

Shoreline embankment protection from oil spills

Case Hernesaari in Helsinki, Finland

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ABSTRACT

Oil transportation in the Gulf of Finland has increased significantly during the past 20 years. At the same time also other marine traffic has been increasing. The majority of the oil transportation traffic runs from Russia's new oil terminals in an east to west direction. This combined with the Helsinki – Tallinn traffic creates a risk hotspot in the shipping lanes crossing south from Helsinki. The worst case scenario that has been identified as possible, is a collision of a fast passenger ferry and an oil tanker vessel that may cause a major oil spill just in front of Helsinki.

The aim of an oil spill response operation at sea is to keep the spillage away from the shores and to collect as much of it from the water as possible. If the spillage reaches the shores, the collection and cleanup is very slow and costly – in many locations the changing of the contaminated landmasses is the only solution. In Helsinki the Hernesaari area is very open to waves and winds from open sea, the shoreline is completely manmade by land fillings. If an oil spillage contaminates the Hernesaari shores, the rough structure will most likely have to be rebuilt by changing the landmasses in the shoreline.

The purpose of this work is to find solutions for land filled shoreline protection from oil spillages from the sea and to find out if the regulations in Finland concerning the planning of this type of structures acknowledge the need for an assessment of the probability of an oil spill contaminating the built embankments. The information for the study was collected from Helsinki City's Hernesaari area partial Master Plan's and City Plan's background material, an expert interview meeting in Helsinki City Planning Department and from the oil spill response authorities' publications.

The results show clearly that there is a need for structural protection against extensive and deep penetrating shore embankment contamination. This work proposes using impermeable groundwater protection materials in shoreline land fills. The results also indicate that the regulations concerning the planning and building of seashore land fills do not sufficiently take into account the risk of an offshore oil spill.

Keywords: Oil spillage, preparedness, land filling, waterfront construction

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ESTLANDER, VILLE: Rantapenkkarakenteen suojaus öljyvahingolta
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TIIVISTELMÄ

Suomenlahden öljykuljetukset ovat lisääntyneet huomattavasti viimeisten 20 vuoden aikana, samaan aikaan muu meriliikenne on lisääntynyt. Liikenne on erityisen vilkasta Helsingin edustalla, missä tiheään liikennöity Helsinki-Tallinna väylä ja öljykuljetusten itä-länsi-suuntainen liikenne kohtaavat. Pahin todennäköisenä pidetty skenaario Suomenlahden meriliikenteessä on nopean matkustajalautan ja öljytankkerin törmäys väylien risteysalueella. Tällainen onnettomuus voisi aiheuttaa huomattavan öljyvahingon aivan Helsingin edustalla.

Öljytorjuntaoperaatiossa merellä pyritään pitämään vuoto pois rannoilta ja keräämään öljy pois suoraan vedestä. Öljyn poistaminen rannoilta on erittäin hidasta ja kallista. Usein saastuneiden maa-aineiston poisto ja korvaaminen puhtailla on ainoa mahdollisuus. Esimerkkialue Helsingin Hernesaari on avoin aallokon ja tuulen vaikutuksille ja rantaviiva on kokonaan täyttömaata. Hernesaaren rannan saastuminen öljyvahingon seurauksena edellyttäisi karkearakenteisen rantapenkkarakenteen rakentamista uusiksi vaihtamalla saastuneet maamassat puhtaisiin.

Tämän työn tarkoitus on löytää ratkaisuja täyttömaalla rakennettujen rantavallien suojaamiseksi öljyvahingon vaikutuksilta. Lisäksi työ pyrkii selvittämään tunnistavako suunnittelua koskevat säädökset öljyvahinkojen riskin. Työ on laadittu käyttäen Hernesaaren osayleiskaavan ja valmisteilla olevan asemakaavan taustadokumentteja, Helsingin Kaupunkisuunnitteluviraston asiantuntijahaastattelua sekä öljytorjuntaviranomaisten julkaisuja.

