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Repeated environmental baseline survey at AF Miljøbase Vats in conjugation with the Ekofisk cessation EPRD project

Norwegian Institute for Water Research

REPORT

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Abstract

In this study, the environmental contamination by AF Environmental Base Vats (AFEBV) was assessed before and after the facilities demolition activities in the Ekofisk cessation EPRD project. Seafloor debris and contaminant concentrations in soil, groundwater and fjord sediments were measured in 2015 and compared to data from the 2009 baseline study. ROV inspections found normal biological conditions of algae and benthic animals but much anthropogenic scrap remain at the seabed, although much is removed as a result of clean-up operations. Sediments collected in the fjord adjacent to the demolition plant showed PAH16 levels in Class II in one sample (Raunes 2), whereas three others were in Class I. One individual PAH component was in Class IV in the Raunes 2 sample. TBT was detected in Class IV in two sediment samples (Raunes 2 and Vats 4) and in Class II in two samples from Grønavika. The sediment TBT and PAH levels were consistent with levels reported in 2009, indicating that the contamination level in sediments close to the base has been more or less stable between 2009 and 2015. Levels of PCB7, mercury and other metals were low (Class I) in sediment samples from all fjord stations. Top-soil in the ultimate vicinity of the base has become more contaminated, especially with regard to mercury, and these data are also confirmed by the annual monitoring programme. Assessment of groundwater samples showed low levels of all contaminants, indicating that the impermeable deck at the base prevents contaminant transfer.

4 keywords, Norwegian	4 keywords, English
1. AF Offshore Decom	1. AF Offshore Decom
2. Vatsfjorden	2. Vatsfjord
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Repeated environmental baseline survey at AF Miljøbase Vats in conjugation with the Ekofisk cessation EPRD project

Preface

An environmental survey by the AF Environmental base Vats (AFEBV) was performed in 2015 to compare the current environmental status to its baseline condition in 2009, when AFEBV's work in the Ekofisk Cessation EPRD project started. Soil, groundwater, marine sediments and anthropogenic debris at the seafloor were investigated.

AF Offshore Decom commissioned the investigation and organised shipment and order of analyses (at ALS) of soil and sediment samples.

NIVA was responsible for performance of the ROV survey, collection of samples for analyses (soil, groundwater and sediment) and interpretation and reporting of all data. The groundwater data included in the present report were obtained from NIVAs regular environmental monitoring program at AFEBV and Anders Hobæk is responsible for that activity.

The NIVA personnel involved in the 2015 survey have been Jonny Beyer (PL and reporting), Jarle Håvardstun (collection of soil and sediment samples), Mats Gunnar Walday (ROV fieldwork and reporting), Hege Gundersen (ROV data interpretation) and Morten T. Schaanning (Quality Assurance of report).

Some of the data shown in the present report stem from the previous baseline study in 2009. In connection with the study in 2009, Astri JS Kvassnes was PL whereas Mats Walday, Hege Gundersen and Torgeir Bakke (QA) were contributors.

Contact persons at AFEBV for the 2015 work have been Veslemøy Eriksen and Jøran Baann.

The present revised report was made after the project client submitted a list of comments to the original report. The comments and NIVAs responses to them are shown in Appendix 5.5.

Oslo, 20.11.2015

Jonny Beyer

Contents

Summary

AF Offshore Decom recycles decommissioned offshore installations at the AF Environmental Base Vats, AFEBV (AF Miljøbase Vats) at Raunes in Vindafjord Municipality, Rogaland, Norway. The installations are separated into large sections at sea and towed to shore at AFEBV where they subsequently are hoisted onshore and further taken apart. All materials are sorted after value. Hazardous components and waste materials are treated separately. The AFEBV facility is equipped with a water treatment plant for surface water / processing water as well as other infrastructures targeted for minimizing release of chemical contaminants to the neighbouring environment. On commission from AF Offshore Decom, NIVA has in 2015 performed a repeated environmental baseline investigation in the area close to AFEBV. The aim was to compare the locations environmental status to its condition in 2009 when the previous baseline study (Kvassnes et al. 2010) was done prior to the onset of AFEBVs work with installations from the Ekofisk Cessation EPRD project (2009-2015). Both years, samples of soil, groundwater and marine sediments were collected and analysed and visual inspections of the seafloor outside the quays at AFEBV were carried out with ROV to map the amount of anthropogenic debris and provide a general picture of the ecological condition at the site.

The visual examinations of the seafloor showed a variable benthic substrate consisting of bedrock, deposited rocks and boulders containing variable degree of biotic fouling, and sand, gravel and stony substrate in the shallow part where the quay has been expanded, to normal soft bottom with multiple traces of marine in-fauna as well as other visible benthic fauna. The benthic community that was observed with ROV was generally as expected for a harbour area like the one outside AFEBV, with benthic algae, kelp, starfish, fish and crab. The ROV survey identified and positioned a number of debris objects located at 80 individual positions within the two inspection areas Raunesvika and Grønavika. The observed debris included many different objects, such as steel ropes, floating ropes, iron-rods, metal plates, ladders, various plastic debris, parts of canvas and silt-curtains, fish-cages, boards, fish nets, trees and wooden structures, and a number of car-tires of variable sizes. It is likely that the total amount of debris was decreased in 2015 as compared to in 2009 as clean-up operations had been performed and large amount of scrap was removed, according to information from AFEBV. The present data does not provide a basis for determining whether the amount of scrap on the seabed close to the base has been reduced.

Both in 2009 and 2015, sediments collected in the fjord adjacent to the demolition plant showed PAH16 levels in Class II in one sample (Raunes 2), whereas three other sediment samples were in Class I. One individual PAH (benso(ghi)perylene, which was analysed in 2015 only) was determined to Class IV in the Raunes 2 sample, but was under the limit of detection in at the other sediment stations. TBT was detected in Class IV in two sediment samples (Raunes 2 and Vats 4) and in Class II in two samples from Grønavika. Similar increased TBT and PAH levels in Raunesvika have been seen by studies reported earlier than 2009. Both in 2009 and 2015, the concentration of PCB7, mercury and other metals were low (Class I) in sediment samples from all fjord stations. In sum, the sediment data gave no evidence for a consistent change in contaminant levels in these fjord sediments between 2009 and 2015. The baseline study in 2009 revealed the occasional presence of elevated (Class II) levels of PAH, TBT and lead at several fjord stations located far from AFEBV indicating that anthropogenic and/or industrial activities had left some foot-prints in the area also before 2009.

The soil contamination study was restricted to two soil stations (J1 and J2) both located just adjacent to the plant, i.e. within the narrow area between the Raunes River and the fence/concrete wall that borders the AFEBV area. The soil analyses indicated an increase in the soil contamination level; especially for PAH, mercury and some other metals, although the measurements in large fell within Class I (according to guideline TA-2553). For mercury, the concentration measured at the most contaminated J1 position in 2015 was increased 20 times in comparison to the concentration measured in 2009, and was classified to Class III (moderate) according to guideline TA-2553. The concentrations of mercury, zinc and four PAH components in the J1 sample exceeded the guideline norm value for most sensitive land use, according to guideline TA-1629. The observed increase in contamination appeared to be very patchy distributed, as the J2 soil station was significantly less contaminated although it was located just a few dozen meters away from the J1 station. Furthermore, it is relevant to comment that the 2015 soil contamination data are corroborated by NIVAs annual monitoring program which found increased concentrations of mercury and other heavy metals at the J1 and J2 soil stations already in 2010.

The assessment of groundwater samples from four wells within the base area showed low levels of all contaminants measured, signalling a good condition of the groundwater and that the impermeable deck at the base prevents contaminant transfer to the ground beneath the demolition facility.

Sammendrag

AF Offshore Decom resirkulerer utrangerte offshoreinstallasjoner ved AF Miljøbase Vats (AFMBV) på Raunes i Vindafjord kommune, Rogaland. Installasjonene blir delt opp i store deler og slept til land ved miljøbasen hvor de heises på land og blir videre tatt fra hverandre. Alle metaller sorteres for resirkulering og farlige komponenter og avfall behandles separat. Miljøbasen er utstyrt med et vannbehandlingsanlegg for overvann / prosessvann samt annen infrastruktur målrettet for å minimere utslipp av kjemiske forurensninger til det omkringliggende miljøet. På oppdrag fra AF Offshore Decom utførte NIVA i 2015 en gjentatt baseline undersøkelse i nærområdet ved AFMBV. Målsetningen var å sammenligne områdets miljøtilstand med situasjonen fra 2009 da den forrige basisundersøkelsen (Kvassnes et al. 2010) ble utført før starten av basens arbeid med installasjoner fra Ekofisk Cessation EPRD prosjektet. Både i 2009 og 2015 ble prøver av jord, grunnvann og marine sedimenter samlet inn og analysert og undervannsbefaring med ROV ble utført utenfor kaianlegget ved basen for å kartlegge mengden skrap og for å gi et generelt bilde av den økologiske tilstanden i området.

De visuelle undersøkelsene viste vekslende bunnforhold bestående av grunnfjell, steinblokker med varierende grad av begroing og sand, grus og større steiner i den grunnere delen der utfyllinger er gjort i sammenheng med utvidelser av kaianlegget, samt vanlig myk fjordbunn med mange spor av sedimentlevende fauna som samt andre synlige bunnfauna. Organismesamfunnet som kunne påvises med ROV var omtrent som forventet for denne typen kystlokalitet, med fastsittende alger, tare, sjøstjerner, fisk og krabbe. ROV undersøkelsen i 2015 identifiserte 80 enkeltposisjoner hvor menneskeskapt skrap ble påvist innenfor de to inspeksjonsområder Raunesvika og Grønavika. Mange forskjellige objekter ble påvist, for eksempel kvaser av vaier og tau, jernstenger, metallplater, stiger, ulike plast objekter, deler av lerreter og silt-gardiner, ruser, fiskegarn, trekonstruksjoner og mange bildekk av variable størrelser. Det er sannsynlig at den totale mengden skrap var blitt mindre i 2015 i forhold til 2009 ettersom en opprydningsaksjon var utført og en stor mengde skrap var blitt fjernet fra sjøbunnen, dette ifølge informasjon fra AFMBV. Det foreliggende datamaterialet gir imidlertid ikke grunnlag for å avgjøre om mengden skrap på bunnen ved basen har blitt redusert.

Både i 2009 og 2015 ble PAH16 påvist i tilstandsklasse II på en stasjon (Raunes 2) i Raunesvika, mens nivået var lavt (Klasse I) på tre andre stasjoner. En PAH-komponent (benso(ghi)perylen) som bare ble analysert i 2015 viste Klasse IV på en stasjon (Raunes 2), men var under deteksjonsgrensen på den andre stasjonen i Raunesvika og på begge de to stasjonene som ble undersøkt i Grønavika. TBT ble påvist i Klasse IV ved to sedimentstasjoner i Raunesvika (Raunes 2 and Vats 4) og i Klasse II i to prøver fra Grønavika. Tilsvarende forhøyede nivåer av TBT og PAH i Raunesvika er blitt påvist også i undersøkelser før 2009. PCB7, kvikksølv og andre metaller forelå kun i lave nivåer (Klasse I) og lå under den analytiske deteksjonsgrensen på alle stasjoner begge år både i Raunesvika og Grønavika. Samlet sett gir ikke sedimentundersøkelsene grunnlag for å konkludere at konsentrasjonsnivået av noen av de undersøkte forbindelsene i sedimentene i fjorden utenfor basen er endret i perioden mellom 2009 og 2015. Baseline undersøkelsen i 2009 avdekket imidlertid sporadisk forhøyede konsentrasjoner (Klasse II) av TBT, PAH og bly på stasjoner i Yrkefjorden og Krossfjorden, langt unna AFMBV's bedriftsområde, noe som tyder på at det forelå et svakt miljømessig fotavtrykk fra menneskelige og /eller industrielle aktiviteter i området fra perioden før 2009.

Undersøkelsen av jordforurensning begrenset seg til to jord-prøve stasjoner (J1 og J2) som begge var lokalisert rett ved AFMBV, nærmere bestemt innenfor det smale arealet mellom Rauneselva og betongveggen som markerer grensen til anleggsområdet. Jordanalysene indikerte at forurensningsnivået hadde økt mellom 2009 og 2015; spesielt for PAH, kvikksølv og enkelte andre metaller, selv om nivåene stort sett lå innenfor tilstandsklasse I etter veileder TA-2553. Kvikksølvnivået på den mest forurensede J1 stasjonen var 20 ganger høyere i 2015 enn i 2009, og ble klassifisert til tilstandsklasse III (moderat) etter veileder TA-2553. Måleverdiene for kvikksølv, sink og fire PAH komponenter i prøven fra J1i 2015 overskred normverdien for mest følsom arealbruk (veileder TA-1629). Den observerte økningen av kontamineringsnivå virket å være svært ujevnt fordelt ettersom betydelig lavere verdier ble målt på jordstasjonen J2 som kun ligger noen få titalls meter fra J1. Det er dessuten relevant å anmerke at analyseresultatene av jordprøver fra 2015 samsvarer godt med data fra NIVAs årlige miljøovervåkingsprogram ved AFMBV, som påviste økt konsentrasjon av kvikksølv og enkelte andre tungmetaller ved J1 og J2 stasjonene allerede i 2010.

Målingene av grunnvannsprøver samlet fra fire brønner lokalisert inne på basen viste lave nivåer av alle forurensningskomponentene som ble målt, noe som signaliserer god tilstand av grunnvannet og at den ugjennomtrengelige membranen som ligger under anleggsområdet virker etter hensikten og hindrer forurensning fra å trenge ned i bakken.

1. Introduction

1.1 Background and aim of study

In 2009, the AF Environmental Base Vats (AFEBV) started to demolish parts of the offshore installations dismantled in conjugation with the Ekofisk Cessation EPRD Project (Figure 1), a project which ends in 2015. Before the Ekofisk demolition activities started in 2009, a separate "baseline survey" was performed at AFEBV location at Raunes (Kvassnes et al. 2010) targeted to measure the contamination level in various environmental matrices (fjord sediments, soil samples, and groundwater samples) collected within or close by the AFEBV facility.

In the present study from 2015 similar assessments were conducted of the same environmental matrices obtained from the same positions close to AFEBV in 2009. The key objective of the present work is to provide a *before vs. after comparison* of the environmental contamination level at the AFEBV location. Furthermore, the amount of anthropogenic scrap at the seafloor close to AFEBV was assessed both in 2009 and 2015 by means of ROV inspections and these results are also compared in general terms in the present report.

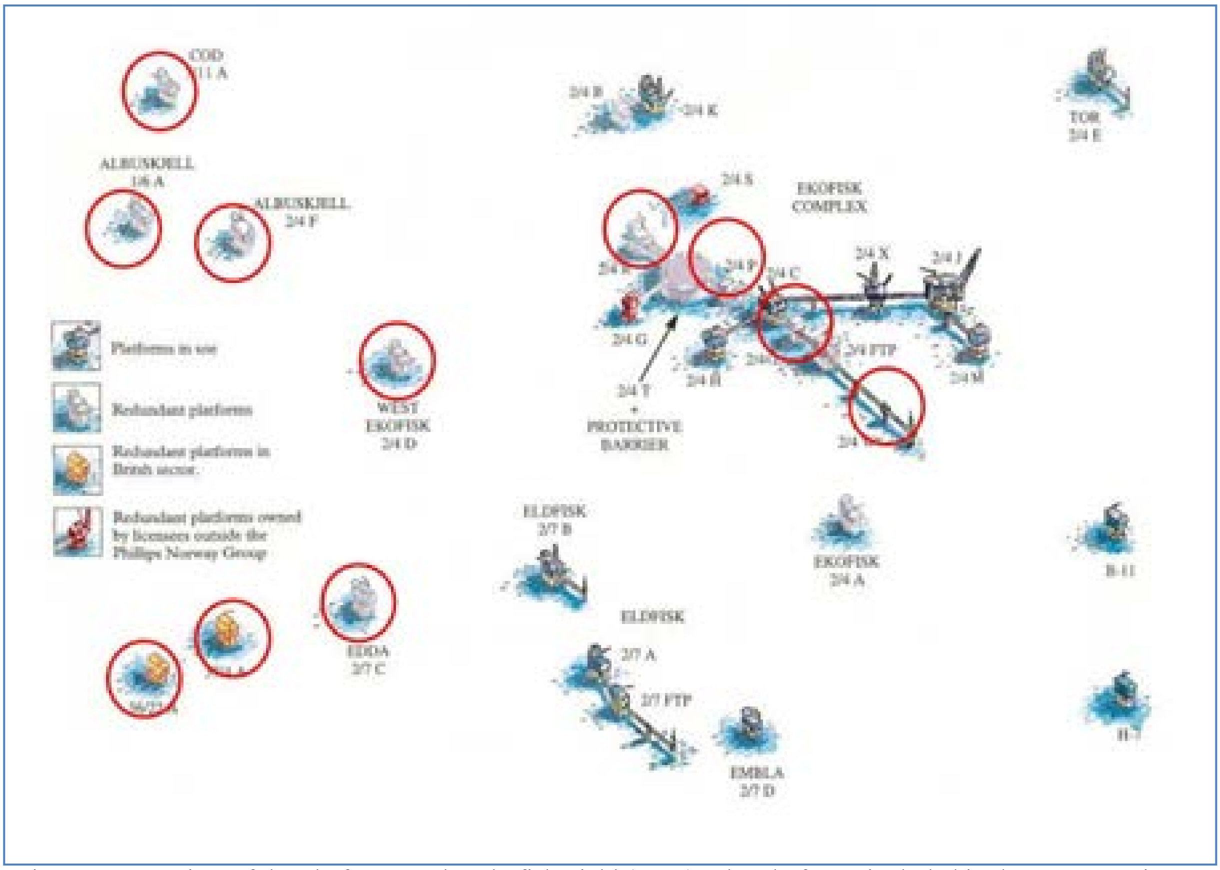

Figure 1: Overview of the platforms at the Ekofisk Field (2008). The platforms included in the EPRD project are flagged with a red circle.

In the same period as the EPRD project was performed, a number of other demolition projects have been conducted at AFEBV, these include:

- 2009 Kittiwake loading buoy,
- EKOW platform
- 2010 Ekofisk debris removal
- 2011 Ekofisk debris removal
- 2012 SFC loading buoy,
- Ekofisk debris removal,
- Stena Carron rig maintenance,
- Ocean Rig Corcovado rig maintenance
- 2013 SFC loading buoy,
- H7 platform,
- ELDE WHRU,
- TOGI surplus equipment,
- Ekofisk debris removal,
- Stena Carron rig maintenance
- 2014 Valhall produced water hose,
- Deepsea Atlantic rig maintenance
- 2015 B11 platform

1.2 Brief description of the AFEBV location

AFEBV (AF Miljøbase Vats) is located at Raunes in Rogaland, on the west side of the Vatsfjord, a 5 km long fjord that meets the larger and deeper Yrkjefjord to the south (Figure 2 and Figure 3). AFEBV has expanded its quay areas over the years (Figure 3), presenting a deep-water quay with free access to the ocean (no sills).

The Vatsfjord has two basins that are separated by shallower glacial sills. AFEBV is located just south of the southernmost sill at Raunes. From the area close to AFEBV facility, the fjord deepens from the 30 meter deep sill to 160 meters depth where the Vatsfjord meets the Yrkjefjord (Figure 2).

The ground under the large quay area at AFEBV is protected against pollution by an impermeable membrane located under an inward-sloping tarmac quay deck. Water that falls on the tarmac deck includes rainwater, process water from decontamination of steel structures and water used for dust reducing measures. All this water is collected and thoroughly cleansed in a sand-filter based water treatment system before the resulting effluent is discharged to the sea, this as a key measure for minimizing environmental release of chemical contaminates from the demolition facility.

The Raunes location has a long history of commercial and industrial activities also from before AFEBV was established at this site in 2005 and expanded significantly in the period 2008-2009. The earlier activities include sawmill activities, construction and anchoring of offshore platforms, jetty, tires reception and aquaculture. The environmental conditions at the location has been investigated a number of times and an overview of these studies is provided in Table 1. Regular environmental monitoring activities with annual reports have been conducted in the area around the AFEBV facility since 2009. A summary of the results of these environmental assessment studies was recently provided by Beyer et al (2015b).

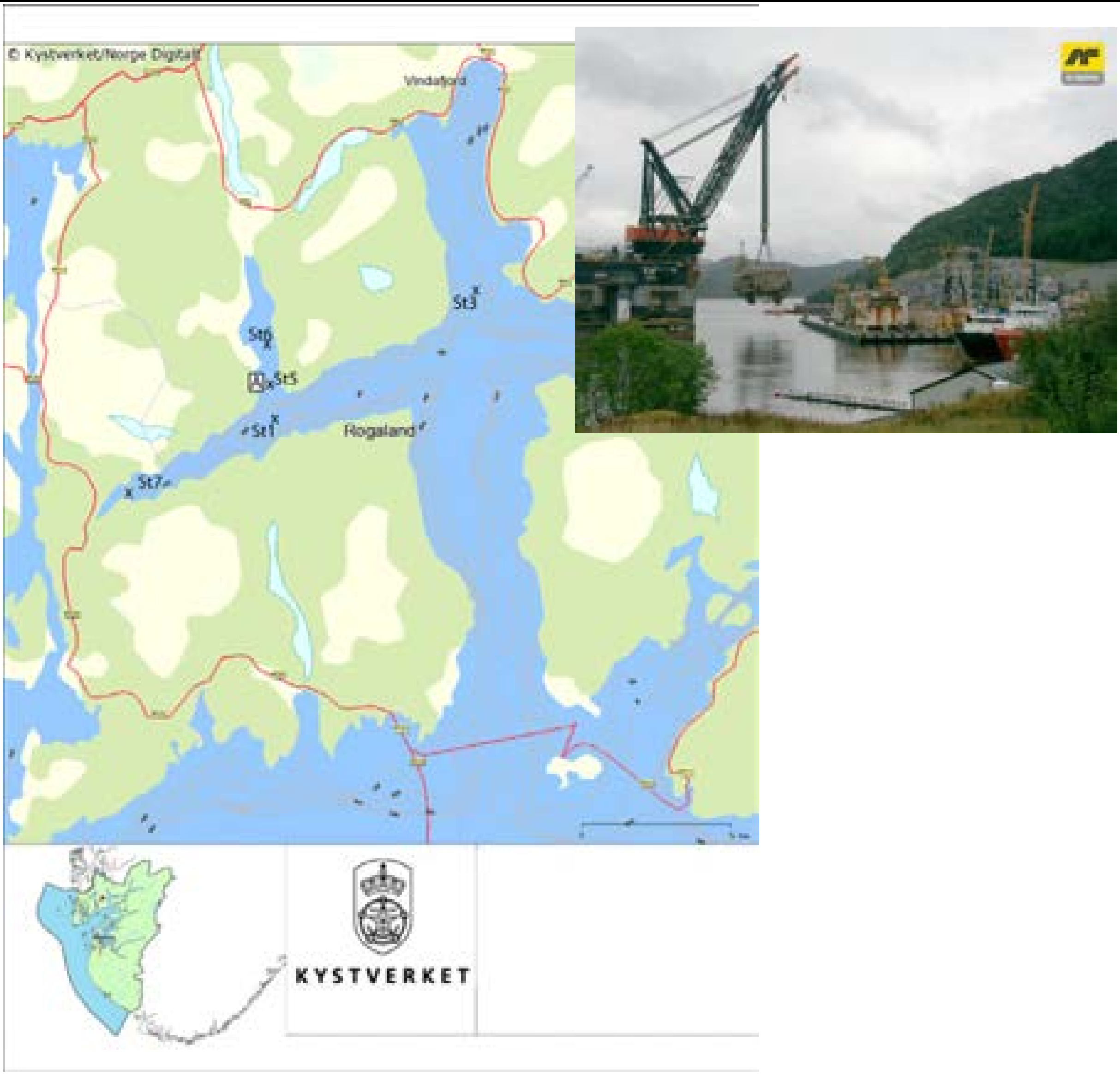

Figure 2. Sampling stations where 3-4 replicates of the fjord sediments have been collected. "A" refers to the area shown in Figure 1B, which includes the site of AF Miljøbase Vats (photo inserted).

