REPORT SNO 5915-2010

AFD2-D-GEN-EG-0001 Environmental Baseline Survey Report Ekofisk Cessation EPRD Project

Norwegian Institute for Water Research
– an institute in the Environmental Research Alliance of Norway

REPORT

Main Office
Gaustadalléen 21
NO-0349 Oslo, Norway
Phone (47) 22 18 51 00
Telefax (47) 22 18 52 00
Internet: www.niva.no

Regional Office, Sørlandet
Televeien 3
NO-4879 Grimstad, Norway
Phone (47) 22 18 51 00
Telefax (47) 37 04 45 13

Regional Office, Østlandet
Sandvikaveien 41
NO-2312 Ottestad, Norway
Phone (47) 22 18 51 00
Telefax (47) 62 57 66 53

Regional Office, Vestlandet
Thormøhlens gate 53 D
NO-5006 Bergen Norway
Phone (47) 22 18 51 00
Telefax (47) 55 31 22 14

Regional Office Central
Pirsenteret, Havnegata 9
P.O.Box 1266
NO-7462 Trondheim
Phone (47) 22 18 51 00
Telefax (47) 73 54 63 87

Title	Serial No.	01.02.2010
AFD2-D-GEN-EG-0001 Environmental Baseline Survey Report Ekofisk Cessation EPRD Project	5915-2010	05.05.2010
	Report No. Sub-No. O-28440.BAS	Pages Price 36
Author(s) Astri JS Kvassnes, Mats Walday and Hege Gundersen	Topic group 313	Distribution Fri
	Geographical area Rogaland, Norway	Printed NIVA

Client(s)	Client ref.
AF Decom Offshore	1699

Abstract

An Environmental Baseline Investigation was performed at AF Miljøbase Vats in Rogaland, Southwest Norway. The contamination of seafloor sediments, well-water and soil was analyzed, and the occurrence of anthropogenic debris and biological state at the bottom outside the facility was investigated with an ROV. The results show that the sediments are contaminated with TBT (Poor environmental status (Klif Class IV), TA-2229/2007) and PAH (Good environmental status (Class II)), but not at a higher level than was shown in previous studies. The remaining components (As, Ba, Cd, Co, Cr, Cu, Hg, Mo, Ni, P, Pb, V, Zn, PCBs, 5CB, alpha- and gamma-HCH, HCB, OCS, DDE, DDD, MBT, DBT, MPT, DPT and TPT) in sediments close to the site were either in environmental status "very good" (Class I), not included in TA-2229/2007, or not detected. This includes mercury that leaked into the bays between 2004 and 2006. The well-water was not contaminated, whereas soil samples were slightly contaminated with benzo(b)fluoranthene just above the Klif norm for sensitive land use. Large rocks and metallic debris are found along the shore, smothered with rock-dust due to the recent expansion of the quay areas. The biological state is typical for a quay area in this region.

4 keywords, Norwegian	4 keywords, English
1. AF Decom Offshore	1. AF Decom Offshore
2. Vatsfjorden	2. Vatsfjord
3. Miljøundersøkelse	3. Environmental survey
4. ROV	4. ROV

Astri JS Kvassnes
Project manager

Karl Jan Aanes
Research manager

Bjørn Faafeng
Senior Adviser

ISBN 978-82-577-5650-5

AFD2-D-GEN-EG-0001

Environmental Baseline Survey Report

Ekofisk Cessation EPRD Project

Preface

An Environmental Baseline Investigation was performed by the Norwegian Institute of Water Research NIVA at AF Miljøbase Vats in the late spring and early summer of 2009. The purpose of the study was to investigate the state of the site before the onset of the Ekofisk Cessation EPRD-project. Soil, groundwater, marine sediments and anthropogenic debris were investigated. AF Decom Offshore commissioned this investigation. Astri JS Kvassnes has been Project Leader, and the report was written by Kvassnes, Mats Walday and Hege Gundersen. The report was quality-assured by Torgeir Bakke. The contact person at AF Miljøbase Vats has been Jorunn Hafstad.

Oslo, 05.05.2010

Astri Jæger Sweetman Kvassnes, PhD

Contents

Summary

AF Decom Offshore recycles decommissioned offshore installations at AF Miljøbase Vats at Raunes in Vindafjord Muncipality, Rogaland, Norway. The installations are cut into large sections at sea and towed to shore at the Miljøbase. The installations are subsequently hoisted on shore and the materials sorted as hazardous waste and materials of value. The site of AF Miljøbase Vats has recently been expanded and new quay areas have been built into the sea. The quays incline inwards from the shore to avoid rainwater washing hazardous materials into the sea. A new treatment-plant for the processing-water and surface-water has been installed.

The Norwegian Institute for Water Research has, on commission from AF Decom Offshore, studied the state of the environment at and around AF Miljøbase Vats in the second quarter of 2009. The investigation was performed as a "baseline" investigation where the intent was to know the state of the environment before the initiation of the Ekofisk Cessation EPRD Project starting in 2009. The goal of the investigation is thus to be able to compare the state of the environment before and after the project to document whether it has influenced the surroundings.

NIVAs Baseline Survey includes ROV-investigations to observe debris and visually evaluate the biological state of the environment outside the quays at Raunes, and sampling and chemical analysis of marine sediments near the quays and also further away from the site. In addition, chemical analysis of soil samples from the site and water in wells drilled through the tarmac has been performed.

The ROV-investigations indicate that the benthic substrate outside Raunes varies from being dominated by recently deposited blasted rocks without fouling, and smothering of rock flour where the quay has been expanded, to normal soft bottom with traces of marine bottom in-fauna and also visible fauna. The flora and fauna is as expected in a harbour area like the one outside AF Miljøbase Vats, with e.g. benthic algae, kelp, starfish, fish and crab. The substrate in Raunesvika consists of soft sediments, mixed with sand, gravel and some stones in the shallower areas, but also some areas with bedrock. We have identified and positioned scrap including rope-remains, iron-rods and other metal, parts of silt-curtains, fish-cages, boards, helmet, nets, buckets, trees and bushes, and some few car-tires, of which one large one.

A literature-study of previous reports indicate an increase of mercury in the marine sediments outside AF Miljøbase Vats in the period from 2004 and 2006, but a general increase in concentrations of the analyzed substances has not been reported since then. Our investigation of marine sediments shows that the chemical state of the sediments is about the same as in previous investigations, or at slightly lower concentrations. Relative to the Norwegian sediment classification guideline (Klif TA-2229/2007) the PAH-concentration in sediments sampled had a "good" environmental status (Class II), whereas TBT is "poor" in (Class IV). Mercury is only found to be in a "very good" environmental status (Class I). The other substances investigated (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) from the samples close to the site are either in Class I or not classified in TA-2229/2007. Surprisingly, the samples from the reference stations far from AF Miljøbase Vats have partly elevated values higher than Class I, PAH16 is in Class II in Krossfjorden and inner Vatsfjord and where Vatsfjorden and Yrkjesfjorden meet. The inner Vatsfjord also has TBT in Class II. The sample in the deep area outside Raunes did not show the elevated levels, suggesting that AF Miljøbase Vats is not the primary source of the pollution in the reference-stations.

We did not identify any natural soil areas inside the quay area, so we sampled directly outside the wall at the north end of the site, where COWI previously investigated the soil for mercury and zinc. One of these samples was taken closer to the central quay areas, the other closer to sea. The investigation showed concentrations of benzo(b)fluoranthene above the criteria from Klif for polluted soil. The other values for the samples meet the criteria for sensitive land use. We do recommend, however, that these sites are followed with regular sampling, as the sample closest to the central quay area consistently had the higher values of the two samples.

Water from four permanent five-meter deep wells drilled through the tarmac and membrane inside the quays had an acceptable water quality in terms of the substances analyzed. The heavy metals were below the analytical limit of detection, whereas the iron levels were below the acceptable level for drinking water in two of the samples. We expected some seawater penetration into the groundwater after the membrane sealed off the rainwater from the subsoil. This was indicated by the pH in the subsurface water.

Sammendrag

Tittel: **AFD2-D-GEN-EG-0001: Environmental Baseline Survey Report**, Ekofisk Cessation EPRD Project
År: 2009
Forfattere: Astri JS Kvassnes, Mats G Walday og Hege Gundersen
Kilde: Norsk institutt for vannforskning ISBN-978-82-577-5650-5

AF Decom Offshore resirkulerer utrangerte offshoreinstallasjoner ved AF Miljøbase Vats ved Raunes i Vindafjord (Rogaland). Dette innebærer at installasjonene blir delt opp i store deler offshore og tauet inn til land ved Miljøbasen, hvor installasjonene blir heist på land, demontert og sortert som farlig avfall eller resirkulert. Anlegget er nylig utvidet og nye kaiområder er bygget ut i sjøen. Kaiene heller innover fra sjøsiden for å unngå avrenning av forurenset vann. Et nytt renseanlegg er bygget for å ta hånd om alt vann som kommer fra kaiområdet.

