waste Directive (EWD, Directive 2006/21/EC).

The EWD aims to 'prevent or reduce as far as possible any adverse effects on the environment, in particular on water, air, soil, fauna and flora and the landscape, and any resultant risks to human health, brought about as a result of the management of waste from the extractive industries'. The Directive indicates (paragraph 24) that 'for the purposes of minimising water pollution, the discharge of waste into any receiving body of water should comply with Directive 2000/60/EC' (the Water Framework Directive).

Article 13(4) of the EWD on prevention of water status deterioration requires that Member States 'make the disposal of extractive waste, whether in solid, slurry or liquid form, into any receiving body of water other than one constructed for the purpose of disposing of extractive waste conditional upon compliance by the operator with the relevant requirements of Directives 76/464/EEC, 80/68/EEC and 2000/60/EC'. Guidelines are currently being drafted for best risk management approaches in the extractive sector (European Commission, nd2); these are related to, but distinct from, the application of best available techniques (BAT). The full guidelines are not yet available, but an initial background document does not appear to cover disposal of mining waste in water.

The implementation of the EWD is supported by the best available techniques reference document for the management of waste from extractive industries (MWEI BREF) published by the European Commission (2018).

The MWEI BREF describes sea disposal of extractive waste as 'uncommon practice in the EU' while noting it is applied in Norway 'in specific cases after Environmental Risk and Impact Evaluation'. The Environmental Assessment requires that comparisons are made between land disposal alternatives and sea disposal to evaluate the environmental acceptance and the technical feasibility of any relevant alternatives.

The MWEI BREF notes that a challenge in the assessment of environmental impacts from sea disposal is the lack of baseline studies (i.e. limited information on habitat, environmental conditions, and conditions of flora and fauna that might be affected by the disposal). The BREF also notes that there is limited research which enables an understanding of marine ecosystems and the influence of the mining waste, noting a 'lack of published scientific knowledge of the biodiversity patterns and functioning of the marine ecosystems, particularly in the deep sea, including the effects of metals and chemicals on deep-sea biota'.

The Initiative for Responsible Mining Assurance (IRMA) is a coalition of NGOs, mining companies, businesses purchasing minerals and metals for resale in other products, affected communities, and trade unions. According to the MWEI BREF, the IRMA only certifies land-based disposal at present, and not sea disposal. They highlight that 'the necessary science to determine the impacts on existing resources is not in place, nor is there any defined programme to collect this information [and] the fact that the economic advantage of utilising a natural body of water for extractive waste disposal, over construction of an engineered impoundment for this waste, is so large that it currently distorts the evaluation of the social and environmental factors involved in a waste disposal location decision'.

The MWEI BREF describes possible benefits but also risks associated with submarine disposal which are summarised in the table below.

Table 4-1 Information on risks associated with sea disposal of mining waste

Possible benefits (compared to land based)	Risks
Increased physical stability on the seabed: no risk of a dam burst	Negative environmental impact on the ecosystem: obliteration of the benthic fauna; alteration of the bottom habitat; biological diversity not maintained; impacts on fish stocks
Increased chemical stability: extractive waste is less likely to oxidise in the submarine environment, thus reducing the breakdown of minerals releasing toxic metals; in addition, the alkalinity of seawater is understood to decrease the mobilisation of metals (reduced ARD)	Negative impact on seawater quality: slow release of flocculants and leaching of metals and metalloids in the sea; turbidity created by underwater slides or other mechanisms
Reduced dust and odour emissions	Larger footprint: the seabed surface affected by sea disposal is larger than for land-based deposition
Reduced visual impact	Reduced circular economy potential: reduced possibilities for the re-mining of mineral resources from the extractive waste disposed of in the sea
Reduced investment and operational costs	Hyper sedimentation
	Fine-grained waste material may create a barren area close to the discharge and is likely to cause the disappearance of species

Possible benefits (compared to land based)	Risks
	Changes in the community composition and structure, as well as changes in population abundances
	Longer term, the community composition and structure will reflect the degree of disturbance, with sensitive species disappearing and more tolerant species dominating the new ecosystem
	Toxic effects of reagents and flotation chemicals, particularly on sessile fauna
	Chemicals might also be present in the sediments closest to the discharge points for several years after cessation

Source: MWEI BREF (European Commission, 2018).

As set out in the MWEI BREF, today, comprehensive baseline studies are required in order to obtain a permit for discharge of extractive waste into the sea. An Environmental and Social Impact Assessment is then carried out prior to site selection (comparing sea disposal and land-based facilities), with sea disposal selected only if it is found to be the best alternative compared to land-based options (in terms of the overall environmental and social risks and impacts).

Section 4.3.2 of the MWEI BREF, on “techniques to prevent or minimise surface water status deterioration”, also specifically mentions the Water Framework Directive as one of a number of considerations in the setting of permit conditions.

Regardless of whether sea disposal or land-based disposal is found to be the preferred option in any given location, it is clear that there will always be risks, and associated environmental harm/damage, associated with sea disposal.

4.3 Risks and potential damage from disposal of mining waste into fjords

It is clear from the discussion in Section 3 that:

- Various hazardous substances and materials are (and have, in the past, been) discharged during disposal of mining wastes to fjords in Norway.
- These substances and materials will spread, to varying degrees, in the aquatic environment. For example, materials discharged in bulk form will behave differently to those discharged in particulate form.
- Environmental media, biota, and ultimately people, will be exposed to those substances and materials to varying degrees, through uptake by organisms and transfer through food chains.
- In some cases, those exposure levels will clearly lead to harm to the environment, such as plants and animals being directly covered by deposition of tailings. This will have an effect over long periods, depending on the conditions in the fjord and of the discharge.
- In other cases (e.g. discharge of chemicals), the extent to which harm will be caused is very situation-dependent, and is affected by the specific chemicals used or present

in the tailings; discharge parameters; local environmental conditions; and uptake by organisms. For some chemicals, the degradation products may also be relevant.

- Several of the chemicals that are known to be used can have both short-term and long-term effects on aquatic organisms, and some of the most harmful (e.g. CMR substances) can have serious effects on humans. Some of those chemicals are naturally present in the source rock, so their discharge is in effect inevitable (while deposition to sea is allowed in environmental permit conditions); others are deliberately added during the mining process but are still relevant if the wider tailings materials are discharged. The extent to which these substances are able to cause harm in practice is also highly situation-dependent[24].

The risks posed will also be very dependent on the environmental "receptors" in any given discharge situation. For example, various fjords are either used by migratory fish or are used for commercial fish farms. Given the hazardous properties and exposures highlighted in the previous chapter, adverse effects on these are clearly possible. The use of fjords for such purposes is considered in Section 2.5.

By way of example, the table below summarises the possible impact of particulate material in the water on salmon fish farms, based on a report concerning tailings disposal in Norway.

Table 4-2 Possible impact of particulate material in the water on salmon in fish farms

Cause	Impact	Comments
Reduced visibility in the water due to large volumes of mud in the water	Increased stress, which in general results in increased probability of outbreak of disease	The threshold level is not known. The type of particle may be decisive for stress levels, with highest stress caused by sharp particles and lowest stress caused by eroded, rounded particles.
Damage caused to gills by sharp particles.	Reduced capacity for osmoregulation.	Needle-shaped, sharp particles (fibres similar to asbestos) appeared to cause most damage.
	Increased probability of intake of contaminants from the water masses.	Wounds on the gills will be open to bacteria and virus in the water masses.

Source: NEA (2019) (reworked from Dragsund and Thendrup, 1990).

4.4 Permitting requirements for assessment and management of risks

Permits for various mining operations in various fjords have been reviewed as part of this analysis. These permits are issued under the Norwegian Pollution Control Act[25], and set out the (environmental) conditions to be met in order to operate. The permits reviewed follow a similar

[24] It is not practicable with the available data to provide any quantitative indication of the scale of such impacts.

[25] Act of 13 March 1981 No.6 Concerning Protection Against Pollution and Concerning Waste

format and include the following elements as regards requirements for assessment and management of risks:

- Details of the process chemicals used, and the associated quantities.
- Emission limits for releases of suspended material and of specific chemicals to water and air in particular (point source and diffuse emissions).
- For chemicals that may pose a risk of contamination, an assessment of health and environmental properties.
- A system for substitution of harmful chemicals, including an ongoing assessment of the risks/hazards caused by the chemicals used, and whether alternatives exist (considering effects during production, use and final disposal).
- A requirement to comply with the REACH Regulation and other legislation applicable to chemicals, such as the Water Framework Directive.
- Requirements for environmental risk assessment of the activities undertaken and for monitoring of discharges.
- Requirements for additional surveys and studies.

It is also clear that there are provisions in place for auditing and inspection of installations[26], and that the results of these are made publicly available. This is not always the case with other permitted installations in other countries.

The permits also include a duty to take action in the event of an increased risk of pollution. For example, the specific requirement typically reads:

“If, as a result of abnormal operating conditions or for other reasons, there is a risk of increased pollution, the company is obliged to implement the measures necessary to eliminate or reduce the increased risk of pollution, including, if necessary, reducing or ceasing operations. The company must as soon as possible inform the Norwegian Environment Agency about abnormal conditions that have or may have a pollution significance. Acute pollution must be notified.”

The requirements here relate to pollution in general, but there are also examples of more specific permit conditions linked to compliance with the water framework directive. For example, a recent permit for Nussir ASA (NEA, 2016) includes a requirement for a programme for monitoring including:

- how disposal of tailings at sea affects the biological diversity in the Repparfjord and in nearby watercourses (including whether the requirements of the water regulations are complied with);
- effects on vulnerable / important species and habitats and on the fjord's ecosystem (particularly in important spawning areas for cod);
- documenting the possible presence of substances from the effluents, including process chemicals, in marine species and organisms that may be important for food safety in and near the disposal area;
- a basic characterisation of the content of relevant substances before the deposition of effluents is implemented;

[26] For example, details of audit results published online, such as in NEA (2019b). The permits do not typically specify an audit/inspection frequency.

- proposals for monitoring the water quality in rivers in order to be able to detect any changes in the water quality at an early stage; and
- a requirement to register data obtained by monitoring in water, including sediment and biota, in the Aquatic Environment database (Vannmiljø).

In principle, the NEA can revoke the permit, or may issue fines, or require implementation of pollution control measures. It is understood that, to date, no environmental permits from these mining activities have been revoked (NEA, 2022).

4.5 Emerging policies affecting assessment and management of risks

Overview

This section provides a brief overview of some emerging policy areas and how these might affect the assessment and management of risks associated with disposal of mining wastes.

Nanoforms of chemicals

Various concerns have been raised about the release of nanomaterials from deposition of mining wastes in fjords (see Section 2.2 and Section 7).

As of 2020, under the REACH Regulation, there are specific requirements for companies that manufacture or import nanoforms of substances, including characterisation of nanoforms (Annex VI); chemical safety assessment (Annex I); registration information requirements; and downstream user obligations. The amendments apply to all new and existing registrations covering nanoforms.

However, most of the concerns raised in respect of releases of nanomaterials from mining waste disposal into fjords seem to relate to disposal of waste tailings material, rather than substances that are deliberately manufactured, imported or used and then released, as is the case for the provisions under REACH.

It is currently unclear how, if at all, nano-sized materials released to water (e.g. mining wastes) would be treated under REACH and other chemicals legislation. The ongoing registration of nanoforms of chemicals under REACH, and evaluation of information submitted by the authorities, seems to be focused on intentionally-produced nanomaterials, rather than those that may arise through mining. Therefore, while disposal of mining wastes to fjords may include discharge of substantial quantities of nanomaterials, this does not appear to be covered by any (nano-specific) provisions in law.

Microplastics

The European Commission (2022b) has recently taken forward a proposal to restrict the use of intentionally added microplastics in products[27].

NGOs have highlighted that blasting in mines produces plastic waste, e.g. related to use of detonators, which are transformed into microplastic particles as the rock is fed to crushers and mills, and subsequently the plastic waste is transformed to microplastic particles, and follows the

[27] Specifically, this would restrict the use of polymers that are solid and which either are contained in particles and constitute at least 1 % by weight of those particles, or build a continuous surface coating on particles, where at least 1 % by weight of those particles either have all dimensions of the particles ≤ 5 mm or length of the particles is ≤ 15 mm and length to diameter ratio is greater than 3. Certain other polymers will also be exempt from the requirements.

tailings to be fed to the fjords. They suggest that, as plastic has low density, these particles will probably be widely spread in the fjords (Naturvernforbundet, 2021a). This appears to be a reasonable conclusion, though there does not appear to be any evidence available to determine how much of a problem this might be.

It is expected that such releases of microplastics would be outside the scope of the impending restriction on the use of microplastics (as they are not intentionally added). Therefore, there does not seem to be any existing or impending legal mechanism by which such discharges would be addressed at European level (and indeed such discharges are not routinely covered in permits in other European regimes).