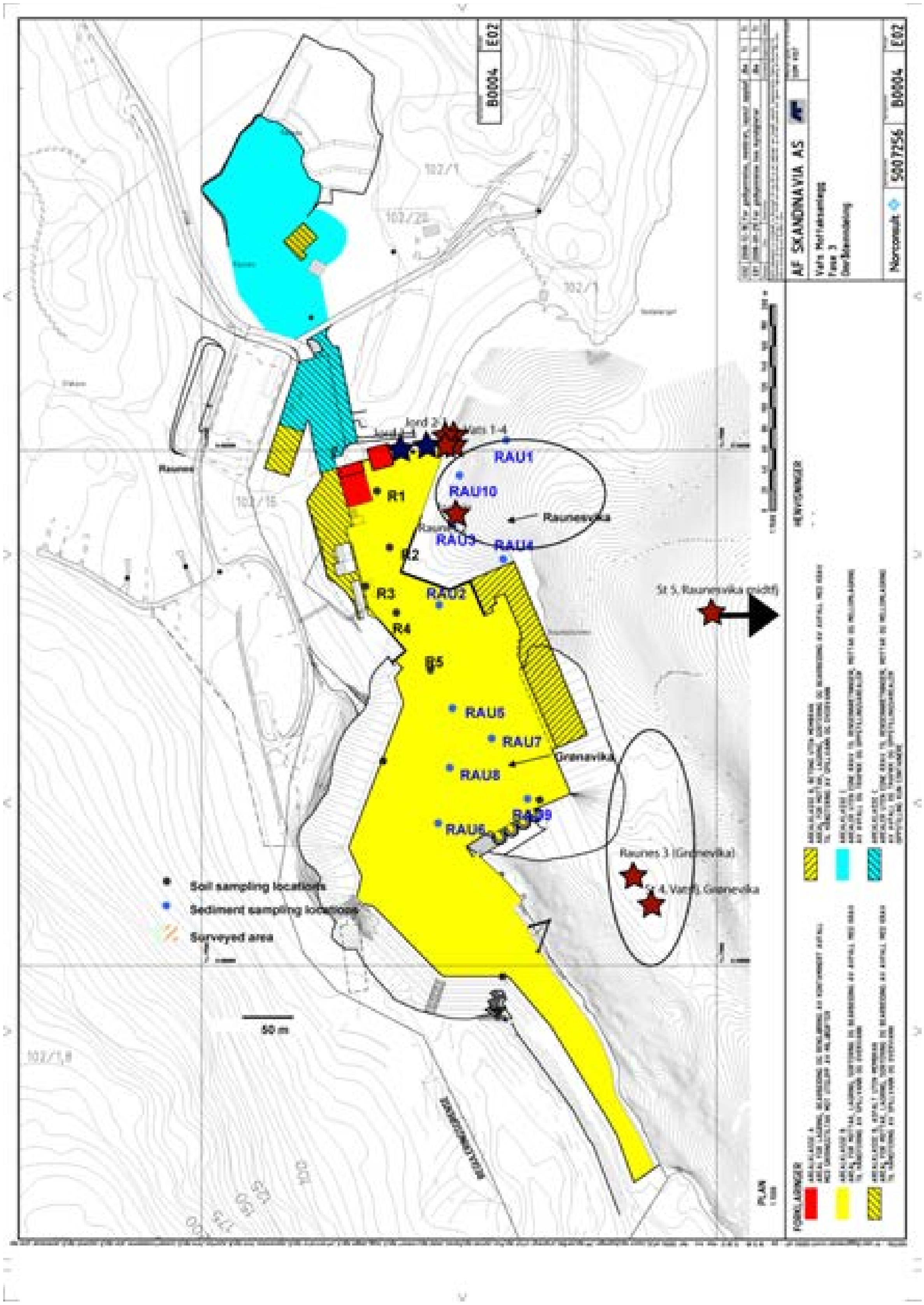

Figure 3. Sampling sites on and around AF Miljøbase Vats. Blue text (RAU#) indicates earlier sediment sampling sites. Black text (R#) indicates earlier soil sampling. Blue stars (Jord#) indicate sites for soil sampling in this study, brown stars indicate sediment sites. The ellipsoids indicate areas where sediment sampling was attempted in this study. The yellow field indicates the new quay areas.

Table 1. Overview of all environmental studies performed at or near the AFEBV facility.

Year	Title / by	Main conclusions
1999	Resipientundersøkelse i Vats-fjorden, Vindafjord Kommune. Rogalandsforskning (Tvedten, 1999)	The sewage discharge should be placed on the seaward side of the sill at Raunes due to the stagnant water on the inside of the sill give limited recipient capacity in the inner basins of the Vatsfjord. Thus, this mid-fjord discharge is spilled at depth in the same immediate basin as AF Miljøbase Vats.
2002	Assessment of environmental implications of mooring the Hutton TLP in Vatsfjorden. Rogalands-forskning (Kjeilen et al., 2002)	The environmental conditions along the quay in Grønavika are generally good. The site sediments and water column is considered to be little polluted and there are no differences between the stations at the quay and the reference stations. TBT was not analyzed.
2004	Environmental Baseline Report for Raunes, Vindafjord Kommune. Miljøbistand AS (Kristensen, 2004)	The soil is largely uncontaminated. For the sediments, there is TBT-contamination in Raunesvika (Class 4), and Grønavika in class 2-3; PAH Class 2-3 and 2-4 respectively. One sample detected DDT in Grønavika. Foreign debris was mapped.
2007	Miljøundersøkelse Vats-Ekofisk, avsluttende undersøkelse. COWI (Misund, 2007)	The soil is considered clean, with exception of chromium and oil-levels at a higher level than the limits for sensitive land use. Sediments in Raunesvika are still polluted with TBT (up to Class 4) but show a decreasing trend. Mercury is registered in class 2 in one sample. All other metals were in class 1. The sediments in Grønavika are still polluted with TBT (class 4 in one site, other sites class 1 and 2). PAH levels are low, and lower than in 2004. Mercury was registered in class 2 in one point (RAU7), possibly due to activities on site. DDT was not detected. Foreign objects consisted of tires, metal debris and pipes were registered.
2008	Miljøundersøkelse Vats – Ekofisk, baseline undersøkelse. COWI, (Misund, 2008b)	The soil is considered clean, with the exception of chromium and oil-levels at a higher level than the limits for sensitive land use. Mercury is not detected. Somewhat increased zinc. Sediments are still polluted with TBT up to class 4. PAH is increased but still in class 2. Mercury is in class 1 in all points and the positive effect of the new sandfilter is observed. The other metals are in class 1. Grønavika has less TBT contamination than Raunesvika. Some samples, however, show an increase. PAH is low, class 1. All measurements for mercury are in class 1 and 2. DDT was found in one sample. Foreign objects were tires and metal debris in both bays.
2008	Analyser av Blåskjell ved og rundt Vats Mottaksanlegg. NIVA, (Kvassnes, 2008)	The current heavy metal level in the mussels is low, and arsenic is the only metal that is in the lower end of environmental class 2 (SFTs veileder 97:3) and it appears that this represents a general higher level of this metal in the bay.
2008	Gjennomgang av rapporter fra undersøkelser i Vatsfjorden – Fokus på Vats Mottaksanlegg. COWI (Misund, 2008a)	A review of previous investigations at Miljøbase Vats. They find it likely that small amounts of mercury have been released into the bays of Grønavika and Raunesvika. In Raunesvika it is likely that the mercury was released before the initiation of the sandfilter was added to the process-water line in 2006. TBT was slightly increased in Raunesvika but decreased in Grønavika. The ROV investigations found metal-debris and rubber-tires in the bays but there is no significant change in the environmental state from 2007 to 2008.
2009	Undersøkelser av mulig transport av tungmetaller via Rauneselva ut i sjøen. COWI (Misund, 2009)	Norway's local branch of Green Warriors had sampled sediments 20m from the mouth of Rauneselva and the sample showed a very high level of mercury (2.3 mg/kg) and zinc (1000mg/kg). A hot-spot investigation was performed and attempts were made to reproduce the values. The hotspot was not found and no mercury-levels were at the level found by the GW. There was, however, evidence of leaky seals along a concrete wall leading to elevated levels of mercury in the soil directly outside them.
2009	Partikkelforurensing i Vatsfjorden. NIVA (Johnsen and Dale, 2009)	Increased turbidity in relation to construction of the new quay-areas at AFEBV was investigated. Small, platy mineral-grains were found in the water-masses and some layers of the water-column carried these rock-particles inward in the Vatsfjord. Particles were mostly not carried across the fjord and it was concluded that environmental impact of particles for marine fish or mussels was unlikely.
2009	AFD2-D-GEN-EG-0001: environmental baseline survey report : Ekofisk Cessation EPRD Project. NIVA (Kvassnes et al., 2010b)	Sediments at the study site is contaminated with TBT (SFT Class IV, TA-2229) and PAH (Class II), but not at a higher level than was previously shown. The remaining components (As, Ba, Cd, Co, Cr, Cu, Hg, Mo, Ni, P, Pb, V, Zn, PCBs, Pentaclorbenzene, alpha-HCH, Hexachlorbenzene, Gamma-HCH, Octachlorstyrene, 4,4-DDE, 4,4-DDD, MBT, DBT, MPT, DPT and TPT) analyzed in the samples close to the site are in SFT Class I, not classified or not detected. This includes mercury, a heavy metal, of which some material leaked into the bays between 2004 and 2006. The well-water appears to be in good condition, whereas there is a slightly elevated level of contamination in the soil samples, where zinc and arsenic are right above the SFT norm levels for sensitive land use. Large rocks and metallic debris are found along the shore, with smothering from fine rock-dust due to the recent expansion of the quay areas. The biological state is as expected in Raunesvika, an active quay area, with fish, kelp and other typical fauna and flora for the region.
2009 - 2014	Five annual reports and one summary report of the environmental monitoring program at EFEBV for the period 2009-2014. NIVA. (Beyer et al., 2015a; Beyer et al., 2014; Beyer et al., 2015b; Kvassnes and Hobæk, 2012; Kvassnes et al., 2013; Kvassnes et al., 2011; Kvassnes et al., 2010a)	Monitoring of emissions to sea from the water treatment plant shows that AFEBV has operated within the discharge permit, assessed on the basis of annual emissions. For high priority pollutants, such as mercury, the discharge has been consistently well below the discharge permit. However, specific groups of substances in the discharge, such as PFOS, should be followed up closely in the further monitoring. Analyses of groundwater collected under the quay deck show low levels of pollutants, apart from a few single samples early in the program period. This indicates that the protection membrane positioned under the quay deck works as intended. In the first years of the monitoring program, a moderate increase of metal contamination (including mercury) was observed in samples of stream water, soil and moss collected in the ultimate vicinity of AFEBV. This local contamination was most likely due to dust spreading from the facility. Measures implemented for limiting the dust problem led to declining contamination in the latter phase of the program period. In the sea adjacent to AFEBV, bottom sediments showed broadly good environmental status, but older pollution (especially TBT) was still markedly present. The monitoring of fish (Atlantic cod, plaice and tusk) and shellfish (mussels and crab) in the fjord outside AFEBV showed generally low levels of pollutants, predominately within environmental Class I or II according to the Norwegian classification system for coastal waters. Time trend analyses for all pollutants measured in fish, crabs and mussels showed several significant upward and downward trends over the five years period. However, most of these trends appear to be regional and none could be attributed to discharges from AFEBV. In summary, the results obtained within the environmental monitoring program by AFEBV indicate that emissions from the facility have had very little impact, if any, on the pollution status in the fjord environment outside the base during the period 2009-2014.
2014	Metaller og organiske miljøgifter i sjømat fra Vatsfjorden. NIFES, (Frantzen and Måge, 2014)	Results of a field survey of contaminant levels in mussels, crabs and fish in Vatsfjord and Yrkjefjord suggest that the seafood in the area is somewhat affected by mercury and PCBs, but not at levels that provide a basis for dietary advice.

2. The field surveys at AFEBV in 2009 and 2015

2.1 ROV inspection of the seabed in 2015

2.1.1 Description of ROV survey

The survey in the fjord environment adjacent to AFEBV included registration of scrap and waste objects at the seabed, as well as a simple biological / sedimentology evaluation of the area. In 2015, the survey was performed 26th – 27th of May using an Argus Mariner ROV (Figure 4) that was operated from the parent vessel MS Scuba (Amundsen Diving) by the crew. This ROV is fitted with sonar, several cameras, lights and subsea navigational equipment, and its technical specification sheet is found here: https://d37oegmkfg78j3.cloudfront.net/1444208932/argus-mariner-spec.pdf). The ROV was run in a search patterns within the two specified areas (Raunesvika and Grønavika). A depth range from 1-60 meters was covered. The visibility conditions in the water was very good (> 10m) during the work in 2015 and this made it easy for the ROV to spot debris objects. In 2009, the visibility was somewhat reduced due to ongoing construction work on the quayside at AFEBV. Marine biologist Mats Walday (NIVA) did the ROV registrations both in 2015 and in 2009.

Figure 4: Left: The Argus Mariner ROV from Amundsen Diving which was used during the registrations 26th-27th of May 2015. Right: The control room of parent vessel MS Scuba where the ROV pilot sits and where the recordings and records were made.

The scope of the ROV survey in 2015 was to assess and map the amount of anthropogenic scrap materials at the seabed in the area of Raunesvika and Grønavika (Figure 7) and also to provide a general assessment of the biological conditions of the seabed in the area. The survey log included registration, numbering and positioning of all significant scrap objects observed. In many cases the registered objects were also photographed (e.g. Figure 5 and Figure 6). Some of the registered positioning and depth data may not be 100% accurate, this because the Argus Mariner ROV films down towards the bottom and because the distance between the ROV and the different objects that were registered varied to a certain degree. However, the resulting inaccuracy is small and was not considered to represent any significant problem in the present context. All movies and photos from the ROV recordings in 2015 are stored by NIVA.

Raunesvika and Grønavika have been ROV surveyed several times previously, i.e. in 2004, 2009 (the previous baseline) and in 2012, but it was *not practically feasible* to provide a detailed comparison of the scrap observations done in the 2015 survey with the observations done in the earlier surveys. Each ROV survey used different equipment with variable positioning accuracy. As described in the 2009 baseline report, some of the registered scrap positions were even positioned to be on dry land, thus clearly illustrating the lack of accuracy of the ROV positioning system used. Furthermore, the seabed clean-up operations that have been conducted at the Raunesvika/Grønavika locations have not systematically registered in detail the identity and individual positions of all scrap items that were removed. As a consequence, the 2015 scrap recordings will only enable a general comparison to the situation registered in 2009. A comparison at the level of each individual scrap object is not possible. However, the presently reported scrap data provides a trustworthy description of the current situation in the Raunesvika/Grønavika and will also provide a good basis for the planning and performance of further seabed clean-up operations in this area.

Figure 5: Left: Many holes and grooves in the bottom indicate a live bottom. Here at ca. 30 m depth in the area north of the main quay. Right: A piece of corrugated iron and in the background tires (arrow) can be seen. The picture is taken from ca. 15 m depth in the area north of the main quay. Relatively many tires were observed at approximately 10-15m depth in this area.

2.1.2 Results of the ROV survey

Generally in both Raunesvika and Grønavika, the seabed was in a 'living bottom' condition status. In both areas, we encountered holes and traces of benthic animals on the sediment surface (Figure 5). There was relatively little degree of fouling to be found on the rocks and boulders on the seabed. This was especially the case in the slightly deeper areas of Grønavika south of the quay where the seafloor was filled with a lot of rocks (Figure 6). In the upper 10-12 m we found scattered occurrences of sugar kelp and commonly occurring threadlike brown algae (Figure 6). A few places, dense occurrences of large hydroids were observed and in the shallow part of the study area, quite a lot of small wrasse fish were observed along the shoreline. We also saw a several larger fish individuals which most probably were saithe. It is a challenge to estimate the density of fish at a location as based on ROV filming as it is very likely that the same fish will be recorded several times during the filming.

In the 2015 survey, anthropogenic scrap objects at the seabed were registered at 80 individual positions within the surveyed area (Table 2). It included various scrap iron, plastic debris, wires, cables, pieces of tubes, corrugated iron sheets, scaffolding residues, fishing gear, various rubber tires, and several trees. In addition, a number of waterpipes and tubes were observed at the seafloor in Raunesvika. Most of these pipes were positioned on the sea chart and they were not included at the list of scrap objects. In 2015 and 2009 scrap objects were registered at 80 and 59 positions, respectively. However, these two results are not fully comparable, partly due to the issues commented in section 2.1.1. To give a coarse comparison between years, the positions of all scrap objects recorded during the 2009, 2012 and 2015 surveys are shown on aerial images below (Figure 7, Figure 8 and Figure 9). According to information from AFEBV, a large amount of scrap had been removed from the seabed outside the base after the previous baseline survey in 2009, suggesting that the amount of scrap had decreased. But unfortunately, there were no systematic registration of the objects removed during the clean-up process (e.g. type of object and positions at seabed). Even though much scrap was removed, the ROV data from 2015 clearly show that a considerable amount of anthropogenic scrap still persist on the seabed in this area.

Figure 6: These pictures show the area south of the main quay which was scattered with large rocks and boulders. Left picture show rocks at 26 m depth with only little algal fouling. Right picture: at approx. 11 m depth there was with significantly more fouling present, in particular sugar kelp and hydroids as can be seen on the rocks in the foreground.

Table 2: This table provides a summary of all anthropogenic materials that have been registered and positioned during the 2015 ROV survey. Objects with ID numbers 1-41 are located within Raunesvika in the area north of the main quay, whereas objects with ID numbers 42-80 are located in Grønavika in the area south of the main quay. Time, depths and position data for all objects registered are shown. Position data are shown by Geographic Coordinate System (GCS_WGS_1984) and Projected Coordinate System (WGS_1984_UTM_Zone_32N).

				GCS		WGS		
Object ID	**Obs. Time**	**Depth**	**Scrap object**	**N**	**E**	**N**	**E**	**Film**
1	26/05 17:02	26	Steel rod	59.44048	5.74918	6593606	315672	1
2	26/05 17:04	28	Part of construction scaffold	59.44047	5.74940	6593604	315684	1
3	26/05 17:08	29	Concrete blocks, canvas, steel rope	59.44102	5.74995	6593664	315718	1
4	26/05 17:14	31	Ladder and pipe section	59.44098	5.74977	6593660	315708	1
5	26/05 17:16	36	Rubber mat	59.44067	5.74962	6593626	315697	1
6	26/05 17:20	19	Water pipe (probably in use`?)	59.44053	5.74873	6593613	315647	1
7	26/05 17:22	25	Rubber mat	59.44067	5.74902	6593627	315663	1
8	26/05 17:24	24	Car tire	59.44073	5.74898	6593635	315662	1
9	26/05 17:25	31	Corrugated iron plate	59.44095	5.74928	6593658	315680	1
10	26/05 17:27	29	Box, canvas, loose weights for water pipe	59.44112	5.74947	6593676	315691	1
11	26/05 17:30	29	Rubber mat and several tires	59.44082	5.74912	6593644	315670	1
12	26/05 17:31	25	Big car tire	59.44073	5.74890	6593635	315657	1
13	26/05 17:34	11	Tire with kelp on	59.44048	5.74828	6593609	315621	1
14	26/05 17:37	21	Tire	59.44078	5.74860	6593641	315640	1
15	26/05 17:39	25	Thin water pipe with lead rope around	59.44090	5.74867	6593654	315645	1
16	26/05 17:40	25	Corrugated iron plate (with fish, ling)	59.44102	5.74878	6593667	315652	1
17	26/05 17:42	27	Tire	59.44123	5.74923	6593690	315679	1
18	26/05 17:46	16	Corrugated iron plate and many tires	59.44087	5.74833	6593651	315626	2
19	26/05 17:52	6	Staircase	59.44032	5.74820	6593591	315615	2
20	26/05 17:55	9	Tire (with fish, wrasse)	59.44042	5.74797	6593602	315602	2
21	26/05 17:57	16	Corrugated iron plate	59.44082	5.74820	6593646	315618	2
22	26/05 17:58	17	Ladder	59.44087	5.74820	6593652	315618	2
23	26/05 17:59	16	Corrugated iron plate and several tires	59.44092	5.74818	6593657	315617	2
24	26/05 18:00	16	Thin pipeline with lead rope around	59.44113	5.74823	6593681	315621	2
25	26/05 18:02	17	Plate	59.44140	5.74852	6593710	315639	2
26	26/05 18:03	16	Rope	59.44147	5.74840	6593718	315633	2
27	26/05 18:05	14	One big and one small tire	59.44140	5.74830	6593711	315627	2
28	26/05 18:09	15	2 tires	59.44115	5.74818	6593683	315619	2

				GCS		WGS		
Object ID	**Obs. Time**	**Depth**	**Scrap object**	**N**	**E**	**N**	**E**	**Film**
29	26/05 18:12	14	2 tires	59.44082	5.74783	6593647	315597	2
30	26/05 18:13	14	4 tires	59.44065	5.74787	6593629	315598	2
31	26/05 18:14	9	9 tires	59.44048	5.74763	6593611	315584	2
32	26/05 18:16	8	Unknown object and tire	59.44042	5.74755	6593604	315579	2
33	26/05 18:17	6	Silt curtain (SILTDUK)	59.44032	5.74773	6593592	315589	2
34	26/05 18:19	5	Tire	59.44027	5.74747	6593587	315573	2
35	26/05 18:32	5	Crab trap	59.44023	5.74738	6593584	315568	3
36	26/05 18:36	5	Rope, floating upwards	59.44052	5.74737	6593615	315569	3
37	26/05 18:36	6	Big tire	59.44050	5.74750	6593613	315576	3
38	26/05 18:43	7	Several tubes	59.44147	5.74807	6593719	315614	3
39	26/05 18:47	5	Parts of pipes	59.44110	5.74748	6593680	315579	3
40	26/05 18:48	5	Plastic grid	59.44080	5.74790	6593645	315601	3
41	26/05 18:50	5	Grid	59.44080	5.74722	6593647	315562	3
42	26/05 19:18	38	Plastic debris	59.43787	5.75132	6593309	315778	4
43	26/05 19:35	52	Scrap	59.43600	5.75322	6593096	315876	4
44	26/05 19:37	49	Pipe parts	59.43613	5.75303	6593112	315866	4
45	26/05 20:03	41	Small part of a ventilation pipe	59.43760	5.75098	6593281	315758	5
46	26/05 20:29	37	Tire	59.43673	5.75145	6593183	315780	5
47	26/05 20:32	35	Traffic obstruction objects	59.43702	5.75103	6593216	315758	5
49	27/05 08:59	27	Big part of a Tree	59.43760	5.74995	6593283	315700	7
50	27/05 09:00	35	Rod	59.43748	5.75040	6593269	315724	7
51	27/05 09:02	34	Rope/band	59.43722	5.75060	6593239	315734	7
52	27/05 09:06	31	Rope / tube	59.43627	5.75160	6593131	315786	7
53	27/05 09:28	31	Steel rope	59.43552	5.75227	6593045	315820	8
54	27/05 09:34	26	Plastic debris/big box?	59.43662	5.75095	6593171	315751	8
55	27/05 09:37	29	'Rod'-like structure	59.43725	5.75025	6593244	315715	8
56	27/05 09:38	28	Part of a tube	59.43737	5.74992	6593258	315696	8
57	27/05 09:39	30	Big tire and steel rope	59.43757	5.74977	6593280	315689	8
58	27/05 09:42	18	Steel rope	59.43775	5.74957	6593301	315679	8
59	27/05 09:46	12	Steel rope	59.43787	5.74937	6593315	315668	8
60	27/05 09:49	17	Tire	59.43778	5.74918	6593306	315657	8
61	27/05 09:53	19	Steel ring, steel rope, water pipe(?)	59.43710	5.74982	6593228	315689	8
62	27/05 09:55	22	Parts of a construction scaffold	59.43690	5.75022	6593205	315711	8
63	27/05 10:04	10	Tree	59.43540	5.75160	6593034	315781	8
64	27/05 10:07	14	Tree	59.43587	5.75133	6593087	315769	8
65	27/05 10:13	15	Plastic tube	59.43697	5.74990	6593213	315693	9
66	27/05 10:17	14	Reinforcing rods (?)	59.43767	5.74912	6593293	315653	9
67	27/05 10:24	10	Scrap by a column	59.43733	5.74935	6593255	315664	9
68	27/05 10:26	11	Rod-like structure	59.43702	5.74972	6593219	315683	9
69	27/05 10:27	14	Long iron chain	59.43688	5.74985	6593204	315690	9
70	27/05 10:28	13	Fish trap	59.43683	5.75003	6593198	315700	9
71	27/05 10:36	7	Tree	59.43572	5.75110	6593071	315754	9
72	27/05 10:44	9	Unknown object	59.43663	5.75023	6593175	315710	9
73	27/05 10:45	8	Thin floating rope	59.43665	5.75015	6593177	315706	9
74	27/05 10:48	7	Wooden pole	59.43717	5.74940	6593237	315666	9
75	27/05 10:52	7	White plastic scrap and pipe part	59.43750	5.74888	6593275	315639	9
76	27/05 10:53	7	Bended metal scrap, grids, tires	59.43752	5.74893	6593277	315641	10
77	27/05 10:57	6	Tree	59.43777	5.74857	6593306	315622	10
78	27/05 11:01	8	Metal and pipe parts	59.43743	5.74902	6593268	315646	10
79	27/05 11:08	6	Fish net	59.43685	5.74980	6593200	315687	10
80	27/05 11:12	5	White electric cable	59.43657	5.74998	6593168	315696	10