Työ esittää täyttömaarakenteisten rantapenkkojen suojaamista öljyvahingon varalta sijoittamalla imeytymistä estävää materiaalia rantapenkkaan paikoissa, joissa ranta on alttiina avoimille tuulille ja korkealle aallokelle. Tuloksista ilmenee myös, että kaavoitusta ja täyttömaarakenteiden suunnittelua koskevia säännöksiä olisi tarkennettava ja täydennettävä siten, että mereltä rantaa uhkaava öljyvahinko tunnistettaisiin todelliseksi riskiksi.

Avainsanat: Öljyvahinko, torjuntavalmius, täyttömaa, ranta-alue, rakentaminen

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1 INTRODUCTION

Oil transportation in the Gulf of Finland has been increasing for the past two decades, the volumes of oil and oil products going through the area have risen by seven times in volume since the mid 1990's. At the same time other commercial traffic has also been increasing, the passenger vessel traffic between Helsinki and Tallinn has become very dense and the ship sizes have grown. The crossing area of ship lanes from west to east and from south to north in the middle on the Gulf of Finland, right between Helsinki and Tallinn is recognized as the highest marine traffic risk area in the Gulf. A collision of a fast passenger ship and an oil tanker in this risk area would cause a very large scale accident involving a search and rescue (SAR) operation and an oil spill response operation. If the released oil reaches the shorelines, it will cause a long lasting and expensive cleaning operation, which will include the changing and handling of huge contaminated landmasses where the shoreline structure cannot be otherwise cleaned.

Helsinki's shoreline is to a large extent manmade, the land fillings carried out in the past years have totally covered small islands and created the city's outline in its current shape. There are still areas where land filling is being performed, the Hernesaari area being the largest and most visible from the sea.

The author of this thesis report has the responsibility for oil spill preparedness and response planning for the Helsinki City Rescue department (HCRD), this is the reason for the subject of structurally protecting the shoreline embankments at the Hernesaari area. Especially the possibilities to protect this newly built shoreline in the case of a large scale oil spill accident at sea in front of Helsinki is of interest to the author and also the Department, this point of view to a possible oil spill accident preparedness is new to the response authorities and also to the city planning department.

Helsinki Rescue Department (HCRD) and other responsible authorities are quite well prepared for oil spill protection and response, there are still quite large uncertainties about how to successfully protect the areas that are open to high winds and waves. Hernesaari is the most vulnerable shoreline in Helsinki area in this sense, at the same time it is being developed into a housing and business area, with the added value of being one of the finest seafront areas in Helsinki.

From the numerous oil spill response exercises at the sea area in front of Helsinki with multiple authorities participating, we know that it is close to very likely that substantial quantities of oil will reach Helsinki's shorelines during a bigger spill accident – regardless of the response authorities efforts to keep the accident and released oil as far from the shores as possible. The weather is a factor we cannot change, if the winds blow hard the oil containment booms will at least partially fail and leak – this will allow the waste to continue its spreading towards the shores and to finally contaminate both natural and manmade embankments.



IMAGE 1. Hernesaari land filled shoreline (Estlander 2017)

2 PURPOSE OF THE RESEARCH, METHODS AND MATERIAL

2.1 Purpose of the research

The main objective for this study is to create understanding of the need for structural solutions against possible extensive damage by oil spillages to shore embankment from the sea and to find feasible options for their implementation. An additional objective is to find out if the planning and engineering regulations for the shoreline land fills recognize the possibility of an oil spill coming from sea and contaminating the shore embankment. Hernesaari east coast in Helsinki is used as an example case for this study.

2.2 Methods

This study has been done using qualitative methods. Most of the findings are related to the author's work at Helsinki City Rescue Department and are results of more than 12 years of dealing with environmental issues, especially oil spillage related ones, in the point of view of an authority responsible for oil spill response and preparedness. Numerous maritime accident exercises with marine pollution or simply oil spill response activities have given the author a comprehensive understanding of the challenges that have indicated the need for this study.