NIVA har, etter oppdrag fra AF Decom Offshore, studert miljøtilstanden rundt AF Miljøbase Vats i andre kvartal 2009. Undersøkelsen ble gjort som en forundersøkelse for å skaffe grunnlagsmateriale om miljøtilstanden i området før Ekofisk Cessation EPRD Prosjektet startet opp. Dataene som er hentet inn skal gjøre det mulig å kunne spore eventuelle effekter av virksomheten til Ekofisk Cessation EPRD Prosjektet i fremtiden.

NIVAs undersøkelser omfatter undersøkelser med fjernstyrt undervannsbåt (ROV) for å observere skrot og biologisk tilstand utenfor kaiene ved Raunes. Videre er det foretatt prøvetaking og kjemisk analyse av marine sedimenter i sjøen nært kaiene og i ulik avstand fra anlegget. Datamaterialet inneholder også resultater fra kjemiske analyser av jordprøver fra anleggsområdet, og fra kjemiske analyser av vann i brønner inne på området til AF Miljøbase Vats.

ROV-undersøkelsene viser at bunnforholdene i det undersøkte området varierer fra å være dominert av stor, ikke-begrodd sprengstein i Grønavika der kaien nylig er utvidet, med et dekkende lag av steinstøv i områdene rundt innfyllingen, til normal bløtbunn med synlig fauna på bunnen og spor etter gravende fauna. Flora og fauna ved Raunesvika er som forventet ved et kaianlegg som dette, med blant annet bunnlevende alger, tare, sjøstjerner, fisk og krabbe. Bunnen består her av bløtbunn med innslag av grovere partikler som sand og grus, samt en del stein. På litt større dyp er det mest bløtbunn, men også innslag av fjell. Det er i denne undersøkelsen funnet og geo-referert rester etter rep, jernstenger og annet jernskrot, deler av siltgardiner, fiskeruser, takplater, hjelm, garn, bøtter, trær og busker, og noen få bildekk derav ett stort, sannsynligvis fra en anleggsmaskin. Tidligere rapporter fra området indikerer at det har vært en økning av kvikksølv i de marine sedimentene utenfor AF Miljøbase Vats i perioden fra 2004-2006. Det er senere ikke er påvist økte konsentrasjoner. Vår undersøkelse av marine sedimenter viser at den kjemiske tilstanden til sedimentene er omtrent som i tidligere undersøkelser eller med noe lavere konsentrasjoner. I forhold til Statens Forurensningstilsyns veileder (Klif TA-2229/2007) var PAH16 i sedimenter nært anlegget i ”god miljøtilstand” (tilstandsklasse II), mens TBT er opp til ”dårlig miljøtilstand” (klasse IV). Kvikksølvundersøkelsene i 2009 ga resultater som alle var ”veldig gode” (i tilstandsklasse I). De andre stoffene som ble undersøkt (As, Ba, Cd, Co, Cr, Cu, Mo, Ni, P, Pb, V, Zn, PCB-stoffene, Pentaklorbensen, alfa-HCH, Hexaklorbenzen, Gamma-HCH, Octaklorstyren 4,4-DDE, 4,4-DDD, MBT, DBT, MPT, DPT and TPT) har konsentrasjonsnivåer i tilstandsklasse I, eller er under deteksjonsgrensen eller stoffene mangler i klassifiseringsveilederen, TA-2229. Noe overraskende hadde referanseprøvene som ble tatt langt fra Miljøbasen i Vats delvis forhøyete verdier for PAH 16 og TBT, noe som ga en miljøtilstand i tilstandsklasse II. Konsentrasjonen av PAH16 gir tilstandsklasse II i Krossfjorden, i indre Vatsfjorden og i området der Vatsfjorden og Yrkjesfjorden møtes. Indre Vatsfjorden har også TBT verdier i tilstandsklasse II. Dypvannsprøven utenfor Raunes viste ikke forhøyete verdiene, noe som indikerer at AF Miljøbase Vats ikke er kilden til forurensingen i referansestasjonene.

Vi fant ingen naturlige jordområder inne på anleggsområdet, Prøver ble derfor tatt rett utenfor muren på nordenden av anlegget. COWI har tidligere undersøkt grunnen her for kvikksølv. Undersøkelsene våre viste konsentrasjon av benzo(b)fluoranten over Klifs normverdier. De andre analyserte stoffene hadde verdier under miljøkravene satt av Klif. Vi anbefaler at disse jordprøvene følges opp med nye undersøkelser fremover for å følge miljøtilstanden i dette området

Vannprøver fra fire faste, omtrent fem meter dype, brønner boret igjennom membranen inne på anlegget hadde et akseptabelt innhold av de stoffene som ble analysert. Tungmetallene var under deteksjonsgrensen, mens jerninnholdet var under grenseverdien for drikkevann i to av prøvene. Det var forventet en viss saltvannsinntrengning i grunnen etter at membranen ble lagt, og pH i brønnvannet samsvarer med dette.

1. Introduction

This Environmental Baseline Survey Report AFD2-D-GEN-EG-0001 summarizes previous investigations in the area and compares them to our latest environmental survey performed before the first delivery of the Ekofisk Cessation EPRD Project. Thus, in terms of Baseline Surveys, this is not an investigation of the conditions before any activity had been performed at AF Miljøbase Vats, but the state immediately before the Ekofisk Cessation EPRD Project.

In the Ekofisk Cessation EPRD Project, parts of the offshore installations once used in the Ekofisk area in the North Sea are decommissioned at AF Miljøbase Vats. The platforms are thus taken apart, and the hazardous substances are separated from valuable materials. Subsequently, the dangerous substances are sent to a holding facility and the valuables are recycled. The County Governors Office (Fylkesmannen i Rogaland) has given the facility clear and strict guidelines (permit from the 9th of June, 2009) to follow in terms of the avoidance of polluting the surroundings. The Norwegian Institute for Water Research (NIVA) has performed sampling of materials in the area before the onset of the work in the summer of 2009, as a baseline survey being the first step in an extensive environmental survey-program running every year until 2014. The study-elements of the program are shown in Table 1.

2. Background

2.1 The study site at AF Miljøbase Vats and its geographical surroundings

AF Miljøbase Vats is situated in Rogaland, on the west side of the Vatsfjord, a 5km long fjord that meets the Yrkjesfjord to the south (Figure 1, Figure 2). The Vatsfjord has two basins that are separated by shallower glacial sills. South of the southernmost sill at Raunes, north of the facility the fjord deepens from the 30 meter deep sill to 160 meters depth where the Vatsfjord meets the Yrkjesfjord.

AF Miljøbase Vats has expanded its quay areas over the last years (Figure 2), presenting a sill-free deep-water quay. The subsurface is protected by membranes, and the water that falls on the inward-sloping tarmac is collected and run through a sand-filter before discharge.

Table 1. The scope of the environmental investigations at AF Miljøbase Vats.

The study-elements of NIVAs investigations	Extensive environmental survey 2009-2014	AFD2-D-GEN-EG-0001
Chemical pollutant stress imposed by the facilities on freshwater streams	X	
Soil samples around, and wells in the new quay area	X	X
Soft bottom conditions near the site and laterally in the fjord, including analysis of:	X	X
chemical state of the sediments	X	X
biological state of the soft-bottom benthic communities	X	
oxygen consumption of the sediments	X	
ecotoxicological analysis of the sediments	X	
Contaminant levels in commercial fish and shellfish species	X	
Heavy metal contamination of moss on and around the site, documenting airborne contamination, including Hg	X	
Analysis of low-radioactive isotopes in water and sediments, -	X	
Underwater ROV survey	X	X
inspections for foreign objects	X	X
inspection of previous tapes and comparison to the biological state of the quay area	X	