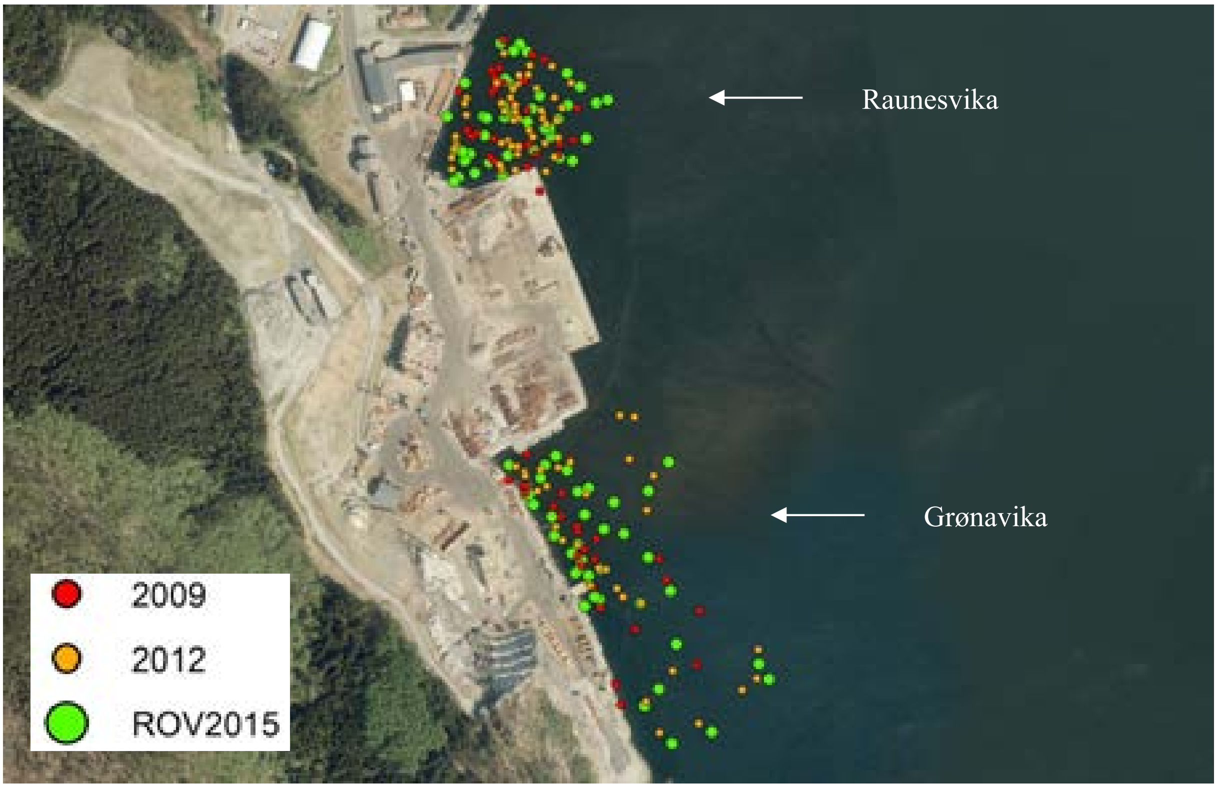

Figure 7: This overview picture shows positions where anthropogenic scrap objects at the seabed close to AFEBV have been registered during ROV surveys in 2009, 2012 and 2015. For all ROV surveys the search areas were limited to Raunesvika and Grønavika. Each spot represents a position where one or several scrap objects are registered. In 2009, construction work was performed in the sea at the same time as the ROV survey contributing to a somewhat reduced visibility, whereas in 2015 survey conditions were very good, making it easier for the ROV to spot scrap objects. Different ROVs were used in 2009 and 2015. These differences combined with unsystematic clean-up operations conducted between 2009 and 2015 make it unfeasible to provide a detailed comparison of the scrap observation data between years.

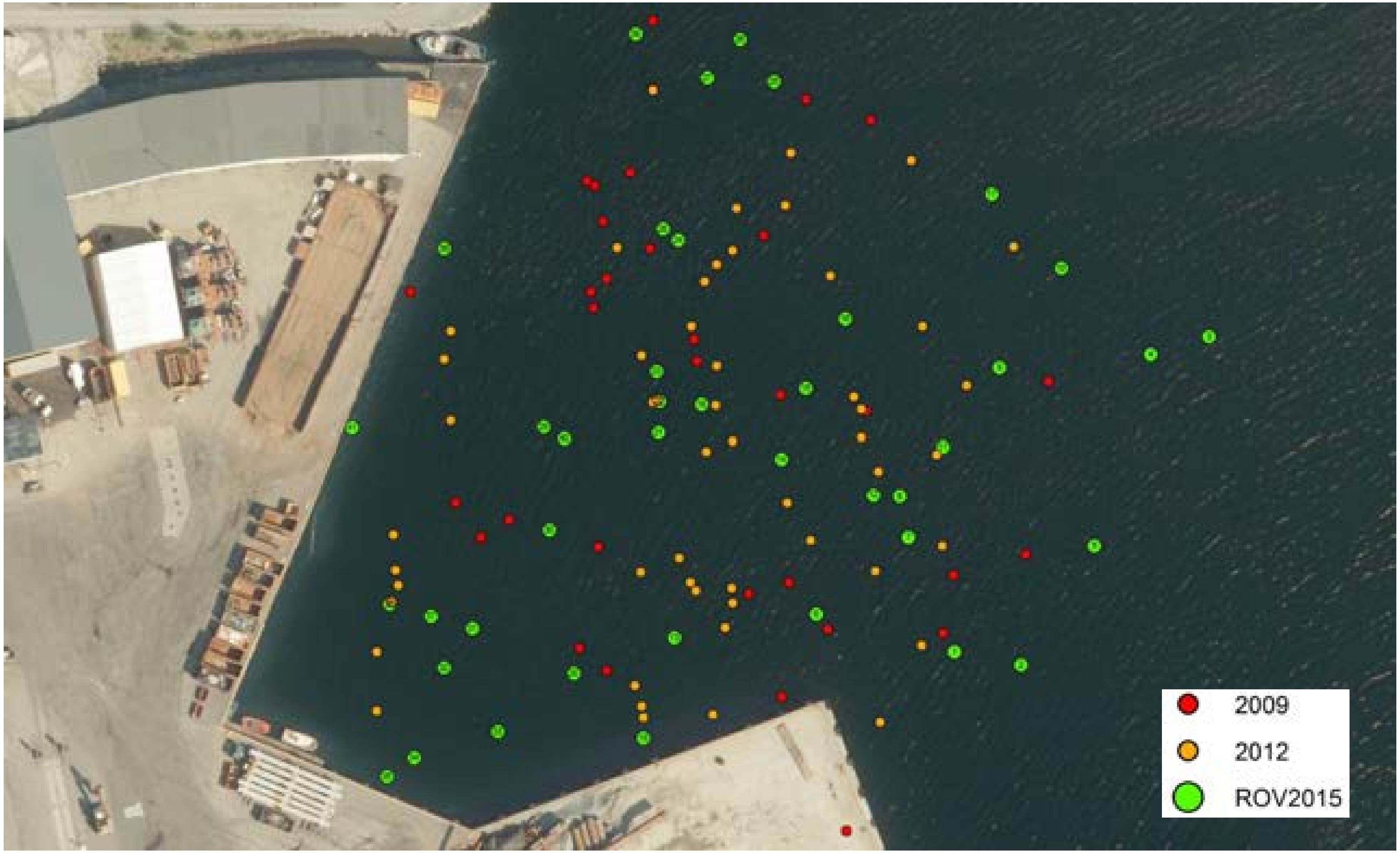

Figure 8: This picture shows the positions of all anthropogenic materials that have been registered and positioned in the area Raunesvika (north of the main quay) during the ROV surveys conducted in 2009, 2012 and 2015. For data registered in 2015, each individual debris object is given a ID number which also is referring to the observations summarised in Table 2.

Figure 9: This picture shows the positions of all anthropogenic materials that have been registered and positioned in the area Grønavika (south of the main quay) during the ROV surveys conducted in 2009, 2012 and 2015. For data registered in 2015, each individual debris object is given an ID number which also is referring to the observations summarised in Table 2.

2.2 Contaminant concentrations in groundwater

The demolition area of AFEBV has an impermeable membrane / tarmac deck which have the purpose of preventing contaminated surface water from penetrating into the ground. All surface water is collected and treated in the water treatment facility. Samples of the groundwater under demolition area can be collected from four sealed wells which all are going through the impermeable membrane under the tarmac of the quays (

Figure 10). Each of these wells is approximately 5 m deep and the locations of the four wells are shown in Figure 11.

The main purpose of the sampling of the groundwater wells is to investigate whether the membrane functions properly, and is successful in preventing leaks to the subsoil area. The water sample is obtained by use of a 5-meter long water-hose and a sub-surface pump. Each well is sampled with its individual and clean pump and hose. The water was siphoned directly into the sample bottles, sealed and sent to the laboratory.

The results of the analyses for the 2009 and 2015 samples are shown in Table 3.

Figure 10: This picture shows how groundwater samples for analysis of contaminant levels were collected from four wells in the quay deck.

2.2.1 Results

As can be seen from the results, the concentration-levels of contaminants are generally low. In 2009, many values were below the level of detection for most parameters (Cd, Hg and Pb), but this could partly be due to an unsatisfactory poor analytical quantification levels for these analyses at that rime. For the 2015 analyses, the levels of analytical quantification for the Cd, Hg and Pb analyses were significantly improved. However, as can be seen from the numbers given in Table 3, the observed contamination values for these parameters in the 2015 samples were consistently low. The observed iron-levels indicate a decrease in three of four wells between 2009 and 2015. The recorded pH values is as expected for groundwater and if there is seawater in the subsurface (groundwater ranges from pH 7-8.2 (source NGU), whereas seawater has a general pH around 8.15.

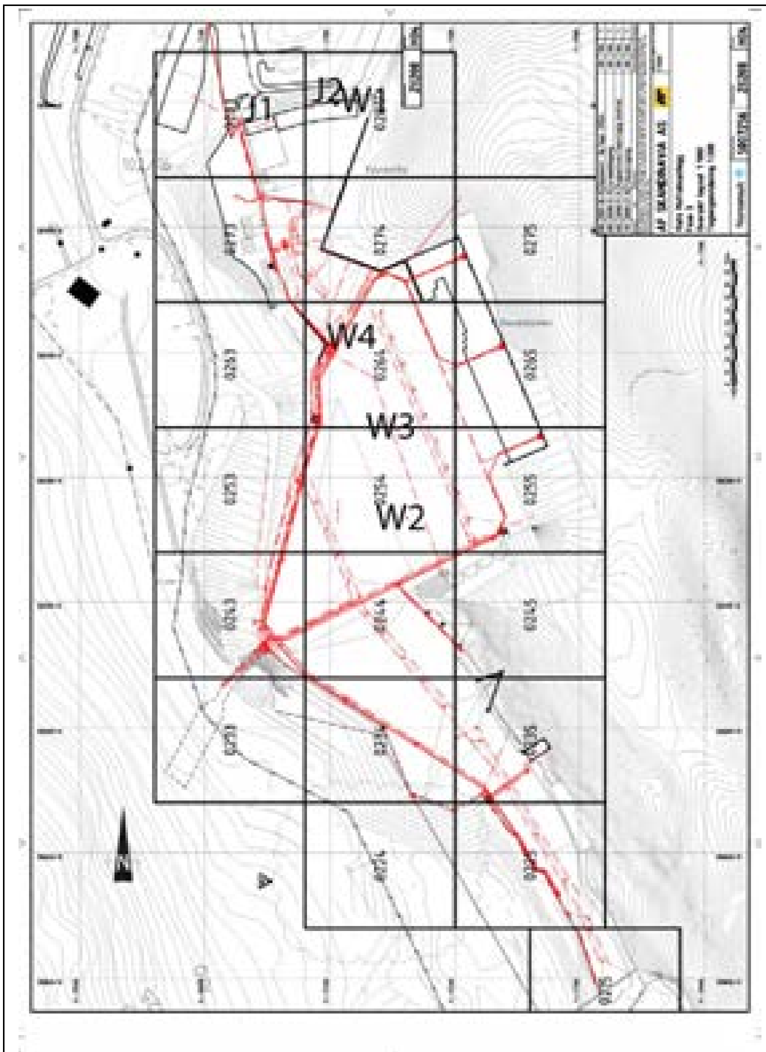

Figure 11. Location of wells (W1-W4) and soil samples (J1, J2) at AF Miljøbase Vats

Table 3: Analysis results for 2009 and 2015 for contaminant levels detected in groundwater samples from the four wells located within the demolition area of AFEBV.

Date	Sample	pH	Cadmium µg/l	Iron mg/l	Mercury µg/l	Lead µg/l	Oils µg/l
20090706	Well 1	7,95	<2	0,188	<0.05	<20	<50
20090706	Well 2	7,71	<2	0,121	<0.05	<20	<50
20090706	Well 3	8,02	<2	0,755	<0.05	<20	<50
20090706	Well 4	7,93	<2	0,744	<0.05	<20	<50
20150527	Well 1	7,65	<0,06	0,059	0,003	0,10	<50
20150527	Well 2	7,76	<0,03	0,13	0,002	0,16	<50
20150527	Well 3	7,78	0,08	0,259	0,002	0,45	<50
20150527	Well 4	7,86	<0,03	0,177	0,004	0,23	<50

Water samples from the four wells at AFEBV have also been analyzed twice a year throughout the period 2009 – 2014, in connection with the environmental monitoring program of the facility. A relevant finding from those analyses was a few observations of temporarily increased contamination level early in the monitoring program, e.g. for mercury (Figure 12). These results indicated that there were occasional leakages of contamination into the well water early in the monitoring program, and this was explained as most likely being caused by with improper sealing at the wells were the contamination was found. For example, some insulating plates from the lids of the wells were observed to have fallen into the wells. After better sealing of the wells was implemented, only low levels have been found after 2012, as can be seen in Figure 12.

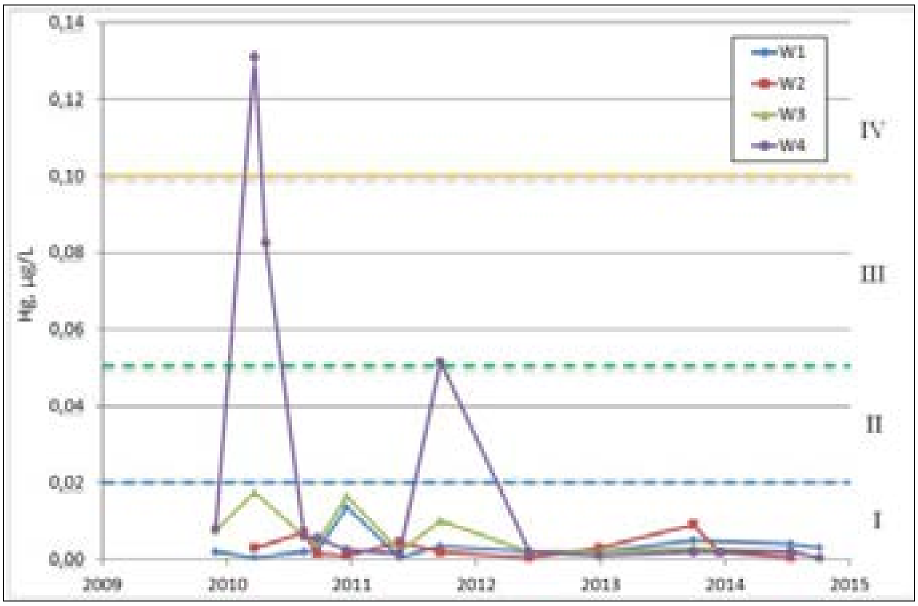

Figure 12: Time trend of Hg levels in water samples from the groundwater wells at AFEBV during the period 2010 – 2014 (data from the environmental monitoring program at AFEBV).

2.3 Contaminant concentrations in soil samples

There is currently not any natural soil areas left inside the facility area of AF EBV, and soil samples were therefore obtained from two positions (J1 and J2) located just outside the plant, in the narrow brim between the Raunes River and the wall at the north end of the AFEBV area (Figure 13). The positions of the two soil stations (J1 and J2) are shown in the area map in Figure 11. Both soil stations J1 and J2 were used in the 2009 and the 2015 soil collection.

The J1 station was located close to seals in the northern wall where a study performed by COWI had found elevated levels of mercury and zinc and is taken at the same site as the R11 sample in the COWI report (Misund, 2009).

In 2009, each soil sample was taken from the top 10 cm of soil material and scooped up into burnt glass-jars and submitted to the analytical laboratory for determination of heavy metals and a selection of other contaminants. In the 2015 soil sample collection, the 10-15 cm top layer of the ground was removed and the soil was sampled into Rilsan plastic bags, which are particularly suitable for collection and transport of samples, including soil samples.

A larger number of contaminants were determined in 2015 as compared to 2009 when the Eurofins SFTJ analytical package was used, an analytical package that satisfied the regulatory norms for sensitive land use at that time (Aquateam 2009).

Figure 13: Collection of soil samples was done from two positions within the narrow riverside brim which is located between the Raunes River and the concrete wall which borders the north end of the AFEBV area.

2.3.1 Results

Results of contaminant analyses for soil samples from the J1 and J2 stations in 2009 and 2015 are shown in Table 4. Both years, the J1 position was more contaminated than the J2 position. A fold change comparison of 2009 and 2015 values indicate an increasing trend for most of the detected contaminants, although the concentrations were still generally low (within Class I, very good) for most of the contaminants. The largest increase was seen for mercury at J1 with a 20 fold higher concentration in 2015 in comparison to 2009, and leading the status to change from Class I to Class III (moderate) according to the TA-2553 guideline. For Zn the level at J1 classified in Class II (good) both in 2009 and 2015. Both years, the measured PAH concentrations classed generally within Class I, although there was an increase in the number of PAHs that exceeded the norm value for most sensitive land use, according to the TA-1629 guideline. For the metals, Hg and Zn in the 2015 J1 sample exceeded the TA-1629 norm value (Table 4).

Table 4: Comparison of soil contamination data from 2009 and 2015 for the two soil stations J1 and J2. The fold change between 2009 and 2015 are calculated when both data values are above the limits for analytical determination. Norm values for sensitive land use according to guideline TA-1629 are shown, and values exceeding the norm are marked with solid box lines. Colours indicate the classification of contaminant levels according to guideline TA-2553, with blue colour representing Class I (very good), green represents Class II (good) and yellow represents Class III (moderate).

		NORM		J1 position			J2 position	
Parameter	Unit	TA-1629	2009	2015	Fold change	2009	2015	Fold change
Dry matter (E)	%		98	89,4	0,91	99	88,9	0,90
As (Arsen)	mg/kg TS	8	3,3	2,42	0,73	1,9	1,92	1,01
Cd (Kadmium)	mg/kg TS	1,5	0,28	<0.10	-	0,44	<0.10	-
Cr (Krom)	mg/kg TS	50	16	25,20	1,58	7	18,4	2,63
Cu (Kopper)	mg/kg TS	100	12	32,6	2,72	8,4	19,8	2,36
Hg (Kvikksølv)	mg/kg TS	1	0,14	2,84	20,29	0,014	<0.20	-
Ni (Nikkel)	mg/kg TS	60	14	23	1,64	5,6	16,5	2,95
Pb (Bly)	mg/kg TS	60	13	18,7	1,44	6,2	10,4	1,68
Zn (Sink)	mg/kg TS	200	200	428	2,14	100	96	0,96
Cr6+	mg/kg TS			0,364	-		0,22	-
Cyanid-fri	mg/kg TS	1	n.d.	<0.10	-	n.d.	<0.10	-
THC	mg/kg TS		n.d.		-	n.d.		-
Sum PCB-7	mg/kg TS	0,01	n.d.	n.d.	-	n.d.	n.d.	-
g-HCH (Lindan)	mg/kg TS		n.d.	<0.0010	-	n.d.	<0.0010	-
o,p'-DDT	mg/kg TS	0,04	n.d.	<0.010	-	n.d.	<0.010	-
p,p'-DDT	mg/kg TS			<0.010	-		<0.010	-
o,p'-DDD	mg/kg TS		n.d.	<0.010	-	n.d.	<0.010	-
p,p'-DDD	mg/kg TS		n.d.	<0.010	-	n.d.	<0.010	-
o,p'-DDE	mg/kg TS			<0.010	-		<0.010	-
p,p'-DDE	mg/kg TS		n.d.	<0.010	-	n.d.	<0.010	-
1,2,3,5+1,2,4,5-Tetraklorbensen	mg/kg TS	0,05	n.d.	<0.020	-	n.d.	<0.020	-
Heksaklorbensen	mg/kg TS	0,03	n.d.	<0.0050	-	n.d.	<0.0050	-
Naftalen	mg/kg TS	0,8	0,0019	<0.010	-	n.d.	<0.010	-
Acenaftylen	mg/kg TS		n.d.	<0.010	-	n.d.	<0.010	-
Acenaften	mg/kg TS	0,8	0,0023	0,011	4,78	n.d.	<0.010	-
Fluoren	mg/kg TS	0,8	0,056	<0.010	-	n.d.	<0.010	-
Fenantren	mg/kg TS	0,8	0,013	0,049	3,77	0,001	<0.010	-
Antracen	mg/kg TS	0,8	0,034	<0.010	-	n.d.	<0.010	-
Fluoranten	mg/kg TS	1	0,025	0,114	4,56	0,0038	0,037	9,74
Pyren	mg/kg TS	1	0,022	0,094	4,27	0,0038	0,032	8,42
Benso(a)antracen	mg/kg TS	0,03	0,015	0,055	3,67	0,0041	0,023	5,61
Krysen	mg/kg TS	0,03	0,022	0,056	2,55	0,0066	0,026	3,94
Benso(b)fluoranten	mg/kg TS	0,01	0,026	0,092	3,54	0,0044	0,044	10,00
Benso(k)fluoranten	mg/kg TS	0,09	0,019	0,028	1,47	0,0038	0,015	3,95
Benso(a)pyren	mg/kg TS	0,2	0,022	0,052	2,36	0,0036	0,025	6,94
Dibenso(ah)antracen	mg/kg TS	0,05	0,0045	0,012	2,67	n.d.	<0.010	-
Benso(ghi)perylen	mg/kg TS	0,1	0,024	0,049	2,04	0,003	0,023	7,67
Indeno(123cd)pyren	mg/kg TS	0,05	0,027	0,051	1,89	0,0027	0,024	8,89
Sum PAH-16	mg/kg TS	2	0,26	0,66	2,54	0,036	0,25	6,94
Xylener	mg/kg TS	1	0,021	<0.0150	-	n.d.	<0.0150	-
Pentaklorfenol	mg/kg TS	0,005	n.d.	<0.006	-	n.d.	<0.006	-

< Concentration value is below the given analysis detection limit.
n.d. Not detected, i.e. concentration value is below LOQ (limit of analytical quantification)
(-) Not analysed

2.4 Contaminant concentrations in fjord sediments

The field work in 2009 included sediment sampling also at several reference stations in Yrkjefjorden, relatively far from AFEBV, this was done in order to provide information about the typical background level of contamination in this region. It was considered to be unnecessary to repeat the sampling at these far-away stations for the 2015 sediment sampling, as it was the stations close to AFEBV that were relevant for the before-after comparison that is addressed in this study.

The variable conditions of the seafloor within Vatsfjorden suggest a need for using varied sampling-approach to obtain good quality samples. In particular, in the area close to AFEBV the seafloor is largely consisting of rocks and hard-bottom which makes it difficult to find positions that allow van Veen sediment grabbing. At these stations, several repeated grab shots will often be required to provide enough sediment material.