The latest developments in the authorities' preparedness and discussions with colleagues and e.g. City Planning Department's experts have only strengthened the idea of the need for alternative approaches to mitigation of spillages effects on shore.

2.2.1 Case Hernesaari

The partial master plan for the Hernesaari area was just approved at the time of the writing of this report (Helsingin kaupunginhallitus 8.1.2018) and the more detailed city planning for the area is proceeding in the Helsinki City Planning Department, when the latter of the plans will be approved,

the actual engineering and building of the area will begin and the final shoreline land fillings will be carried out. At Hernesaari there are many types of shoreline structures planned to be realized. The longest part of the east side shoreline (figure 1, green area) is studied as a case example in this work because it is exposed to open sea and thus demanding to protect against spillages by only traditional response methods. If the final shoreline will remain structurally as it is now, the oil that splashes with the waves on the shore will push deep in the structure and cause a very expensive cleaning operation in the form of replacing all the polluted land fill material with new and clean material –it is impossible to clean this type of ground material by other means.

Also some nonstructural options for the protection of the Hernesaari shores are handled in this work to give an idea of the usability of optional methods; these are mostly similar to the ones the response authorities use as reactive means if and when accidents happen.

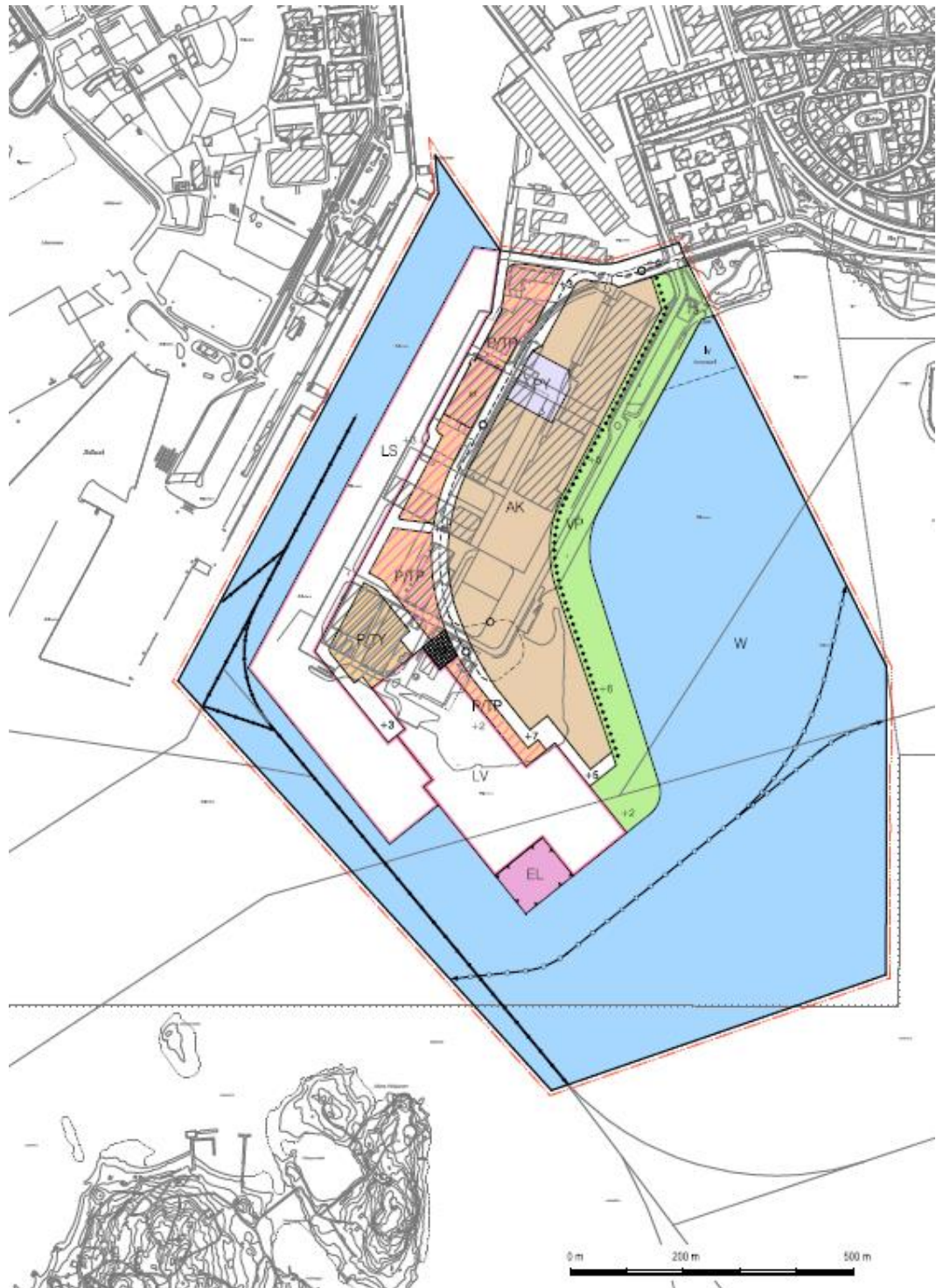


FIGURE 1. Map of the Partial Master Plan area of Hernesaari in Helsinki. (Helsinki City Planning Department 2017)

2.3 Study material

2.3.1 Expert knowledge

The material that have been used in this project has mostly been collected during several years of expert work in the field of environmental accidents preparedness, the experiences and the tacit knowledge created in duty give the basis for the information in the report. The documents concerning oil spill operations and preparedness are mostly produced and published by the Finnish Environmental institute, the representative for the Ministry responsible of the overall preparedness for oil spillages response in Finland.