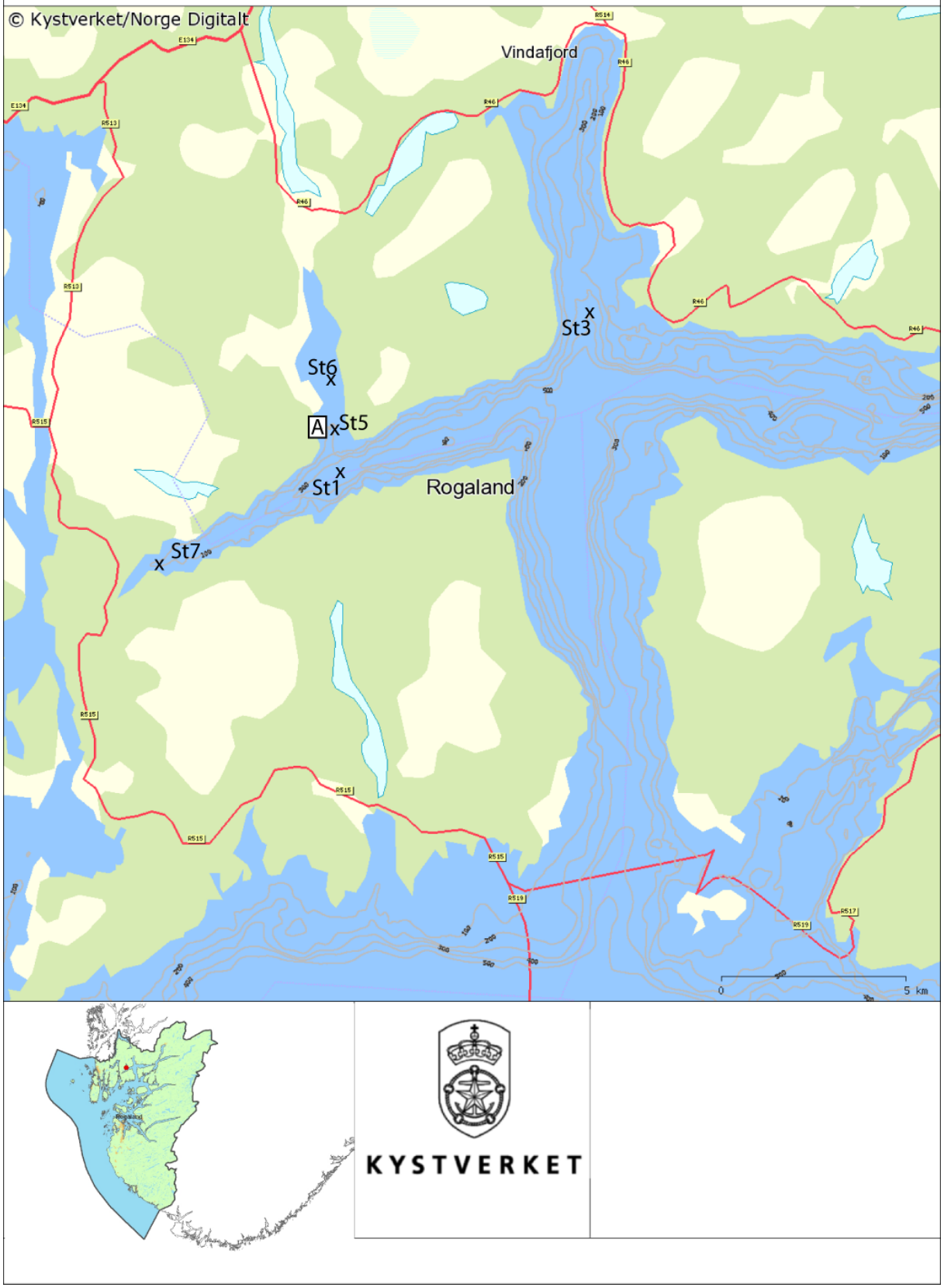

Figure 1. : Sampling stations where 3-4 replicates of the fjord sediments have been collected. "A" refers to the area shown in Figure 2, which includes the site of Miljøbase Vats. The insert indicates the location in southwestern Norway with a red dot.

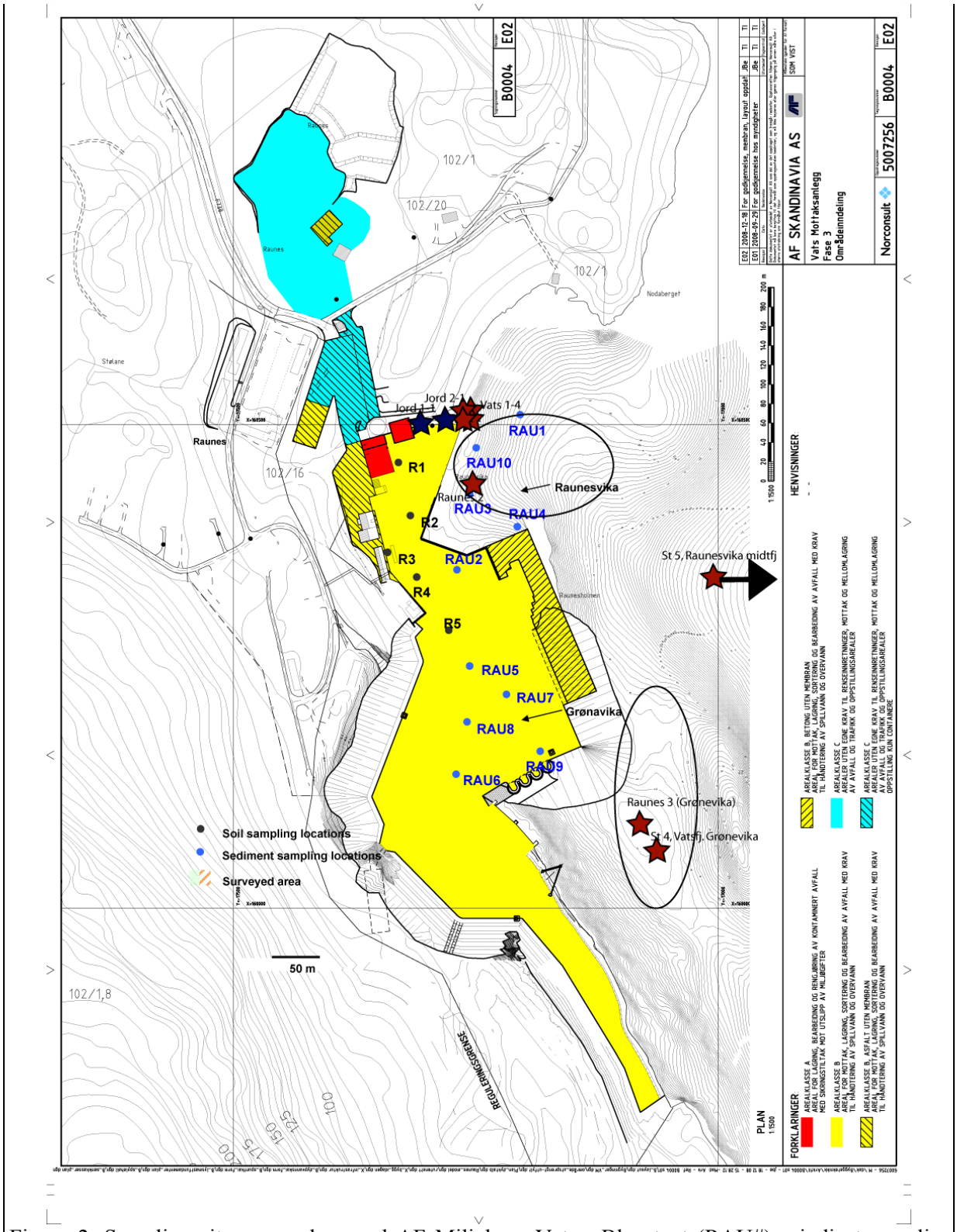

Figure 2. Sampling sites on and around AF Miljøbase Vats. Blue text (RAU#) indicates earlier sediment sampling sites. Black text (R#) indicates earlier soil sampling. Blue stars (Jord#) indicate sites for soil sampling in this study, brown stars indicate sediment sites. The ellipsoids indicate areas where sediment sampling was attempted in this study. The yellow field indicates the new quay areas.

2.2 Previous studies at the site of AF Miljøbase Vats

Several environmental studies have been performed at the site, and Table 2 shows a summary of these.

Table 2. Summary of studies performed at or near the site of AF Miljøbase Vats.

Title	Year	By	Main conclusions
Resipientundersøkelse i Vatsfjorden, Vindafjord Kommune	1999	Tvedten, Rogalandsforskning	The sewage discharge should be placed on the seaward side of the sill at Raunes due to the stagnant watermasses and thus 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.
Assessment of environmental implications of mooring the Hutton TLP in Vatsfjorden	2002	Kjeilen et al., Rogalandsforskning	The environmental conditions along the quay in Grønavika are 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 in this study, but it was TBT that in later studies was found to indicate Class 4 contamination (see below).
Environmental Baseline Report for Raunes, Vindafjord Kommune	2004	Kristensen, Miljøbistand AS	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.
Miljøundersøkelse Vats-Ekofisk, avsluttende undersøkelse	2007	Misund, COWI	The soil is considered clean, with the exception of chromium and oil-levels at a higher level than the limits for sensitive land use. The 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 concentrations are low, and lower than in 2004. Mercury in class 2 was registered in one point (RAU7). It is inferred that the increased values of mercury is due to activities on site. DDT was not detected. Foreign objects consisted of tires, metal debris and pipes.
Miljøundersøkelse Vats – Ekofisk, baseline undersøkelse	2008	Misund, COWI	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 sand-filter 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.
Analyser av Blåskjell ved og rundt Vats	2008	Kvassnes, NIVA	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 (Klifs veileder 97:3) and it appears that this represents a

Mottaksanlegg			general higher level of this metal in the bay.
Gjennomgang av rapporter fra undersøkelser i Vatsfjorden – Fokus på Vats Mottaksanlegg	2008	Misund, COWI	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 sand-filter was added to the process-water line in 2006. TBT was slightly increased in Raunesvika but decreased in Grønavika. The ROV investigations have found metal-debris and rubber-tyres in the bays but there is no significant change in the environmental state from 2007 to 2008.
Undersøkelser av mulig transport av tungmetaller via Rauneselva ut i sjøen	2009	Misund, COWI	Green Warriers of Norway's local branch 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.
Partikkelforurensing I Vatsfjorden	2009	Johnsen, NIVA	Increased turbidity in relation to the construction of the new quay-areas at Miljøbase Vats 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. The concentrations of particles was in literature-studies not found to result in acute lethality for marine fish or mussels, but it cannot be excluded that they led to stress and reduced resistance to disease.