However, it is worth noting that the European Commission is also considering possible measures to address microplastics from other sources, including those that are not intentionally added to products (European Commission, nd3).

Co-exposure to chemicals in unintentional mixtures

As set out in the European Commission (2020) progress report on chemical mixtures, even exposures at concentrations regarded as safe for the individual substance (i.e., where no effects are expected), can result in adverse (eco)toxicological effects when several substances occur together in a mixture.

The Commission's Chemicals Strategy for Sustainability recognises the need for a targeted revision of REACH, with possible measures being considered including the introduction of Mixtures Assessment Factor (MAF) in REACH. The aim would be to help address the risks from unintentional mixtures for substances registered under REACH.

The rationale behind this is that, under REACH, companies are required to assess and manage the safety of their substances, but they are not required to take into account the possibility of co-exposure to other substances. In practice, they often are not able to do so, as they do not have information on how other substances (to which people and the environment may be exposed) are used.

The environmental permits issued to mining companies discharging to fjords typically refer to the need to comply with the requirements of REACH. Those requirements could change if a MAF is introduced into the registration process within REACH.

The Commission is considering the implementation of a MAF as part of the chemical safety assessment under REACH. A MAF would be a factor by which the regulatory threshold of a given substance (PNEC or DNEL) needs to be divided in order to ensure a level of protection against unintended mixture effects that is similar to the level of protection aimed for in a single substance assessment.

This would lead to a greater level of protection at the level of individual substances, in order to protect against the contribution of those substances to co-exposure of people and the environment with other substances. In practice, this could lead to a tightening of emission limit values for substances released during disposal of mining wastes to fjords.

If implemented, a MAF could have implications for chemicals released from mining waste disposal, ensuring that releases of other substances from other sources (to the same receiving environments) are taken account. Primarily this would involve a reduction in the levels of emissions that are considered to be safe, as compared to the single-substance approach adopted today.

5. General description of the currently known effects to the environment regarding mining waste chemicals and materials

5.1 Overview

This section presents a summary of the analysis of water body status (ecological and chemical) and changes observed in status. This section relies on two main categories of sources: the data and information gathered as part of the implementation of the WFD, and wider sources of information including site-specific analysis.

5.2 Analysis of status data

The analysis of the data reported under the WFD and presented in the Vann Nett platform is presented below. The aim was to review these data to identify potential worsening of status, either at overall status level (ecological, chemical) or for the individual components of the status (e.g., biological quality elements, BQEs).

General context

As indicated, 2016 was the first full reporting under the WFD made by Norway. The data from 2016 is used as a reference to identify whether the situation in the relevant fjords has worsened over time. However, it is important to note that in 2016, many of the water body statuses were determined by expert judgement rather than relying on data as the classification methodology was not finalised until 2018 and the (high) number of water bodies in Norway makes the use of expert judgements necessary.

In addition, some statuses were set to ‘undefined’ where data gaps were too significant, and no expert judgements could be applied.

Norway is currently finalising its second reporting under the WFD. Some fjords are expected to still have ‘undefined’ status, in particular Tosen-indre and Tosen-ytre where priority substances have not been monitored. In addition, in Stjernesundet, priority substances (Cd, Hg, Ni and Pb) were monitored last in 2006 and are deemed to be too old to be representative for chemical status in 2022.

Ecological status

An overview of the changes in ecological status between 2016 and 2022 for the water bodies considered is presented below.

Table 5-1 Information on ecological status in 2016 and 2022

Water body	VANN NET reference	Area (km²)	Ecological Status 2016	Ecological Status 2022
Jøssingfjord	0240000100-C	0.82	Poor	Moderate
Førdefjorden-ytre	0281010202-C	30.57	Good	Moderate
Elnesvågen	0302012400-2-C	4.49	Poor	Good
Tosen-ytre	0360011100-1-C	28.91	Good	Good
Tosen-indre	0360011100-2-C	23.99	Good	Moderate
Ranfjorden - Mo	0362011000-2-C	14.42	Undefined	Moderate
Tysfjorden	0364020100-6-C	191.68	Good	Moderate
Indre Tysfjorden (Kjøpsviksundet)	0364020603-C	23.02	Moderate	Moderate
Bergsfjorden	0401011400-C	39.60	Good	Good
Stjernsundet	0420030200-7-C	105.37	Undefined	Good
Repparfjorden ytre	0421010500-1-C	30.62	Good	Good
Bøkfjorden-ytre	0424030500-3-C	48.03	Good	Moderate

From the data available a worsening of the status can be observed in Førdefjorden, Tosen-indre and Bøkfjorden.

Further details on the statuses changes were provided by the Norwegian Environment Agency (NEA) indicating that:

- Only Repparfjorden ytre had ecological status reported in 2016 at BQE-level ('Good' status for benthic invertebrate fauna). All other fjords had ecological status at WB-level only, i.e., reported as 'Expert judgement'.
- For Førdefjorden-ytre, 'moderate' in 2022 is caused by RBSP (2014-2018) Zinc (MAC EQS).
- For Tosen-indre, 'moderate' in 2022 is caused by BQE (2020-2021) benthic invertebrate fauna.
- For Tysfjorden, 'moderate' in 2022 is caused by RBSP (2013) Arsenic (AA EQS) and Zinc (both AA-EQS and MAC_EQS).
- For Bøkfjorden, 'moderate' in 2022 is caused by BQE phytoplankton, Chla (2016-2021) and total phosphorous (2016-2021).

Further details on substances failing in 2022 are presented in the table below.

Table 5-2 Details of BQEs at water body level in 2022

Water body name	WaterBodyID	Phytoplankton	Macroalgae	Invertebrate fauna	Nitrogen cond.	Phosphorous cond.	RBSP (EQS)
Jøssingfjord	0240000100-C		-		Nitrate + nitrite	-	Cu, Zn
Førdefjorden-ytre	0281010202-C	-	-				Zn
Elnesvågen	0302012400-2-C	-	-		-	-	-
Tosen-ytre	0360011100-1-C	-	-		-	-	
Tosen-indre	0360011100-2-C	-	-	NQI1, ISI_{2012}	-	-	-
Ranfjorden - Mo	0362011000-2-C	-	-	NSI, ES_{100}; H', ISI_{2012}	-	-	Cu, Zn, PAH
Tysfjorden	0364020100-6-C						As, Zn
Indre Tysfjorden (Kjøpsviksundet)	0364020603-C	-	-	-	-	-	As, Zn
Bergsfjorden	0401011400-C	-	-		-	-	
Stjernsundet	0420030200-7-C	-	-		-	-	
Repparfjorden ytre	0421010500-1-C	-	-		-	-	
Bøkfjorden-ytre	0424030500-3-C	Chla	-			Total phosphorus	

Status colour: blue – very good, green – good, yellow – moderate, red - bad

Chemical status

An overview of the changes in chemical status between 2016 and 2022 for the water bodies considered is presented below. As can be observed, chemical status remains undefined for some of the fjords considered. This point was discussed with the NEA. When looking at other countries reporting under the WFD for the 2nd RBMP reporting cycle, c. 22% of water bodies were in unknown chemical status (EEA, 2022). As such the remaining 'undefined' status is not unusual but efforts should be made to reduce these as far as possible.

Table 5-3 Information on chemical status in 2016 and 2022

Water body	Vann Nett ID	Area (km^2)	Chemical Status 2016	Chemical Status 2022
Jøssingfjord	0240000100-C	0.82	Undefined	Poor
Førdefjorden-ytre	0281010202-C	30.57	Undefined	Good
Elnesvågen	0302012400-2-C	4.49	Undefined	Poor
Tosen-ytre	0360011100-1-C	28.91	Undefined	Undefined
Tosen-indre	0360011100-2-C	23.99	Undefined	Undefined
Ranfjorden - Mo	0362011000-2-C	14.42	Poor	Poor
Tysfjorden	0364020100-6-C	191.68	Undefined	Poor
Indre Tysfjorden (Kjøpsviksundet)	0364020603-C	23.02	Undefined	Poor
Bergsfjorden	0401011400-C	39.60	Undefined	Good
Stjernsundet	0420030200-7-C	105.37	Undefined	Undefined
Repparfjorden ytre	0421010500-1-C	30.62	Good	Good
Bøkfjorden-ytre	0424030500-3-C	48.03	Poor	Poor

From the information presented, there is no apparent worsening of the chemical status. However it is clear that a large number of the water bodies' chemical status in the first cycle was 'undefined', which might hide a potential worsening.

When considering EQS failings in 2022, the table below shows the parameters responsible for the poor status in the selected water bodies considered in this study.

Table 5-4 Details of chemical substances failing in water bodies in 2022

Water body name	WaterBodyID	Chemical (EQS)
Jøssingfjord	0240000100-C	Ni
Førdefjorden-ytre	0281010202-C	
Elnesvågen	0302012400-2-C	Hg
Tosen-ytre	0360011100-1-C	Undefined
Tosen-indre	0360011100-2-C	Undefined
Ranfjorden – Mo	0362011000-2-C	PAH, TBT
Tysfjorden	0364020100-6-C	Pb, Hg, PAH
Indre Tysfjorden (Kjøpsviksundet)	0364020603-C	Pb, PAH
Bergsfjorden	0401011400-C	
Stjernsundet	0420030200-7-C	Undefined
Repparfjorden ytre	0421010500-1-C	
Bøkfjorden-ytre	0424030500-3-C	Hg, PAH, TBT

For the six fjords classed as being of 'poor' chemical status in 2022 , the following information was provided by NEA:

- Jøssingfjorden: Nickel failing and exceeding EQS limits in 2015,2016 and 2017. However, levels are going down and below the EQS in 2018, 2019, 2020, and 2021. NEA indicated that there used to be a zinc smelting plant active between 1915 and 1926 and that runoffs from contaminated soil is responsible for the levels of zinc in the fjord. Measures for remediation and removal of the contaminated soil were taken in 2016-2017 which were found to not be sufficient, so new measures were imposed in 2019.
- Elnesvågen: Mercury failing. There is only data for one year available so no trend is available.
- Ranfjorden: Primarily PAHs are failing. Based on NEA data there is a decreasing trend in levels of metals and PAHs. NEA notes that it is a complicated water body with several sources of pressures due to the area's long industrial history.
- Tysfjord: Anthracene, lead and mercury are failing in biota. There is only one year worth of measurements, so it is unclear what the trend is. Data from settled sediment is in good status.
- Indre tysfjord: Anthracene and lead are failing. There is only data from one year, so no trend is available.
- Bøkfjorden ytre: TBT and anthracene are failing. There is only data from one year, so no trend is available.

5.3 Limits to use of WFD data

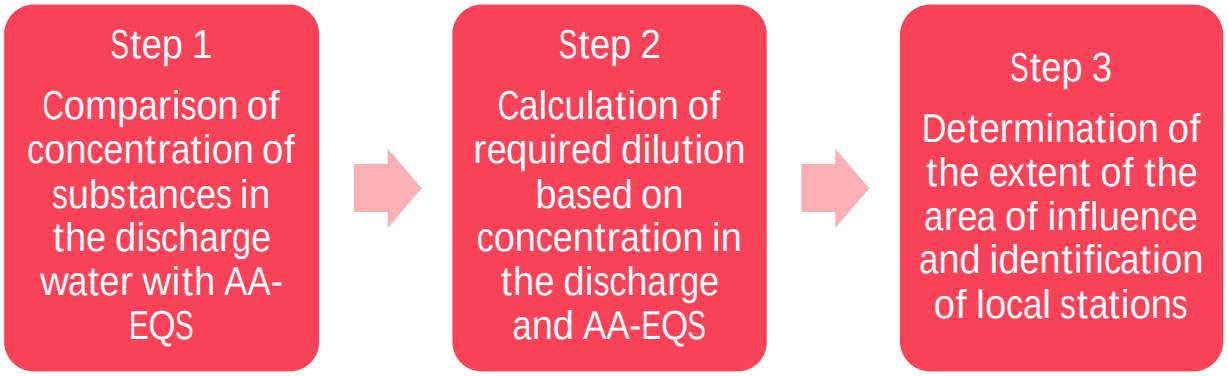
There are limits to what information can be derived from the monitoring programmes for assessment of status required under the WFD. The water body status should reflect condition of

the water body as a whole; as such, the monitoring stations are located throughout the water body which will hide local impacts / effects. Indeed, the water body status is not based on e.g., concentration/BQE monitoring data from one site but rather by taking into account a wide range of different data sources, from different locations and averaged over time.

The monitoring conducted as part of the WFD is different from the monitoring conducted as per requirements of the operation permits that need to be near the discharge point to check there is no acute effect from the permitted activity. However, this specific monitoring is not taken into account in the assessment of status.

For permit monitoring, the approach to selecting points for 'near' water monitoring was provided by the Norwegian Environment Agency. Water monitoring is performed in the so called 'area of influence' for the discharges (NEA, 2019c). The monitoring area must not cover more than 5% of the area of the water body.