2.3.2 Planning materials

The Hernesaari area specific information and material was mostly gathered from Helsinki City information systems, the Partial Master Plan and the City Plan related documentation is available also on open web at the Helsinki City website. Documents and other information regarding the different possibilities of structural solutions for the planning area were collected by discussing with land construction engineers and other experts in this field, also material available from internet sources was used.

2.3.3 Group discussion

One meeting with the Helsinki Planning Department experts and engineers was organized on April 26th 2018 to discuss the topic of this work. The author prepared general questions about the subject for the meeting, the issues discussed were as follows.

- Does the City Planning usually consider oil pollution issues when the planning is performed on the shoreline or close to it?
- What would be the triggering aspects that would include the possible spillages effects into the City Plan's structural

requirements?- What are the constraints that limit the inclusion of the structural requirements into the City Plan?

- If the oil spillages response authority, the Rescue department, would like to have a direct influence on the City Plan´s demands of shoreline structures, what would be the correct method to pursue the requirement to the Plan?
- What kind of structural solutions could be used as applicable examples for the purpose of protection from oil spillages in shore embankments?

The meeting was held at Helsinki City Planning Department, the representatives from the Planning Department were

- Ms. Mari Soini, Landscape Architect
- Mr. Jarkko Nyman, Engineer for City Planning
- Mr. Pekka Leivo, M.Sc. in technology – Geotechnical engineer.

3 PRESENT SITUATION AND PREPAREDNESS

Land fillings have been changing the shorelines on Helsinki to what they are, in the past years the regulations and guidelines regarding the planning and carrying out of these were practically none existing. Present day regulations require geotechnical engineering before commencing with land filling, some guidance is also given in Finnish Environmental ministry's Building Code collection –namely part B3 which is a decree concerning the base or foundation structures (Rakennusmääräyskokoelma B3).