3. Results of the Environmental Baseline Study

3.1 Underwater ROV survey with inspection of foreign objects

3.1.1 Purpose

This ROV-study documented the extent and nature of foreign objects near the quay areas. The use of an underwater ROV is important to assess the status and properties of the seabed with regards to the required sailing depth. In addition the operator was assisted by a marine biologist inspecting the images to assess the biological condition and sediment appearance along the quays. A future change in these parameters may indicate an impact from the quay activity. The initial ROV-study documented whether there are foreign objects on the seafloor prior to the Ekofisk Cessation EPRD Project that need to be removed. While the main purpose of the investigation was to register anthropogenic debris, the environmental state of the seafloor was evaluated by performing biological evaluations. Some times it was difficult to ascertain what kind of debris was observed in the recordings. These are indicated with quotes or question-marks in the tables. The depths recorded are those the ROV had at the time of registration, not necessarily the same depth of which the debris lies.

The investigation was concentrated on the areas in close proximity to the two bays. The video recordings included correct depth and bearing, and were displayed in real-time on deck.

It should be noted that a clean-up was performed with another ROV from Amundsen Diving after the completion of the quay areas in the first week of August 2009, after our investigation.

3.1.2 Methods

The investigations were performed on the 7th and 8th of May 2009 using an ROV of the type Subfighter 7500 with a HPR positioning system, DGPS, gyro-rack, sonar, depth recorder, manipulator arm and a small grab-arm. The ROV uses 3D transponders to ensure accurate tracking. All ROV-tracks were logged electronically and stored, and a manual field-log was produced (Appendix, Table 9). All anthropogenic material registered during the survey was recorded and positioned (Appendix Table 9), including what we assume is in the water on purpose, like pipelines, concrete pillars and the like. The ROV-operator was Knut Bergen from Sperre AS. The strategy for registrations was adapted to the local conditions on each site and is described in the appendix together with the details of the positioning of the ROV along the seafloor. Other construction work was performed in the sea at the same time as the investigations. Thus, the visibility was somewhat reduced.

3.1.3 Results

Grønavika

We followed depths 5, 10, 15, 20, 25, 30, 35 and 40 meters to the south and north in the bay. A fairly steep bottom was found down to 20 meters depth. The bottom is characterized by the dumping of rocky material, including both freshly blasted rocks without growth of organisms, and by that the "older" bottom is smothered by fine-grained rock-material. At deeper waters, particularly in the southern end, we found apparently healthy soft-bottom environments.

Table 3. ROV-observations in Grønavika

Tracking depth in meters below sea-surface	Observations
5-10	In the shallow waters fresh fill of rocks was found. Rope, silt-curtain remains, fouled iron-rods, and concrete reinforcing-rods were observed. Nearly no fauna and flora were present, possibly due to the amount of newly deposited rock.
15	Poor visibility, 1-2 meters. Blasted rocks, solid rock-faces. Remains of wood and scrub. Smothering of the bottom by fine grained rock flour. Pollock (*Pollachius virens*), (may have been following the ROV), sugarkelp (*Saccharina latissima*), kelp (*Laminaria hyperborea*) and some red algae (Rhodophyceae), the edible crab(*Cancer pagurus*), the common sea star – *Asterias rubens*, one purple sunstar - *Solaster endeca*.
20	A more level bottom. Partly a lot of blasted rocks, but also vast areas with rockfaces smothered by rockflour. South end: Soft bottoms with shells of the ocean quahog (*Arctica islandica*), hydroids of the large solitary species *Corymorpha nutans*, the common sea star (*A. rubens*) and the red cushion star– *Porania pulvillus*, kelp-plants growing on stones.
25	Areas with rocks and soft bottom, some parts are steeper and smothered. No anthropogenic debris. North end: More blasted rocks, trees and scrubs.
30	North end: Blasted rocks. One actinarian (cf. *Urticina eques*) and flatfish (cf. *Microstomus kitt*), Southern area: Soft bottom with some protruding rocks. Polychaetes (cf. *polydora* sp.) and mussel shells (cf *Mytilus edulis*).
35	Inclined soft bottoms with some rock faces protruding. Smothered by rock flour, not many animals. Steep areas to the north.
40	Blasted rocks in the inner, northern area, but fairly quickly a change into flat soft-bottoms further south. Flat fish (Pleuronectiformes) and sea pens (Pennatulacida) were relatively abundant, soft-bottom environment apparently in good condition. Rocky outcrops towards the southern end.

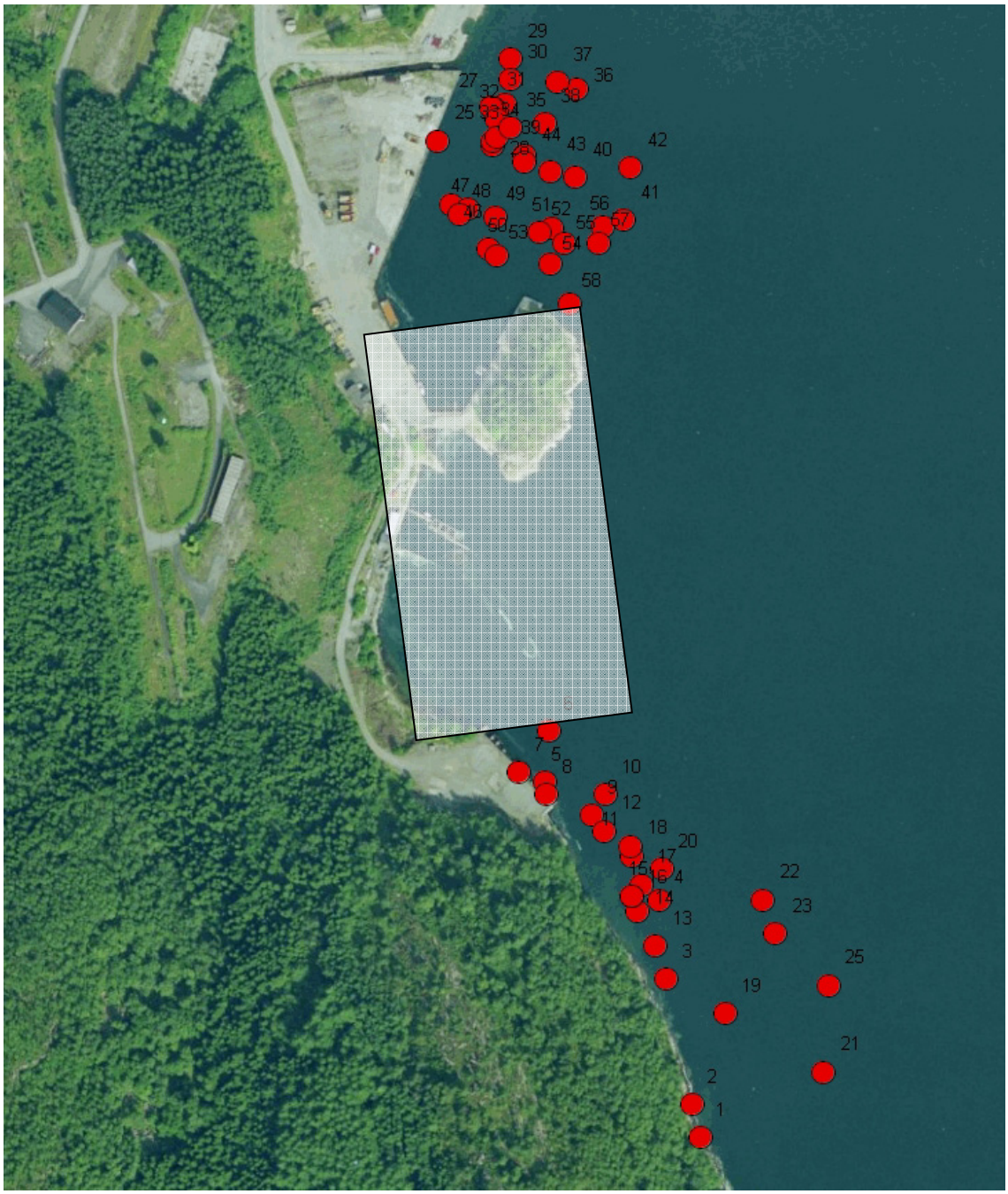

Figure 3.. Registered anthropogenic material at AF Miljøbase Vats. See **Table 9** for description of each numbered point. Please observe that the aerial photograph was taken before the recent constructions were finalized. The grey area gives a coarse indication of the area now filled in.