Table 5-5 Steps in selection of the monitoring stations for WFD



For status classification, the NEA indicated that, in order to define the status of each BQE, a mean of all BQE collected is calculated from all stations within each year. This means that some of the stations might show impact of a certain pressure even though this is not reflected in the overall status of the water body.

Finally, the size of the water body related to the scale of pressure is an important factor when assessing the status according to the quality elements in the WFD. As can be seen in the tables in the ecological and chemical statuses section, some water bodies are very large, thus increasing the possibility that local impacts are not visible in the overall status assessment.

It is acknowledged that one of the main impacts of STD is on the seabed fauna, in particular benthic communities, and invertebrate bottom fauna. However it also impacts morphological conditions by changing the landscape of the seabed. NEA indicated that it had so far focused on developing criteria for hydromorphological changes in coastal zone to 10 metres depth, where it is most likely to find a direct link between degree of impact and ecological response. As such the picture on impacts on hydromorphology might also be incomplete.

5.4 Other information on possible harm

Beyond WFD data, there is relevant information that was identified which indicates potential local impacts of the mining waste deposition. This information is summarised below, per fjord, with more details included in Appendix D.

Table 5-6 Summary of information on possible harm from STD in selected fjords

Fjord	Information
Ranfjorden	From the Environment Directorate: 'The results from the surveillance in 2018 show moderate to bad condition of several components in Ranfjorden […] *active sea disposal area for Rana Gruber, and the disposal of suspended materials from Rana Gruber has increased significantly since 2013, the negative development is as expected.' (NEA, 2019d, cited in Naturvernforbundet (2020), original document not seen by WSP)* In 2018, NIVA conducted an examination of Ranfjorden which concluded that it was primarily mining waste adversely affecting the soft bottom fauna. A further report from 2022 (NIVA, 2022) described the outcome of the monitoring programme in the fjord, the purpose of which was to identify whether the discharges from the mining waste affected the chemical and ecological condition of the water body. It concluded that, out of the twelve stations assessed, nine had a condition worse than good for ecological status, and the chemical condition for three out of the five of the sediment stations was as not good due to exceeding limit values for priority substances. Nine out of the twelve benthic fauna stations surveyed were in a worse condition than good.
Bøkfjorden	Use of the flotation agent Lilaflot is planned to take place in this fjord. In toxicity testing, NIVA found no effects on any of the organisms when testing tailings without flotation agent. In contrast, effects were observed when testing tailings with the flotation agents. In particular, NIVA (2010) noted significant acute toxic effects for algae and crustaceans, with mortality for fish at a higher concentration of the flotation agents. IMR reports that NIVA concluded that future use of the flotation agent will result in acute toxic effects for aquatic organisms. The report also noted that effects were likely to be experienced in the immediate vicinity of the discharge point. However, IMR notes that both algae and crustaceans are food sources for other organisms which could mean more extended effects than considered by NIVA. IMR noted that there was not enough consideration of the discharge of flocculants, of the particle size distribution or of the release of microplastics. IMR noted that fauna affected during previous activities until 2015 had to some extent recolonised the sediments, but that benthic surveys were not systematic. IMR also highlighted that the water body is part of the salmon fjord Neiden-Bøkfjorden (IMR, 2020c).
Førdefjord	A study reviewed the impacts of the discharge of mining waste to the marine environment in the fjord (Kvellestad, 2021) and concluded that there were uncertainties on the decomposition of one chemical substance to be used in the mining activity: SIBX. It highlighted that chemical substance effects were assessed separately, so there was no assessment of possible combined effects. It also concluded that the EIA underpinning the permit application would have benefited from investigation of metals, chemicals and their interactions. The Norwegian IMR responded to a public consultation for the permitting of the discharge. It emphasised that Førdefjorden has a specific status emphasising its importance in natural salmon. Indeed, salmon from Nausta migrate through the area being considered for disposal. IMR indicated that the Førdefjorden national salmon fjord status was established to give the salmon stock in Nausta special protection against man-made interference (IMR, 2019). NGOs indicated that salmon farming is of high relevance in the area and valued the industry at 1 billion kroner in the outer Førdefjord, with 60 individual

Fjord	Information
	companies involved (including affiliated industries such as tourism) reaching a value of 16 billion kroner in 2014 (Naturvernforbundet, 2022a).
Repparfjord	The IMR published a study in 2021 described as a baseline study to be used as a basis for future comparison if the Nussir copper mine site starts disposing of tailings in the fjord (IMR, 2021). The study reviewed content of heavy metals in fish and seafood samples and compared it to samples from Bøkfjorden where tailings from an iron mine have been deposited. A conclusion from the study is that iron, chromium, copper and nickel should be monitored . A study from 2022 reviewed the leaching of metals from in Repparfjord, noting there are no threshold values set in permits for leaching of metals due to the absence of standardised test to assess metal leaching (Pedersen and Evenset, 2022). As part of the PAMERA project, sampling, and analysis were conducted to gain a better understanding of leaching and environmental impact of mining tailings.
Jøssingfjorden	A 2019 study (Schaanning et al, 2019) investigated the mobilisation and bioavailability of trace metals in old deposits, and on the status of the macrobenthic communities. Sampling from deposits in the fjord and in a more exposed coastal basin were compared. The results found that “nickel and copper exceeded environmental quality standards in sediment and pore water from the 0-1 cm layer and fluxes of nickel, copper and cobalt to the overlying water was high compared to adjacent reference stations”. The study also found no evidence of leaching from tailings buried below the bioturbated zone. It concluded that ongoing discharges might contribute to further slowing down the restoration process. A NYKOS study (New Knowledge on Sea Deposits, funded by the Research Council of Norway) in the same area found “clear signs of faunal restitution of the entire area”, but found similar remaining signs of disturbance, noting that the initial restitution is rapid but that up to several decades are needed for the faunal composition to return to its original state. It also notes that, for chemical status, the ongoing discharges of suspended particles are thought to slow down the restitution process (Schaanning et al, 2019).
Tingvollfjorden	A NIVA report from 2020 presented results from a 2019 investigation of environmental toxins and metals in the sediments of the fjord. It noted that the benthic fauna had a good ecological status at stations investigated, with little changes from a 2013 survey. However, it noted a reduced number of species and individuals. Sediment sampling showed excess copper at all stations. Concentrations of lead and cadmium were low, while concentrations of nickel were high. The level of toxins in sediments had increased since the 2013 survey (SNV, 2022 and NIVA, 2020). NIVA suggested that the results are a reflection of industrial activities, past and current, without identifying specific activities.
Huddingsvatnet østre	Evidence was submitted by NGO on this water body (lake) where mining tailings are deposited. NGOs indicated that, according to the information presented in Vann Nett, the water body was part of those for which an extension of the deadline to 2033 to meet the environmental objectives was requested, and the

Fjord	Information
	justification for this extension was that no organisation was identified as responsible for cleaning up the mine tailings in the lake[28]. NGOs indicate that the technical reason used to justify the exemption should not be acceptable, and that the lack of identification of a responsible entity does not equate to a lack of 'technical feasibility' as per the WFD article (Naturvernforbundet et al, 2021b).

The information gathered shows clear localised impacts (e.g. Ranfjorden, Jøssingfjorden) affecting in particular soft bottom fauna, crustaceans and fish. There is also evidence that sediments can become polluted (e.g. Jøssingfjorden, Tingvollfjorden) which can then further affect aquatic ecosystems. Ongoing research projects, such as the NYKOS[29] project and the PAMERA[30] project are dedicated to a better understanding and management of the impacts of mining waste deposits on water environments, and their findings will be important to be taken into account when considering future activities. Furthermore, reports from inspection in Ranfjorden clearly highlight that the active mining disposal activity is leading to negative developments (linked to the moderate or bad status of that water body).

Finally, concerns have been raised by NGOs on flotation agents, in particular Lilaflot, use of which is planned in Bøkfjorden. These seem to be corroborated by testing from NIVA which found significant acute toxic effects for algae and crustaceans, at concentrations expected near to the tailings discharge point.

5.5 Causal link

The information gathered from the WFD status assessment monitoring does not allow for the establishment of a direct link between the STD activities and local instances of pollution or impacts. While it is likely that the activities have an impact on the seabed, at the very least affecting ecology, including seabed fauna, it is not possible to conclude on a direct or sole causal link between the STD and the worsening of the ecological status observed in some of the water bodies. However, it can be observed that ecological status has worsened between 2016 and 2022 in a number of fjords where the STD is yet to start noting the impact of other activities that might affect the fjords (e.g., Førdefjorden, Tosen-indre) and where deposits are ongoing and further waste deposits permits are considered (e.g., Bøkfjorden).

With regard to chemical pollution, it is noticeable that many of the fjords are in poor chemical condition. The STD activities are likely to further worsen the chemical state of the fjords or, at the very least, increase the pressures on the water bodies. An overview of pressures reported, and corresponding measures is presented in the next section.

The information gathered on individual fjords has shown, in many instances, the local impact of the deposition activities on fauna and flora, with impacts lasting long after the activities have ended.

[28] Note that at the time of drafting this report (August 2022) this information was verified on Vann-Nett. However it has been updated since and the derogation, and justification associated with lack of organisation responsible have been removed. The environmental objectives are still recorded as being met by 2033 (https://vann-nett.no/portal/#/waterbody/307-1124-2-L).
[29] NYKOS = New knowledge on Sea Disposal.
[30] PAMERA = Pollutant Availability and Mobility in Environmental Risk Assessment management tools.

6. General description of the risk management measures in place in Norway regarding mining waste chemicals and materials and their effectiveness

6.1 Permitting of waste disposal in Norway

In Norway, the control of environment impacts of industrial activities is conducted through permitting. Generally speaking, permits set out operating conditions, discharge content, frequencies and limits and obligations for operators. These permits cover discharge of chemicals (e.g., flotation chemicals and flocculation chemicals) from the preparation process together with the effluents to the marine deposits. Permits establish limit values within stipulated averaging periods, and state that any variations in the emissions within the stipulated averaging periods shall not deviate from what is usual for the type of activity in question to such an extent that it may lead to increased damage or inconvenience to the environment. Moreover, companies, even if emissions are kept within set emission limits, have the obligation to reduce emissions, as far as possible without unreasonable costs. Thus, it is stated that the company must work continuously to reduce the amount of waste / waste rock deposited by finding alternative uses for the waste. Information on individual permits reviewed and their contents, including with regard to monitoring and reporting is presented in Section 2 and on content related to risk management in section 4.4.

The permits analysed were granted to mining companies by the *Miljødirektoratet* (Norwegian Environment Agency) under the Pollution Control Act (pursuant to the Act on Protection against Pollution and on Waste of 13 March 1981 no. 6, § 11, cf. § 16 and amended pursuant to § 18).

The table below provides information about the identified permits which was available.

Table 6-1 Identified permits

Water body	Company	Permit Number	Granted	Last modified
Jøssingfjord	Titania AS	2002.0072.T	April 2002	February 2021
Førdefjorden-ytre	Nordic Rutile AS	2016.0721.T	June 2015	January 2019
Elnesvågen	Omya Hustadmarmor AS	1994.0092.T	November 2015	June 2018
Tosen-ytre / Tosen-indre	Bindal Gruver AS	Not granted		
Ranfjorden – Mo	Rana Gruber AS	2012.305.T	December 2012	June 2015

Water body	Company	Permit Number	Granted	Last modified
Indre Tysfjorden (Kjøpsviksundet)	Norcem AS	Identified permits are unrelated to STD		
Tysfjorden	Quartz Corp AS	2010.0161.T	December 2011	June 2020
Bergsfjorden	Skaland Graphites AS	1989.0061.T	September 1989	January 2002
Repparfjorden ytre	Nussir AS	2016.0051.T	January 2016	Not updated
Bøkfjorden-ytre	Sydvaranger Drift AS	2008.190.T	April 2008	October 2014

Every permit contains a similar core content. The permits include general references to applicable legislation and the overall regulatory framework. The name of the titles and order of the structure may vary from permit to permit, but the following areas are generally always included:

- Framework of the permit / production conditions and emissions
- General terms and conditions, including the duty to restrict emissions; to comply with limit values; to reduce pollution as far as possible (without unreasonable costs); to replace equipment satisfying the principle of using best available techniques; to exercise preventive maintenance; to take action in the event of an increased risk of pollution; and to establish an internal control
- Amounts of waste discharged to water
- Amounts and types of chemicals discharged to water
- Measurement programme, as part of the company's documented internal control
- Waste management plan
- Preventive and emergency measures against acute pollution
- Emission control and reporting to the authorities
- Environmental monitoring
- Investigation and studies / Investigation and reports
- Replacement of equipment
- Measures in case of closure
- Inspection (obligation of having representatives of the pollution authority)

Additionally, permits usually establish limits regarding emissions to air, noise, or energy.