3.1 Helsinki's landfilled shores

Helsinki was originally founded in the year 1550 on Swedish King Kustaa Vaasa's order in a location what is now called the Vanhakaupunki in Helsinki, next to the mouth of the river Vantaa. This was too difficult a location for ships to reach the town port and the growth of the city or town was very slow, at this location the population did not reach more than 700 persons. (Saarikivi 2017.) In the year 1640 the decision to move Helsinki to its current location at Vironiemi peninsula was made, one major need for this was to create a better and more accessible port for commercial purposes. Helsinki was meant to compete in commerce with the Hansa City of Tallinn on the south side of the Gulf of Finland. (Helsingin historia2018). The area was scattered and consisted of numerous small islands. The map below shows the original shorelines of Helsinki in the year 1770, and the current situation drawn on top of it. The area of interest in this thesis work is the southernmost area on the on the map in figure 2, Hernesaari. Even though the mapping at that time was not as precise as now, one can see that the name Hernesaari refers to a small island that is now completely covered by land fills – the ones that form the current shoreline.



FIGURE 2. Map of Helsinki by Carl P.Hagström from year 1777 with the present day shorelines drawn on it by Juuso Koponen. (Informaatiomuotoilu 2018)

The map in figure 2 shows clearly how the city's shoreline has been remodified over the centuries, also many names of areas in Helsinki reflect this history. For example places like Siltasaari, Jätkäsaari, Hernesaari, Hanasaari and Hakaniemi have completely lost their properties to which the name refers; saari means island and niemi is peninsula in Finnish language. (Saarikivi 2018).