Raunesvika

We drove back and forth underneath the barges, parallel to the quay edge, with increasing distance to it by 4, 8, 12, 16, 20, 25, 30, 40, 50, 60 and 75 meters. The floating platform was moored at the south end of one of the barges. We did not inspect the area next to the quay to the south, since the ROV might be entangled in equipment moored in the water including a silt-containment curtain. The area outside the curtain consists of weakly sloping soft bottom with sand and some rock. The biological conditions were natural for a harbour area like this.

Table 4. ROV-observations from Raunesvika

Meters away from quay edge	Observations
Northern area	
0-5	Smaller anthropogenic debris at 6m depth. Spots of the bacteria *Beggiatoa* close to the river mouth (possibly due to organic materials coming with fresh water).
8-16	7m deep sandy soft bottom with some boulders, filamentous algae (cf *Ectocarpus*, cf *Polysiphonia/Ceramium*), some individuals of the common sea star (*A. rubens*), hydroids (Hydroida) and a lot of serpulid worms (cf. *Pomatoceros triqueter*), two individuals of sugar kelp (*S. latissima*). Not much anthropogenic debris recorded in this area. Wrasse (Labridae), goby (Gobiidae), spaghetti kelp (cf *Chorda filum*) was scattered, and so was cf. *Polysiphonia elongata*.
20	More rocks and a steeper bottom in this area. Closer to the mouth of the creek we found less rocky bottom. A lot of biological fouling on the boulders, one kelp individual (cf *L. hyperborea*), and several sugarkelp (*S. latissima*) were seen at 11 m depth. Flatfish (cf *Microstomus kitt*) was seen at 16 m, sugar kelp (*S. latissima*) at 13 m depth. Below 15 meters depth: Softer bottom and fewer rocks were present. Little or no algae were found. Many burrows in the soft bottom indicate active infauna. At 22 meters depth: disturbance tracks, from silt curtain being pulled along the seafloor? Flounders (Pleuronectiformes) and some starfish (*A. rubens*).
Southern area	
0-15	Soft bottoms with some large rocks were found at 7 meters right at the quay. Sugarkelp (*S. latissima*), the common sea star (*A. rubens*), hydroides (Hydroida), filamentous algae, wrasse (Labridae), serpulid worms (Serpulidae) on boulders. More rocks were found on the bottom further north. A flounder (Pleuronectidae) at 7m. Leaf-shaped red algae (Rhodophyceae) on rocks, flounder, starfish (*A. rubens*) and sugarkelp (*S. latissima*) at 8m.
20-30	At 10 m depth, fewer rocks, flounder (Pleuronectidae), sugarkelp (*S. latissima*), filamentous algae. At 12 m depth, some sugarkelp (*S. latissima*).
40-100	Below 15 m, few rocks, gently sloping soft bottom (little substrate for algae and none were registered), some mussel-shells, the sea-floor apparently relatively healthy, but with little visible fauna. Survey was finished at 28m depth.

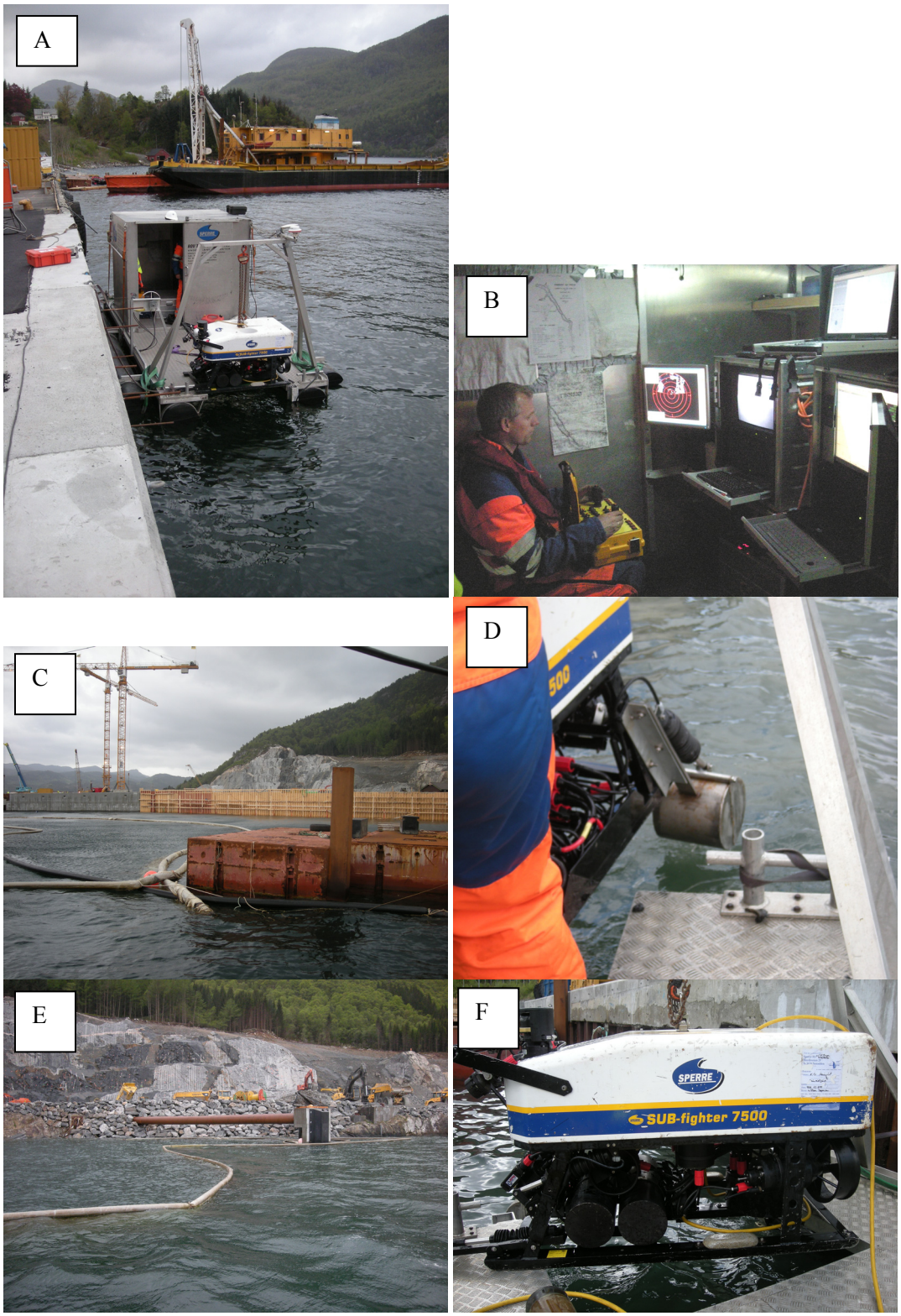

Figure 4. Photos from the fieldwork. A: The floating stage with the ROV moored to it in Raunesvika. This was the starting-off point for the tracks in Raunesvika (red dots in Figure 7) B: The ROV pilots in the control-room on the floating stage. C: The inaccessible area in Raunesvika where there was too much equipment in the sea to investigate. D: The ROV with its grab that sampled sediment-samples in shallow water in Raunesvika. E: Grønavika with the filled in edge and silt curtains in the sea. F: The ROV Sub-fighter 7500 used in the investigation.

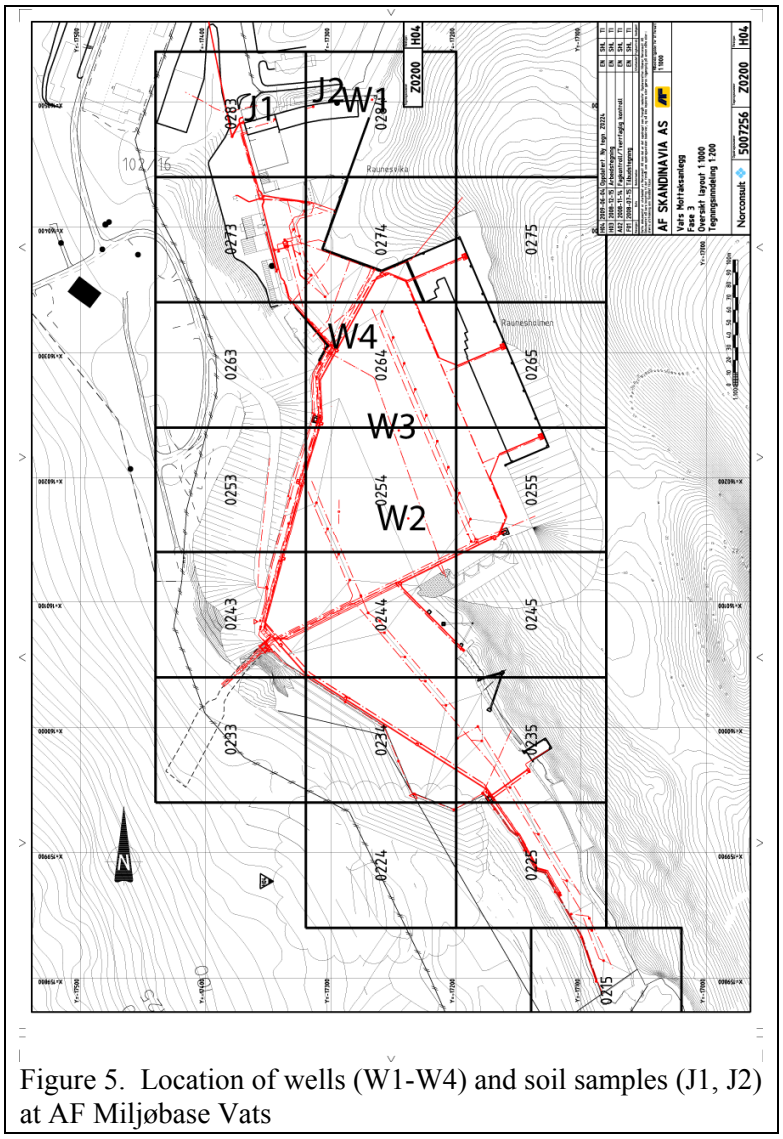

Figure 5. Location of wells (W1-W4) and soil samples (J1, J2) at AF Miljøbase Vats