In 2009, NIVA performed the sampling of the soft-bottom sediments from the 5th to the 8th of May 2009 using the vessel MS Solvik, in varying weather conditions ranging from calm to gale. “St4, Vatsfj. Grønavika” and “St6 Indre Vatsfjorden” was sampled with a van Veen grab and the top 2 cm of sediments was sub-sampled from undisturbed sediments.

In 2015, the sediment samples were taken from the boat «Scallop» operated by Kvitsøy Sjøtjenester AS and with Bjarte Espevik as crew. Responsible for field work from NIVA was Jarle Håvardstun and Lise Tveiten. Since geographical coordinates of sediment stations were not given in the earlier baseline report (NIVA report 5915-2010), the localization of the sediment stations close to AFEBV was based on the station maps (Figure 3). The exact sampling points used in 2015 can therefore differ slightly from the 2009 sampling. The geographical coordinates for the sediment stations used in 2015 were registered and are given in Table 5, whereas the sampling depths, and a visual description of each sediment sample collected for analysis is given in Table 6. For the 2015 sediment sampling we used a van-Veen bottom sampler collecting a surface area of 0,1m^2. All replicate samples had a clear water surface on top of the sediment layer. This water was removed with a siphon before taking out a surface sample of approximately 0-2 cm of the surface layer.

Figure 14: Drone picture from the sediment collection in Raunesvika in 2015, with the boat located approximately over the Raunes 2 sediment station.

Table 5: Station names and geographical coordinates for the sediment stations close to AFEBV used in the 2015 sediment survey.

Station name	N	E
St. 4 Vatsfjord	59°26,252	5°45,057
St. Raunes 3	59°26,268	5°45,043
St. Raunes 2	59°26,437	5°44,866
St. Vats 1	59°26,485	5°44,867
St. Vats 2	59°26,485	5°44,878
St. Vats 3	59°26,485	5°44,890
St. Vats 4	59°26,485	5°44,902

Table 6: Station names, sampling depth, and a visual description of the sediments collected in the 2015 sediment survey.

Station	Depth (m)	Sample nr	Sediment description
St. 4 Vatsfjord	41	I	Brown fine particulated and sandy sediment. No H_2S smell. Sand worms.
	42	II	Brown fine particulated and sandy sediment. No H_2S smell. Sand worms.
	42	III	Brown fine particulated and sandy sediment. No H_2S smell. Sand worms.
	41	IV	Brown fine particulated and sandy sediment. No H_2S smell.
St. Raunes 3	40	I	Brown fine particulated and sandy sediment. Some gravel and smaller stones no H_2S smell sea urchins and sand worms.
	40	II	Brown fine particulated and sandy sediment. Some gravel and smaller stones No H_2S smell sand worms.
	41	III	Brown fine sediment. No H_2S smell
	40	IV	Brown fine sediment. No H_2S smell
St. Raunes 2	16	I	Sandy sediment with smaller stones and fine particulated material.
	16	II	Sandy sediment with smaller stones and fine particulated material.
	16	III	Sandy sediment with smaller stones and fine particulated material.
	16	IV	Sandy sediment with smaller stones and fine particulated material.
Vats 1	6	I	Fine sand and smaller stones with fine particulated materials
Vats 2	6,3	I	Fine sand and smaller stones with fine particulated materials
Vats 3	11	I	Fine sand and smaller stones with fine particulated materials
Vats 4	14,5	I	Brown fine particulated sediment. No H_2S smell. Sand worms.
Vats 4	14,5	II	Brown fine particulated sediment. No H_2S smell. Sand worms
Vats 4	14,5	III	Brown fine particulated sediment. No H_2S smell. Sand worms

In 2009, in all the sampling methods we collected approximately 25cc of sediments from the upper 2 cm from each sample and mixed them together thus representing a pooled average of 3 samples from each site. When the sediments were recovered on deck, the sediments were covered with clear water, indicating the undisturbed surface. The water was then siphoned off. The remaining four stations were sampled with a box-corer, also achieving sediment samples of the same, or better, quality. In addition, four individual samples (Vats 1-4) were sampled by an ROV at the outlet of Raunes River in order to investigate a possible mercury problem at this specific location. One of our four samples (Vats 4) was analyzed for all the variables in the study. In sites “Raunes 2” and “Raunes 3 (Grønavika)” a small grab was used from a small boat due to the occurrence of rocks on the marine sediments potentially harming the box-corer. The sediments were kept cool and sent to the laboratories at NIVA in Oslo and analyzed at NIVAs accredited laboratories.

In the 2015 sediment collection survey, the seafloor condition was rather challenging at the stations: St. 4 Vatsfjord, St Raunes 3 and St Raunes 2, and it was necessary to take four replicate samples to get enough sediment material of good sample quality. These four replicate samples were mixed to make a composite sediment sample from each station. From the station Vats 4 there were taken three replicate samples to make the composite sample, whereas from the stations Vats 1, Vats 2 and Vats 3 there was taken only 1 sample, as the seafloor condition at these locations was better and more suitable for sediment collection when using the van Veen grab equipment.

Most of the sediment parameters analyzed in the 2009 and 2015 samples were determined and quantified with use of accredited analyses. Whenever possible, the contaminant data were used to classify the sediment samples according to the Norwegian guidelines for classification of marine sediments after their contaminant content (TA-1467/1997, TA-2229/2007 and TA-2230/2007).

2.4.1 Results

Chemical contaminants were measured in marine sediments collected close to AFEBV in 2009 and 2015 (station map in Figure 3). The results of these analyses are shown in Table 7. Sediment contaminant data from a selection of reference sites (data from 2009 only) are shown in Table 8 (station map in Figure 2). The number of sediment parameters was somewhat expanded in 2015 in comparison to 2009.

Most analyses from Raunesvika were performed on samples collected at the Vats 4 and Raunes 2 stations (Figure 3). In Raunesvika as well as in Grønavika (St. 4 Vatsfjorden and Raunes 3 stations) the measured levels mercury and other heavy metals were consistently low (Class I levels), and the measured levels of PCB7 were below analytical detection limits for individual congeners, both in 2009 and 2015.

In Raunesvika, some PAH components reached Class II whereas TBT reached Class IV both in 2009 and 2015. Also the PAH-component benso(ghi)perylene, which was not analysed in 2009, reached Class IV in 2015. The concentrations of TBT (tributyltin) were slightly higher than in 2009, whereas the levels of MBT (monobutyltin) and DBT (dibutyltin) were slightly lower. The observations of slightly elevated levels of PAH and TBT contaminants in Raunesvika correspond with data reported in other studies done prior to 2009.

The data on individual PAHs in Table 7 indicate improved precision of the PAH analysis in 2015 in comparison to 2009. This may to some degree have contributed to differences observed.

In Grønavika, MBT, DBT and TBT was not detected in 2009 but present in Class II in 2015 (classification valid for TBT only). All other contaminants analyzed were present in low concentrations (Class I) in this area.

From the reference stations investigated in 2009 (Figure 2, Table 8), it can be noted that several compounds showed elevated (Class II) levels of lead (St. 1 and 3), PAH16 (St. 1, 3 and 6), benso(a)pyren (all stations) and TBT (St. 5 and 6)). These observations clearly revealed occasional presence of traces of anthropogenic and industrial activities from before 2009.

Table 7: Concentrations of contaminants in samples of marine sediment collected close to AFEBV in 2009 and 2015. When possible, the sediment contamination data are used to classify the sediment according to Norwegian guidelines for classification of marine sediment (TA-1467/1997 or TA-2229), with the colour codes as follows: Blue, green, yellow, orange and red representing the condition classes I, II, III, IV and V, respectively.

		Vats 1 Raunesvika		Vats 2 Raunesvika		Vats 3 Raunesvika		Vats 4 Raunesvika		Raunes 2 Raunesvika		Raunes 3 Grønavika		St 4 Vatsfj Grønavika	
Parameter	Unit	2009	2015	2009	2015	2009	2015	2009	2015	2009	2015	2009	2015	2009	2015
Dry matter (E)	%	-	76	-	72,5	-	72,2	-	70,3	-	63,0	-	58,3	-	85,2
Dry matter (G)	%	-	-	-	-	-	-	-	71,9	-	59	-	68,1	-	70,5
Water content	%	-	-	-	-	-	-	-	29,7	-	37	-	41,7	-	14,8
Grains <63 µm	% TS	-	-	-	-	-	-	19	-	65	-	69	-	43	-
Grains >63 µm	%	-	-	-	-	-	-	-	80,6	-	70,1	-	79,2	-	62,9
Grains <2 µm	%	-	-	-	-	-	-	-	0,6	-	0,7	-	0,6	-	1
TOC	% TS	-	-	-	-	-	-	1,71	1,05	2,19	1,16	0,35	0,539	0,27	0,648
As (Arsen)	mg/kg TS	-	-	-	-	-	-	7,4	2,99	9,2	3,3	3	3,1	3	3,86
Cd (Kadmium)	mg/kg TS	-	-	-	-	-	-	n.d.	<0.10	n.d.	<0.10	n.d.	<0.10	n.d.	<0.10
Cr (Krom)	mg/kg TS	-	-	-	-	-	-	18	11,8	27,8	14,0	23,8	21,4	23,1	22,6
Cu (Kopper)	mg/kg TS	-	-	-	-	-	-	17,4	14,8	27,9	15,7	17,3	14,6	15	16,6
Hg	mg/kg TS	0,081	<0.20	0,034	<0.20	0,031	<0.20	0,04	<0.20	0,133	<0.20	0,059	<0.20	0,016	<0.20
Ni (Nikkel)	mg/kg TS	-	-	-	-	-	-	9,9	8,1	16,3	8,9	12	10,3	11	11,3
Pb (Bly)	mg/kg TS	-	-	-	-	-	-	14	10,3	17	13,8	13	11,3	8,3	13,2
Zn (Sink)	mg/kg TS	-	-	-	-	-	-	53,7	58,3	105	75,8	135	120	88	104
Ba (Barium)	mg/kg TS	-	-	-	-	-	-	45,4	34,5	92,3	42,7	191	110	128	121
Co (Kobolt)	mg/kg TS	-	-	-	-	-	-	5,3	6,52	9,3	5,91	9,4	10,8	8	11,8
Mo (Molybden)	mg/kg TS	-	-	-	-	-	-	2	0,79	3	1,47	2	0,67	2	0,87
V (Vanadium)	mg/kg TS	-	-	-	-	-	-	20,1	18,5	38,8	18,8	37,8	29,2	30,4	32,3
P (Fosfor)	mg/kg TS	-	-	-	-	-	-	539	644	702	613	717	669	626	685
N-total	mg/kg TS	-	-	-	-	-	-	1300	659	n.d.	933	n.d.	787	n.d.	801
Sum NPD	µg/kg TS	-	-	-	-	-	-	n.d.	-	90,5	-	n.d.	-	n.d.	-
Naftalen	µg/kg TS	-	-	-	-	-	-	-	<10	-	<10	-	<10	-	<10
Acenaftylen	µg/kg TS	-	-	-	-	-	-	-	<10	-	<10	-	<10	-	<10
Acenaften	µg/kg TS	-	-	-	-	-	-	-	<10	-	<10	-	<10	-	<10
Fluoren	µg/kg TS	-	-	-	-	-	-	-	<10	-	<10	-	<10	-	<10
Fenantren	µg/kg TS	-	-	-	-	-	-	-	<10	-	74	-	<10	-	<10
Antracen	µg/kg TS	-	-	-	-	-	-	-	<10	-	16	-	<10	-	<10
Fluoranten	µg/kg TS	-	-	-	-	-	-	-	11	-	122	-	<10	-	<10
Pyren	µg/kg TS	-	-	-	-	-	-	-	10	-	86	-	<10	-	<10
Benso(a)antracen	µg/kg TS	-	-	-	-	-	-	-	<10	-	41	-	<10	-	<10
Krysen	µg/kg TS	-	-	-	-	-	-	-	<10	-	48	-	<10	-	<10
Benso(b)fluoranten	µg/kg TS	-	-	-	-	-	-	-	10	-	47	-	<10	-	<10
Benso(k)fluoranten	µg/kg TS	-	-	-	-	-	-	-	<10	-	27	-	<10	-	<10
Benso(a)pyren	µg/kg TS	-	-	-	-	-	-	3,4	<10	21	44	n.d.	<10	n.d.	<10
Dibenso(ah)antracen	µg/kg TS	-	-	-	-	-	-	-	<10	-	<10	-	<10	-	<10
Benso(ghi)perylen	µg/kg TS	-	-	-	-	-	-	-	<10	-	39	-	11	-	10
Indeno(123cd)pyren	µg/kg TS	-	-	-	-	-	-	-	<10	-	35	-	<10	-	<10
Sum PAH-16	µg/kg TS	-	-	-	-	-	-	66	31	323	580	166	11	40	10
Sum PAH carcinogene	µg/kg TS	-	-	-	-	-	-	n.d.	10	132	240	n.d.	n.d.	n.d.	n.d.
Sum PCB-7	µg/kg TS	-	-	-	-	-	-	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Monobutyltinnkation	µg/kg TS	-	-	-	-	-	-	9,6	4,5	7,2	5,1	n.d.	1,2	n.d.	1,2
Dibutyltinnkation	µg/kg TS	-	-	-	-	-	-	23	8,7	12	7,7	n.d.	1,4	n.d.	1,2
Tributyltinnkation	µg/kg TS	-	-	-	-	-	-	21	40	20	27	n.d.	1,4	n.d.	1
Monofenyltinnkation	µg/kg TS	-	-	-	-	-	-	n.d.	<1.0	n.d.	<1.0	n.d.	<1.0	n.d.	<1.0
Difenyltinnkation	µg/kg TS	-	-	-	-	-	-	n.d.	<1.0	5,6	<1.0	n.d.	<1.0	n.d.	<1.0
Trifenyltinnkation	µg/kg TS	-	-	-	-	-	-	n.d.	<1.0	4	1,2	1,4	<1.0	n.d.	<1.0

< Concentration value is below the given analysis detection limit.
n.d. Not detected, i.e. concentration value is below LOQ (limit of analytical quantification)
(-) Not analysed

Table 8: Contaminant concentrations in reference sediment samples collected in the 2009 field work. These stations are all located relatively far from AFEBV in comparison to the stations shown in Table 7. The colour codes referring to the classes of pollution state are the same as for Table 7.

Analytic Variable	Unit	St 1, Yrkesfj/Vatsfj	St 3, Krossfjorden	St 5, Raunesvika midtfj.	St 6 Indre Vatsfjorden	St 7 Indre Yrkesfjorden
Grains<63µm	% dry weight	87	91	36	88	60
TN/F	µg N/mg TS	1.7	1.0	n.d.	2.0	1.5
TOC/F	µg C/mg TS	19.0	13.5	11.3	26.7	11.3
As/ICP-Sm	µg/g	15	10	6	7.9	5
Ba/ICP-Sm	µg/g	79.1	66.8	44.8	44.5	23.9
Cd/ICP-Sm	µg/g	n.d.	n.d.	n.d.	n.d.	n.d.
Co/ICP-Sm	µg/g	16.9	16.3	4.8	7.9	4.5
Cr/ICP-Sm	µg/g	33.8	33.2	14	25.9	11
Cu/ICP-Sm	µg/g	22.2	20.1	9.97	18.5	8.34
Hg-Sm	µg/g	0.047	0.043	0.028	0.076	0.028
Mo/ICP-Sm	µg/g	3.5	3.6	0.7	2	0.9
Ni/ICP-Sm	µg/g	29	29.8	9.6	19.7	9.7
P/ICP-Sm	µg/g	883	798	653	871	772
Pb/ICP-Sm	µg/g	44	39	13	29	14
V/ICP-Sm	µg/g	63	56.4	21.9	39.7	18.9
Zn/ICP-Sm	µg/g	108	98.4	49.9	91.8	43.7
TBT-Sm	µg/kg t.v.	n.d.	n.d.	1.1	4.7	n.d.
Sum PAH16	µg/kg t.v.	668	760.3	137.3	565	256.6
Sum PCB_7	µg/kg t.v.	0.61	n.d.	n.d.	n.d.	n.d.
BAP-Sm	µg/kg t.v.	24	15	8.2	30	11
Sum KPAH	µg/kg t.v.	415	475.1	n.d.	359.6	170.7
Sum NPD	µg/kg t.v.	50.4	n.d.	n.d.	n.d.	n.d.
MBT-Sm	µg MBT/kg	n.d.	4.2	n.d.	14	5.3
DBT-Sm	µg/kg t.v.	n.d.	n.d.	n.d.	6.2	n.d.
MPhT-Sm	µg/kg t.v.	n.d.	n.d.	n.d.	n.d.	n.d.
DPhT-Sm	µg/kg t.v.	n.d.	n.d.	n.d.	n.d.	n.d.
TPhT-Sm	µg/kg t.v.	<1	n.d.	n.d.	n.d.	n.d.

3. Discussion and conclusion

NIVAs Baseline Survey in 2009 showed that the environmental status of the AFEBV location was generally good, possibly apart from the older contamination of TBT and PAH found in fjord sediments in Raunesvika and a large amount of scrap objects located at the seafloor. Both these observations were corroborated in the present repetition survey at the AFEBV location in 2015.

Some of the scrap observed during ROV surveys in 2009 and 2015 stem from activities before AFEBV was established (e.g. tires). Seabed clean-up operations performed at the location within the period 2009-2015 have apparently managed to remove a significant amount of scrap (pers. info from AFEBV). Unfortunately, these clean-up operations were done without detailed and systematic registration of removed objects. Different ROVs were used in 2009 and 2015 and the visibility in the water was significantly better in 2015 as compared to 2009. Because of these differences, it is not feasible to give a detailed comparison of the seabed scrap situation in 2009 and 2015. However, since the ROV survey in 2015 identified scrap objects at 80 individual positions, it may seem necessary to carry out further clean-up of the seafloor targeted to remove the remaining scrap.

Both in 2009 and 2015, sediments collected in the fjord adjacent to the demolition plant showed PAH16 levels in Class II in one sample (Raunes 2), whereas three other sediment samples were in Class I. One individual PAH (benso(ghi)perylene, which was analysed in 2015 only) was determined to Class IV in the Raunes 2 sample. TBT was detected in Class IV in two sediment samples (Raunes 2 and Vats 4) and in Class II in two samples from Grønavika. In large, the sediment TBT and PAH levels measured in 2015 were consistent with levels reported in 2009, indicating that the contamination level in marine sediments close to the AFEBV base has been more or less stable between 2009 and 2015. Similar findings of TBT and PAH in Raunesvika has been reported by several studies conducted before 2009, and several more remote fjord stations investigated in 2009 revealed the occasional presence of elevated (Class II) levels of PAH, TBT and lead, showing that anthropogenic and industrial activities had left some foot-prints in the area also before 2009. Both in 2009 and 2015, the concentration of PCB7, mercury and other metals were low (Class I) in sediment samples from all fjord stations. At the two stations Vats 4 and Raunes 2 (both in Raunesvika) the concentrations of TBT were slightly higher in 2015 than in 2009, but within the same class (Class IV). Sum PAH16 was lower at one of the two stations investigated and higher at the other, but the classification had remained the same (Class I and Class II, respectively). At both stations TOC and metals frequently associated with TOC (Cu, Pb), was lower in 2015 than in 2009. The fact that TBT and PAH (at one of the two stations) does not follow the same pattern might indicate a specific source for these contaminants, but the signal is very weak and the present data material is too sparse, to determine for sure if the difference is coincidental or represent a real increase. It is therefore concluded that neither the baseline studies nor any other available information provide clear evidence for a consistent change in contaminant levels in these fjord sediments between 2009 and 2015.

The soil contamination part of the present study is limited to top-soil samples from only two soil stations (J1 and J2). Generally, it must be noted that two soil stations provides a very sparse basis for assessing trends in soil contamination. The two soil stations are placed just a few dozen meters apart from each other and both are located within the narrow riverside brim between the Raunes River and the fence/concrete wall that borders the AFEBV area (see pictures in Figure 8 and Figure 13). According to information from workers at AFEBV, this riverside area was flattened during the construction work which was conducted before 2009. In connection with the flattening process a combination of soil materials obtained locally and materials “imported” from the south-end of the AFEBV construction area were used. Especially the position where J1 is located received much of the imported soil material whereas the J2 spot received preferably local soil materials. This information implies that neither of the two stations represented virgin soil profiles when the samples in the 2009 baseline study were obtained and it may also explain the slight difference in contaminant concentrations between the two soil stations at that time, J1 being slightly more contaminated than J2. The fence/concrete wall was built during the same construction phase (before 2009) and the wall made the riverside brim inaccessible for heavy machinery. Therefore, from the time when the 2009 soil samples were obtained there has apparently not been any significant disturbance of the soil surface at the J1 and J2 positions. In the 2009 baseline study, the soil contamination data showed generally low levels of all contaminants, apart from Zn at J1 which just reached the Class II threshold (guideline TA-2553). The norm value for most sensitive land use (guideline TA-1629) was reached or exceeded by Zn and one PAH compound in the J1 sample. In 2015 as compared to 2009, the results show a general increase in the contamination level at both soil stations, although most of the parameters still fall within Class I (guideline TA-2553). The most significant increase (20 fold up, Class III) is seen for mercury at the J1 station. Mercury, zinc and four PAH components in the J1 sample exceeded the norm value for most sensitive land use (TA-1629), although all PAHs fall within Class I (very good). The 2015 data show that the J2 soil station was significantly less contaminated than J1, although the distance between the two stations is just a few dozen meters, indicating a very patchy contaminant distribution. It is also important to note that the 2015 soil contamination data are generally in line with the soil contaminant data in NIVAs annual monitoring program, which found increased concentrations of mercury and several other metals at the J1 and J2 soil stations already in 2010, and which also demonstrated that an increase of metal levels in moss samples in the ultimate surroundings of AFEBV took place between 2009 and 2010 (Beyer et al, 2015b). The same monitoring programme also indicated that remedial actions at AFEBV against spreading of airborne dust from the working area after have contributed to a stabilisation and partly decrease of the metal contaminant level in both soil and in moss samples from the area close up to AFEBV.

The assessment of groundwater samples from under the base demonstrates low levels of all contaminants measured, signalling a good condition of the groundwater and that the impermeable deck at the base prevents contaminant transfer to the ground beneath the demolition facility.

4. References

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5. Appendix

5.1 Appendix 1 – Technical description of ROV survey in 2009

We had more difficult conditions for registrations in Grønavika than in Raunesvika, due to more turbid waters and less light. The inaccuracy in the positioning of the ROV is fairly wide in the shallower waters but narrows at depth. This was particularly obvious in Raunesvika where some positions were registered to be on land

We received a total of 10 electronic log-files from the ROV, although half of these were from a different project not pertaining to this one. Our data contained one file from the 7th of May and four files from the 8th of May 2009 (Table 6). The files were in an npd-format and were treated in Excel before exported to ArcGIS (ver. 9.3). The first 73 lines in 080509_000 lacked positions and were therefore deleted. Some of the positions are incorrect or insecure, particularly those taken in shallow water. This pertains particularly to those from the 7th of May. The outliers were removed and the following procedure was followed to define these: positions more than 10 meters from the previous and consecutive position were removed using an Excel algorithm based on Pythagoras'. In addition, we inspected the positions visually in ArcGIS to remove obvious outliers not eliminated using the algorithm. In total 2541 outliers were removed.

Some positions are still uncertain, particularly in the areas of Grønavika closest to shore (070509_000). Here, some positions are still on shore, but as this pertains to so many positions, we would remove a substantial part of the material if we remove all of these. Thus one should be aware of the potential position errors in the inner parts of Grønavika. The remaining positions are better, but there is still an insecurity of up to 10 meters, or more in the shallow areas. The positions of anthropogenic remains found in these outliers have been moved to the nearest correct position. This pertains to 8 out of 59 registered remains and the points have been moved up to 24 meters.

Table 9. Overview over the removal of outliers from 5 logfiles

Place	***Date***	***Fliename***	***Number of positions***	*Number of outliers removed*
Grønavika	7. mai 2009	070509_000	7456	1610
Grønavika	8. mai 2009	080509_000	5972	271
Raunesvika	8. mai 2009	080509_001	42	0
Raunesvika	8. mai 2009	080509_002	3363	420
Raunesvika	8. mai 2009	080509_003	2088	240

We have used the UTM/WGS1894/Zone32N coordinate system. The background-picture in the map is from http://www.norgeibilder.no from Statens Kartverk from 2004, and may deviate from the conditions of today, due to the recent constructions. Red markers in Figure 2.3 indicate anthropogenic remains and the numbers refers to the ID in table 2.2.