The permits do not include a reference to the non-deterioration principle, nor do they require the gradual phasing out of pollutants; however they include the requirement to limit pollution as far as

possible. The permits reviewed do not specifically mention issues such as nano-forms of discharged materials, microplastics or degradation products.

The permits are granted for a limited amount of time, although if the company wants to make changes in operating conditions that could increase pollution risk (in addition to that which was assumed when the permit was granted/changed), the company must apply for a change of the permit. Thus, the company must consult in advance with the authorities if it wishes to make any changes in the conditions that may have added environmental impact. It is also stated that, if any significant parts of the permit have not been used within 4 years after the permit enters into force, the company must send a statement of the company's scope so that the pollution authority can consider any changes in the permit. A breach of permit conditions can lead to a temporary or definitive cessation of activities; conditions under which breach can happen are detailed in the legislation.

According to the MWEI BREF (European Commission, 2018), Norway requires a comprehensive baseline study to be submitted as part of the application for a permit to discharge extractive waste into the sea, which is then used to interpret monitoring data related to the impact of the STDs.

Further details on permits and their contents are included in sections 2 and 4.

6.2 Use of exemptions to WFD in Norway

As detailed in Section 1, water bodies must meet the environmental objective of good status by 2027, unless an exemption has been applied.

Exemptions were identified for Jøssingfjord, Frænfjorden and Ranfjord under paragraph 9 arguing a disproportionate cost. The justification reads ‘The deadlines in section 8, first and second paragraph, may be extended by up to 6 years to ensure a gradual achievement of goals, provided that there is no further deterioration of the condition of the affected water body and at least one of the following conditions applies:

a) the improvements cannot be implemented within the deadline for technical reasons;

b) it would be disproportionately costly to implement the improvement within the deadline, or

c) there are such natural conditions that an improvement of the water body within the deadline cannot be implemented.’

The status for exemption is unclear for Førdefjord.

Note the status of exemptions should be updated with the latest River Basin Management Plans of Norway (2nd cycle) whose publication is expected in Q4 2022.

It is not possible to compare with the overall use of exemptions as the first reporting period RBMPs did not include any exemptions under article 4. Instead the water bodies were classified as at risk or not of achieving good status. Out of the 24,053 water bodies, 8,293 were at risk of not achieving good or better in 2021 (European Commission, 2012). This includes five of the water bodies on which this analysis focused.

Table 6-2 Status of water bodies considered ‘at risk’

Name	Status	Reference on Vann Nett	At risk?	HMWB?
Jøssingfjord	Ongoing	0240000100-C	Yes – New measures needed to achieve good environmental conditions	No

Name	Status	Reference on Vann Nett	At risk?	HMWB?
Førdefjord	Not yet started (approved)	0281010202-C	Yes – Expected deterioration of environmental conditions due to increased impacts or increased effects of the current impacts	No
Frænfjorden (Elnesvågen)	Ongoing	0302012400-2-C	Yes – New measures needed to achieve good environmental conditions	No
Ranfjord	Ongoing	0362011000-2-C	Yes – Good ecological status not realistic	Yes
Tysfjord	Ongoing	0364020603-C	Yes – Uncertainties due to data	No
Bøkfjord (Bøkfjorden-ytre)	Ongoing	0424030500-3-C	Yes – New measures required to achieve good environmental conditions	No

6.3 Measures to reduce and eliminate risk of deterioration

The Vann Nett platform provides water body passports for each water body in Norway; these present, in one location, a range of relevant information on the identification of each water body, its pressures, the impacts of these pressures, how these translate into a risk of not achieving the objectives of the WFD, and measures to reach the objectives of the legislation. We have reviewed both pressures and measures for the selected fjords we have focused on, where submarine disposal of mining waste has happened, is happening or is planned to happen.

The first step in water management planning is to identify pressures experienced by the water bodies. The table below highlights instances where the marine disposal has been identified as a pressure as well as its significance (i.e., importance) for the water body. The significance of the pressure indicates that it needs to be managed to ensure it does not prevent the achievement of the overall environmental objectives of the WFD. It can be observed that, where the mining deposit activity is on-going, the pressure is systematically identified as being either medium or large. The only exceptions are Bergsfjord and Førdefjord for which the pressure from mining disposal is considered to be affecting the water body to a small degree.

Table 6-3 Pressures in fjords considered

Name	Reference on Vann Nett	Status	Pressures	Significance of the pressure?	Link pressures
Jøssingfjord	0240000100-C	Ongoing and new	Diffuse runoff from mines/disposal Deposit of mine waste from the 1960s. This deposit has now been stopped	Medium	Link
Førdefjord	0281010202-C	Not yet started (approved)	Diffuse emissions, run off from mining	Small Notes that Engebø mine: how big an effect it will have in the next few years is uncertain, as it has not been started up yet. Emission permit is given in 2015. 2020: there has not been a start-up here yet, so the impact is set to small for a long time.	Link
Frænfjorden (Elnesvågen)	0302012400-2-C	Ongoing	Hustadamoor has landfill affecting hydromorphology Point emissions from industry - noting there is sea disposal from Hustadamoor	Large Large	Link
Ranfjord	0362011000-2-C	Ongoing	Diffuse runoff from mines/disposal and chemical pollution	Medium Large	Link

Name	Reference on Vann Nett	Status	Pressures	Significance of the pressure?	Link pressures
			Diffuse runoff from mine sludge		
Tosenfjord	0360011100-2-C	Not yet started (awaiting approval)	No pressure related to mining deposit identified	n/a	n/a
Tysfjord	0364020603-C	Ongoing	No pressure related to mining deposit identified	n/a	n/a
Bergsfjord	0401011400-C	Ongoing	Skaland Graphites. The concentrations of chromium, copper and nickel were above background levels for marine sediments. The release of chromium and copper could be traced at least 7 km from the discharge point. In the surface layers, departure could be traced for 0.5 km. There was no clear impact on benthic fauna 0.5 to 7 km from discharge. Effect on sediment biology was limited to < 500 m from discharge. in today's operation, gray rock is placed on land at Trælen. Proposes new monitoring.	Small	Link
Stjernsundet (Lillebukta - Ytre Simavik)	0420030200-7-C	Ongoing	No pressure related to mining deposit identified	n/a	n/a

Name	Reference on Vann Nett	Status	Pressures	Significance of the pressure?	Link pressures
Repparfjord (Repparfjorden ytre)	0421010500-1-C	Ongoing	No pressure related to mining deposit identified	n/a	n/a
Repparfjord (Repparfjorden indre)	0421010500-2-C	Ongoing	Pressures from old mining activities Parts of the water body are still affected by former mining activities, closed Folldal works. Specifically, there is talk of somewhat elevated copper values in sediment in the old sea landfill for Folldal works in the innermost part of the fjord. See Akvaplan-niva AS Report 4973-02, chapter 6.4: "The reason for the elevated level ends is probably that these stations are affected by the departure from the old Folldal works"	Medium	Link
Bokfjord (Bøkfjorden-ytre)	0424030500-3-C	Ongoing	Diffuse runoff from another source from AS Sydvaranger	Unknown	Link

Following the identification of pressures, the WFD requires that, for each water body, a set of necessary measures is identified to address the pressure and reduce the risks of not achieving good environmental status.

A review of the measures of relevance for marine disposal has been conducted and the measures are presented in table below. It can be noticed that, for Repparfjord where the pressure from mining is medium, there is no corresponding measure adopted, which can be considered as a gap.

Table 6-4 Measures of relevance for STD in RBMPs for fjords considered

Name	Reference on Vann Nett	Measures	Link measure
Jøssingfjord	024000010000-C	Two measures: 5104-1706-MJøssingfjorden - Problem mapping, Landfill of mine waste (IN12) Improvement of the knowledge base Diffuse runoff from mines/landfill 5104-2084-MTitania - Reduction of emissions of suspended matter (IN12) Industry – emission reduction measures Diffuse runoff from mines/landfill (1) Description of the measure notes Nickel as problematic	Link
Førdefjord	028101020200-C	No measure detailed	
Frænfjorden	030201240000-2-C	Improving knowledge base on impact of filing with waste in particular for Lead (Bly CAS_7439-92-1)	Link
Ranfjord	036201100000-2-C	108-2012-M Knowledge acquisition (IN12) Improvement of the knowledge base Diffuse runoff from mines/landfill The comments note not sure if this applies to Bosmo or Rana Gruber	Link
Tosenfjord	036001110000-2-C	No measure related to mining deposit identified	n/a
	036001110000-1-C	No measure related to mining deposit identified	n/a
Tysfjord	036402060303-C	No measure related to mining deposit identified	n/a
Bergsfjord	040101140000-C	Skaland Graphite AS received a new discharge permit on 1 July 2019 with a requirement for an environmental monitoring programme. No measure identified	Link
Stjernsundet	042003020000-7-C	No measure related to mining deposit identified	n/a
Repparfjord	042101050000-1-C	No measure related to mining deposit identified	n/a
	042101050000-2-C	Improving knowledge base on impact from mining activities	Link
Bokfjord	042403050000-3-C	No measure related to mining deposit identified	n/a

It can be seen from the above table that there are generally a small number of measures directed at addressing the pressures from the STD activities. Where they are in place (4 fjords), the measures are focused on improving the knowledge base and understanding of the pressures rather than diminishing these. Additional measures, including developing action plans to identify how good status (or less stringent objectives if relevant) could be met should also be considered, in particular as only one of the water bodies is designated as a heavily modified water body (i.e., Ranfjord).

7. Conclusions

7.1 Findings

The key findings from this report are as follows:

- Disposal of mining waste in water is a dying practice, performed in only three countries globally.
- Concerns regarding the impacts of discharge of mining waste into water have been recorded by stakeholders and in the literature.
- In Norway, the discharge of mining waste to fjords is controlled by permitting that stipulates quantities, frequencies and concentrations and monitoring.
- Various hazardous substances and materials are (and have been) discharged during disposal of mining wastes to fjords in Norway.
- Environmental media, biota, and ultimately people, will be exposed to those substances and materials to varying degrees.
- In some cases, those exposure levels will clearly lead to harm to the environment, such as plants and animals being directly covered by deposition of tailings. This will have an effect over long periods, depending on the conditions in the fjord and of the discharge.
- In other cases (e.g., discharge of chemicals), the extent to which harm will be caused is very situation-dependent and is affected by the specific chemicals used or present in the tailings; discharge parameters; and local environments. Several of the chemicals that are known to be used can have both short-term and long-term effects on aquatic organisms, and some of the most harmful (e.g., CMR substances) can have serious effects on humans. Some of those chemicals are naturally present in the source rock, so their discharge is in effect inevitable (while deposition to sea is permitted); others are deliberately added during the mining process but are still relevant if the wider tailings materials are discharged. The extent to which these substances are able to cause harm in practice is also highly situation-dependent. However, information reviewed suggests that acute toxic effects may be expected, near to the discharge points, at concentration levels expected during discharge.
- Pressures from mining disposal are recognised in the river basin management plans covering several of the fjords considered. However, it is noticeable that the measures identified to address the pressures are focused on increasing the understanding of possible impacts of the discharges rather than more ambitious measures looking at stopping the discharges or reducing their impacts.
- The fact that sea disposal is presented as unavoidable due to lack of space and topography of the Norwegian environment is becoming less relevant as an example from industry shows that a ‘no sea disposal’ approach is possible. For example, the mining project by Arctic Mineral Resources AS includes a plan for a ‘no waste’ approach, without any sea disposal or land disposal and all tailings either sold, reused or backfilled into the mine (AMR, 2022). AMR argues that mining without disposal is possible, profitable and as such should be considered as BAT.
- Disposal of mining waste is an activity regulated by permitting. A review of the permits has shown that, while they contain a range of obligations to prevent pollution and

minimise impacts, they do not contain requirements to actively seek to reduce impacts (although they do include a requirement to reduce pollution as far as possible considering technical and economic feasibility) and recycle waste where possible. Based on both the precautionary principle, but also the waste hierarchy, looking at reusing waste should be encouraged or at least reviewed.

- Article 4(8) of the WFD provides that an EEA State must ensure that the application of the Article 4(7) WFD exemption "does not permanently exclude or compromise the achievement of the objectives of [the] Directive in other bodies of water within the same river basin district and is consistent with the implementation of other Community environmental legislation". The permitting of STD activities in fjords covered by exemptions calls into question whether the long-term achievement of environmental objectives is being compromised by additional industrial activities in water bodies which are failing to achieve good status.

7.2 Data gaps

A systematic assessment was complicated by the lack of availability of historical technical data on BQEs and the fact that the first assessment of the ecological and chemical status of the water bodies in Norway relied to a large extent to expert judgement. In many instances, changes in status (either improvement or worsening) were explained as reflecting better availability of data and improved methodologies. This hampered the ability to determine whether there has been a deterioration in either chemical or biological status.