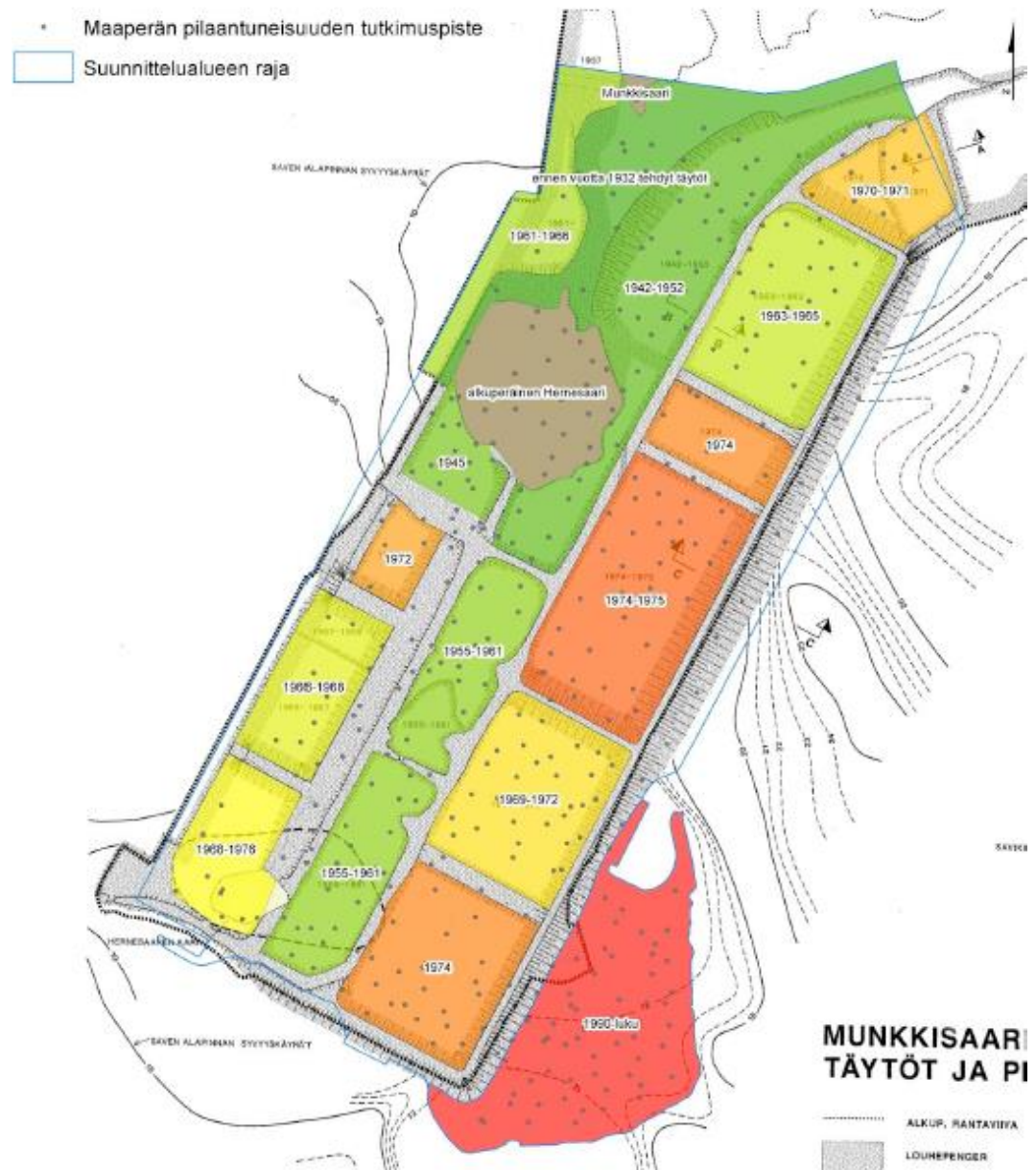


FIGURE 3. Hernesaari area land fillings and year of their execution. (Ramboll Finland 2015)

Figure 3 illustrates the land fillings done in Hernesaari area, the oldest ones are from the beginning of the last century and the latest ones still ongoing. The original Hernesaari can be seen as a greyish area in the middle of the figure. To ensure the safety and quality of the ground in Hernesaari area, Helsinki City Planning department ordered a ground research from Ramboll Finland Oy in 2015. The research indicates the

need for further analysis of some of the landfilled areas before the actual building may be started (Ramboll Finland 2015).

3.2 The risk of an oil spill contaminating the shorelines

The overall risk for a large scale oil spill accident in the Gulf of Finland, in front of Helsinki is relatively high. This is the result of Russia's new oil ports and terminals at the eastern end of the Gulf, it is estimated that the volume of oil transported through the Gulf of Finland will reach 170 – 200 million tonnes by the year 2020 – in the mid 1990's the volume was less than 20 million tonnes. At the same time, other marine traffic is also increasing, especially the passenger traffic between Helsinki and Tallinn. The risk of two ships colliding and causing a large oil spill together with a demanding maritime accident with a huge rescue operation at the traffic's crossing area in the middle of the Gulf of Finland –between Helsinki and Tallinn is very high. (Suomenlahden alusöljyvahinkojen hallinta ja vastuut 2014.) The Gulf of Finland is very demanding environment for marine traffic as it is relatively narrow and the numbers of ships crossing and passing are high, for example the port of Helsinki was reported to be the busiest passenger harbour in Europe on 2017. (Port Of Helsinki 2018)