3.2 Well samples

Four sealed wells were drilled by AF Miljøbase Vats through the membrane under the tarmac of the quays, down to the subsoil down to approximately 5 meters. The locations of the wells are shown in Figure 5. As the subsoil now is shielded from the rainwater, it is likely that there is a significant portion of seawater penetrating into the groundwater below the quay, particularly where the quay is built into the sea. Salinity was not been measured at this time, but may be measured in subsequent sampling. The purpose of the sampling of the wells was to investigate whether the membrane functions properly, and is successful in preventing leaks to the subsoil area. These wells shall be available for easy sampling throughout the entire project duration. We sampled the wells using a 5-meter long water-hose and a sub-surface pump. Each well was 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 are shown in Table 5. As can be seen from the results, the concentration-levels are generally below the level of detection. The relatively high background level for mercury suggests that a different technique should be (and has been used) in subsequent analyses, and we have found the mercury levels to be 7.5 and 8 ng/l for wells #2 and #3 respectively in analyses performed in the autumn. The pH is as is to be 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). The iron-levels in the newly constructed area fall below 0.8mg/l and two wells have levels below the regulations of drinking-water at 0.2mg/l iron. The iron may stem from the materials in the subsurface

themselves or from water penetrating from peaty areas. Some insulating plates from the lids of the wells were observed to have fallen into the wells, and oil-films were seen on the water in the wells even if it was not registered deeper in the water. We suggest that the surface oil-film is monitored, and that the insulation material is removed.

Table 5. Analysis result for the four wells in the quay areas in Miljøbase Vats

	Variables	pH	Cadmium	Iron	Mercury	Lead	Oils
	Units	pH	mg/l	mg/l	µg/l	mg/l	µg/l
Date	Sample #						
20090706	Well 1	7.95	<0.002	0.188	<0.05	<0.02	<50
20090706	Well 2	7.71	<0.002	0.121	<0.05	<0.02	<50
20090706	Well 3	8.02	<0.002	0.755	<0.05	<0.02	<50
20090706	Well 4	7.93	<0.002	0.744	<0.05	<0.02	<50

3.3 Soil Samples

There is currently not any natural soil areas left inside the quay areas of AF Miljøbase Vats, and drilling through the tarmac to sample below it would be unwise, as the integrity of the tarmac is crucial in terms of pollution control. NIVA sampled two areas right outside the north end of the quay area, towards the Raunes river (Figure 5). The samples were taken close to seals in the northern wall enclosing the quay area where there previously (Misund, 2009) had been found elevated levels of mercury and zinc. At each site we removed the top 10 cm of material and scooped up the soil into burnt glass-jars. Sample J1 is taken at the same site as R11 of Misund (2009). These two samples are being analyzed with Eurofins KlifJ-package, an analytical package that satisfies the Klif norms for sensitive land use (Aquateam 2009), and thus have lower detection limits than the previously used Eurofins Terratest. As can be seen in Table 6, only benzo(b)fluoranthene is higher than the norm at 0,026 mg/kg vs 0.01 (norm). It should also be noted that the sample closest to the sea (J2) generally has the lowest levels of all the heavy metals and PAH. Cadmium is higher in J2, but is at 0.44mg/kg far below the norm-limit at 1.5 mg/kg.

We suggest that these sites are monitored regularly. While the chemical compositions are below the norm limit at the moment, there is a clear difference between J1 (close to shore) and J2 (close to sea) and this must be watched closely.

Table 6. The results of samples J1 and J2. The "Norm" values for sensitive land-use are also shown. The value in bold are higher than the norm Klif TA-1629.

Parameters	Unit	Jord 1-J1	Jord 1-J2	Norm
Tetrachlorbenzene	mg/kg	n.d.	n.d.	0.05
Cyanide	mg/kg	n.d.	n.d.	1
OCB:o,p-TDE(=p,p-DDD)	mg/kg	n.d.	n.d.	
Pentachlorphenol	mg/kg	n.d.	n.d.	0.005
OCB:o,p-TDE(=o,p-DDD)	mg/kg	n.d.	n.d.	
OCB:p,p-DDE	mg/kg	n.d.	n.d.	
OCB:o,p-DDE	mg/kg	n.d.	n.d.	
o,p-DDT	mg/kg	n.d.	n.d.	0.04
gamma-HCH	mg/kg	n.d.	n.d.	
Hexachlorbenzene	mg/kg	n.d.	n.d.	0.03
TS	%	98	99	
Arsenic	mg/kg	3.3	1.9	8
Lead	mg/kg	13	6.2	60
Cadmium	mg/kg	0.28	0.44	1.5
Copper	mg/kg	12	8.4	100
Chromium	mg/kg	16	7	50
Mercury	mg/kg	0.14	0.014	1
Nickel	mg/kg	14	5.6	60
Zinc	mg/kg	200	100	200
m,p-Xylene	mg/kg	0.013	n.d.	0.5
o-Xylene	mg/kg	0.0077	n.d.	0.5
PAH 16 EPA				
Naphtalene	mg/kg	0.0019	n.d.	0.8
Acenaphtylene	mg/kg	n.d.	n.d.	0.8
Acenaphtene	mg/kg	0.0023	n.d.	0.8
Fluorene	mg/kg	0.056	n.d.	0.8
Phenantrene	mg/kg	0.013	0.001	0.8
Antracene	mg/kg	0.034	n.d.	0.8
Fluorantene	mg/kg	0.025	0.0038	1
Pyrene	mg/kg	0.022	0.0032	1
Benzo(a)antracene	mg/kg	0.015	0.0041	0.03
Chrysene/Triphenylene	mg/kg	0.022	0.0066	0.03
Benzo(b)fluoranthene	mg/kg	**0.026**	0.0044	0.01
Benzo(k)fluoranthene	mg/kg	0.019	0.0038	0.09
Benzo(a)pyrene	mg/kg	0.022	0.0036	0.1
Ideno(1,2,3-cd)pyrene	mg/kg	0.027	0.0027	0.05
Dibenzo(a,h)antracene	mg/kg	0.0045	n.d.	0.05
Benzo(ghi)perylene	mg/kg	0.024	0.003	0.1
sum 16PAH (16EPA)	mg/kg	0.26	0.036	2
PCB 7	mg/kg	n.d.	n.d.	0.01
THC	mg/kg	n.d.	n.d.	n.d.

3.4 Soft-Bottom Fjord Sediments

3.4.1 Materials and methods

The Vatsfjord and Yrkjesfjord are not expected to be completely pristine in any areas, but sites more remote from Miljøbase Vats could be expected to be less environmentally stressed than the local samples close to the quay areas and may thus act as reference stations. We thus sampled both in the near and far areas around the site to register the variation of the chemistry of the sediments, and describe the "normal state" (See figure Figure 1 and Figure 2 for site locations). The conditions of the marine sediments suggested a varied sampling-approach to obtain good samples. In all the sampling methods we collected approximately 25cc of sediments from the upper 2cm from each sample and mixed them together thus representing a pooled average of 3 samples from each site. The sediments were kept cool and sent to the laboratories at NIVA in Oslo and analyzed at NIVAs accredited laboratories.

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. 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 indicated by one sample taken by the local branch of Green Warriors (Miljøvernforbundet) in Vats in 2008. 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.

Most of the analyzed components are done with accredited analyses, excluding MTB,DBT, TBT, and the phenyltins. These are, however, performed in the same manner as otherwise would be expected, using certified reference material for the BTs, and the laboratory is in the process of having the methods accredited. There are no certified reference-materials available for the PhTs and thus there are no accredited methods. The individual CB analyses are very low in concentration (Appendix 2), and according supplements to the Water Framework Directive of the EC (2000/60/EC) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:201:0036:0038:EN:PDF, article 5.3), the Calculated Seven Dutch ("PCB7") shall therefore be set to 0, as opposed to adding the background-values together

3.4.2 Method of classification

The Norwegian Pollution Control Authority (Klif) has recently published new guidelines for the risk evaluation of sediments (STF TA-2230/2007). The PNEC value (Predicted No Effect Concentration) for chronic exposure is the limit between Class II and III in Klif TA-2229/2007, whereas the PNEC value for acute exposure to marine life is the limit between Class III and IV.