In addition, while the available WFD monitoring data provides an overview of trends for the overall water bodies, the averaging of monitoring data does hide local impacts (as BQE data are averaged out to get a measure of the status of the whole water body).

7.3 Recommendations for future action

Other relevant points, beyond the implementation of the WFD and the Extractive Waste Directive should be considered and include:

- The application of the precautionary principle in permitting process; and
- The application of the polluter pays principle, which can be seen as lacking in some instances (e.g., one fjord where no remediation is undertaken due to lack of a responsible entity being identified).

Appendix A Bibliography

This appendix lists information that is specifically referenced in this report. It includes information submitted to the call for information, as well as other literature and data sources referred to in the course of the study. Other sources of information submitted as part of the call for information and obtained through other research were taken into account in the study, but are not directly referenced here.

Arctic Mineral Resources (AMR), The Vevring Garnet Project, February 2022. Submitted to ESA call for information.

Directorate of Fisheries, Norway (not dated, nd), Fisheries portal. Available at: https://portal.fiskeridir.no/portal/apps/webappviewer/index.html?id=87d862c458774397a8466b148e3dd147.

DNV GL, Kommentarer vedrørende miljørisiko ved deponering av fine mineralpartikler i Førdefjorden, 31 January 2014. Submitted to ESA call for information.

EFTA Surveillance Authority (ESA) (2021a), Pre-closure letter – Complaint against the Norwegian Government in the area of the environment regarding the implementation of the Water Framework Directive and water bodies used for hydropower production, Brussels, 19 October 2021, Case No: 81034, Document No: 1179709.

EFTA Surveillance Authority (ESA) (2021b), Pre-closure letter – Complaint against the Norwegian Government in the area of the environment (Ranfjorden and others), Brussels, 16 July 2021, Case No: 80750, Document No: 1206134.

EFTA Surveillance Authority (ESA) (2021c), Pre-closure letter – Complaint against the Norwegian Government in the area of the environment (Complaint against the Norwegian Government in the area of the environment (Repparfjord and Førdefjorden)), Brussels, 16 July 2021, Case No: 78488, Document No: 1171317.

EFTA Surveillance Authority (ESA, 2022), Call for information on the effects of mining waste on Norwegian fjords and water bodies, Document No: 1264063, Brussels 2022. Available at: https://www.eftasurv.int/cms/sites/default/files/documents/gopro/Case 86194%2C Call for Information%2C 18 February 2022_0.pdf.

European Chemicals Agency (ECHA, 2022), CLP inventory database (https://echa.europa.eu/information-on-chemicals/cl-inventory-database/) for substance classifications, accessed September 2022.

European Chemicals Agency (ECHA, 2020), Committee for Risk Assessment (RAC) Committee for Socio-economic Analysis (SEAC), Opinion on an Annex XV dossier proposing restrictions on intentionally-added microplastics, 11 June 2020. Available at: https://echa.europa.eu/documents/10162/5a730193-cb17-2972-b595-93084c4f39c8.

European Commission (2022a), COM(2022) 540 final, Proposal for a Directive amending the Water Framework Directive, the Groundwater Directive and the Environmental Quality Standards Directive, 26 October 2022.

European Commission (2022b), Draft amendment to Annex XVII to Regulation (EC) No 1907/2006 of the European Parliament and of the Council concerning the Registration, Evaluation,

Authorisation and Restriction of Chemicals (REACH) as regards synthetic polymer microparticles. Available at: https://ec.europa.eu/transparency/comitology-register/screen/documents/083921/1/consult?lang=en.

European Commission (2020), Staff working document (SWD (2020) 250 final), Progress report on the assessment and management of combined exposures to multiple chemicals (chemical mixtures) and associated risks, Brussels 14 October 2020.

European Commission (2018), Best Available Techniques Reference Document for the Management of Waste from Extractive Industries, in accordance with Directive 2006/21/EC, Seville, 2018.

European Commission (2012), COM (2012) 670 final, SWD on the Implementation of the Water Framework Directive (2000/60 EC). Available at: https://ec.europa.eu/environment/water/water-framework/pdf/3rd_report/CWD-2012-379_EN-Vol3_NO.pdf.

European Commission (2011), Commission Recommendation of 18 October 2011 on the definition of nanomaterial, Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011H0696&from=EN.

European Commission (nd1), Mining waste, https://environment.ec.europa.eu/topics/waste-and-recycling/mining-waste_en, accessed 2022.

European Commission (nd2), Study supporting the elaboration of best risk management approaches in the extractive sector, https://environment.ec.europa.eu/topics/waste-and-recycling/mining-waste/study-supporting-elaboration-best-risk-management-approaches-extractive-sector_en, accessed 2022.

European Commission (nd3), Microplastics, https://environment.ec.europa.eu/topics/plastics/microplastics_en, accessed 2022.

European Environment Agency (EEA), Surface water bodies: Chemical status, https://tableau-public.discomap.eea.europa.eu/views/WISE_SOW_SurfaceWaterBody/SWB_ChemicalStatus, accessed 2022.

European Observatory on Nanomaterials (EUON) (not dated, nd), Regulation, European Chemicals Agency, https://euon.echa.europa.eu/regulation.

Geological Survey of Norway (NGU), Industrial Minerals, 2020. Available at: https://www.ngu.no/geologiske-ressurser/industrimineraler.

Green Warriors, Complaint: Dumping of mining waste in the national salmon fjord Førdefjorden, 20 March 2022. ESA document number 1277669).

Guardian, Norway and Turkey vote against ban on dumping mining waste at sea, The Guardian, 14 September 2016. Available at: https://www.theguardian.com/environment/2016/sep/14/norway-and-turkey-vote-against-ban-on-dumping-mining-waste-at-sea.

Halleraker, JH., Sorby, L.,Keto, A. and Gudmundsdottir, H, Nordic collaboration on implementation of the water framework directive – status and further challenges, Reykjavík, 2013. Available at: https://www.researchgate.net/publication/263503812_NORDIC_COLLABORATION_ON_IMPLEMENTATION_OF_THE_WATER_FRAMEWORK_DIRECTIVE_-_STATUS_AND_FURTHER_CHALLENGES.

Helgelands Blad, Vil lete etter gull i Bindal, 16 August 2019. Available at: https://www.hblad.no/2019/nyheter/vil-lete-etter-gull-i-bindal/.

IFE, Degradation of sodium isobutyl xanthate (SIBX) in marine water, report for Nordic Mining AS, report IFE/F-2020/, 24 February 2020.

Institute of Marine Research (IMR, 2022), Deposition of mine tailings in Norwegian fjords, presentation. Submitted to ESA.

Institute of Marine Research (IMR, 2021), Undersøkelse av grunnstoffer i sjømat fra Repparfjorden og Revsbotn (study of elements in seafood from the Repparfjord and the Revsbotn), report 2021-50, 29 November 2021.

Institute of Marine Research (IMR, 2020a), Hearing Statement Regarding Regulatory Plan With Impact Assessment For The Extraction Of Gold In Bogadalenkolsvik In Bindal Municipality (in Norwegian). Available at: https://www.hi.no/resources/HI-Horingsuttalelse-Bogadalen-og-Tosenfjorden-24-02-2020.pdf.

Institute of Marine Research (IMR, 2020b),Hearing Statement from the Institute of Marine Research, "Nordic Rutile application for amended emission permit for process chemicals related to mining in Engebøfjellet" (in Norwegian). Available at: https://www.hi.no/resources/20-01392-Horingssvar-HI-endret-utslippstillatelse-Nordic-Mining-inkl-vedlegg.pdf.

Institute of Marine Research (IMR, 2020c), Hearing Statement Regarding The Revision Of The Permit To Sydvaranger Drift As, (in Norwegian). Available at: https://www.hi.no/resources/20-02773-Rapport-om-horingsuttalelse-Sydvaranger-11122020.pdf.

Institute of Marine Research (IMR, 2019), HI om gruvedrift i Førdefjorden: Ikke bærekraftig bruk av fjorden (HI on mining in the Førdefjord: Unsustainable use of the fjord), 8 October 2019. Available at: https://www.hi.no/hi/nyheter/2019/oktober/hi-om-gruvedrift-i-fordefjorden-ikke-berekraftig.

Institute of Marine Research (IMR, 2009), Hearing Statement From The Marine Research Institute Regarding The Application For A Discharge Permit For The Extraction Of Rutil In Engebofjellet - Nordic Mining ASA, 2009 (in Norwegian). Available at: https://www.hi.no/resources/Horingsuttalelse_Havforskningsinstituttet_utslippssoknad-fra-Nordic-Mining.pdf.

IUCN, Protecting coastal and marine environments from mining waste, WCC-2016-Res-053-EN, 2016. Available at: https://portals.iucn.org/library/node/46470.

Jensen, T. and Hylland, K., Environmental adaptive management: application on submarine mine tailings disposal. Integrated environmental assessment and management, July 2019, 15(4), 575-583. Available at: https://www.duo.uio.no/bitstream/handle/10852/76094/jensen%20hylland%20ieam%202019.pdf?sequence=5.

KEMI, Guidance on national chemicals control: Hazard and risk assessment of chemicals – an introduction, Swedish Chemicals Agency, November 2020.

KLIF, Gruvedrift i Engebøfjellet – Klifs vurdering og anbefaling (Mining in Engebøfjellet - Klif's assessment and recommendation), 19 March 2012. Submitted to ESA call for information.

Kvellestad, A., A permitted discharge of mining waste to the marine environment, Norway - critical review regarding heavy metals and chemicals, Oslo 16 August 2021.

Naturvernforbundet (2022a), Response to ESA's call for information on the effects of mining waste on Norwegian fjords and water bodies, 25 March 2022. Submitted to ESA call for information.

Naturvernforbundet (2022b), Organizations will sue to prevent mine waste dumping in Førdefjorden, 20 July 2022. Available at: https://web.archive.org/web/20220817070255/https://naturvernforbundet.no/fordefjorden/organizations-will-sue-to-prevent-mine-waste-dumping-in-fordefjorden-article43260-4261.html.

Naturvernforbundet (2022c), Overview of projects, pollutants and environmental status. Submitted to ESA call for information.

Naturvernforbundet (2021a), Case number 86194, letter to EFTA Surveillance Authority, Friends of the Earth Norway, 18 March 2021 (ESA document number 1474948).

Naturvernforbundet et al (2021b), Complaint - Norway fails to comply with the Water Framework Directive, by using an invalid reason to allow extended deadline for achieving the environmental goals of Hudningsvatnet Aust, Norway, Trøndelag county, Trondheim and Namsos 2021.02.22. Submitted to ESA call for information.

Naturvernforbundet (2021c), Presentation: WFD and Norway's disposal of mining waste, Meeting with ESA 17.12.2021.

Naturvernforbundet (2015), Friends of the Earth (FoE) Norway, Submarine Tailings Disposal violates the Water Framework Directive, 2015. Submitted to ESA call for information.

Naturvernforbundet (2020), Reminder of ESA's assessment of our complaints; Norway's violation of the Water framework directive, 4 May 2020. Submitted to ESA call for information.

Nordic Mining, Engebø Rutile and Garnet - Updated Definitive Feasibility Study, 11 May 2021.

Norsk Bergindustri, Norwegian experiences with sea disposal of mine tailings, report number 1, 2014. Submitted to ESA call for information.

Norwegian Environment Agency (NEA, 2022), meeting of 25 May 2022.

Norwegian Environment Agency and Ministry of Climate and Environment (NEA and KLD, 2022), meeting of 26 April 2022.

Norwegian Environment Agency (NEA) (2019a), Mining industry and tailings disposal - Status, environmental challenges and gaps of knowledge, M-1335|2019, 2010/2019. Available at: https://www.miljodirektoratet.no/globalassets/publikasjoner/m1335/m1335.pdf.

Norwegian Environment Agency (NEA) (2019b), Inspeksjonsrapport Inspeksjon ved Rana Gruber AS, Kontrollnummer: 2019.009.I.miljodir. Available at: https://www.norskeutslipp.no/WebHandlers/PDFDocumentHandler.ashx?documentID=567069&documentType=K&companyID=5124&aar=2019&epslanguage=no.

Norwegian Environment Agency (NEA, 2019c), Vannovervåking: Identifisering av nærstasjoner (water monitoring: Identification of local stations), Factsheet M1288-2019. Available at: https://www.miljodirektoratet.no/globalassets/publikasjoner/m1288/m1288.pdf.

Norwegian Environment Agency (NEA, 2019d), Tilbakemelding på vannovervåkingen gjennomført i 2018 i Ranfjorden og Mobekken. Brev til bedrifter i Mo, Miljødirektoratet 29.05.2019. (Original source not seen.)