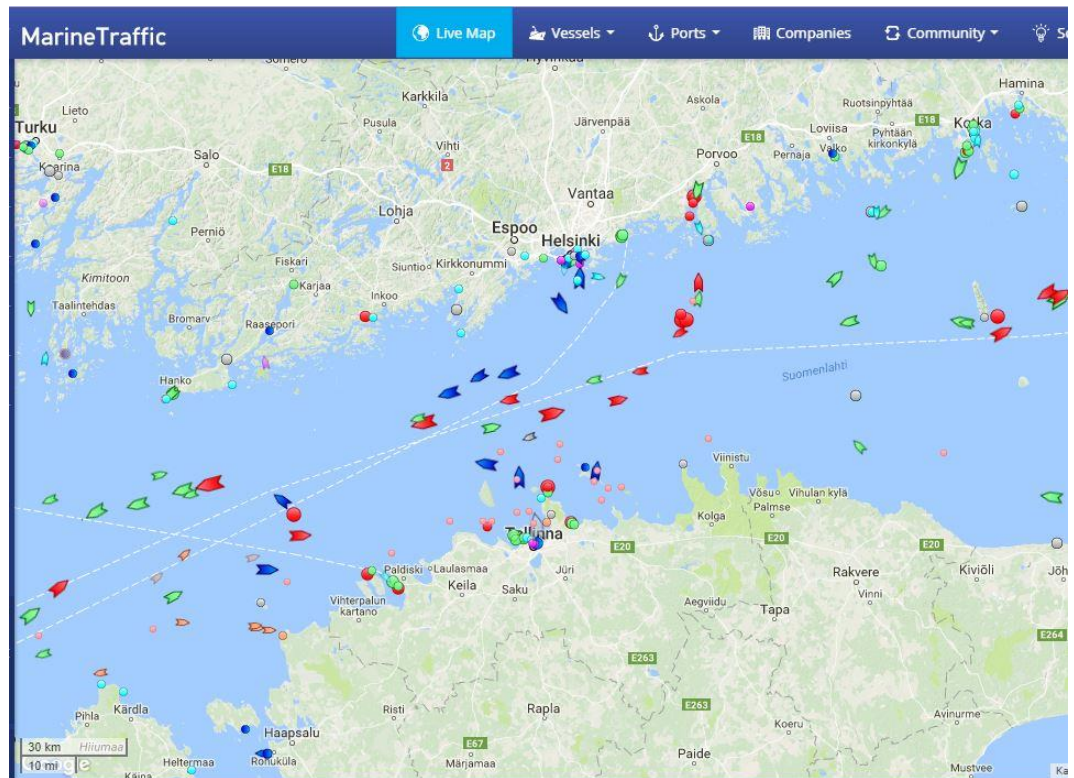


FIGURE 4. An example of a traffic situation in the Gulf of Finland on March 28th 2018 at 19:11 hrs. The red symbols are tanker vessels (13 underway on the viewed area), blue ones passenger vessels and the green ones cargo vessels. (MarineTraffic 2018).

Figure 4 demonstrates quite well the normal winter traffic situation in the Gulf of Finland. In summertime or whenever the sea is free from ice, the number of vessels is even larger and the total number of vessels is growing all the time. Figure 5 shows clearly how dense the crossing traffic was in the area between Helsinki and Tallinn in the year 2014.



FIGURE 5. The main marine traffic crossing in the Gulf of Finland. (Finnish Environmental Institute 2014)

3.3 Marine traffic safety in Gulf of Finland

In the late 1990 and beginning of 2000, when the marine traffic development in the Gulf of Finland was seen to be increasing in the coming years, the coastal countries around it – Finland, Estonia and Russia – started a survey on the advantages of implementing a joint Vessel Traffic Management and Information System for the Gulf of Finland. The results led to the mentioned countries' respective ministries signing a Memorandum of Understanding (MoU) on Strengthening the Cooperation to Further Enhance the Maritime Safety in the Gulf of Finland, this was done in 2001. The most important issues of the MoU were the need to adjust the traffic separation schemes, i.e. the main shipping lanes and their traffic directions of the gulf and to launch the development of a joint Vessel Traffic System (VTS) (VTT Industrial Systems 2002.)



FIGURE 6. The GOFREP area map with main ports for commercial traffic in Gulf of Finland. (Finnish Maritime Authority 2005)

The MoU with the actions following it led into development and implementation of the GOFREP, Gulf of Finland reporting system and its launching to operation on 1st of July 2004. Adopted and agreed by International Maritime Organization, IMO, in its Maritime Safety Committee on 5th of December 2002 (Resolution MSC.139(76), the system is mandatory for all ships of size 300 Gross Tonnes or more, the GOFREP area is shown in figure 6 (VTT Industrial Systems 2002). Practically GOFREP means that all the above mentioned vessels have to report to traffic centers when entering the area or when departing a harbour in the GOFREP area.