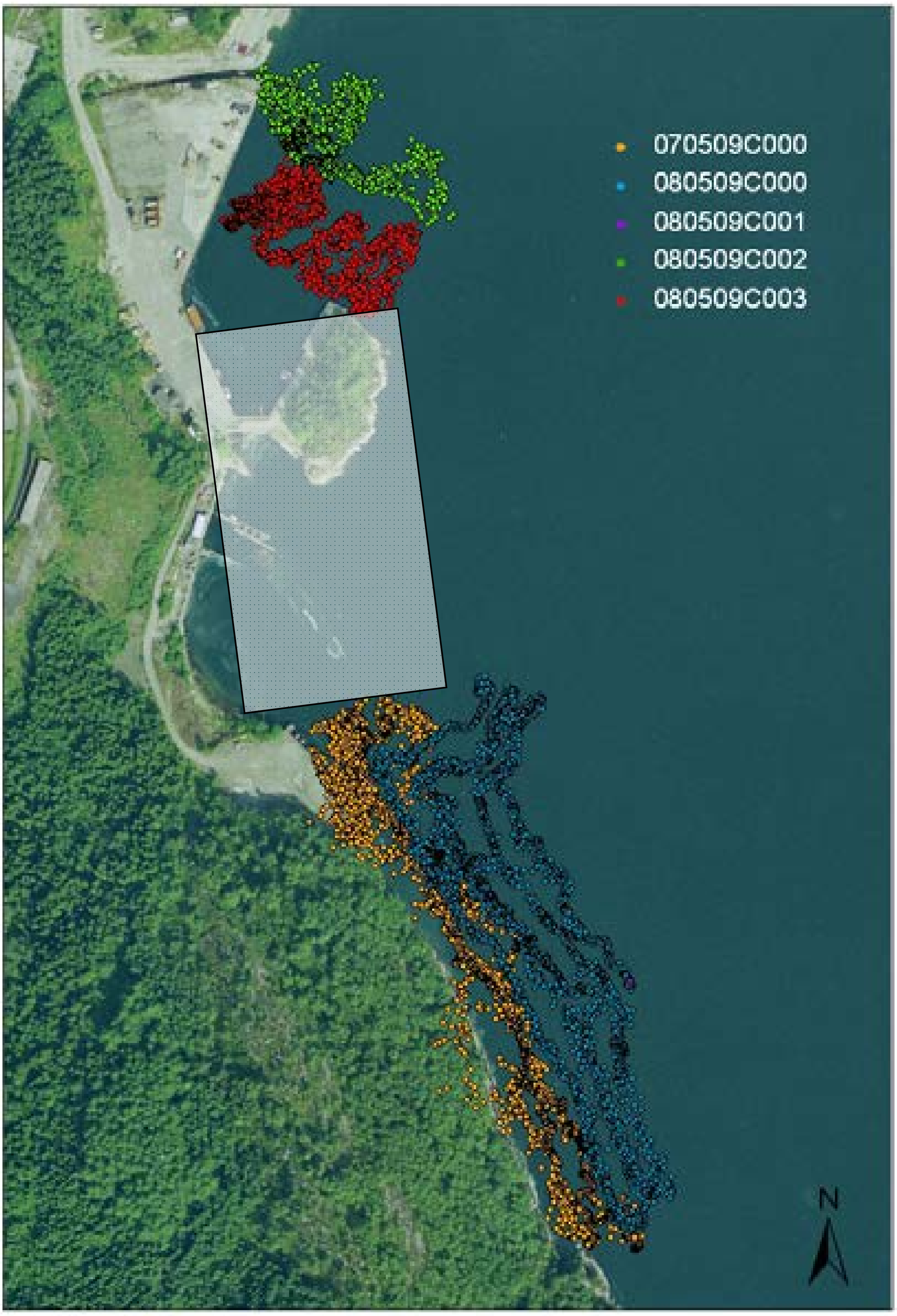

Figure 15.'Tracking' of the movements of the ROV at AF Miljøbase Vats the 7th and 8th of May 2009. The areal photo is taken before the recent constructions were performed. The gray area indicates a coarse indications of the newly filled-in areas.

Table 10. Registrations of antropogenic materials from the ROV-recordings in Grønavika and Raunesvika the 7th and 8th of May 2009. The ROV-depth is the depth at which the ROV was at the time of registration, not the depth at which the debris rests.

ID	Registrering	ROV-dyp	Ø	N	Dato	Klokke-slett	Flyttet (m)	Ø	N
	Grønavika								
1	trestamme/jernstang overgrodd	4	315760	6593034	07.05.2009	21:58:06	9	315731	6593072
2	trestamme/jernstang overgrodd	5	315743	6593049	07.05.2009	21:59:56	7	315726	6593091
3	trestamme/jernstang overgrodd	4,9	315715	6593096	07.05.2009	22:05:41			
4	trestamme/jernstang overgrodd	1,8	315667	6593204	07.05.2009	22:24:38			
5	siltduk (?)	5,2	315637	6593279	07.05.2009	22:40:40			
6	siltduk (fungerende)	5,2	315644	6593269	07.05.2009	22:43:52			
7	tauverk	9,8	315630	6593304	07.05.2009	22:55:08	15	315634	6593284
8	armeringsjern, 'sprenghylser'	10,3	315639	6593302	07.05.2009	22:55:34			
9	betongsøyle	10	315650	6593259	07.05.2009	23:01:05			
10	duk fungerende (?)	9,6	315644	6593245	07.05.2009	23:01:47			
11	armeringsjern	14,7	315644	6593303	07.05.2009	23:10:28	11	315678	6593243
12	sammenfiltret duk	14,6	315670	6593249	07.05.2009	23:13:03			
13	duk	14,7	315684	6593246	07.05.2009	23:19:08			
14	søyle 'no.4'	9,8	315699	6593193	07.05.2009	23:40:53			
15	garn	9,5	315686	6593209	07.05.2009	23:42:44			
16	duk	9,7	315693	6593208	07.05.2009	23:44:02			
17	betongring, rør ca Ø 10cm, tauver, duk	19,7	315696	6593221	08.05.2009	08:01:42			
18	rør eller vaier som vi fastnet i	22	315694	6593229	08.05.2009	08:05:55			
19	rør	20,8	315692	6593230	08.05.2009	08:18:22			
20	dekk	29,5	315691	6593289	08.05.2009	08:48:33			
21	2 tau m oppdrift	34	315831	6593037	08.05.2009	09:04:54			
22	'tau/vaier m oppdrift'	40,1	315709	6593251	08.05.2009	09:26:41			
23	betongblokk/moring	39,9	315749	6593248	08.05.2009	09:27:34			
24	dekk m tauverk	36,5	315775	6593195	08.05.2009	09:30:50			
	Raunesvika								
25	stålrør, tau	6,2	315590	6593677	08.05.2009	10:30:26			
26	metallskrap	6	315573	6593672	08.05.2009	10:17:41			
27	lang rørledning	9,7	315598	6593714	08.05.2009	10:38:20			
28	fiskeruse, tau	9,7	315611	6593698	08.05.2009	10:40:42			
29	2 bildekk	8	315606	6593686	08.05.2009	10:45:16	24	315617	6593721
30	stålrør, tau	11,3	315606	6593680	08.05.2009	10:55:53	24	315617	6593709
31	stor 'plate'	11,2	315617	6593673	08.05.2009	10:56:03	20	315605	6593692
32	3 dekk, det ene stort	12	315576	6593710	08.05.2009	10:57:09			
33	vajer, rørledning	15,2	315615	6593721	08.05.2009	10:58:36			
34	stort dekk	13,9	315610	6593686	08.05.2009	10:59:52			
35	nedgrodde 'jernstenger'	12,3	315598	6593696	08.05.2009	11:00:20			
36	langt smalt 'rør'	11,5	315600	6593700	08.05.2009	11:01:10	3	315657	6593703
37	dekk + noen jernstenger	13,5	315612	6593676	08.05.2009	11:04:00			
38	rørledning (også synlig på 20m dyp)	17,3	315621	6593693	08.05.2009	11:04:41			
39	duk som ligger delvis på stor rørledning	18,8	315636	6593708	08.05.2009	11:06:18			
40	duk, hanske	22,3	315643	6593696	08.05.2009	11:08:18			

ID	Registrering	ROV-dyp	Ø	N	Dato	Klokke-slett	Flyttet (m)	Ø	N
41	2 takplater, hjelm	18,6	315617	6593664	08.05.2009	11:13:30			
42	takplate	23	315640	6593657	08.05.2009	11:15:20			
43	stor rørledning	23	315652	6593647	08.05.2009	11:16:27			
44	stor rørledning	33,6	315682	6593648	08.05.2009	11:18:46			
45	stor rørledning	31,9	315683	6593663	08.05.2009	11:19:59			
46	litt skrot	7,1	315589	6593643	08.05.2009	12:01:10			
47	div skrap	7,7	315588	6593638	08.05.2009	12:04:45			
48	jernstang	7	315610	6593643	08.05.2009	12:07:04			
49	traktordekk - nedgrodd	9,6	315579	6593624	08.05.2009	12:09:46			
50	jernstang/rør/tau	12,4	315609	6593629	08.05.2009	12:12:45			
51	bøtte, tau	13,4	315589	6593600	08.05.2009	12:14:45			
52	2 dekk	15,2	315595	6593606	08.05.2009	12:15:10			
53	rør + rørledning, tau	17,6	315615	6593612	08.05.2009	12:16:22			
54	rør eller jernstang, hjelm	21,1	315641	6593605	08.05.2009	12:18:30			
55	duk	19	315624	6593600	08.05.2009	12:19:24			
56	dekk, rørledning, kjetting opp til duk?	19,3	315614	6593588	08.05.2009	12:20:45			
57	takplate	22,2	315643	6593593	08.05.2009	12:21:26			
58	søppel, rørledning/kabel	24,6	315662	659360	08.05.2009	12:22:58			
59	rørledning, 'tykk duk'	28,2	315651	6593594	08.05.2009	12:26:05			

5.2 Appendix 2: Analysis report of marine sediments in 2009

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Nr. TEST009

Norsk Institutt for Vannforskning
Gaustadalléen 21
0349 Oslo
Tel: 22 18 51 00
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Navn **Vats Sediment**
Adresse

Deres referanse:

Vår referanse:
Rekv.nr. 2009-952
O.nr. O 28440BBK

Dato
20/11/2015

Prøvene ble levert ved NIVAs laboratorium av forsker, og merket slik som gjengitt i tabellen nedenfor. Prøvene ble analysert med følgende resultater (analyseusikkerhet kan fås ved henvendelse til laboratoriet):

Prøvenr	Prøve merket	Prøvetakings-dato	Mottatt NIVA	Analyseperiode
1	Vats 1	2009.05.08	2009.05.19	2009.06.17-2009.06.17
2	Vats 2	2009.05.08	2009.05.19	2009.06.17-2009.06.17
3	Vats 3	2009.05.08	2009.05.19	2009.06.17-2009.06.17
4	Vats 4	2009.05.08	2009.05.19	2009.05.25-2010.01.13
5	Raunes 2	2009.05.08	2009.05.19	2009.05.25-2010.01.13
6	Raunes 3 (Grønevika)	2009.05.08	2009.05.19	2009.05.25-2010.01.13
7	St 1, Yrkesfj/Vatsfj	2009.05.08	2009.05.19	2009.05.25-2010.01.13

Prøvenr Analysevariabel Metode	Enhet	1	2	3	4	5	6	7
Kornfordeling <63µm Intern*	% t.v.				19	65	69	87
Nitrogen, total 6	µg N/mg TS G				1,3	<1,0	<1,0	1,7
Karbon, org. total 6	µg C/mg TS G				17,1	21,9	3,5	19,0
Arsen 9-5	µg/g E				7,4	9,2	3	15
Barium 9-5	µg/g E				45,4	92,3	191	79,1
Kadmium 9-5	µg/g E				<0,2	<0,2	<0,2	<0,2
Kobolt 9-5	µg/g E				5,3	9,3	9,4	16,9
Krom 9-5	µg/g E				18,0	27,8	23,8	33,8
Kobber 9-5	µg/g E				17,4	27,9	17,3	22,2
Kvikksølv 4-3	µg/g E	0,081	0,034	0,031	0,040	0,133	0,059	0,047
Molybden 9-5	µg/g E				2	3,0	2	3,5

Nikkel 9-5	µg/g	E				9,9	16,3	12	29,0
Fosfor 9-5	µg/g	E				539	702	717	883
Bly 9-5	µg/g	E				14	17	13	44,0
Vanadium 9-5	µg/g	E				20,1	38,8	37,8	63,0
Sink 9-5	µg/g	E				53,7	105	135	108
PCB-28 3-3	µg/kg t.v.	H				<0,5	<0,5	<0,5	<0,5
PCB-52 3-3	µg/kg t.v.	H				i	i	i	i
PCB-101 3-3	µg/kg t.v.	H				<0,5	<0,5	<0,5	<0,5
PCB-118 3-3	µg/kg t.v.	H				<0,5	<0,5	<0,5	<0,5
PCB-105 3-3	µg/kg t.v.	H				<0,5	i	<0,5	<0,5
PCB-153 3-3	µg/kg t.v.	H				<0,5	i	i	i
PCB-138 3-3	µg/kg t.v.	H				<0,5	<0,5	<0,5	<0,5
PCB-156 3-3	µg/kg t.v.	H				<0,5	<0,5	<0,5	<0,5
PCB-180 3-3	µg/kg t.v.	H				<0,5	<0,5	<0,5	0,61
PCB-209 3-3	µg/kg t.v.	H				<0,5	<0,5	<0,5	<0,5
Sum PCB Beregnet	µg/kg t.v.					<4,5	<3,5	<4	<4,11
Seven Dutch Beregnet	µg/kg t.v.					<3	<2,5	<2,5	<2,61
Pentaklorbenzen 3-3	µg/kg t.v.	H				<0,3	<0,3	<0,3	<0,3
Alfa-HCH 3-3	µg/kg t.v.	H				<0,5	<0,5	<0,5	<0,5

i : Forbindelsen er dekket av en interferens i kromatogrammet.
* : Metoden er ikke akkreditert.

Kommentarer

1 Metallresultatene er oppgitt på tørrvekt.

4 PCB: CB52, CB105 og CB153 er dekket av en interferens i kromatogrammet av en eller flere av prøvene. Siden konsentrasjonen av de øvrige PCB-kongenerene er under deteksjonsgrensen (0.5µg/kg) og med kjennskap til kongenersammensetningen i kommersielle PCB-oljer, er det usannsynlig at konsentrasjonen av de nevnte kongenerene er høyere enn 0.5 µg/kg.
Et referansemateriale ble analysert parallelt med prøvene. Resultatet for cb156 var høyere enn øvre aksjonsgrense.
SnOrg: Prøven er analysert sammen med et sertifisert referansemateriale. Verdiene for TBT lå under nedre aksjonsgrense. Det finnes ikke noen sertifisert verdi for fenylkomponentene og vi rapporterer derfor ikke disse verdiene siden de ikke viser tilfredsstillende stabilitet.

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Rekv.nr. 2009-952

(fortsettelse av tabellen):

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1	Vats 1	2009.05.08	2009.05.19	2009.06.17-2009.06.17
2	Vats 2	2009.05.08	2009.05.19	2009.06.17-2009.06.17
3	Vats 3	2009.05.08	2009.05.19	2009.06.17-2009.06.17
4	Vats 4	2009.05.08	2009.05.19	2009.05.25-2010.01.13
5	Raunes 2	2009.05.08	2009.05.19	2009.05.25-2010.01.13
6	Raunes 3 (Grønevika)	2009.05.08	2009.05.19	2009.05.25-2010.01.13
7	St 1, Yrkesfj/Vatsfj	2009.05.08	2009.05.19	2009.05.25-2010.01.13

Analysevariabel	Enhet	Prøvenr Metode	1	2	3	4	5	6	7
Hexaklorbenzen	µg/kg t.v.	H 3-3				<0,3	<0,3	<0,3	<0,3
Gamma-HCH	µg/kg t.v.	H 3-3				<0,5	<0,5	<0,5	<0,5
Oktaklorstyren	µg/kg t.v.	H 3-3				<0,5	<0,5	<0,5	<0,5
4,4-DDE	µg/kg t.v.	H 3-3				<0,5	<0,5	<0,5	<0,5
4,4-DDD	µg/kg t.v.	H 3-3				<1	<1	<1	<1
Naftalen i sediment	µg/kg t.v.	H 2-3				3,3	3,0	<2	13
Acenaftylen	µg/kg t.v.	H 2-3				<2	<2	<2	<2
Acenaften	µg/kg t.v.	H 2-3				<2	<2	<2	<2
Fluoren	µg/kg t.v.	H 2-3				<2	<2	<2	3,3
Dibenzotiofen	µg/kg t.v.	H 2-3				<2	2,5	2,7	2,4
Fenantren	µg/kg t.v.	H 2-3				6,2	85	120	35
Antracen	µg/kg t.v.	H 2-3				<2	2,7	<2	5,7
Fluoranten	µg/kg t.v.	H 2-3				6,0	38	9,8	40
Pyren	µg/kg t.v.	H 2-3				6,3	34	4,5	35
Benz(a)antracen	µg/kg t.v.	H 2-3				2,8	15	<2	21
Chrysen	µg/kg t.v.	H 2-3				4,9	16	<2	25
Benzo(b+j)fluoranten	µg/kg t.v.	H 2-3				10	36	4,2	100
Benzo(k)fluoranten	µg/kg t.v.	H 2-3				2,9	13	<2	35
Benzo(e)pyren	µg/kg t.v.	H 2-3				8,3	22	3,2	54
Benzo(a)pyren	µg/kg t.v.	H 2-3				3,4	21	<2	24
Perylen	µg/kg t.v.	H 2-3				15	16	2,2	13
Indeno(1,2,3cd)pyren	µg/kg t.v.	H 2-3				4,3	24	3,4	170
Dibenz(ac+ah)antrac.	µg/kg t.v.	H 2-3				<2	4,0	<2	27
Benzo(ghi)perylen	µg/kg t.v.	H 2-3				5,5	25	4,3	130
Sum PAH	µg/kg t.v.	Beregnet				<90,9	<363,2	<174,3	<737,4
Sum PAH16	µg/kg t.v.	Beregnet				<65,6	<322,7	<166,2	<668
Sum KPAH	µg/kg t.v.	Beregnet				<33,6	132	<19,6	415
Monobutyltinn	µg MBT/kg	H 14-1*				9,6	7,2	<2	<1
Dibutyltinn	µg/kg t.v.	H 14-1*				23	12	<2	<2
Tributyltinn	µg/kg t.v.	H 14-1*				21	20	<1	<1

* : Metoden er ikke akkreditert.

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Rekv.nr. 2009-952

(fortsettelse av tabellen):

Prøvenr	Prøve merket	Prøvetakings-dato	Mottatt NIVA	Analyseperiode
1	Vats 1	2009.05.08	2009.05.19	2009.06.17-2009.06.17
2	Vats 2	2009.05.08	2009.05.19	2009.06.17-2009.06.17
3	Vats 3	2009.05.08	2009.05.19	2009.06.17-2009.06.17
4	Vats 4	2009.05.08	2009.05.19	2009.05.25-2010.01.13
5	Raunes 2	2009.05.08	2009.05.19	2009.05.25-2010.01.13
6	Raunes 3 (Grønevika)	2009.05.08	2009.05.19	2009.05.25-2010.01.13
7	St 1, Yrkesfj/Vatsfj	2009.05.08	2009.05.19	2009.05.25-2010.01.13

Analysevariabel	Enhet	Prøvenr Metode	1	2	3	4	5	6	7
Monophenyltinn	µg/kg t.v.	H 14-1*				n.d	n.d	n.d	n.d
Diphenyltinn	µg/kg t.v.	H 14-1*				n.d	n.d	n.d	n.d
Triphenyltinn	µg/kg t.v.	H 14-1*				n.d	n.d	n.d	n.d

* : Metoden er ikke akkreditert.

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ANALYSE RAPPORT

NORSK AKKREDITERING Nr. TEST009

Rekv.nr. 2009-952

(fortsettelse av tabellen):

Prøvenr	Prøve merket	Prøvetakings-dato	Mottatt NIVA	Analyseperiode
8	St 3, Krossfjorden	2009.05.08	2009.05.19	2009.05.25-2010.01.13
9	St 4, Vatsfj. Grønevika	2009.05.08	2009.05.19	2009.05.25-2010.01.13
10	St 5, Raunesvika midtfj.	2009.05.08	2009.05.19	2009.05.25-2010.01.13
11	St 6 Indre Vatsfjorden	2009.05.08	2009.05.19	2009.05.25-2010.01.13
12	St 7 Indre Yrkesfjorden	2009.05.08	2009.05.19	2009.05.25-2010.01.13

Analysevariabel	Enhet	Prøvenr / Metode	8	9	10	11	12
Kornfordeling <63µm	% t.v.	Intern*	91	43	36	88	60
Nitrogen, total	µg N/mg TS	G 6	1,0	<1,0	<1,0	2,0	1,5
Karbon, org. total	µg C/mg TS	G 6	13,5	2,7	11,3	26,7	11,3
Arsen	µg/g	E 9-5	10	3	6	7,9	5
Barium	µg/g	E 9-5	66,8	128	44,8	44,5	23,9
Kadmium	µg/g	E 9-5	<0,3	<0,2	<0,2	<0,2	<0,2
Kobolt	µg/g	E 9-5	16,3	8,0	4,8	7,9	4,5
Krom	µg/g	E 9-5	33,2	23,1	14,0	25,9	11,0
Kobber	µg/g	E 9-5	20,1	15,0	9,97	18,5	8,34
Kvikksølv	µg/g	E 4-3	0,043	0,016	0,028	0,076	0,028
Molybden	µg/g	E 9-5	3,6	2	0,7	2,0	0,9
Nikkel	µg/g	E 9-5	29,8	11	9,6	19,7	9,7
Fosfor	µg/g	E 9-5	798	629	653	871	772
Bly	µg/g	E 9-5	39	8,3	13	29	14
Vanadium	µg/g	E 9-5	56,4	30,4	21,9	39,7	18,9
Sink	µg/g	E 9-5	98,4	88,0	49,9	91,8	43,7
PCB-28	µg/kg t.v.	H 3-3	<0,5	<0,5	<0,5	<0,5	<0,5
PCB-52	µg/kg t.v.	H 3-3	i	i	i	i	i
PCB-101	µg/kg t.v.	H 3-3	<0,5	<0,5	<0,5	<0,5	<0,5
PCB-118	µg/kg t.v.	H 3-3	<0,5	<0,5	<0,5	<0,5	<0,5
PCB-105	µg/kg t.v.	H 3-3	<0,5	<0,5	<0,5	<0,5	<0,5
PCB-153	µg/kg t.v.	H 3-3	i	i	i	<0,5	<0,5
PCB-138	µg/kg t.v.	H 3-3	<0,5	<0,5	<0,5	<0,5	<0,5
PCB-156	µg/kg t.v.	H 3-3	<0,5	<0,5	<0,5	<0,5	<0,5
PCB-180	µg/kg t.v.	H 3-3	<0,5	<0,5	<0,5	<0,5	<0,5
PCB-209	µg/kg t.v.	H 3-3	<0,5	<0,5	<0,5	<0,5	<0,5
Sum PCB	µg/kg t.v.	Beregnet	<4	<4	<4	<4,5	<4,5
Seven Dutch	µg/kg t.v.	Beregnet	<2,5	<2,5	<2,5	<3	<3
Pentaklorbenzen	µg/kg t.v.	H 3-3	<0,3	<0,3	<0,3	<0,3	<0,3
Alfa-HCH	µg/kg t.v.	H 3-3	<0,5	<0,5	<0,5	<0,5	<0,5

i : Forbindelsen er dekket av en interferens i kromatogrammet.
* : Metoden er ikke akkreditert.