3.4.3 Results

The two small bays near the quays (Raunesvika and Grønavika) have previously been sampled in 2002 (Kjeilen, 2002), in 2004 (Kristensen, 2004), in 2007 (Misund, 2007) and in 2008 (Misund, 2008), as summarized in Misund (2008). In addition to comparing our findings with the averages from each of these studies, we compare our samples to the environmental standards set by the government for the sustainable chemical state of these types of sediments (Klif TA-2229/2007). The complete analysis report is attached to this document in Appendix 2, and the chemical compositions where we found levels above the detection-limit can be found in Table 7 (A&B).

Mercury is in Class I in all the samples. Compared to the previous studies by COWI the levels of mercury seem to have decreased. In addition, like in Misund (2009) the samples from the mouth of

Table 7A. The results from the analyses from the marine sediments close to AF Miljøbase Vats and the classes of pollution grade set by Klif TA-2229 indicated in blue (Class 1), green (Class 2), yellow (Class 3), orange (Class 4) and red(Class 5). n.d. indicates that the results were below the detection limit.

Analytic Variable	Unit	Vats 1	Vats 2	Vats 3	Vats 4	Raunes 2	Raunes 3 (Grønevika)	St 4, Vatsfj. Grønevika
Grains<63µm	% dry weight				19	65	69	43
TN/F	µg N/mg TS				1.3	n.d.	n.d.	n.d.
TOC/F	µg C/mg TS				17.1	21.9	3.5	2.7
As/ICP-Sm	µg/g				7.4	9.2	3	3
Ba/ICP-Sm	µg/g				45.4	92.3	191	128
Cd/ICP-Sm	µg/g				n.d.	n.d.	n.d.	n.d.
Co/ICP-Sm	µg/g				5.3	9.3	9.4	8
Cr/ICP-Sm	µg/g				18	27.8	23.8	23.1
Cu/ICP-Sm	µg/g				17.4	27.9	17.3	15
Hg-Sm	µg/g	0.081	0.034	0.031	0.04	0.133	0.059	0.016
Mo/ICP-Sm	µg/g				2	3	2	2
Ni/ICP-Sm	µg/g				9.9	16.3	12	11
P/ICP-Sm	µg/g				539	702	717	629
Pb/ICP-Sm	µg/g				14	17	13	8.3
V/ICP-Sm	µg/g				20.1	38.8	37.8	30.4
Zn/ICP-Sm	µg/g				53.7	105	135	88
TBT-Sm	µg/kg t.v.				21	20	n.d.	n.d.
Sum PAH16	µg/kg t.v.				65.6	322.7	166.2	39.7
Sum PCB_7	µg/kg t.v.				n.d.	n.d.	n.d.	n.d.
BAP-Sm	µg/kg t.v.				3.4	21	n.d.	n.d.
Sum KPAH	µg/kg t.v.				n.d.	132	n.d.	n.d.
Sum NPD	µg/kg t.v.				n.d.	90.5	n.d.	n.d.
MBT-Sm	µg MBT/kg				9.6	7.2	n.d.	n.d.
DBT-Sm	µg/kg t.v.				23	12	n.d.	n.d.
MPhT-Sm	µg/kg t.v.				n.d.	n.d.	n.d.	n.d.
DPhT-Sm	µg/kg t.v.				n.d.	5.6	n.d.	n.d.
TPhT-Sm	µg/kg t.v.				n.d.	4	1.4	n.d.

Rauneselva did not have elevated levels of mercury, thus we have failed to reproduce the results from the local branch of Green Warriors. The concentrations of PAH16 reach Class II and TBT Class IV in our samples from Raunesvika and Grønavika. The elevated levels of the chemical substances have previously been recorded close to AF Miljøbase Vats, and the levels are not higher than previously measured. Surprisingly, however, some of the reference sites have elevated levels of lead (Krossfjorden and Vats/Yrkjesfjord), PAH16 (Indre Yrkjesfjorden and Indre Vatsfjorden), and TBT (Indre Vatsfjorden). As the sample in the deep fjord directly outside AF Miljøbase Vats does not show these values, this suggests other sources of this pollution.

Table 7B: The results from the analyses from the marine sediments laterally away from AF Miljøbase Vats and colours referring to the classes of pollution state set by Klif TA-2229 as in the Table 9A.

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.

4. Conclusion

NIVAs Baseline Survey at AF Miljøbase Vats has shown that the environmental status is, in general, similar to previous investigations. ROV investigations show anthropogenic debris on the rocky to soft bottom, with a flora and fauna in Raunesvika as is expected along quays like these. Grønavika is dominated by the deposited rock-material and associated smothering with fine rock-dust, particularly in the shallowest areas. The soft bottom sediments close to AF Miljøbase Vats have elevated levels of TBT (up to Klif Class IV) and PAH16 (up to Klif Class II). Mercury is found in class I along with the other chemical components analyzed (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). Soil samples taken north of the site show elevated values of one of the aromatic hydrocarbons (benzo(b)fluoranthene) and we recommend that the area is sampled regularly to monitor change. The wells through the quay have indications of seawater infiltration in the subsurface due to pH's higher than 7. The chemical analyses reveal low levels of the analyzed components.

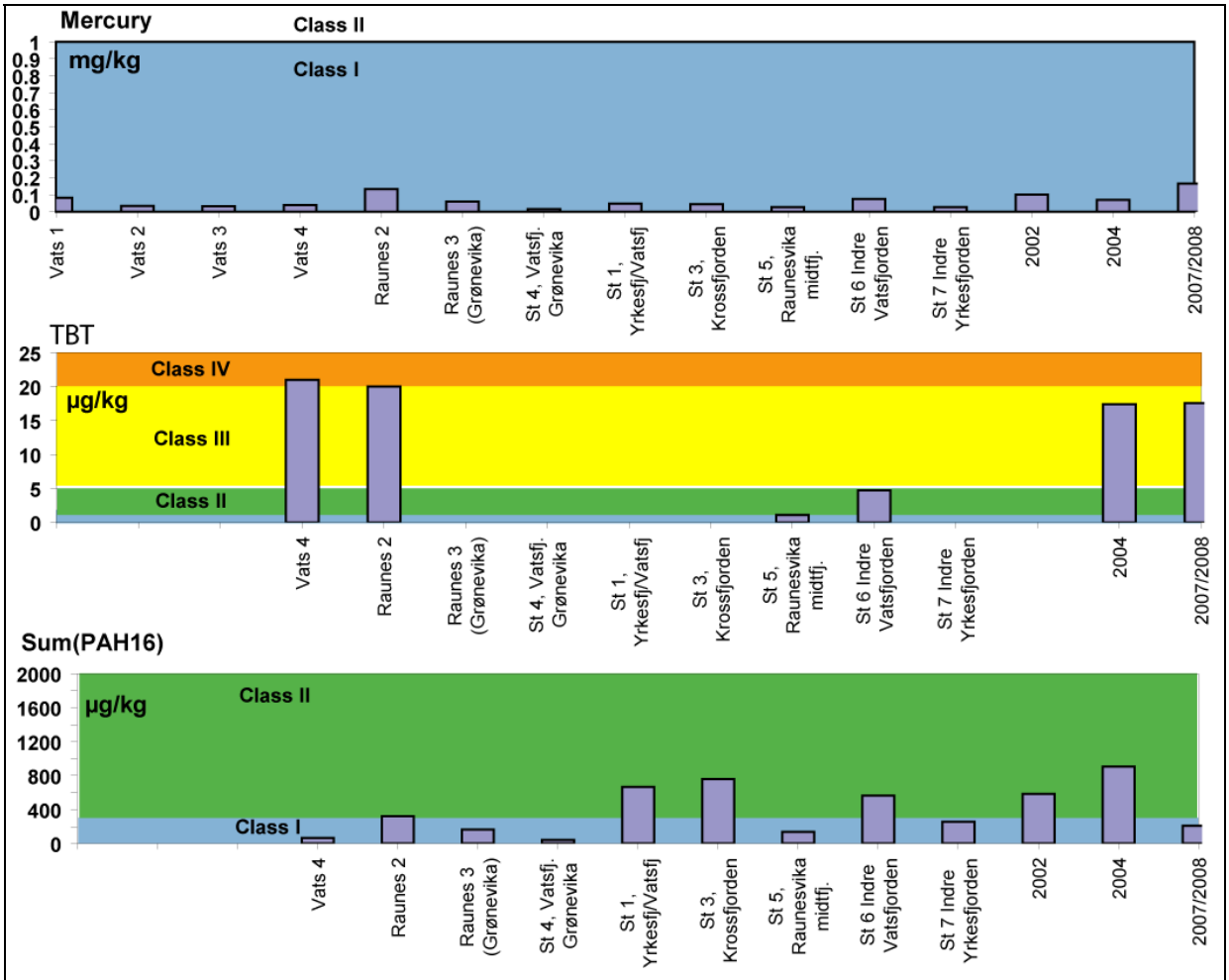

Figure 6. The chemical composition of the pooled marine sediments from the sampled sites compared to the average results from the study performed before the start of AF Miljøbase Vats ("2002" = Kjeilen, 2002), and between recent operations ("2004" = Kristiansen 2004, "2007/2008" = Misund 2007 and 2008). The analyses in 2004 were performed before the initiation of AF Miljøbase Vats activities at Raunes. If the site is not listed on the figure, then the chemical was not analyzed for those samples. The coloured fields represent the classes of pollution, blue (class I), green (class II), yellow (class III) orange (class IV) and red (class V).