Norwegian Environment Agency (NEA, 2016), Permit to operate under the Pollution Control Act for Nussir ASA (2016.0051.T), 2016, as last modified on 15 January 2019. Current version available at: https://www.norskeutslipp.no/WebHandlers/PDFDocumentHandler.ashx?documentID=86501&documentType=T&companyID=43356&aar=0&epslanguage=en.

Norwegian Environment Agency (NEA) (2015a), Permit to operate under the Pollution Control Act for Nordic Rutile (2016.0721, 1433.0015.01), 2015, as last modified on 18 January 2021. Current version available at: https://naturvernforbundet.no/content/uploads/2023/09/2023-06-23_Revidert-utslippstillatelse.pdf.

Norwegian Environment Agency (NEA) (2015b), Permit to operate under the Pollution Control Act for Omya Hustadmarmor AS (1548.0006.01), 1994, as last modified on 18 January 2021. Current version available at: https://www.norskeutslipp.no/WebHandlers/PDFDocumentHandler.ashx?documentID=805346&documentType=T&companyID=5294&aar=0&epslanguage=no.

Norwegian Environment Agency (NEA, 2012), Permit to operate under the Pollution Control Act for Rana Gruber AS (2012.305.T), 2012, as last modified on 26 June 2015. Current version available at: https://www.norskeutslipp.no/WebHandlers/PDFDocumentHandler.ashx?documentID=770968&documentType=T&companyID=5124&aar=0&epslanguage=en.

Norwegian Environment Agency (NEA, 2011), Permit to operate under the Pollution Control Act for The Quartz Corp AS (2010.0161.T), 2011, as last modified on 23 June 2020. Current version available at: https://www.norskeutslipp.no/WebHandlers/PDFDocumentHandler.ashx?documentID=590872&documentType=T&companyID=6230&aar=0&epslanguage=no.

Norwegian Environment Agency (NEA, 2002), Permit to operate under the Pollution Control Act for Titania AS (2002.0072.T 1111.0007.01), 2002, as last modified on 4 February 2021. Current version available at: https://www.norskeutslipp.no/WebHandlers/PDFDocumentHandler.ashx?documentID=770063&documentType=T&companyID=18742&aar=0&epslanguage=en.

Norwegian Environment Agency (NEA, 2008), Permit to operate under the Pollution Control Act for Sydvaranger gruve AS (2008.190.T), 2008, as last modified on 8 October 2014. Current version available at: https://www.norskeutslipp.no/WebHandlers/PDFDocumentHandler.ashx?documentID=727032&documentType=T&companyID=18222&aar=0&epslanguage=en.

Norwegian Research Institute for Water and the Environment (NIVA, 2022), Tiltaksorientert overvåking av Ranfjorden i 2021 (Action-oriented monitoring of the Ranfjord in 2021), report L.NR 7708-2022, 24 February 2022. Submitted to ESA call for information. Available at: https://niva.brage.unit.no/niva-xmlui/handle/11250/2982336.

Norwegian Research Institute for Water and the Environment (NIVA, 2020), Undersøkelser I bløtbunnsfauna, miljøgifter og metaller i sedimentene i Tingvollfjorden ved Raudsand, report L.NR 7539-2020, 7 October 2020. Submitted to ESA call for information.

Norwegian Research Institute for Water and the Environment (NIVA, 2018), Overvåking av marin bløtbunnsfauna for Titania A/S i 2018, Report 7291-2018, 25 September 2018. Submitted to ESA call for information.

Norwegian Research Institute for Water and the Environment (NIVA, 2013), Sporstoff-forsøk i Ranfjorden 2012-2013 (Trace element experiments in Ranfjorden 2012-2013), Report L. NR 6576-2013, November 2013. Submitted to ESA call for information.

Norwegian Research Institute for Water and the Environment (NIVA, 2010), Giftighetstester med flotasjonskjemikaliet Lilaflot D 817M. Effekter på alger, børstemark, krepsdyr og fisk (Toxicity tests with the flotation agent Lilaflot D 817 M. Effects on algae, polychaets, crustaceans and fish), report L.NR 6044-2010, 28 October 2010. Submitted to ESA call for information.

Nussir, presentation on copper ore and STP, 17 December 2021. Submitted to ESA call for information.

Nussir, Project overview, accessed 2022. Available at: https://nussir.no/what-we-do/project-overview/.

Olsgard, F. and Iiasle JR, Impact of waste from titanium mining on benthic fauna, J. Exp. Mar. Biol. Ecol., 172 (1993), 185-213.

Pedersen K.B. and Evenset, A., Leaching of metals from mine tailings in Repparfjorden, FRAM FORUM 2022. Available at: https://framsenteret.no/leaching-of-metals-from-mine-tailings-in-repparfjorden/.

Ramirez-Llodra et al., New insights into submarine tailing disposal for a reduced environmental footprint: Lessons learnt from Norwegian fjords, Marine Pollution Bulletin 174 (2022) 113150.

Schaanning MT., Trannum HC., Øxnevad, S. and Ndungu, K., Benthic community status and mobilization of Ni, Cu and Co at abandoned sea deposits for mine tailings in SW Norway, Marine Pollution Bulletin 141 (2019) 318–331.

Søre Nordmøre vassområdeutval (watershed committee) (SNV), Utlysing (Call for information) av undersøking om verknader av gruveavfall på norske fjordar og vassforekomstar – INNSPEL, 31 March 2022. Submitted to ESA call for information.

Troms and Finnmark County Governors, Permission to operate under the Pollution Control Act for Skaland Graphite AS (1989.0061.T), 1989 as last modified on 24 January 2022.

Appendix B
Limitations and remaining data gaps

A range of limitations are important to note:

- **Data**: There was limited data on Vann Nett for 2016: Much of the data for individual chemical substances and BQEs was not available for the 2016 period. As a result, Norwegian authorities had used expert judgement to establish an overall ecological and chemical status for most fjords in 2016.
- **Chemical and ecological statuses** relied on expert judgements: It was noted by the Norwegian authorities that expert judgement was used to establish the status of these fjords based on data from monitored sites and empirical knowledge. It was noted that expert judgement was used primarily in the absence of monitoring data and that many of the 2016 statuses were determined by expert judgment because data was less available (not imported to the database) and the classification procedure not developed (until 2018).
- **Delineation of fjords**: It was noted that the overall classifications of chemical and ecological statuses were obtained from an average across the entirety of each fjord. However, the submarine tailings disposal sites, and the surrounding areas which are most impacted by the disposal sites, constitute only a small area of the total area of the fjord. It was observed that this could lead to a better chemical/ecological status when the delineation of the fjord was much larger than the disposal site. Note that the appropriateness of the delineation of water bodies has not been considered in this study.

Appendix C Methodology

The project relied on the analysis of multiple data sources. The data sources used as input ranged from literature provided by ESA, received in response to the call for evidence; data submitted by stakeholders; data obtained from Norway's Vann-Nett portal; emissions portal; and aquatic environment monitoring portal, as well as from data supplied by the Norwegian authorities (both datasets and clarifications obtained through correspondence). There was overlap in the order in which these data acquisition steps took place, although for clarity, the steps can be viewed as having taken place in the following order.

Review of literature supplied to ESA

A range of literature sources were provided by ESA at the start of the project. The sources were submitted by a range of stakeholders including NGOs, trade associations and researchers. The literature, previously sent to ESA, was reviewed, screened and logged internally by the team.

The project team attempted to capture a range of information which could later be used in the collation of available information in this report. To do this, the project team established a series of parameters against which literature could be screened, including those parameters shown below.

- Unique ID, author, year, and title: Basic information to identify the documents was established.
- Confidentiality: Due to the sensitive nature of this project, the confidentiality of literature sources was established.
- Geographical coverage (name of the fjords / region if specific) and mining companies' coverage
- Chemical substances covered: This was an open text field in which a list of chemical substances mentioned in literature sources was noted.
- Reference to legislation: Similar to the above field, legislation mentioned by literature was noted here.
- Potential impact on ecology/environment: Yes/no field to determine whether information was available on this topic.
- Aquatic monitoring data : Yes/no field to determine whether information was available on this topic.
- Waste characterisation / information on waste: Yes/no field to determine whether information was available on this topic.
- Information on regulatory compliance: Yes/no field to determine whether information was available on this topic.

Call for evidence

ESA Internal Market Affairs Directorate started a call for evidence, *Call for information on the effects of mining waste on Norwegian fjords and water bodies* on 18 February 2022, which lasted until 18 March 2022. The call was publicly available on ESA's website at *Newsroom,* in the

subsection *Updates*[31]. It requested all stakeholders to provide information on the effects of mining waste on Norwegian water bodies, particularly scientific and technical data. The reason for this call was to assess whether there is potential non-compliance with the Water Framework Directive requirements and related law.

In response to this call, a total of 182 submissions were received, which comprised 426 documents coming from researchers, NGOs, trade associations, mining companies, consultancies, and public authorities. Including the documents provided by ESA, the total amount of evidence equalled 440 documents. These were classified and reviewed by the project team.

It was found that the inputs covered a wide range of fjords including, Jøssingfjorden, Førdefjord, Frænfjorden, Ranfjord, Tosenfjord, Tysfjord, Kjopsviksundet, Bergsfjord, Stjemsundet, Repparfjord, and Bokfjord.

Within these documents, there was information on:

- Mining companies: Arctic Mineral Resources AS, Nordic Rutile AS, Nordic Mining ASA, Nussir ASA, Jomin AS, North Cape Minerals AS, Norock & co, Norwegian Crystallites AS, Nussir ASA, Omya Hustadmarmor AS, the Quartz Corp, Rana Gruber ASA, Sibelco, Skaland Graphite AS, Sydvaranger Drift AS, Titania AS.
- Other companies: Aleris Aluminum Norway AS, Aluscan AS, Luteland offshore AS.
- Hydropower plant Nedra Otta and hydroelectric plant AS Eidefoss and Hafslund E-CO.

Review of data available online

Our team reviewed information coming from Norway's Vann Nett portal[32], Emissions portal[33], and the Aquatic environment monitoring portal[34] as shown below.

Assessment of ecological and chemical status

The project team conducted research into the available information on ecological and chemical status of Norwegian fjords with submarine tailings disposal sites in 2016 and 2022, using data available publicly from Norway's Vann Nett portal. This information was extracted into an internal log such that information on both the overall ecological and chemical status classification for these fjords was available to the project team, as well as information on the statuses related to individual biological quality elements (BQE) and chemical concentrations.

Assessment of permitting

This was followed up by a review of permitting data found in the permits available on the Norwegian Emissions portal. Permits were downloaded and data were extracted into an internal permit log. The captured information was divided under three main topics: use (permitting restrictions on the use of specific substances), emissions (permitting restrictions on the emissions of specific substances), and checks (further information from reviews carried out by Norwegian authorities on compliance with permitting restrictions).

General information for all permits included the name of the mining company and plant number, and the permit number.

The information collected specifically under the topic of 'use' includes:

[31] https://www.eftasurv.int/newsroom/updates/call-information-effects-mining-waste-norwegian-fjords-and-water-bodies.
[32] https://vann-nett.no/portal/
[33] https://www.norskeutslipp.no/no/Listesider/Virksomheter-med-utslippstillatelse/?SectorID=90&f=34
[34] https://vannmiljo.miljodirektoratet.no/

- Active substance;
- Quantity permitted per annum; and
- Dates use restrictions are valid from and to.

The information collected under the topic of 'emissions' includes:

- Substance;
- Receiving water body;
- Emission limits (variable, but sometimes listed as short-term limits and in other instances as long-term limits);
- Dates use restrictions are valid from and to;
- Monitoring and reporting requirements;
- Required characteristics of the sea landfill site.
- In the extraction of information for 'checks' by the Norwegian authorities, any deviations in compliance with the permits was noted.

Scrutiny of data from Norwegian Authorities

The Norwegian authorities supplied the project team with data on chemical and ecological status changes between 2016 and 2022 and further detail on the underlying changes to BQEs and chemical substances which led to these status changes. Specifically, two spreadsheets were provided, *Vannmiljo Export Data from fjords with mining deposits,* and *ESA case metal monitoring.* In theory, this data would have reflected the information collated by the project team previously in the step titled 'Assessment of ecological and chemical statuses'. However, there were some discrepancies in relation to what was found in Norway's Vann Nett portal, as there was some data missing, some additional data, and some data which presented disparities. After the project team scrutinised this data, further questions were raised with the Norwegian authorities on specific points.

Several of the questions centred on

- The exact processes and calculation through which statuses were derived;
- The process through which expert judgement of several 2016 statuses was conducted;
- Which chemical parameters have contributed to 'poor' chemical status in several fjords;
- Which chemical parameters have contributed to 'moderate' ecological status in Tysfjorden and Bøkfjorden;
- The reason why some of the water bodies status remain as 'undefined';
- The reason why tailings in fjords have not worsened BQE levels;
- The monitoring process for BQEs listed in Annex V of the WFD;
- The monitoring process for benthic invertebrate fauna (Annex V);
- The monitoring process for morphological conditions;
- The criteria through which measuring stations are placed and how mining disposal sites and their respective pollution are taken into account for this purpose;

- The process through which NO derives the status of certain water bodies for which there are only measurements available for one year (which makes trends identification unfeasible);
- Specifically, the reason and measures regarding the excessive presence of Zinc according to its EQS range in Jøssingfjorden.