ANALYSE RAPPORT

NORSK AKKREDITERING Nr. TEST009

Rekv.nr. 2009-952

(fortsettelse av tabellen):

Prøvenr	Prøve merket	Prøvetakings-dato	Mottatt NIVA	Analyseperiode
8	St 3, Krossfjorden	2009.05.08	2009.05.19	2009.05.25-2010.01.13
9	St 4, Vatsfj. Grønevika	2009.05.08	2009.05.19	2009.05.25-2010.01.13
10	St 5, Raunesvika midtfj.	2009.05.08	2009.05.19	2009.05.25-2010.01.13
11	St 6 Indre Vatsfjorden	2009.05.08	2009.05.19	2009.05.25-2010.01.13
12	St 7 Indre Yrkesfjorden	2009.05.08	2009.05.19	2009.05.25-2010.01.13

Analysevariabel	Enhet	Prøvenr Metode	8	9	10	11	12
Hexaklorbenzen	µg/kg t.v.	H 3-3	<0,3	<0,3	<0,3	<0,3	<0,3
Gamma-HCH	µg/kg t.v.	H 3-3	<0,5	<0,5	<0,5	<0,5	<0,5
Oktaklorstyren	µg/kg t.v.	H 3-3	<0,5	<0,5	<0,5	<0,5	<0,5
4,4-DDE	µg/kg t.v.	H 3-3	<0,5	<0,5	<0,5	<0,5	<0,5
4,4-DDD	µg/kg t.v.	H 3-3	<1	<1	<1	<1	<1
Naftalen i sediment	µg/kg t.v.	H 2-3	9,1	<2	<2	9,6	36
Acenaftylen	µg/kg t.v.	H 2-3	<2	<2	<2	<2	<2
Acenaften	µg/kg t.v.	H 2-3	<2	<2	<2	<2	<2
Fluoren	µg/kg t.v.	H 2-3	2,1	<2	<2	<2	<2
Dibenzotiofen	µg/kg t.v.	H 2-3	<2	<2	<2	<2	<2
Fenantren	µg/kg t.v.	H 2-3	22	3,5	6,0	14	6,2
Antracen	µg/kg t.v.	H 2-3	2,1	<2	<2	2,4	<2
Fluoranten	µg/kg t.v.	H 2-3	23	<2	8,9	28	9,8
Pyren	µg/kg t.v.	H 2-3	22	2,1	8,8	25	8,9
Benz(a)antracen	µg/kg t.v.	H 2-3	13	<2	5,3	15	6,3
Chrysen	µg/kg t.v.	H 2-3	19	<2	5,3	16	7,1
Benzo(b+j)fluoranten	µg/kg t.v.	H 2-3	82	4,1	22	100	39
Benzo(k)fluoranten	µg/kg t.v.	H 2-3	27	<2	8,4	40	14
Benzo(e)pyren	µg/kg t.v.	H 2-3	42	2,7	13	66	24
Benzo(a)pyren	µg/kg t.v.	H 2-3	15	<2	8,2	30	11
Perylen	µg/kg t.v.	H 2-3	16	<2	5,3	23	8,8
Indeno(1,2,3cd)pyren	µg/kg t.v.	H 2-3	270	3,8	25	130	50
Dibenz(ac+ah)antrac.	µg/kg t.v.	H 2-3	40	<2	3,4	19	7,3
Benzo(ghi)perylen	µg/kg t.v.	H 2-3	210	4,2	26	130	53
Sum PAH	µg/kg t.v.	Beregnet	<820,3	<46,4	<157,6	<656	<291,4
Sum PAH16	µg/kg t.v.	Beregnet	<760,3	<39,7	<137,3	<565	<256,6
Sum KPAH	µg/kg t.v.	Beregnet	475,1	<19,9	<79,6	359,6	170,7
Monobutyltinn	µg MBT/kg	H 14-1*	4,2	<2	<2	14	5,3
Dibutyltinn	µg/kg t.v.	H 14-1*	<2	<2	<4	6,2	<3
Tributyltinn	µg/kg t.v.	H 14-1*	<1	<1	1,1	4,7	<1

* : Metoden er ikke akkreditert.

Side nr. 42/67

ANALYSE RAPPORT

NORSK AKKREDITERING
Nr. TEST009

Rekv.nr. 2009-952

(fortsettelse av tabellen):

Prøvenr	Prøve merket	Prøvetakings-dato	Mottatt NIVA	Analyseperiode
8	St 3, Krossfjorden	2009.05.08	2009.05.19	2009.05.25-2010.01.13
9	St 4, Vatsfj. Grønevika	2009.05.08	2009.05.19	2009.05.25-2010.01.13
10	St 5, Raunesvika midtfj.	2009.05.08	2009.05.19	2009.05.25-2010.01.13
11	St 6 Indre Vatsfjorden	2009.05.08	2009.05.19	2009.05.25-2010.01.13
12	St 7 Indre Yrkesfjorden	2009.05.08	2009.05.19	2009.05.25-2010.01.13

Analysevariabel	Enhet	Prøvenr Metode	8	9	10	11	12
Monophenyltinn	µg/kg t.v.	H 14-1*	<1	<1	<1	<1	<1
Diphenyltinn	µg/kg t.v.	H 14-1*	<9	<8	<8	<9	<6
Triphenyltinn	µg/kg t.v.	H 14-1*	<1	<1	<1	<1	<1

* : Metoden er ikke akkreditert.

Norsk institutt for vannforskning

Astri JS Kvassnes
Forsker

ANALYSE RAPPORT

NORSK AKKREDITERING
Nr. TEST009

Rekv.nr. 2009-952

(fortsettelse av tabellen):

VEDLEGG

SUM PCB er summen av polyklorerte bifenyler som inngår i denne rapporten.

Seven dutch er summen av polyklorerte bifenyler 28,52,101,118,138,153 og 180.

SUM PAH16 omfatter flg forbindelser: naftalen, acenaftylen, acenaften, fluoren, fenantren, antracen, fluoranten, pyren, benz(a)antracen, chrysen, benzo(b+j)fluoranten, benzo(k)fluoranten, benzo(a)pyren, indeno(1,2,3-cd)pyren, dibenz(a,c+a,h)antracen, benzo(ghi)perylen.

SUM KPAH er summen av benz(a)antracen, benzo(b+j+k)fluoranten, benzo(a)pyren, indeno(1,2,3-cd)pyren, dibenz(a,c+a,h)antracen, chrysen og naftalen[1]. Disse har potensielt kreftfremkallende egenskaper i mennesker i flg International Agency for Research on Cancer, IARC (1987, Chrysen og naftalen fra 2007). De tilhører IARC's kategorier 2A + 2B (sannsynlig + trolig carcinogene). Chysen og naftalen ble inkludert i våre rapporter f.o.m. 18.09.2008.

SUM PAH er summen av alle PAH-forbindelser som inngår i denne rapporten.

[1] Bare a,h-isomeren har potensielt kreftfremkallende egenskaper

5.3 Appendix 3: Analysis report of soil and marine sediments in 2015

Rapport **N1507677**

Side 1 (18)

Y42X1DM2G

Registrert 2015-06-09 13:19
Utstedt 2015-06-18

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Prosjekt EkofiskEPRD/1699
Bestnr AFD2-ALS-C-0213-GENERAL-Analyses of sediments/soil

Analysis of soil

Deres prøvenavn J1
Soil

Labnummer N00368075

Analyse	Resultater	Usikkerhet (±)	Enhet	Metode	Utført	Sign
Tørrstoff (E)	89.4	5.39	%	1	1	HABO
As (Arsen)	2.42	0.48	mg/kg TS	1	1	HABO
Cd (Kadmium)	<0.10		mg/kg TS	1	1	HABO
Cr (Krom)	25.2	5.04	mg/kg TS	1	1	HABO
Cu (Kopper)	32.6	6.52	mg/kg TS	1	1	HABO
Hg (Kvikksølv)	2.84	0.57	mg/kg TS	1	1	HABO
Ni (Nikkel)	23.0	4.6	mg/kg TS	1	1	HABO
Pb (Bly)	18.7	3.7	mg/kg TS	1	1	HABO
Zn (Sink)	428	85.6	mg/kg TS	1	1	HABO
Cr6+	0.364	0.073	mg/kg TS	1	1	HABO
Cyanid-fri	<0.10		mg/kg TS	1	1	HABO
PCB 28	<0.0030		mg/kg TS	1	1	HABO
PCB 52	<0.0030		mg/kg TS	1	1	HABO
PCB 101	<0.0030		mg/kg TS	1	1	HABO
PCB 118	<0.0030		mg/kg TS	1	1	HABO
PCB 138	<0.0030		mg/kg TS	1	1	HABO
PCB 153	<0.0030		mg/kg TS	1	1	HABO
PCB 180	<0.0030		mg/kg TS	1	1	HABO
Sum PCB-7*	n.d.		mg/kg TS	1	1	HABO
g-HCH (Lindan)	<0.0010		mg/kg TS	1	1	HABO
o,p'-DDT	<0.010		mg/kg TS	1	1	HABO
p,p'-DDT	<0.010		mg/kg TS	1	1	HABO
o,p'-DDD	<0.010		mg/kg TS	1	1	HABO
p,p'-DDD	<0.010		mg/kg TS	1	1	HABO
o,p'-DDE	<0.010		mg/kg TS	1	1	HABO
p,p'-DDE	<0.010		mg/kg TS	1	1	HABO
Monoklorbensen	<0.010		mg/kg TS	1	1	HABO
1,2-Diklorbensen	<0.020		mg/kg TS	1	1	HABO
1,4-Diklorbensen	<0.020		mg/kg TS	1	1	HABO
1,2,3-Triklorbensen	<0.010		mg/kg TS	1	1	HABO
1,2,4-Triklorbensen	<0.030		mg/kg TS	1	1	HABO
1,3,5-Triklorbensen	<0.010		mg/kg TS	1	1	HABO
1,2,3,5+1,2,4,5-Tetraklorbense	<0.020		mg/kg TS	1	1	HABO
Pentaklorbensen	<0.010		mg/kg TS	1	1	HABO
Heksaklorbensen	<0.0050		mg/kg TS	1	1	HABO

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Rapport

N1507677

Side 2 (16)

Y42X1DMI2G

Deres prøvenavn	J1 Soil					
Labnummer	N00368075					
Analyse	**Resultater**	**Usikkerhet (±)**	**Enhet**	**Metode**	**Utført**	**Sign**
Diklormetan	<0.060		mg/kg TS	1	1	HABO
Triklormetan (kloroform)	<0.020		mg/kg TS	1	1	HABO
Trikloreten	<0.010		mg/kg TS	1	1	HABO
Tetraklormetan	<0.010		mg/kg TS	1	1	HABO
Tetrakloreten	<0.010		mg/kg TS	1	1	HABO
1,2-Dikloretan	<0.0030		mg/kg TS	1	1	HABO
1,1,1-Trikloretan	<0.010		mg/kg TS	1	1	HABO
1,2-Dibrometan	<0.0040		mg/kg TS	1	1	HABO
1,1,2-Trikloretan	<0.010		mg/kg TS	1	1	HABO
Naftalen	<0.010		mg/kg TS	2	1	HABO
Acenaftylen	<0.010		mg/kg TS	2	1	HABO
Acenaften	**0.011**	0.003	mg/kg TS	2	1	HABO
Fluoren	<0.010		mg/kg TS	2	1	HABO
Fenantren	**0.049**	0.015	mg/kg TS	2	1	HABO
Antracen	<0.010		mg/kg TS	2	1	HABO
Fluoranten	**0.114**	0.034	mg/kg TS	2	1	HABO
Pyren	**0.094**	0.028	mg/kg TS	2	1	HABO
Benso(a)antracen^	**0.055**	0.016	mg/kg TS	2	1	HABO
Krysen^	**0.056**	0.017	mg/kg TS	2	1	HABO
Benso(b)fluoranten^	**0.092**	0.028	mg/kg TS	2	1	HABO
Benso(k)fluoranten^	**0.028**	0.008	mg/kg TS	2	1	HABO
Benso(a)pyren^	**0.052**	0.016	mg/kg TS	2	1	HABO
Dibenso(ah)antracen^	**0.012**	0.003	mg/kg TS	2	1	HABO
Benso(ghi)perylen	**0.049**	0.015	mg/kg TS	2	1	HABO
Indeno(123cd)pyren^	**0.051**	0.015	mg/kg TS	2	1	HABO
Sum PAH-16*	**0.66**		mg/kg TS	2	1	HABO
Bensen	<0.0050		mg/kg TS	2	1	HABO
Toluen	<0.10		mg/kg TS	2	1	HABO
Etylbensen	<0.020		mg/kg TS	2	1	HABO
Xylener	<0.0150		mg/kg TS	2	1	HABO
Sum BTEX*	**n.d.**		mg/kg TS	2	1	HABO
Fraksjon C5-C6	<7.0		mg/kg TS	2	1	HABO
Fraksjon >C6-C8	<7.0		mg/kg TS	2	1	HABO
Fraksjon >C8-C10	<10		mg/kg TS	2	1	HABO
Fraksjon >C10-C12	<2.0		mg/kg TS	2	1	HABO
Fraksjon >C12-C16	<3.0		mg/kg TS	2	1	HABO
Fraksjon >C16-C35	**53**	16	mg/kg TS	2	1	HABO
Sum >C12-C35*	**53.0**		mg/kg TS	2	1	HABO
2-Monoklorfenol	<0.020		mg/kg TS	2	1	HABO
3-Monoklorfenol	<0.020		mg/kg TS	2	1	HABO
4-Monoklorfenol	<0.020		mg/kg TS	2	1	HABO
2,3-Diklorfenol	<0.020		mg/kg TS	2	1	HABO
2,4+2,5-Diklorfenol	<0.040		mg/kg TS	2	1	HABO
2,6-Diklorfenol	<0.020		mg/kg TS	2	1	HABO
3,4-Diklorfenol	<0.020		mg/kg TS	2	1	HABO
3,5-Diklorfenol	<0.020		mg/kg TS	2	1	HABO
2,3,4-Triklorfenol	<0.020		mg/kg TS	2	1	HABO
2,3,5-Triklorfenol	<0.020		mg/kg TS	2	1	HABO
2,3,6-Triklorfenol	<0.020		mg/kg TS	2	1	HABO
2,4,5-Triklorfenol	<0.020		mg/kg TS	2	1	HABO
2,4,6-Triklorfenol	<0.020		mg/kg TS	2	1	HABO

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Rapport

N1507677

Side 3 (18)

Y42X1DMI2G

Deres prøvenavn	J1 Soil					
Labnummer	N00368075					
Analyse	**Resultater**	**Usikkerhet (±)**	**Enhet**	**Metode**	**Utført**	**Sign**
3,4,5-Triklorfenol	<0.020		mg/kg TS	2	1	HABO
2,3,4,5-Tetraklorfenol	<0.020		mg/kg TS	2	1	HABO
2,3,4,6-Tetraklorfenol	<0.020		mg/kg TS	2	1	HABO
2,3,5,6-Tetraklorfenol	<0.020		mg/kg TS	2	1	HABO
Pentaklorfenol	<0.006		mg/kg TS	2	1	HABO

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Rapport

N1507677

Side 4 (18)

Y42X1DMI2G

Deres prøvenavn J2
Soil

Labnummer N00368076

Analyse	Resultater	Usikkerhet (±)	Enhet	Metode	Utført	Sign
Tørrstoff (E)	88.9	5.37	%	1	1	HABO
As (Arsen)	1.92	0.38	mg/kg TS	1	1	HABO
Cd (Kadmium)	<0.10		mg/kg TS	1	1	HABO
Cr (Krom)	18.4	3.68	mg/kg TS	1	1	HABO
Cu (Kopper)	19.8	3.96	mg/kg TS	1	1	HABO
Hg (Kvikksølv)	<0.20		mg/kg TS	1	1	HABO
Ni (Nikkel)	16.5	3.3	mg/kg TS	1	1	HABO
Pb (Bly)	10.4	2.1	mg/kg TS	1	1	HABO
Zn (Sink)	96.0	19.2	mg/kg TS	1	1	HABO
Cr6+	0.220	0.045	mg/kg TS	1	1	HABO
Cyanid-fri	<0.10		mg/kg TS	1	1	HABO
PCB 28	<0.0030		mg/kg TS	1	1	HABO
PCB 52	<0.0030		mg/kg TS	1	1	HABO
PCB 101	<0.0030		mg/kg TS	1	1	HABO
PCB 118	<0.0030		mg/kg TS	1	1	HABO
PCB 138	<0.0030		mg/kg TS	1	1	HABO
PCB 153	<0.0030		mg/kg TS	1	1	HABO
PCB 180	<0.0030		mg/kg TS	1	1	HABO
Sum PCB-7*	n.d.		mg/kg TS	1	1	HABO
g-HCH (Lindan)	<0.0010		mg/kg TS	1	1	HABO
o,p'-DDT	<0.010		mg/kg TS	1	1	HABO
p,p'-DDT	<0.010		mg/kg TS	1	1	HABO
o,p'-DDD	<0.010		mg/kg TS	1	1	HABO
p,p'-DDD	<0.010		mg/kg TS	1	1	HABO
o,p'-DDE	<0.010		mg/kg TS	1	1	HABO
p,p'-DDE	<0.010		mg/kg TS	1	1	HABO
Monoklorbensen	<0.010		mg/kg TS	1	1	HABO
1,2-Diklorbensen	<0.020		mg/kg TS	1	1	HABO
1,4-Diklorbensen	<0.020		mg/kg TS	1	1	HABO
1,2,3-Triklorbensen	<0.010		mg/kg TS	1	1	HABO
1,2,4-Triklorbensen	<0.030		mg/kg TS	1	1	HABO
1,3,5-Triklorbensen	<0.010		mg/kg TS	1	1	HABO
1,2,3,5+1,2,4,5-Tetraklorbense	<0.020		mg/kg TS	1	1	HABO
Pentaklorbensen	<0.010		mg/kg TS	1	1	HABO
Heksaklorbensen	<0.0050		mg/kg TS	1	1	HABO
Diklormetan	<0.060		mg/kg TS	1	1	HABO
Triklormetan (kloroform)	<0.020		mg/kg TS	1	1	HABO
Trikloreten	<0.010		mg/kg TS	1	1	HABO
Tetraklormetan	<0.010		mg/kg TS	1	1	HABO
Tetrakloreten	<0.010		mg/kg TS	1	1	HABO
1,2-Dikloretan	<0.0030		mg/kg TS	1	1	HABO
1,1,1-Trikloretan	<0.010		mg/kg TS	1	1	HABO
1,2-Dibrometan	<0.0040		mg/kg TS	1	1	HABO
1,1,2-Trikloretan	<0.010		mg/kg TS	1	1	HABO
Naftalen	<0.010		mg/kg TS	2	1	HABO
Acenaftylen	<0.010		mg/kg TS	2	1	HABO
Acenaften	<0.010		mg/kg TS	2	1	HABO

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Rapport

Side 5 (18)

N1507677

Y42X1DMI2G

Deres prøvenavn	J2 Soil					
Labnummer	N00368076					
Analyse	**Resultater**	**Usikkerhet (±)**	**Enhet**	**Metode**	**Utført**	**Sign**
Fluoren	<0.010		mg/kg TS	2	1	HABO
Fenantren	<0.010		mg/kg TS	2	1	HABO
Antracen	<0.010		mg/kg TS	2	1	HABO
Fluoranten	0.037	0.011	mg/kg TS	2	1	HABO
Pyren	0.032	0.010	mg/kg TS	2	1	HABO
Benso(a)antracen^	0.023	0.007	mg/kg TS	2	1	HABO
Krysen^	0.026	0.008	mg/kg TS	2	1	HABO
Benso(b)fluoranten^	0.044	0.013	mg/kg TS	2	1	HABO
Benso(k)fluoranten^	0.015	0.005	mg/kg TS	2	1	HABO
Benso(a)pyren^	0.025	0.008	mg/kg TS	2	1	HABO
Dibenso(ah)antracen^	<0.010		mg/kg TS	2	1	HABO
Benso(ghi)perylen	0.023	0.007	mg/kg TS	2	1	HABO
Indeno(123cd)pyren^	0.024	0.007	mg/kg TS	2	1	HABO
Sum PAH-16*	0.25		mg/kg TS	2	1	HABO
Bensen	<0.0050		mg/kg TS	2	1	HABO
Toluen	<0.10		mg/kg TS	2	1	HABO
Etylbensen	<0.020		mg/kg TS	2	1	HABO
Xylener	<0.0150		mg/kg TS	2	1	HABO
Sum BTEX*	n.d.		mg/kg TS	2	1	HABO
Fraksjon C5-C6	<7.0		mg/kg TS	2	1	HABO
Fraksjon >C6-C8	<7.0		mg/kg TS	2	1	HABO
Fraksjon >C8-C10	<10		mg/kg TS	2	1	HABO
Fraksjon >C10-C12	<2.0		mg/kg TS	2	1	HABO
Fraksjon >C12-C16	<3.0		mg/kg TS	2	1	HABO
Fraksjon >C16-C35	30	9	mg/kg TS	2	1	HABO
Sum >C12-C35*	30.0		mg/kg TS	2	1	HABO
2-Monoklorfenol	<0.020		mg/kg TS	2	1	HABO
3-Monoklorfenol	<0.020		mg/kg TS	2	1	HABO
4-Monoklorfenol	<0.020		mg/kg TS	2	1	HABO
2,3-Diklorfenol	<0.020		mg/kg TS	2	1	HABO
2,4+2,5-Diklorfenol	<0.040		mg/kg TS	2	1	HABO
2,6-Diklorfenol	<0.020		mg/kg TS	2	1	HABO
3,4-Diklorfenol	<0.020		mg/kg TS	2	1	HABO
3,5-Diklorfenol	<0.020		mg/kg TS	2	1	HABO
2,3,4-Triklorfenol	<0.020		mg/kg TS	2	1	HABO
2,3,5-Triklorfenol	<0.020		mg/kg TS	2	1	HABO
2,3,6-Triklorfenol	<0.020		mg/kg TS	2	1	HABO
2,4,5-Triklorfenol	<0.020		mg/kg TS	2	1	HABO
2,4,6-Triklorfenol	<0.020		mg/kg TS	2	1	HABO
3,4,5-Triklorfenol	<0.020		mg/kg TS	2	1	HABO
2,3,4,5-Tetraklorfenol	<0.020		mg/kg TS	2	1	HABO
2,3,4,6-Tetraklorfenol	<0.020		mg/kg TS	2	1	HABO
2,3,5,6-Tetraklorfenol	<0.020		mg/kg TS	2	1	HABO
Pentaklorfenol	<0.006		mg/kg TS	2	1	HABO

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Rapport

Side 6 (18)

N1507677

Y42X1DMI2G

Deres prøvenavn	Raunes 2 Marine sediment					
Labnummer	N00368077					
Analyse	**Resultater**	**Usikkerhet (±)**	**Enhet**	**Metode**	**Utført**	**Sign**
Tørrstoff (E)	63.0	3.81	%	3	1	HABO
Vanninnhold	37.0	2.25	%	3	1	HABO
Kornstørrelse >63 µm	70.1	7.0	%	3	1	HABO
Kornstørrelse <2 µm	0.7	0.07	%	3	1	HABO
Kornfordeling	------------		se vedl.	3	1	HABO
TOC	1.16		% TS	3	1	HABO
Naftalen	<10		µg/kg TS	3	1	HABO
Acenaftylen	<10		µg/kg TS	3	1	HABO
Acenaften	<10		µg/kg TS	3	1	HABO
Fluoren	<10		µg/kg TS	3	1	HABO
Fenantren	74	22.3	µg/kg TS	3	1	HABO
Antracen	16	4.66	µg/kg TS	3	1	HABO
Fluoranten	122	36.6	µg/kg TS	3	1	HABO
Pyren	86	25.8	µg/kg TS	3	1	HABO
Benso(a)antracen^	41	12.3	µg/kg TS	3	1	HABO
Krysen^	48	14.3	µg/kg TS	3	1	HABO
Benso(b)fluoranten^	47	14.2	µg/kg TS	3	1	HABO
Benso(k)fluoranten^	27	8.07	µg/kg TS	3	1	HABO
Benso(a)pyren^	44	13.0	µg/kg TS	3	1	HABO
Dibenso(ah)antracen^	<10		µg/kg TS	3	1	HABO
Benso(ghi)perylen	39	11.7	µg/kg TS	3	1	HABO
Indeno(123cd)pyren^	35	10.6	µg/kg TS	3	1	HABO
Sum PAH-16*	580		µg/kg TS	3	1	HABO
Sum PAH carcinogene^*	240		µg/kg TS	3	1	HABO
PCB 28	<0.70		µg/kg TS	3	1	HABO
PCB 52	<0.70		µg/kg TS	3	1	HABO
PCB 101	<0.70		µg/kg TS	3	1	HABO
PCB 118	<0.70		µg/kg TS	3	1	HABO
PCB 138	<0.70		µg/kg TS	3	1	HABO
PCB 153	<0.70		µg/kg TS	3	1	HABO
PCB 180	<0.70		µg/kg TS	3	1	HABO
Sum PCB-7*	n.d.		µg/kg TS	3	1	HABO
As (Arsen)	3.28	0.66	mg/kg TS	3	1	JIBJ
Pb (Bly)	13.8	2.8	mg/kg TS	3	1	JIBJ
Cu (Kopper)	15.7	3.15	mg/kg TS	3	1	JIBJ
Cr (Krom)	14.0	2.79	mg/kg TS	3	1	JIBJ
Cd (Kadmium)	<0.10		mg/kg TS	3	1	JIBJ
Hg (Kvikksølv)	<0.20		mg/kg TS	3	1	JIBJ
Ni (Nikkel)	8.9	1.8	mg/kg TS	3	1	JIBJ
Zn (Sink)	75.8	15.2	mg/kg TS	3	1	JIBJ
Tørrstoff (G)	59.0		%	4	2	HABO
Monobutyltinnkation	5.1	0.66	µg/kg TS	4	2	HABO
Dibutyltinnkation	7.7	1.0	µg/kg TS	4	2	HABO
Tributyltinnkation	27	3.5	µg/kg TS	4	2	HABO
Tetrabutyltinnkation	<1.0		µg/kg TS	4	2	HABO
Monooktyltinnkation	<1.0		µg/kg TS	4	2	HABO
Dioktyltinnkation	<1.0		µg/kg TS	4	2	HABO
Trisykloheksyltinnkation	<1.0		µg/kg TS	4	2	HABO