5. References

Bakke, T, Oen, A, Kibsgaard, A, Breedveld, G, Eek, E, Helland, A, Källqvist, T, Ruus, A, Hylland, Kfl. 2007: Revidering av klassifisering av metaller og organiske, miljøgifter i vann og sedimenter. TA2229/2007. 12s.

Johnsen, TM, Dale, T, 2009: Partikkelforurensing i Vatsfjorden. NIVA report LNR 5823-2009.

Kristensen, M. 2004: Miljøtekniske undersøkelse Raunes i Vindafjord kommune. Oppdragsgiver AF Decom. MiljøBistand report # P-04.019-1.

Kvassnes, AJS, 2008: Analyser av Blåskjell ved og rundt Vats Mottaksanlegg. NIVA Notat.

Misund, A. 2007: Miljøundersøkelser Vats-Ekofisk, avsluttende undersøkelse. Oppdragsgiver AF Decom AS. COWI report, 28th of September 2007.

Misund, A. 2008: Gjennomgang av reporter fra undersøkelser i Vatsfjorden – Fokus på Vats Mottaksanlegg. COWI report, 4th of October, 2008.

Misund, A. 2009: Undersøkelser av mulig transport av tungmetaller via Raunes ut i sjøen. COWI report, 5th of February, 2009.

Tvedten, Ø. F.: Resipientundersøkelse I Vatsfjorden, Vindafjord Kommune. Report Rogalandsforskning, RF 1999/320.

Keilen, G et al., 2002: Assessment of environmental implications of mooring the Hutton TLP in Vatsfjorden. Rogalandsforskning RF 2002/191.

Vik, Eilen A. m.fl. 1999. Risikovurdering av forurenset grunn. SFT veiledning 99:01A. Statens forurensningstilsyn.

Weideborg, 2007: Oppdatering av bakgrunnsdata og forslag til nye normverdier for forurenset grunn. Aquateam - Norsk vannteknologisk senter A/S Rapport nr: 06-039.

5.1 Appendix 1 – ROV investigation – technical descriptions

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 8. 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.

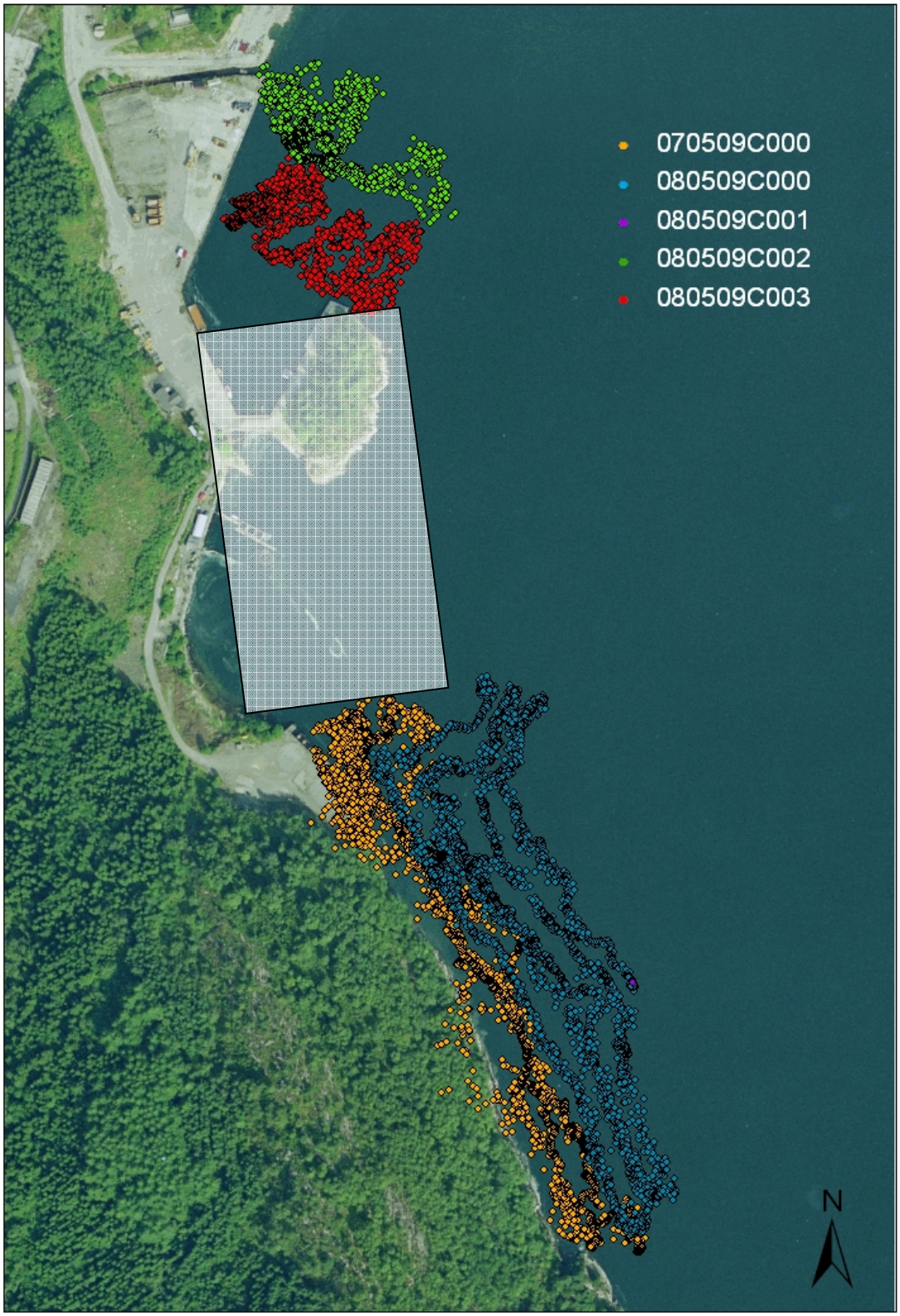

Figure 7.'Tracking' of the movements of the ROV at AF Miljøbase Vats the 7th and 8th of May 2009. The areal photo is taken before the recent constructions were performed. The gray area indicates a coarse indications of the newly filled-in areas.

Table 9. 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: Complete chemical analysis of marine sediments.

Norsk Institutt for Vannforskning
Gaustadalléen 21
0349 Oslo
Tel: 22 18 51 00
Fax: 22 18 52 00

ANALYSE RAPPORT

NORSK AKKREDITERING Nr. TEST009

Navn **Vats Sediment**
Adresse

Deres referanse:

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

Dato
07/05/2010

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	Enhet	Metode	1	2	3	4	5	6	7
Kornfordeling <63µm	% t.v.	Intern*				19	65	69	87
Nitrogen, total	µg N/mg TS	G6				1,3	<1,0	<1,0	1,7
Karbon, org. total	µg C/mg TS	G6				17,1	21,9	3,5	19,0
Arsen	µg/g	E9-5				7,4	9,2	3	15
Barium	µg/g	E9-5				45,4	92,3	191	79,1
Kadmium	µg/g	E9-5				<0,2	<0,2	<0,2	<0,2
Kobolt	µg/g	E9-5				5,3	9,3	9,4	16,9
Krom	µg/g	E9-5				18,0	27,8	23,8	33,8
Kobber	µg/g	E9-5				17,4	27,9	17,3	22,2
Kvikksølv	µg/g	E4-3	0,081	0,034	0,031	0,040	0,133	0,059	0,047
Molybden	µg/g	E9-5				2	3,0	2	3,5

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

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.

ANALYSE RAPPORT

NORSK AKKREDITERING Nr. TEST009

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
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.

ANALYSE RAPPORT

NORSK AKKREDITERING Nr. TEST009

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.

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.

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

NIVA: Norway's leading centre of competence in aquatic environments

NIVA provides government, business and the public with a basis for preferred water management through its contracted research, reports and development work. A characteristic of NIVA is its broad scope of professional disciplines and extensive contact network in Norway and abroad. Our solid professionalism, interdisciplinary working methods and holistic approach are key elements that make us an excellent advisor for government and society.

NIVA
Norwegian Institute for Water Research

Gaustadalléen 21 • NO-0349 Oslo, Norway
Telephone: +47 22 18 51 00 • Fax: 22 18 52 00
www.niva.no • post@niva.no