Appendix D Information identified on possible impacts from marine disposal in selected fjords

Overview

This section presents an overview of the evidence of possible impacts on the environment linked to STD that have been identified in the literature and in evidence submitted by stakeholders. The information is presented per water body.

The Norwegian IMR noted that the research on the effects of STDs is fragmentary, recent, and is concentrated on a few cases, namely:

- the ongoing STD in the Frænfjorden;
- the STD in the Repparfjord which closed 44 years ago; and
- the old and partly closed STD in the Jøssingfjorden which still has a permit of about 1,000 tonnes yearly of suspended solids to the fjord from process water.

The IMR noted that there are gaps in the scientific research, noting for example Ranfjord where a mining company received an extension of their permit in 2015, allowing them to double the amount of tailings, and 'implied that the amount of fine fraction in the tailings increased about 9 times'. IMR notes that the monitoring data are from the Norwegian institute of Water Research (NIVA) which is initiated by the mining company and other industries in the town "Mo i Rana".

Ranfjorden

NGOs (Naturvernforbundet, 2020) raised the impact of the activities of Rana Gruber AS disposal of mining waste in Ranfjorden, quoting the 2018 assessment from the Directorate of Environment (NEA, 2019d)[35]: 'The results from the surveillance in 2018 show moderate to bad condition of several components in Ranfjorden […] *active sea disposal area for Rana Gruber, and the disposal of suspended materials from Rana Gruber has increased significantly since 2013, the negative development is as expected.'*

NGOs also noted that a permit was issued to the companies on the understanding that the activity would not lead to significantly negative consequences (quoting 'Our opinion is therefore that the ecological condition of the water bodies will not be deteriorated due to particles in the water phase'), which seem to be a contradiction with the 2018 findings.

In 2018, NIVA conducted an examination of Ranfjorden that concluded that it was primarily mining waste affecting adversely the soft bottom fauna. A further report from 2022 (NIVA, 2022) described the outcome of the monitoring programme in the fjord whose purpose was to identify whether the discharges from the mining waste affected the chemical and ecological condition of the water body. It concluded that, out of the 12 stations assessed, 9 had a condition worse than good for ecological status, and the chemical condition for 3 out of the 5 of the sediment stations was as not good due to exceeding limit values for priority substances. Nine out of the twelve benthic fauna stations surveyed were in a worse condition than good. NIVA also pointed out a 'negative development for the benthic fauna in the fjord' noting disturbance at least 19 km from the point of discharge of the

[35] Cited in Naturvernforbundet (2020), original document not seen by WSP.

tailings. The reports note that 'at some stations there was almost no benthic fauna present, which is a very unusual finding when there is also plenty of oxygen'. This finding was possibly explained due to lack of nutrient from the sedimentation of effluent particles (NIVA, 2022).

Bøkfjorden

This fjord has had several periods of being used for disposal, with periods of interruption. NGOs indicated that the fjord was used for disposal between 1906-1925, 1927-1942, 1952-1997 and 2010-2014 (Naturvernforbundet, 2022a). One of the main concerns raised focuses on the chemicals used in the mining activities. In response to changes in the permit for Sydvaranger Drift AS, the Institute of Marine Research (IMR, 2020c) points at several weaknesses in the EIA, such as: poor assessment of the particle size distribution, leading to underestimates of the spreading of particles, and possibly large volumes in the nano fraction; the fact that release of microplastic is not considered at all; and the unknown fate of the flocculating agents Magnafloc 10 and LT38, in terms of possible toxicity and their polymeric plastic-like structures.

NIVA published toxicity tests in 2010 which were reported in an IMR report (NIVA, 2010). It summarised that NIVA investigated environmental concerns related to the use of flotation agent with several toxicity tests performed on a range of organisms (algae, crustaceans, bottom living fish and sediments). NIVA found no effects on any of the organisms when using tailings without flotation agent. In contrast, effects were observed when using tailings with the flotation agents. In particular, NIVA noted significant acute toxic effect for algae and crustaceans, with mortality for fish on a higher concentration of the flotation agents. IMR indicated that 'NIVA concluded that future use of the flotation agent will result in acute toxic effects for the water environment organisms'. The report also noted that effects were likely to be experienced in the immediate vicinity of the discharge point. However, IMR notes that both algae and crustacean are food sources for other organisms which could mean more extended effects that considered by NIVA.

An NGO statement (Naturvernforbundet, 2020) noted that NIVA's report on the ecological condition of Bøkfjorden in 2012 found that, after two years of being used as disposal site, the tailings had spread in the fjord with bad ecological condition in large parts of the fjord. It was noted that this was the case despite the fact that the disposal pipe had fallen much deeper in the fjord than planned.

A further complaint from NGOs is that the existing permit was transferred to a new mining company: from Sydvaranger Gruve AS who received the permit in 2008, to Sydvaranger Eiendom AS. They summarised the disagreement between Norway official authorities as follows:

- Representatives from the Directorate of the Environment expressed on 05.02.2019 that it is not permitted to dump mining waste in Bøkfjorden, based on the dumping permit of 2008.
- The Ministry of Trade, Industry and Fisheries wrote in their decision of 19.03.2019 that it is permitted to dump mine waste in Bøkfjorden, using the permit of 2008.
- The Minister of Climate and Environment at that time, Ola Elvestuen, stated on 02.04.2019 that it is permitted to dump mine waste in Bøkfjorden, using the permit of 2008.
- The Directorate of the Environment Miljødirektoratet warned Sydvaranger Eiendom AS 12.12.2019 about revising the dumping permit, and they ordered the company to provide more information.

NGOs argued that a new permit application, with full analysis, should be performed before new deposits are allowed (Naturvernforbundet, 2020).

Finally, IMR (2020d) noted that there was not enough consideration of the discharge of flocculants, of the particle size distribution and of the release of microplastics. It noted that fauna, that was

affected during previous activities before 2015 had, to some extent, recolonised the sediments, but that benthic surveys were not systematic. It also highlighted that the water body is part of the salmon fjord Neiden-Bøkfjorden which should be taken into account.

Førdefjord

As explained by Nordic Mining (2021), the Engebø Deposit was first recognised as a rutile deposit in the 1970s, after development of a local road tunnel on county road Fv611. DuPont carried out comprehensive drilling and sampling programmes in the period 1995 to 1998 with assistance from the Geological Survey of Norway (NGU). The company Fjord Blokk AS also initiated a small-scale quarrying operations in 1998. In September 2006, Nordic Mining acquired the Extraction Permits. Since 2011, the permits have been held by Nordic Mining's wholly owned subsidiary Nordic Rutile AS.

A study by Kvellestad (2021) reviewed the impacts of the discharge of mining waste to the marine environment in the fjord and concluded that there were uncertainties regarding the decomposition of one chemical substance to be used in the mining activity: SIBX. It highlighted that chemical substances effects were assessed separately, so there was no assessment of possible combined effects. It also concluded that the EIA underpinning the permit application would have benefited from investigation of metals, chemicals and their interactions.

The Norwegian IMR (2019) responded to a public consultation for the permitting of the discharge. It emphasised that Førdefjorden has a specific status, highlighting its importance for natural salmon. Indeed, salmon from Nausta migrate through the area considered for disposal. IMR indicated that the Førdefjorden national salmon fjord status was established to give the salmon stock in Nausta special protection against man-made interference. NGOs indicated that salmon farming is of high relevance in the area and valued the industry at 1 billion kroner in the outer Førdefjord, with a range of 60 individual companies involved (including affiliated industries such as tourism) reaching a value of 16 billion kroner in 2014 (Naturvernforbundet, 2022a).

IMR also highlights that the knowledge base used for the permitting has technical shortcomings, and notes that "recent studies of mining deposits from other fjords have shown that it takes many decades before the fjord ecosystem is normalised". IMR's opinion is that the use of Førdefjord, as proposed, will lead to very long-term and significant ecosystem deterioration (IMR, 2019).

On this specific fjord, NGOs pointed out that the use of a paragraph 12 exemption should not be allowed as the additional conditions have not been fulfilled. More specifically, the NGOs consider that alternative environmentally friendly technologies are available, and furthermore that the extraction of titanium dioxide cannot be seen as of 'overriding importance for society' as this is not a rare substance, and it has known harmful effects on health (Naturvernforbundet, 2022a and KLIF, 2012).

On nanoparticles, a note from DNV GL (2014) indicates that 'it is correct that the Nature Conservation Association refers that the discharge from the Engebø can be in the order of 100 tonnes/year of titanium dioxide in the size fraction <100 nm. However, the emission concentrations are low.' The impacts of nanoparticles are further described, noting that chemically produced nanoparticles are typically more reactive than what is found from rutile. It estimates that the concentration in the water masses in titanium dioxide nanoparticles is 70 µg/l, indicating that effects on aquatic organisms were observed from concentration of 100 µg/l. It also notes that sediment in the fjord contains high levels of titanium dioxide particles from the weathering of the rocks in the area. Finally, it notes that, from previous experience in Jøssingfjorden (see below), linked to emissions from Titania over 20 years[36], it was 'unlikely that the emissions of nanoparticles from Engebøfjellet would have an impact beyond what has already been identified in the impact assessment'.

Finally on the use of SIBX, the Norwegian IMR (2020b) expressed its concern on the discharge permitting for several aspects including micro and nanoparticles but also the use of SIBX. It notes that the half-life of SIBX in the marine environment used in the environmental assessment is not realistic. It also expresses doubts on the accuracy of the dispersion modelling which is possibly underestimating the possible spread. IMR adds that the breakdown product of SIBX, CS_2, has been shown to be toxic for fish and plankton in freshwater.

Repparfjord

NGOs raised the example of Repparfjord as a water body where tailings were disposed of in the 1970s and which was still experiencing impacts (Green Warriors, 2022). It noted that after, over 40 years, the seabed where deposit occurred was 'partially lifeless'.

The Norwegian IMR published a study in 2021 described as a baseline study to be used as a basis for future comparison if the Nussir copper mine site starts disposing of tailings in the fjord (IMR, 2021). The study reviewed content of heavy metals in fish and seafood samples and compared it to samples from Bøkfjorden where tailings from an iron mine have been deposited (see above). A conclusion from the study is that iron, chromium, copper and nickel should be monitored.

A study from 2022 reviewed the leaching of metals from in Repparfjord, noting there are no threshold value sets in permits for leaching of metals due to the absence of standardised test to assess metal leaching (Pedersen and Evenset, 2022). As part of the PAMERA project, sampling, and analysis were conducted to gain a better understanding of leaching and environmental impact of mining tailings.

[36] DNV's statement notes that emissions of titanium dioxide particles, where the fines fraction contains a significant proportion of nanoparticles, have not had effects on organisms beyond the landfill area itself

Jøssingfjorden

NGOs highlight a series of studies related to Jøssingfjorden that show it takes a long time for nature to recover from disposal. It states that, while it is more than 30 years since the discharges from Titania have stopped, in some parts of the fjord the ecosystem has still not recovered. NGOs highlighted the impact of fine particles that disperse more widely in the fjord (Green Warriors, 2022).

A 2019 study (Schaanning et al, 2019) investigated the mobilisation and bioavailability of trace metals in old deposits, and on the status of the macrobenthic communities. Samplings from deposits in the fjord and in a more exposed coastal basins were compared. The results found that "nickel and copper exceeded environmental quality standards in sediment and pore water from the 0-1 cm layer and fluxes of nickel, copper and cobalt to the overlying water was high compared to adjacent reference stations". The study also found no evidence of leaching from tailings buried below the bioturbated zone. It concluded that ongoing discharges might contribute to the slow down restoration processes.

A NYKOS study (New Knowledge on Sea Deposits, funded by the Research Council of Norway) in the same area found 'clear signs of faunal restitution of the entire area', but found similar remaining signs of disturbance, noting that the initial restitution is rapid but that up to several decades are needed for the faunal composition to return to its original state. It also notes that for the chemical status, the ongoing discharges of suspended particles are thought to slow down the restitution process (Schaanning et al, 2019).

Tingvollfjorden

NGOs highlighted that the Tingvollfjorden has a poor ecological and chemical status (based on information from Vann Nett) highlighting that elements with poor condition are chlorophyll a, arsenic, copper, zinc, tributylincatenin CAS and nickel in salt water and bottom sediment.