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Rapport

N1507677

Side 7 (18)

Y42X1DMI2G

Deres prøvenavn	Raunes 2 Marine sediment					
Labnummer	N00368077					
Analyse	**Resultater**	**Usikkerhet (±)**	**Enhet**	**Metode**	**Utført**	**Sign**
Monofenyltinnkation	**<1.0**		µg/kg TS	4	2	HABO
Difenyltinnkation	**<1.0**		µg/kg TS	4	2	HABO
Trifenyltinnkation	**1.2**	0.16	µg/kg TS	4	2	HABO
Tørrstoff (E)	**63.0**	3.81	%	5	1	HABO
Ba (Barium)	**42.7**	8.55	mg/kg TS	5	1	HABO
Co (Kobolt)	**5.91**	1.18	mg/kg TS	5	1	HABO
Mo (Molybden)	**1.47**	0.29	mg/kg TS	5	1	HABO
P (Fosfor)	**613**	123	mg/kg TS	5	1	HABO
V (Vanadium)	**18.8**	3.76	mg/kg TS	5	1	HABO
Tørrstoff (G)	**59.0**		%	6	2	HABO
C1-naftalen*	**<0.050**		mg/kg TS	6	2	HABO
C2-naftalen*	**<0.050**		mg/kg TS	6	2	HABO
C3-naftalen*	**<0.050**		mg/kg TS	6	2	HABO
C1-fenantren/antracen*	**<0.050**		mg/kg TS	6	2	HABO
C2-fenantren/antracen*	**<0.050**		mg/kg TS	6	2	HABO
Dibensotiofen*	**<0.050**		mg/kg TS	6	2	HABO
C1-dibensotiofen*	**<0.050**		mg/kg TS	6	2	HABO
C2-dibensotiofen*	**<0.050**		mg/kg TS	6	2	HABO
C3-dibensotiofen*	**<0.050**		mg/kg TS	6	2	HABO
N-total	**933**	190	mg/kg TS	7	1	HABO

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Rapport

N1507677

Side 8 (18)

Y42X1DMI2G

Deres prøvenavn: **Raunes 3**
Marine sediment

Labnummer: N00368078

Analyse	Resultater	Usikkerhet (±)	Enhet	Metode	Utført	Sign
Tørrstoff (E)	58.3	3.53	%	3	1	HABO
Vanninnhold	41.7	2.53	%	3	1	HABO
Kornstørrelse >63 µm	79.2	7.9	%	3	1	HABO
Kornstørrelse <2 µm	0.6	0.06	%	3	1	HABO
Kornfordeling	-----------		se vedl.	3	1	HABO
TOC	0.539		% TS	3	1	HABO
Naftalen	<10		µg/kg TS	3	1	HABO
Acenaftylen	<10		µg/kg TS	3	1	HABO
Acenaften	<10		µg/kg TS	3	1	HABO
Fluoren	<10		µg/kg TS	3	1	HABO
Fenantren	<10		µg/kg TS	3	1	HABO
Antracen	<10		µg/kg TS	3	1	HABO
Fluoranten	<10		µg/kg TS	3	1	HABO
Pyren	<10		µg/kg TS	3	1	HABO
Benso(a)antracen^	<10		µg/kg TS	3	1	HABO
Krysen^	<10		µg/kg TS	3	1	HABO
Benso(b)fluoranten^	<10		µg/kg TS	3	1	HABO
Benso(k)fluoranten^	<10		µg/kg TS	3	1	HABO
Benso(a)pyren^	<10		µg/kg TS	3	1	HABO
Dibenso(ah)antracen^	<10		µg/kg TS	3	1	HABO
Benso(ghi)perylen	11	3.38	µg/kg TS	3	1	HABO
Indeno(123cd)pyren^	<10		µg/kg TS	3	1	HABO
Sum PAH-16*	11		µg/kg TS	3	1	HABO
Sum PAH carcinogene^*	n.d.		µg/kg TS	3	1	HABO
PCB 28	<0.70		µg/kg TS	3	1	HABO
PCB 52	<0.70		µg/kg TS	3	1	HABO
PCB 101	<0.70		µg/kg TS	3	1	HABO
PCB 118	<0.70		µg/kg TS	3	1	HABO
PCB 138	<0.70		µg/kg TS	3	1	HABO
PCB 153	<0.70		µg/kg TS	3	1	HABO
PCB 180	<0.70		µg/kg TS	3	1	HABO
Sum PCB-7*	n.d.		µg/kg TS	3	1	HABO
As (Arsen)	3.10	0.62	mg/kg TS	3	1	JIBJ
Pb (Bly)	11.3	2.3	mg/kg TS	3	1	JIBJ
Cu (Kopper)	14.6	2.92	mg/kg TS	3	1	JIBJ
Cr (Krom)	21.4	4.27	mg/kg TS	3	1	JIBJ
Cd (Kadmium)	<0.10		mg/kg TS	3	1	JIBJ
Hg (Kvikksølv)	<0.20		mg/kg TS	3	1	JIBJ
Ni (Nikkel)	10.3	2.1	mg/kg TS	3	1	JIBJ
Zn (Sink)	120	24.1	mg/kg TS	3	1	JIBJ
Tørrstoff (G)	68.1		%	4	2	HABO
Monobutyltinnkation	1.2	0.16	µg/kg TS	4	2	HABO
Dibutyltinnkation	1.4	0.18	µg/kg TS	4	2	HABO
Tributyltinnkation	1.4	0.18	µg/kg TS	4	2	HABO
Tetrabutyltinnkation	<1.0		µg/kg TS	4	2	HABO
Monooktyltinnkation	<1.0		µg/kg TS	4	2	HABO
Dioktyltinnkation	<1.0		µg/kg TS	4	2	HABO
Trisykloheksyltinnkation	<1.0		µg/kg TS	4	2	HABO

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Rapport

Side 9 (18)

N1507677

Y42X1DMI2G

Deres prøvenavn	Raunes 3 Marine sediment					
Labnummer	N00368078					
Analyse	**Resultater**	**Usikkerhet (±)**	**Enhet**	**Metode**	**Utført**	**Sign**
Monofenyltinnkation	**<1.0**		µg/kg TS	4	2	HABO
Difenyltinnkation	**<1.0**		µg/kg TS	4	2	HABO
Trifenyltinnkation	**<1.0**		µg/kg TS	4	2	HABO
Tørrstoff (E)	**68.3**	3.53	%	5	1	HABO
Ba (Barium)	**110**	22.0	mg/kg TS	5	1	HABO
Co (Kobolt)	**10.8**	2.16	mg/kg TS	5	1	HABO
Mo (Molybden)	**0.67**	0.13	mg/kg TS	5	1	HABO
P (Fosfor)	**669**	134	mg/kg TS	5	1	HABO
V (Vanadium)	**29.2**	5.83	mg/kg TS	5	1	HABO
Tørrstoff (G)	**68.1**		%	6	2	HABO
C1-naftalen*	**<0.050**		mg/kg TS	6	2	HABO
C2-naftalen*	**<0.050**		mg/kg TS	6	2	HABO
C3-naftalen*	**<0.050**		mg/kg TS	6	2	HABO
C1-fenantren/antracen*	**<0.050**		mg/kg TS	6	2	HABO
C2-fenantren/antracen*	**<0.050**		mg/kg TS	6	2	HABO
Dibensotiofen*	**<0.050**		mg/kg TS	6	2	HABO
C1-dibensotiofen*	**<0.050**		mg/kg TS	6	2	HABO
C2-dibensotiofen*	**<0.050**		mg/kg TS	6	2	HABO
C3-dibensotiofen*	**<0.050**		mg/kg TS	6	2	HABO
N-total	**787**	161	mg/kg TS	7	1	HABO

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Rapport

Side 10 (18)

N1507677

Y42X1DMI2G

Deres prøvenavn	**Vatsfjord Grønnevik St 4** **Marine sediment**					
Labnummer	N00368079					
Analyse	**Resultater**	**Usikkerhet (±)**	**Enhet**	**Metode**	**Utført**	**Sign**
Tørrstoff (E)	**85.2**	5.14	%	3	1	HABO
Vanninnhold	**14.8**	0.92	%	3	1	HABO
Kornstørrelse >63 µm	**62.9**	6.3	%	3	1	HABO
Kornstørrelse <2 µm	**1.0**	0.1	%	3	1	HABO
Kornfordeling	-----------		se vedl.	3	1	HABO
TOC	**0.648**		% TS	3	1	HABO
Naftalen	<10		µg/kg TS	3	1	HABO
Acenaftylen	<10		µg/kg TS	3	1	HABO
Acenaften	<10		µg/kg TS	3	1	HABO
Fluoren	<10		µg/kg TS	3	1	HABO
Fenantren	<10		µg/kg TS	3	1	HABO
Antracen	<10		µg/kg TS	3	1	HABO
Fluoranten	<10		µg/kg TS	3	1	HABO
Pyren	<10		µg/kg TS	3	1	HABO
Benso(a)antracen^	<10		µg/kg TS	3	1	HABO
Krysen^	<10		µg/kg TS	3	1	HABO
Benso(b)fluoranten^	<10		µg/kg TS	3	1	HABO
Benso(k)fluoranten^	<10		µg/kg TS	3	1	HABO
Benso(a)pyren^	<10		µg/kg TS	3	1	HABO
Dibenso(ah)antracen^	<10		µg/kg TS	3	1	HABO
Benso(ghi)perylen	**10**	3.02	µg/kg TS	3	1	HABO
Indeno(123cd)pyren^	<10		µg/kg TS	3	1	HABO
Sum PAH-16*	**10**		µg/kg TS	3	1	HABO
Sum PAH carcinogene^*	**n.d.**		µg/kg TS	3	1	HABO
PCB 28	<0.70		µg/kg TS	3	1	HABO
PCB 52	<0.70		µg/kg TS	3	1	HABO
PCB 101	<0.70		µg/kg TS	3	1	HABO
PCB 118	<0.70		µg/kg TS	3	1	HABO
PCB 138	<0.70		µg/kg TS	3	1	HABO
PCB 153	<0.70		µg/kg TS	3	1	HABO
PCB 180	<0.70		µg/kg TS	3	1	HABO
Sum PCB-7*	**n.d.**		µg/kg TS	3	1	HABO
As (Arsen)	**3.86**	0.77	mg/kg TS	3	1	JIBJ
Pb (Bly)	**13.2**	2.6	mg/kg TS	3	1	JIBJ
Cu (Kopper)	**16.6**	3.32	mg/kg TS	3	1	JIBJ
Cr (Krom)	**22.6**	4.53	mg/kg TS	3	1	JIBJ
Cd (Kadmium)	<0.10		mg/kg TS	3	1	JIBJ
Hg (Kvikksølv)	<0.20		mg/kg TS	3	1	JIBJ
Ni (Nikkel)	**11.3**	2.3	mg/kg TS	3	1	JIBJ
Zn (Sink)	**104**	20.9	mg/kg TS	3	1	JIBJ
Tørrstoff (G)	**70.5**		%	4	2	HABO
Monobutyltinnkation	**1.2**	0.16	µg/kg TS	4	2	HABO
Dibutyltinnkation	**1.2**	0.16	µg/kg TS	4	2	HABO
Tributyltinnkation	**1.0**	0.13	µg/kg TS	4	2	HABO
Tetrabutyltinnkation	<1.0		µg/kg TS	4	2	HABO
Monooktyltinnkation	<1.0		µg/kg TS	4	2	HABO
Dioktyltinnkation	<1.0		µg/kg TS	4	2	HABO
Trisykloheksyltinnkation	<1.0		µg/kg TS	4	2	HABO

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Rapport

N1507677

Side 11 (18)

Y42X1DMI2G

Deres prøvenavn	Vatsfjord Grønnevik St 4 Marine sediment					
Labnummer	N00368079					
Analyse	**Resultater**	**Usikkerhet (±)**	**Enhet**	**Metode**	**Utført**	**Sign**
Monofenyltinnkation	**<1.0**		µg/kg TS	4	2	HABO
Difenyltinnkation	**<1.0**		µg/kg TS	4	2	HABO
Trifenyltinnkation	**<1.0**		µg/kg TS	4	2	HABO
Tørrstoff (E)	**85.2**	5.14	%	5	1	HABO
Ba (Barium)	**121**	24.2	mg/kg TS	5	1	HABO
Co (Kobolt)	**11.8**	2.37	mg/kg TS	5	1	HABO
Mo (Molybden)	**0.87**	0.17	mg/kg TS	5	1	HABO
P (Fosfor)	**685**	137	mg/kg TS	5	1	HABO
V (Vanadium)	**32.3**	6.46	mg/kg TS	5	1	HABO
Tørrstoff (G)	**70.5**		%	6	2	HABO
C1-naftalen*	**<0.050**		mg/kg TS	6	2	HABO
C2-naftalen*	**<0.050**		mg/kg TS	6	2	HABO
C3-naftalen*	**<0.050**		mg/kg TS	6	2	HABO
C1-fenantren/antracen*	**<0.050**		mg/kg TS	6	2	HABO
C2-fenantren/antracen*	**<0.050**		mg/kg TS	6	2	HABO
Dibensotiofen*	**<0.050**		mg/kg TS	6	2	HABO
C1-dibensotiofen*	**<0.050**		mg/kg TS	6	2	HABO
C2-dibensotiofen*	**<0.050**		mg/kg TS	6	2	HABO
C3-dibensotiofen*	**<0.050**		mg/kg TS	6	2	HABO
N-total	**801**	164	mg/kg TS	7	1	HABO

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Rapport

Side 12 (18)

N1507677

Y42X1DMI2G

Deres prøvenavn	Vats 4 Marine sediment					
Labnummer	N00368080					
Analyse	**Resultater**	**Usikkerhet (±)**	**Enhet**	**Metode**	**Utført**	**Sign**
Tørrstoff (E)	70.3	4.25	%	3	1	HABO
Vanninnhold	29.7	1.81	%	3	1	HABO
Kornstørrelse >63 µm	80.6	8.1	%	3	1	HABO
Kornstørrelse <2 µm	0.6	0.06	%	3	1	HABO
Kornfordeling	----------		se vedl.	3	1	HABO
TOC	1.05		% TS	3	1	HABO
Naftalen	<10		µg/kg TS	3	1	HABO
Acenaftylen	<10		µg/kg TS	3	1	HABO
Acenaften	<10		µg/kg TS	3	1	HABO
Fluoren	<10		µg/kg TS	3	1	HABO
Fenantren	<10		µg/kg TS	3	1	HABO
Antracen	<10		µg/kg TS	3	1	HABO
Fluoranten	11	3.36	µg/kg TS	3	1	HABO
Pyren	10	3.13	µg/kg TS	3	1	HABO
Benso(a)antracen^	<10		µg/kg TS	3	1	HABO
Krysen^	<10		µg/kg TS	3	1	HABO
Benso(b)fluoranten^	10	3.13	µg/kg TS	3	1	HABO
Benso(k)fluoranten^	<10		µg/kg TS	3	1	HABO
Benso(a)pyren^	<10		µg/kg TS	3	1	HABO
Dibenso(ah)antracen^	<10		µg/kg TS	3	1	HABO
Benso(ghi)perylen	<10		µg/kg TS	3	1	HABO
Indeno(123cd)pyren^	<10		µg/kg TS	3	1	HABO
Sum PAH-16*	31		µg/kg TS	3	1	HABO
Sum PAH carcinogene^*	10		µg/kg TS	3	1	HABO
PCB 28	<0.70		µg/kg TS	3	1	HABO
PCB 52	<0.70		µg/kg TS	3	1	HABO
PCB 101	<0.70		µg/kg TS	3	1	HABO
PCB 118	<0.70		µg/kg TS	3	1	HABO
PCB 138	<0.70		µg/kg TS	3	1	HABO
PCB 153	<0.70		µg/kg TS	3	1	HABO
PCB 180	<0.70		µg/kg TS	3	1	HABO
Sum PCB-7*	n.d.		µg/kg TS	3	1	HABO
As (Arsen)	2.99	0.60	mg/kg TS	3	1	JIBJ
Pb (Bly)	10.3	2.0	mg/kg TS	3	1	JIBJ
Cu (Kopper)	14.8	2.97	mg/kg TS	3	1	JIBJ
Cr (Krom)	11.8	2.36	mg/kg TS	3	1	JIBJ
Cd (Kadmium)	<0.10		mg/kg TS	3	1	JIBJ
Hg (Kvikksølv)	<0.20		mg/kg TS	3	1	JIBJ
Ni (Nikkel)	8.1	1.6	mg/kg TS	3	1	JIBJ
Zn (Sink)	58.3	11.7	mg/kg TS	3	1	JIBJ
Tørrstoff (G)	71.9		%	4	2	HABO
Monobutyltinnkation	4.6	0.59	µg/kg TS	4	2	HABO
Dibutyltinnkation	8.7	1.1	µg/kg TS	4	2	HABO
Tributyltinnkation	40	5.2	µg/kg TS	4	2	HABO
Tetrabutyltinnkation	<1.0		µg/kg TS	4	2	HABO
Monooktyltinnkation	<1.0		µg/kg TS	4	2	HABO
Dioktyltinnkation	<1.0		µg/kg TS	4	2	HABO
Trisykloheksyltinnkation	<1.0		µg/kg TS	4	2	HABO

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Rapport

Side 13 (18)

N1507677

Y42X1DMI2G

Deres prøvenavn	**Vats 4** **Marine sediment**					
Labnummer	N00368080					
Analyse	**Resultater**	**Usikkerhet (±)**	**Enhet**	**Metode**	**Utført**	**Sign**
Monofenyltinnkation	**<1.0**		µg/kg TS	4	2	HABO
Difenyltinnkation	**<1.0**		µg/kg TS	4	2	HABO
Trifenyltinnkation	**<1.0**		µg/kg TS	4	2	HABO
Tørrstoff (E)	**70.3**	4.25	%	5	1	HABO
Ba (Barium)	**34.5**	6.91	mg/kg TS	5	1	HABO
Co (Kobolt)	**6.52**	1.30	mg/kg TS	5	1	HABO
Mo (Molybden)	**0.79**	0.16	mg/kg TS	5	1	HABO
P (Fosfor)	**644**	129	mg/kg TS	5	1	HABO
V (Vanadium)	**18.5**	3.70	mg/kg TS	5	1	HABO
Tørrstoff (G)	**71.9**		%	6	2	HABO
C1-naftalen*	**<0.050**		mg/kg TS	6	2	HABO
C2-naftalen*	**<0.050**		mg/kg TS	6	2	HABO
C3-naftalen*	**<0.050**		mg/kg TS	6	2	HABO
C1-fenantren/antracen*	**<0.050**		mg/kg TS	6	2	HABO
C2-fenantren/antracen*	**<0.050**		mg/kg TS	6	2	HABO
Dibensotiofen*	**<0.050**		mg/kg TS	6	2	HABO
C1-dibensotiofen*	**<0.050**		mg/kg TS	6	2	HABO
C2-dibensotiofen*	**<0.050**		mg/kg TS	6	2	HABO
C3-dibensotiofen*	**<0.050**		mg/kg TS	6	2	HABO
N-total	**680**	136	mg/kg TS	7	1	HABO

Deres prøvenavn	**Vats 1** **Marine sediment**					
Labnummer	N00368081					
Analyse	**Resultater**	**Usikkerhet (±)**	**Enhet**	**Metode**	**Utført**	**Sign**
Tørrstoff (E)	**76.0**	4.59	%	5	1	HABO
Hg (Kvikksølv)	**<0.20**		mg/kg TS	5	1	HABO

Deres prøvenavn	**Vats 2** **Marine sediment**					
Labnummer	N00368082					
Analyse	**Resultater**	**Usikkerhet (±)**	**Enhet**	**Metode**	**Utført**	**Sign**
Tørrstoff (E)	**72.5**	4.38	%	5	1	HABO
Hg (Kvikksølv)	**<0.20**		mg/kg TS	5	1	HABO

Deres prøvenavn	**Vats 3** **Marine sediment**					
Labnummer	N00368083					
Analyse	**Resultater**	**Usikkerhet (±)**	**Enhet**	**Metode**	**Utført**	**Sign**
Tørrstoff (E)	**72.2**	4.36	%	5	1	HABO
Hg (Kvikksølv)	**<0.20**		mg/kg TS	5	1	HABO

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Side 14 (18)

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* etter parameternavn indikerer uakkreditert analyse.
n.d. betyr ikke påvist.
n/a betyr ikke analyserbart.
< betyr mindre enn.
> betyr større enn.