A NIVA report from 2020 presented results from a 2019 investigation of environmental toxins and metals in the sediments of the fjord. It noted that the benthic fauna had a good ecological status at stations investigated, with little change from a 2013 survey. However, it noted a reduced number of species and individuals. Sediment sampling showed excess copper at all stations. Concentrations of lead and cadmium were low, while concentrations of nickel were high. The level of toxins in sediments had increased since the 2013 survey (SNV, 2022 and NIVA, 2020). NIVA suggested that the results are a reflection of industrial activities, past and current.

Tosenfjord

On this fjord, the IMR noted in its comments to the public consultation for the permitting of the mining in Bogadalen-Kolsvik, that the company's EIA does not assess the spreading of nanosized particles and does not consider the currents in the fjord (Naturvernforbundet, 2022a).

Other shortcomings identified include the importance of investigating plastic waste from the wear and tear of pipes, etc., which is not investigated although similar usage of pipes in for instance aquaculture leads to significant release of microplastic. Finally, IMR pointed out that there is insufficient assessment of the arsenic content in the tailings (quoted in Naturvernforbundet, 2022a and see also IMR, 2020b).

Appendix E Chemical substances identified

The table below summarises the information identified with regard to chemical substances that are involved in the mining activities for which marine disposal is ongoing / permitted.

The information has been extracted from both literature and permits. As well as the chemical name, and CAS number, it is noted whether substances are Priority Substances (PS), Priority Hazardous Substances (PHS), and Certain Other Pollutants according to Annex II of Directive 2008/105/EC, or River Basin Specific Pollutants. Information on the quantities involved is also provided.

Table - Summary of substances mentioned in permits and literature

Fjord	Chemical substances mentioned in the literature / permit	CAS number	PS/PHS/ RBSP	Information on quantities involved – included discharges
Jøssingfjord	Nickel Nitrate Ammonium Copper (NIVA, 2018)	Ni: 7440-02-0 Cu: 7440-50-8	PS-Ni RBSP-n/a	The effluent from ilmenite (titanium iron oxide) production was deposited in the Jøssingfjord from 1960 to 1984 and in the adjacent and connected water body, Dyngadypet, from 1984 to 1994. In 1994, a landfill was established (NIVA, 2018). Currently, it is permitted that the Jøssingfjord receives 6 kg per day of nickel and 2,500 kg per day of suspended matter from the open pit, the landfill, the extra beds and the drying plant (NEA, 2002). Moreover, in 2018, NIVA observed that drainage water from the landfill (discharged into the fjord) also contained small amounts of organic tall oil, nitrate and ammonium (NIVA, 2018).
Førdefjorden-ytre	TiO_2 Iron Copper Zinc Lead SIBX Magnafloc 5250 Dowfroth 400	TiO_2-13463-67-7 Fe-7439-89-6 Cu-7440-50-8 Zn-7440-66- Pb- 7439-92-1 SIBX- 25306-75-6	PS - Pb	According to the only available permit identified from 2015, Nordic Rutile is allowed to use and discharge 4 tonnes per year of Magnafloc 5250 (flocculant), 2 tonnes per year of sodium isobutyl xanthate (flotation collector), and 3 tonnes per year of Dow Froth 400 (flotation foam) (NEA, 2015). Kvellestad (2021) reported that a recent permit issued in 2021 by the Norwegian Environment Agency allows 4 millions tonnes of tailing disposal and 250 million tonnes in total in the future (and this is reflected in the above permit). The

Fjord	Chemical substances mentioned in the literature / permit	CAS number	PS/PHS/ RBSP	Information on quantities involved – included discharges
				company estimates a planned annual amount of 1.3 million tonnes of mining waste discharge. This would contain 7,300 tonnes of the mineral pyrite (FeS_2) after its removal from rutile by reverse flotation using the abovementioned chemicals. Discharged waste consists of sludge coming from ore (feedstock) which served the industrial process where rocks were ground into small particles. According to the same source, from the 4 million tonnes above, approximate values for leakage through tailings into the fjord of heavy metals have been estimated, including for cadmium (11kg), nickel (42kg), lead (66kg), cobalt (1,200 kg), manganese (15,000kg), chromium (7 kg), copper (111kg), and zinc (20,000 kg). If, in the future, only 1.3 million tonnes are disposed of, the leakage would be lower (see section 7.3.8, table 18 of Kvellestad (2021)). Friends of the Earth Norway estimated that, up until 2021, 28,000 to 109,200 kg of plastics from cables and tubes for casing and loading have been introduced in the fjord (Naturvernforbundet, 2021c).
Elnesvågen	Adipic acid triethanolamine dimethyl sulphate quaternized Polyacrylamide (Naturvernforbundet, 2021a) Microplastic Fatty acids C14–18 and C16–18 unsaturated fatty acids	Adipic acid-124-04-09 triethanolamine - 102-71-6 dimethyl sulphate quaternized-77-78-1 Polyacrylamide - 9003-05-8	n/a	A permit was issued to Omya Hustadmarmor AS allowing 700,000 tonnes of tailings to be disposed annually into the Elnesvågen. The permit authorises polyacrylamide to be used up to 12.5 tonnes per year. It includes limits for fatty acids, C14-18 and C16-18 unsaturated fatty acids, products with adipic acid and triethanolamine, dimethyl sulfate quaternized, all of which can all be used up to 2.32 tonnes per year (Naturvernforbundet, 2020) Friends of the Earth Norway provided information stating that in 2018 187,000 tonnes of tailings were discharged and in 2016 there was 300,000 tonnes discharged (Naturvernforbundet, 2020). No quantified information on discharge of microplastics was identified.
Ranfjorden - Mo	Lilaflot D817M, diamine acetate PAH's Cadmium	Lilaflot-151789-08-1	PS-Ni/Pb	In 2015 Rana Gruber was granted approval to increase the amount of mining waste that can be discharged into the fjord, from 2 million to 3 million tonnes each year (IMR, 2022d).

Fjord	Chemical substances mentioned in the literature / permit	CAS number	PS/PHS/ RBSP	Information on quantities involved – included discharges
	Chormium Copper Nickel Lead Zinc Arsenic Mercury Iron (NIVA, 2022) Microplastic	Diamine acetate-79234-33-6 PAHs- 50-32-8 Cd-7440-43-9 Cr-7440-47-3 Cu-7440-50-8 Ni-7440-02-0 Pb- 7439-92-1 Zn-7440-66-6 As- 7440-38-2 Hg-7439-97-6 Fe- 7439-89-6	PHS-Cd/PAHs/ TBT	The Norwegian Institute of Marine Research stated that, effectively, in 2015, there was an increase of 1.7 to 3 million tonnes per year of waste in Ranfjord (IMR, 2022d). The available permit (NEA, 2012) indicates that the amount of the substances allowed to be discharged are 40kg per year of Lilaflot D817M, Diamine/ Diamine acetate. A 2013 report produced by the Norwegian Institute for Water Research (NIVA, 2013) indicated that the emissions produced by the mine enter the fjord at two different points, the coarse fraction at a depth of 30 metres and the fine and intermediate fractions at a depth of 45 metres. Before discharging, the water flux is about 1,100 m^3 per hour for coarse material and just over 2,100m^3 per hour for the fine fraction. In 2019, NIVA stated that this change included an increase in fine fraction emissions of the tailing into the fjord which multiplied by 9, going from 39,000 to 350,000 tonnes per year, amounting to 12% of total annual discharges (IMR, 2022d, citing NIVA report 7347-2019). Friends of the Earth Norway estimated that the amount of microplastics discharged into the fjord as 935kg per year (Naturvernforbundet, 2021a).
Tysfjorden	Fluorosilicic acid Petroleum sulphonate Diamine Microplastic Hydrogen fluoride	Fluorosilicic acid-16961-83-4 Petroleum sulphonate-61789-86-4		According to Permit No. 2010.0161.T (NEA, 2011), 37,000 tonnes per year of suspended matter can be discharged into the fjord by the Quartz Corp. Friends of the Earth Norway claimed that actual discharges in 2018 and 2019, amounted respectively to 3,700 tonnes (Naturvernforbundet, 2020) and 4,400 tonnes (Naturvernforbundet, 2021a). Additionally, the permit allows the discharge of up to 8,500 tonnes of fluorosilicic acid, 25 tonnes of petroleum sulfonate, 6 tonnes of diamine, and 230 tonnes of sodium chloride per year (NEA, 2011).

Fjord	Chemical substances mentioned in the literature / permit	CAS number	PS/PHS/ RBSP	Information on quantities involved – included discharges
Bergsfjorden	Chromium Copper Nickel Methyl Isobutyl Carbinol	Cr-7440-47-3 Cu-7440-50-8 Ni-7440-02-0 MIBC-108-11-2	PS-Ni	According to permit number 1989.0061.T, which was first granted to Skaland Graphites AS in 1989 and last modified in 2022, the following discharge limits are included: 1.37g/day of Cr (500 g/year), 4.11g/day of Zn (1500 g/year) 2.74 g/day of Cu (1000 g/year), 14.25g day of Ni (5200 g/year), 40,000 tonnes/year of suspended solids, 30,000 litres/ year of MIBC, 50 mg/year of oil and 5,000 litres of Sepco CE 3040 LH (Troms and Finnmark County Governors, 1989).
Lillebukta - Ytre Simavik (Stjernsundet)	Microplastics Heavy metals (not stated which)			Friends of the Earth Norway provided information for this site, indicating that tailing discharged is expected to include microplastics, however there is no quantification provided (Naturvernforbundet, 2021a).
Repparfjorden ytre	Chromium Copper Nickel Zinc Methyl Isobutyl Carbinol Sodium Isobutyl XanthateCarboxymethyl Cellulose Sodium	Cr-7440-47-3 Cu-7440-50-8 Ni-7440-02-0 Zn-557-21-1 MIBC-108-11-2 SIBX- 25306-75-6 CMC-9004-32-4	PS-Ni	From the permit number 2016.0051.T which was granted in 2016 to Nussir AS there were daily and annual averages set for different substances (NEA, 2016). These include: 600 kg/day of burnt lime, 350 kg/day of CMC, 6500 tonnes/day of suspended soils, 240 kg/day of magnafloc 10, 350 kg/day of MIBC. At the point when the permit was granted, the use of Sodium Isopropyl Xanthat was awaiting further investigations before its use could be permitted (NEA, 2016).. The permit indicates that 2 million tonnes per year of tailings can be discharged in the fjord. For specific substances, Friends of the Earth Norway calculated that limits are set as: 100 tonnes/year for SIBX, 110 tonnes/year of MIBC and CMC and 73 tonnes/year of Magnafloc 10 (Naturvernforbundet, 2021c). They also predicted around 5,000-19,500kg of plastics were going to be used from cables and tubes for casing and loading which could end up in disposed tailings, but the time frame for this was not stated. A note from the Norwegian National Institute of Nutrition and Seafood Research (NIFES) noted that there was concern in 2012 of the levels of

Fjord	Chemical substances mentioned in the literature / permit	CAS number	PS/PHS/ RBSP	Information on quantities involved – included discharges
				copper coming from the mine tailings which were predicted to be around 500mg/kg per tailing which exceeds the 200mg/kg Cu sediment limit which NIFES believes to exceed quality class V (very bad, their comment). It is considered that concentrations above the limit result in acute toxic conditions (ESA, 2021c). The permit for operation allowed 25 million tonnes of mining waste to enter the fjord after the permit was granted in 2016 (Naturvernforbundet, 2021a). In terms of heavy metals, the quantities authorised to be discharged are as follows: 1,400 tonnes/year of Cu, 240 tonnes/year of Ni, 588 tonnes/year of Cr. It is predicted that there will be 0.2g of plastic per m^3 of disposed rock and 400,000 tonnes/year of micro and nanoparticles (Naturvernforbundet, 2022c).
Bøkfjorden-ytre	Polyacylamide polyDAMAC Ni Copper Magnafloc 10/1707 LT38 Lilaflot Microplastics	Polyacrylamide 9003-05-8 polyDAMAC- 26062-79-3 Ni 7440-02-0 Cu 7440-50-8		From permit number 2008.190.T which was granted to Sydvaranger gruver AS in 2008, it was stated that there were 4 million tonnes per year allowed for departure compounds and suspended solids as well as 65 tonnes per year of water treatment chemicals (NEA, 2008). The permit allows for use of 50 tonnes/year of polyacrylamide, 10 tonnes/year of polyDAMAC (15 tonnes before 2015). In the year 2013 it was stated that the company discharged 2.8 million tonnes of tailings in the year, 9.7 tonnes of polyDAMAC and 28.6 tonnes of polyacrylamide (Norsk Bergindustri, 2014). FoE estimated that 1.3 tonnes/year of microplastics were part of the tailings (Naturvernforbundet, 2021a). This information is not available in the permit. FoE also claims that the quantity of tailings disposed of has increased to 9 million tonnes per year and there has been a significant increase in chemicals used. The date for the change in the permit was not provided (Naturvernforbundet, 2015). It is unclear since when the increase is noted and whether this is covered by a permit extension.

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