	Metodespesifikasjon		
1	**Bestemmelse av Normpakke, normverdier for følsom arealbruk, del 1 (2).**		
	Metode:	Metaller:	ISO 11885, EPA 200.7, EPA 6010, SM 3120
		Tørrstoff:	ISO 11465
		Cr6+:	EN 15192, EPA 3060A
		Cyanid-fri:	ISO 6703-2
		PCB-7:	EPA 8082, ISO 10382
		Klorpesticider:	EPA 8081
		Klorbensener:	ISO 15009, EPA 8260, EPA 5021A, EPA 5021, EPA 8015, MADEP 2004, rev.1.1.
		Klorerte løsemidler:	ISO 15009, EPA 8260, EPA 5021A, EPA 5021, EPA 8015, MADEP 2004, rev.1.1.
	Måleprinsipp:	Metaller:	ICP-AES
		Cr6+:	IC-SPC
		Cyanid-fri:	Spektrofotometri
		PCB-7:	GC-ECD
		Klorpesticider:	GC-ECD
		Klorbensener:	GC-FID/MS
		Klorerte løsemidler:	GC-FID/MS
	Rapporteringsgrenser:	Metaller:	0,10-5,0 mg/kg TS
		Cr6+:	0,060 mg/kg TS
		Cyanid-fri:	0,10 mg/kg TS
		PCB-7:	0,0030 mg/kg TS
		Klorpesticider:	0,010 mg/kg TS
		g-HCH (Lindan):	0,0010 mg/kg TS
		Klorbensener:	0,010-0,030 mg/kg TS
		Heksaklorbensen:	0,0050 mg/kg TS
		Klorerte løsemidler:	0,0030-0,060 mg/kg TS
	Relativ måleusikkerhet:	Metaller:	20 %
		Tørrstoff:	10 %
		Cr6+:	20 %
		Cyanid-fri:	40 %
		PCB-7:	40 %
		Klorpesticider:	40 %
		Klorbensener:	40 %
		Klorerte løsemidler:	40 %
	Note:	Resultater rapportert som < betyr ikke påvist	
2	**Bestemmelse av Normpakke, normverdier for følsom arealbruk, del 2 (2).**		
	Metode:	PAH:	EPA 8270, ISO 18287
		BTEX:	ISO 15009, EPA 8260, EPA 5021A, EPA 5021, EPA 8015, MADEP 2004 rev. 1.1
		Klorfenoler:	ISO 14154, EPA 8041, EPA 3500
		Hydrokarboner:	
		>C5-C10	ISO 15009, EPA 8260, EPA 8015, RBCA Petroleum Hydrocarbon Methods
		>C10-C35	EN 14039

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Side 15 (18)

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	Metodespesifikasjon		
	Måleprinsipp:	PAH:	GC-MS
		BTEX:	GC-FID/MS
		Klorfenoler:	GC-MS/ECD
		Hydrokarboner:	
		>C5-C10	GC-FID/ECD
		>C10-C35	GC-FID
	Rapporteringsgrenser:	PAH-16:	0,010 mg/kg TS
		Benzen:	0,0050 mg/kg TS
		BTEX:	0,01-0,10 mg/kg TS
		Klorfenoler:	0,020 mg/kg TS
		Pentaklorfenol:	0,006 mg/kg TS
		C5-C6:	7,0 mg/kg TS
		>C6-C8:	7,0 mg/kg TS
		>C8-C10:	10 mg/kg TS
		>C10-C12:	2,0 mg/kg TS
		>C12-C16:	3,0 mg/kg TS
		>C16-C35:	10 mg/kg TS
	Måleusikkerhet:	PAH:	relativ usikkerhet 30 %
		BTEX:	relativ usikkerhet 40 %
		Klorfenoler:	relativ usikkerhet 25 %
		>C5-C10	relativ usikkerhet 40 %
		>C10-C35	relativ usikkerhet 30 %
	Note:	Resultater rapportert som < betyr ikke påvist	
3	**«Sediment basispakke»**	**Risikovurdering av sediment**	

Bestemmelse av vanninnhold og tørrstoff

Metode:	ISO 11465
Måleprinsipp:	Tørrstoff bestemmes gravimetrisk og vanninnhold beregnes utfra målte verdier.
Rapporteringsgrense:	0,10 %
Måleusikkerhet:	5 %

Bestemmelse av Kornfordeling (<63 µm, >63 µm og <2 µm)

Metode:	ISO 11277:2009
Måleprinsipp:	Laserdiffraksjon
Rapporteringsgrense:	0,10 %

Bestemmelse av TOC

Metode:	ISO 10694, EN 13137, EN 15936
Måleprinsipp:	Coulometrisk bestemmelse
Rapporteringsgrense:	0,010 %TS

Bestemmelse av polysykliske aromatiske hydrokarboner, PAH-16

Metode:	EPA 429, EPA 1668, EPA 3550
Måleprinsipp:	GC/MSD
Rapporteringsgrenser:	10 µg/kg TS
Måleusikkerhet:	30 %

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Side 16 (18)

N1507677

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	Metodespesifikasjon
	Bestemmelse av polyklorerte bifenyler, PCB-7 Metode: EPA 429, EPA 1668, EPA 3550 Måleprinsipp: GC/MSD Rapporteringsgrenser: 0,7 µg/kg TS Måleusikkerhet: 30 % **Bestemmelse av metaller, M-1C** Metode: EPA 200.7, ISO 11885, EPA 6010, SM 3120 Måleprinsipp: ICP-AES Rapporteringsgrenser: As(0.50), Cd(0.10), Cr(0.25), Cu(0.10), Pb(1.0), Hg(0.20), Ni(5.0), Zn(1.0) alle enheter i mg/kg TS Måleusikkerhet: 20 %
4	Bestemmelse av tinnorganiske forbindelser. Metode: DIN ISO 23161 Ekstraksjon: KOH/Heksan Rensing: Alumina Derivatisering: Na tetraetyl borat (NaBEt4) Deteksjon og kvantifisering: GC-FPD Kvantifikasjonsgrenser: 1 µg/kg TS Usikkerhet (2*RSD): 13 - 15% (basert på gjentatte analyser av kontrollprøve)
5	Analyse av tungmetaller (M-1C) (enkelt elementer) Metode: EPA metoder 200.7, ISO 11885 Forbehandling: Sikting 2 mm. Oppslutning jordprøver: HNO3 og 0,5 ml H2O2 i mikrobølgeovn. Oppslutning slam- og sedimentprøver: HNO3/vann (1:1) i mikrobølgeovn.
6	Bestemmelse av PAH-16 og C1-C3 alkylhomologer (NPD). Metode: GC/MSD Ekstraksjon: Sykloheksan Deteksjon og kvantifisering: GC/MSD Note: NPD er ikke akkreditert. Det finnes ikke standarder for alle alkylerte homologer av naftalen, fenantren, antracen og dibenzothiofen. NPD er derfor bestemt ved analysere de NPD standarder som er tilgjengelige og søke etter de karakteristiske massene i de forskjellige NPD gruppene. Alle forbindelser ble således identifisert ved hjelp av fire karakteristiske masser og kvantifisert gjennom en karakteristisk masse (target ion) ved en bestemt retensjonstid i hver gruppe. Følgende grupper og forbindelser er med i analysen: C1-Naftalener: 1-metylnaftalen og 2-metylnaftalen C2-Naftalener: 1-etylnaftalen, 2-etylnaftalen, dimetylnaftalen (5 av 12 mulige homologer var tilgjengelige som standard. Kvantifisering av forbindelser med karakteristisk masse 156 og retensjonstid 2,2 minutter). C3-Naftalener: kun metylerte forbindelser. Ingen etyl- eller propylstandarder tilgjengelige. 2,3,5-trimetylnaftalen benyttet som standard. Kvantifisering av forbindelser med karakteristisk masse 128 og retensjonstid 2 min.

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N1507677

Side 17 (18)

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	Metodespesifikasjon
	Fenantren, antracen og alkylerte homologer kan ikke skilles kvalitativt i massespektumet og er derfor slått sammen i en gruppe. Følgende inndeling av gruppen er utført: C1-fenantren/antracen: 1-metylantracen tilgjengelig som standard. Kvantifisering av forbindelser med karakteristisk masse 192, retensjonstid 1 minutt. C2-fenantren/antracen: kun metylerte forbindelser(9,10-dimetylnaftalen) som standarder, ingen etylstandarder tilgjengelig. Kvantifisering av forbindelser med karakteristisk masse 192 og retensjonstid 1,5 minutter. C1-dibensotiofen: 1- og 3-metyldibensotiofen tilgjengelig som standarder. Kvantifisering av forbindelser med karakteristisk masse 198 og retensjonstid 0,65 minutter. C2-dibensotiofen: 4-etyldibensotiofen og 3,6-dimetyldibensotiofen tilgjengelig som standarder. Kvantifisering av forbindelser med karakteristisk masse 212 og retensjonstid 1 minutter. C3-dibensotiofen: 4-propyldibensotiofen og 2,4,7-trimetyldibensotiofen tilgjengelig som standarder. Kvantifisering av forbindelser med karakteristisk masse 226 og retensjonstid 2,1 minutter.
7	**Bestemmelse av total Nitrogen i jord** Metode: ISO 11261 Måleprinsipp: Spektrofotometri Rapporteringsgrenser: LOR 50 mg/kg TS Andre opplysninger: Modifisert Kjeldahl-metode

	Godkjenner
HABO	Hanne Boklund
JIBJ	Jan Inge Bjørnengen

	Underleverandør[1]
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2	Ansvarlig laboratorium: GBA, Flensburger Straße 15, 25421 Pinneberg, Tyskland Lokalisering av andre GBA laboratorier: Hildesheim — Daimlerring 37, 31135 Hildesheim Gelsenkirchen — Wiedehopfstraße 30, 45892 Gelsenkirchen Freiberg — Meißner Ring 3, 09599 Freiberg Hameln: — Brekelbaumstraße 1, 31789 Hameln Hamburg: — Goldschmidstraße 5, 21073 Hamburg Akkreditering: — DAkks, registreringsnr. D-PL-14170-01-00 Kontakt ALS Laboratory Group Norge, for ytterligere informasjon

[1] Utførende teknisk enhet (innen ALS Laboratory Group) eller eksternt laboratorium (underleverandør).

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Side 18 (18)

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Måleusikkerheten angis som en utvidet måleusikkerhet (etter definisjon i "Evaluation of measurement data – Guide to the expression of uncertainty in measurement", JCGM 100:2008 Corrected version 2010) beregnet med en dekningsfaktor på 2 noe som gir et konfidensinterval på om lag 95%.

Måleusikkerhet fra underleverandører angis ofte som en utvidet usikkerhet beregnet med dekningsfaktor 2. For ytterligere informasjon, kontakt laboratoriet.

Denne rapporten får kun gjengis i sin helhet, om ikke utførende laboratorium på forhånd har skriftlig godkjent annet.

Angående laboratoriets ansvar i forbindelse med oppdrag, se aktuell produktkatalog eller vår webside www.alsglobal.no

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5.4 Appendix 4: Analysis report of groundwater samples in 2015

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ANALYSERAPPORT

RapportID: 367

Kommentar til analyseoppdraget:
Denne versjonen erstatter tidligere versjon(er). Vennligst makuler tidligere versjon(er).

Analyseoppdrag: 116-660
Versjon: 2
Dato: 26.05.2015

Prøvenr.: NR-2015-03274
Prøvetype: FERSKVANN
Prøvemerking: W1 27.04.15
Kommentar:

Prøvetakningsdato: 27.04.2015
Prøve mottatt dato: 04.05.2015
Analyseperiode: 05.05.2015 - 21.05.2015

Analysevariabel	Metode	Resultat	Enhet	MU	LOQ	Underlev.
Kond_Temp	NS ISO 7888:1993	**23,6**	°C			
Konduktivitet	NS ISO 7888:1993	**3279**	mS/m	20%	100,0	
Kvikksølv	NS-EN ISO 12846	**0,003**	µg/l	40%	0,001	Eurofins a)
Bly	NS-EN ISO 17294	**0,1**	µg/l	20%	0,005	
Jern	NS-EN ISO 17294	**59**	µg/l	20%	0,30	
Kadmium	NS-EN ISO 17294	**<0,060**	µg/l		0,0030	
Totalt organisk karbon	NS-EN ISO 1484;1:1997	**2,2**	mg C/l	20%		
pH	NS-EN ISO 10523:2012	**7,65**	pH units	±0,2	3,5	
pH_Temp	NS-EN ISO 10523:2012	**23,2**	°C			
STS	NS-EN ISO 4733;1983 NS-EN ISO 872:2005	**3,6**	mg/l	20%		
>C10-C12	Intern metode (EKSTERN_EF)	**<5,0**	µg/l		5	Eurofins c)
>C12-C16	Intern metode (EKSTERN_EF)	**<5,0**	µg/l		5	Eurofins c)
>C16-C35	Intern metode (EKSTERN_EF)	**<20**	µg/l		20	Eurofins c)
>C5-C8	Intern metode (EKSTERN_EF)	**<5,0**	µg/l		5	Eurofins c)
>C8-C10	Intern metode (EKSTERN_EF)	**<5,0**	µg/l		5	Eurofins c)
Sum THC (>C5-C35)	Intern metode (EKSTERN_EF)	**nd**	µg/l			Eurofins c)
Turbiditet	NS-EN ISO 7027:2000	**0,31**	FNU	32%	0,3	

a) Eurofins Environment Testing Norway AS, NS/EN ISO/IEC 17025:2005 NA TEST 003
c) Eurofins Environment Testing Sweden AB, ISO/IEC 17025 SWEDAC 1125

Prøvenr.: NR-2015-03275
Prøvetype: FERSKVANN
Prøvemerking: W2 27.04.15
Kommentar:

Prøvetakningsdato: 27.05.2015
Prøve mottatt dato: 04.05.2015
Analyseperiode: 05.05.2015 - 21.05.2015

Analysevariabel	Metode	Resultat	Enhet	MU	LOQ	Underlev.
Kond_Temp	NS ISO 7888:1993	**23,6**	°C			
Konduktivitet	NS ISO 7888:1993	**545**	mS/m	20%	10,0	
Kvikksølv	NS-EN ISO 12846	**0,002**	µg/l	40%	0,001	Eurofins a)
Bly	NS-EN ISO 17294	**0,16**	µg/l	20%	0,005	
Jern	NS-EN ISO 17294	**130**	µg/l	20%	0,30	
Kadmium	NS-EN ISO 17294	**<0,030**	µg/l		0,0030	
Totalt organisk karbon	NS-EN ISO 1484;1:1997	**0,76**	mg C/l	20%		
pH	NS-EN ISO 10523:2012	**7,88**	pH units	±0,2	3,5	
pH_Temp	NS-EN ISO 10523:2012	**23,2**	°C			
STS	NS-EN ISO 4733;1983 NS-EN ISO 872:2005	**1,6**	mg/l	20%		
>C10-C12	Intern metode (EKSTERN_EF)	**<5,0**	µg/l		5	Eurofins c)

Tegnforklaring:
* : Ikke omfattet av akkrediteringen
<: Mindre enn, >: Større enn, MU: Måleusikkerhet, LOQ: Kvantifiseringsgrense
Analyserapporten må kun gjengis i sin helhet og uten noen form for endringer. Analyseresultatet gjelder kun for den prøven som er testet.

Side 1 av 3

Prøvenr.:	NR-2015-03275	Prøvetakningsdato:	27.05.2015
Prøvetype:	FERSKVANN	Prøve mottatt dato:	04.05.2015
Prøvemerking:	W2 27.04.15	Analyseperiode:	05.05.2015 - 21.05.2015
Kommentar:			

Analysevariabel	Metode	Resultat	Enhet	MU	LOQ	Underlev.
>C12-C16	Intern metode (EKSTERN_EF)	<5,0	µg/l		5	Eurofins c)
>C16-C35	Intern metode (EKSTERN_EF)	<20	µg/l		20	Eurofins c)
>C5-C8	Intern metode (EKSTERN_EF)	<5,0	µg/l		5	Eurofins c)
>C8-C10	Intern metode (EKSTERN_EF)	<5,0	µg/l		5	Eurofins c)
Sum THC (>C5-C35)	Intern metode (EKSTERN_EF)	nd	µg/l			Eurofins c)
Turbiditet	NS-EN ISO 7027:2000	0,69	FNU	20%	0,3	

a) Eurofins Environment Testing Norway AS, NS/EN ISO/IEC 17025:2005 NA TEST 003
c) Eurofins Environment Testing Sweden AB, ISO/IEC 17025 SWEDAC 1125

Prøvenr.:	NR-2015-03276	Prøvetakningsdato:	27.05.2015
Prøvetype:	FERSKVANN	Prøve mottatt dato:	04.05.2015
Prøvemerking:	W3 27.04.15	Analyseperiode:	05.05.2015 - 21.05.2015
Kommentar:			

Analysevariabel	Metode	Resultat	Enhet	MU	LOQ	Underlev.
Kond_Temp	NS ISO 7888:1993	23,6	°C			
Konduktivitet	NS ISO 7888:1993	946	mS/m	20%	10,0	
Kvikksølv	NS-EN ISO 12846	0,002	µg/l	40%	0,001	Eurofins a)
Bly	NS-EN ISO 17294	0,45	µg/l	20%	0,005	
Jern	NS-EN ISO 17294	289	µg/l	20%	0,30	
Kadmium	NS-EN ISO 17294	0,080	µg/l	20%	0,0030	
Totalt organisk karbon	NS-EN ISO 1484,1:1997	1,0	mg C/l	20%		
pH	NS-EN ISO 10523:2012	7,78	pH units	±0,2	3,5	
pH_Temp	NS-EN ISO 10523:2012	23,2	°C			
STS	NS-EN ISO 4733,1983 NS-EN ISO 872:2005	6,8	mg/l	20%		
>C10-C12	Intern metode (EKSTERN_EF)	<5,0	µg/l		5	Eurofins c)
>C12-C16	Intern metode (EKSTERN_EF)	<5,0	µg/l		5	Eurofins c)
>C16-C35	Intern metode (EKSTERN_EF)	<20	µg/l		20	Eurofins c)
>C5-C8	Intern metode (EKSTERN_EF)	<5,0	µg/l		5	Eurofins c)
>C8-C10	Intern metode (EKSTERN_EF)	<5,0	µg/l		5	Eurofins c)
Sum THC (>C5-C35)	Intern metode (EKSTERN_EF)	nd	µg/l			Eurofins c)
Turbiditet	NS-EN ISO 7027:2000	1,0	FNU	20%	0,3	

a) Eurofins Environment Testing Norway AS, NS/EN ISO/IEC 17025:2005 NA TEST 003
c) Eurofins Environment Testing Sweden AB, ISO/IEC 17025 SWEDAC 1125

Prøvenr.:	NR-2015-03277	Prøvetakningsdato:	27.05.2015
Prøvetype:	FERSKVANN	Prøve mottatt dato:	04.05.2015
Prøvemerking:	W4 27.04.15	Analyseperiode:	05.05.2015 - 21.05.2015
Kommentar:			

Analysevariabel	Metode	Resultat	Enhet	MU	LOQ	Underlev.
Kond_Temp	NS ISO 7888:1993	23,6	°C			
Konduktivitet	NS ISO 7888:1993	248	mS/m	20%	10,0	
Kvikksølv	NS-EN ISO 12846	0,004	µg/l	40%	0,001	Eurofins a)
Bly	NS-EN ISO 17294	0,23	µg/l	20%	0,005	
Jern	NS-EN ISO 17294	177	µg/l	20%	0,30	
Kadmium	NS-EN ISO 17294	<0,030	µg/l		0,0030	
Totalt organisk karbon	NS-EN ISO 1484,1:1997	1,3	mg C/l	20%		
pH	NS-EN ISO 10523:2012	7,86	pH units	±0,2	3,5	
pH_Temp	NS-EN ISO 10523:2012	23,2	°C			

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Prøvenr.:	NR-2015-03277	Prøvetakningsdato:	27.05.2015
Prøvetype:	FERSKVANN	Prøve mottatt dato:	04.05.2015
Prøvemerking:	W4 27.04.15	Analyseperiode:	05.05.2015 - 21.05.2015
Kommentar:			

Analysevariabel	Metode	Resultat	Enhet	MU	LOQ	Underlev
STS	NS-EN ISO 4733;1983 NS-EN ISO 872:2005	2,8	mg/l	20%		
>C10-C12	Intern metode (EKSTERN_EF)	<5,0	µg/l		5	Eurofins c)
>C12-C16	Intern metode (EKSTERN_EF)	<5,0	µg/l		5	Eurofins c)
>C16-C35	Intern metode (EKSTERN_EF)	<20	µg/l		20	Eurofins c)
>C5-C8	Intern metode (EKSTERN_EF)	<5,0	µg/l		5	Eurofins c)
>C8-C10	Intern metode (EKSTERN_EF)	<5,0	µg/l		5	Eurofins c)
Sum THC (>C5-C35)	Intern metode (EKSTERN_EF)	nd	µg/l			Eurofins c)
Turbiditet	NS-EN ISO 7027:2000	0,83	FNU	20%	0,3	

a) Eurofins Environment Testing Norway AS, NS/EN ISO/IEC 17025:2005 NA TEST 003
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5.5 Appendix 5: Comments and corrections of report

Paragraph / Section	Client Comments	Implemented Y /N	Feedback from NIVA with description of corrections (when appropriate)
General	Page numbers only inserted on some pages, insert page numbers.	Y	
Preface	Describe how NIVA was involved in program, sampling and analysis.	Y	
Abstract / summary	"..PAH levels largely in class II". Table 7 show one station with PAH 16 in class 2, three stations in class 1. Recommend to review statement.	Y	These statements in abstract and summary are now amended and made more precise. Necessary similar amendments are also implemented in section 2.4.1.
Abstract / summary	"The soil survey revealed that the ultimate vicinity of AFEBV has become more contaminated with PAHs and metals". Propose to change to what is stated in the Norwegian summary which is more specific to the limited area investigated.	Y	Both the English and Norwegian summaries are reviewed to make the description more precise.
Summary / sammendrag	The english and norwegian summaries are not the same. e.g "den totale mengden av gjenstander hadde gått ned noe I 2015 I forhold til 2009 som følge av opprydding». This text is not existent in the english summary. Summary: PAH levels were largely class II, vs Sammendrag …PAH 16 som viste klasse 2 på en av stajsonene I Raunesvika. These are two examples. Propose NIVA to review whole summary/sammendrag and make them consistent.	Y	Both the English and Norwegian summary are reviewed and made as equal as possible.
English and Norw. summary	We recommend NIVA to include an overall summary of the state of the impact from 2009-2015 e.g as described in first paragraph in section 3.	N	It is NIVAs opinion that the first paragraph in section 3 should not be read isolated from the other paragraphs in section 3.
Summary / Sammendrag	It is indirectly concluded that contamination in J1 and J2 stems from air born pollutants (dust), whereas in 2012 NIVA report the source is not identified. As the levels of contamination are so different in J1 and J2 (in close proximity), it is questioned whether this can be concluded upon or if it is a possible cause. Leakages from seals in wall has been discussed in earlier reports. It is also questioned whether the soil sampled is virgin soil, hence this may also be an uncertainty with regard to earth quality. COWI also found elevated levels of Hg in 2009 near the wall which indicate that the soil was already contaminated before 2009.	Y	NIVA agree that the present soil data are too weak for concluding firmly on airborne dust from AFEBV being the cause/source of increased contamination at J1 and J2. However, the source question is considered as relevant for the study issue and is therefore commented on in the discussion part (section 3) but it is not critically necessary for the summary and therefore it is excluded from that part of the report.

Paragraph / Section	Client Comments	Implemented Y /N	Feedback from NIVA with description of corrections (when appropriate)
Sammendrag	"…vist at det foregikk en spreding av forurensning, spesielt kvikksølv, fra området like etter oppstart i 2009'' Comment, Hg has been focused, but Zn and other HM was also detected in higher concentrations in moss than Hg. Propose to delete "spesielt kvikksølv" or change to "metals and heavy metals" as only metals were analysed in moss.	Y/N	As both summary sections are read now this issue is better described. NIVA sees it as correct to keep a specific attention to the Hg data of the soil analyses.
Sammendrag / Summary	4th paragraph (English), 5 th paragraph Norwegian, we recommend that magnitude of exceedance of norm classes ref, TA 2553 are used instead of order of magnitude of 2009 concentrations because this will give the reader a better understanding of contamination levels (tilstandsklasser).	Y	TA-2553 interpretation is now included in the summaries, and also for table 4 in section 2.3.1.
Introduction	Provide information about which demolition projects that were performed simultaneously with EPRD (2009-2015) at AFEBV (Kitty Wake, Statoil Loading Buoy, H7).	Y	
1.2	Recommend to include that process water from decontamination of steel is also treated in the water treatment system (not only rain water).	Y	
2.1	Include info on positioning equipment and state uncertainty in positioning which was more elaborated on in 2009 report.	Y	This uncertainty issue is now discussed better and the web-link to the technical specification sheet for the ROV is included.
2.1	Based on the description of uncertainty in the positioning mentioned in the 2009 report, it is questioned whether the markings on the figures 2009, 2012 and 2015 are comparable regarding exact location. A plot with all three years surveys in it is only confusing if findings are the same but with different/wrong positions. If debris detected in 2009 and 2012 no longer present this should be clarified. Are all the green dots new debris, or may it be debris recorded with somewhat different position in 2009/2012? Numbers should also be inserted on object findings in figs 8 and 9 as in 2009 report as a means to be able to locate findings in map and compare findings.	Y	The ROV part is somewhat expanded and is now generally clearer described.
2.1	Table 2, for comparison the latitude and longitude should be given as Northing and Easting as done in the 2009 report.	Y	

Paragraph / Section	Client Comments	Implemented Y /N	Feedback from NIVA with description of corrections (when appropriate)
2.3	Check if the soil sampled is "natural soil" or if it has been moved to this location (check with AFD uncertainty whether this is virgin soil).	Y	An informative discussion of the virgin soil issue is included in the soil data discussion in section 3.
Table 4	We question why TA 2553-2009 Tilstandsklasser for forurenset grunn has not been used to define results into the norm classes (tilstandsklasser), instead of using magnitudes of absolute concentrations in the illustration.	Y	
Table 7	NOTED: It is noted that the reporting limit for Hg is considerably higher in 2015 than in 2009, and hence do not show smaller variations. Levels below detection limit and class 1 are not consistently colored blue (only some fields).	Y (partly)	In the cases when a PAH is measured under the detection limit (<10 ug/kg dw): the PAH is classified to blue color (class I) as long as the upper threshold value for class I for this PAH is larger than 10 ug/kg. In cases when the measured PAHs have upper threshold value for class I being less than 10 ug/kg, the data are left unclassified.
3	Ref. soil survey: "The soil contamination survey clearly revealed that the ultimate vicinity of AFEBV has become moderately contaminated…..Same comment as for abstract/summary ref. ultimate vicinity of AFEVB. Propose to change to what is stated in the Norwegian summary which is more specific to the limited area investigated (not the whole vicinity).	Y	All text referring to soil contamination is now revised so the different parts of the report are comparable.
3	Paragraph 5, "The soil contamination survey clearly revealed that the ultimate vicinity of AFEBV has become moderately contaminated with PAHs and metals in the period 2009-2015". When comparing concentration of sum PAH_{16} to TA 2553 the condition is "very good", two classes apart from moderate. For metals only Hg is moderate one sample in J1. Recommend to review statement.	Y	The data are now more thoroughly discussed and better linked to TA-2553 classification.

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