The GOFREP operation is based on surveillance of marine traffic by radar, Automatic Identification System (AIS), navigational marks in the operation area and radio communication. The three Vessel Traffic Centers, Helsinki, Tallinn and Saint Petersburg exchange and share information they receive from the vessels reporting to GOFREP through a common database. The Traffic centers provide information and guidance to vessels in the area to increase safe marine traffic, this includes e.g. information of situations that may cause dangerous traffic movements and other issues concerning the safety of navigation in the GOFREP area. (Sonninen et al 2006.) The Vessel Traffic Service (VTS) the Centers provide have been proven to increase the navigational safety of the marine traffic in Gulf of Finland significantly, every year there are “close call” –situations which would have actualized to serious maritime accidents without the service.

The Baltic Sea and Gulf of Finland as a part of it has been designated as Particularly Sensitive Sea Area (PSSA) by the International Maritime Organization (IMO) in 2005, this decision has important indications on marine traffic safety development in the area (International Maritime Organization 2018). The PSSA status also highlights the sensitiveness of the area to all commercial marine traffic operators that enter the area. This may seem obvious naturally without any statement by the IMO, but the global shipping industry needs these decisions to assure the fleet owners understanding of the importance of safe navigation and environment protection.

3.4 Baltic Sea area international preparedness for oil spill accidents

The Helsinki Convention, HELCOM, agreements are the most important international contracts for oil spillages response and preparedness in the Baltic Sea area. The Baltic Sea cooperation for pollution preparedness and response under HELCOM have been active and developing since 1974 when an Expert Group for Oil Combatting was established under the HELCOM Interim Commission. Currently the same group exists under the name HELCOM Response Working Group. The Group consists of every Baltic Sea country's national pollution response authorities which are responsible for the overall coordination of preparedness nationally, from Finland the representing authority, at the time of writing of this report, is the Finnish Environmental institute. (HELCOM 2018.)

The HELCOM response manual, approved to use in 1983, gives the agreed operational procedures for the contracting parties to the Helsinki Convention in the case of a major international oil accident or a maritime accident with hazardous noxious materials (HNS). The manual also covers the administrative and financial matters related to requesting and receiving international assistance. The procedures are also practiced and tested annually in international alarm and operational exercises, for example a training exercise called the Balex Delta gathers every year several of the HELCOM agreement countries' response vessels together in the field. (HELCOM. 2018.)

The HELCOM contracting parties, Baltic Sea countries have about 80 oil spill response vessels in the Baltic Region in different levels of preparedness for deployment. All of the response vessels that are included in the HELCOM agreement are multifunctional, with their normal operating area mainly in the region. To amend these ships there are also a variety of smaller vessels for operation at e.g. archipelago that are available from national responders and other contractual entities in the area. The Baltic Sea Countries also cooperate in shoreline response issues, oiled wildlife response and aerial surveillance under the HELCOM

agreements. These are a crucial parts of the overall oil spillages response chain. (HELCOM. 2018.)

3.5 Worst case accident scenario

If a collision between a tanker vessel and, for example, a high speed passenger ship should occur in the Gulf of Finland, it is estimated that a maximum of 30 000 tons of oil could be released into the sea. This is the so called worst case scenario, where each tank compartment of the tanker vessels contains 15 000 tons and as it is estimated that a maximum two of them would be breached and emptied totally in a collision with another ship (Toiminta isoissa alusöljyvahingoissa 2011, 19).

If all the available resources to cope with the situation could be appointed strictly to the oil spill part of the accident, the response authorities might have a good chance of succeeding in preventing the leak from spreading very wide and from reaching the shorelines. However, all the response vessels in Finland are designed and built for multipurpose use and have varying level of preparedness for oil spills (Ympäristöministeriö 2011, 22); e.g. the coastguard vessels that are equipped for oil spill situations are primarily used for search and rescue (SAR) and other Border Guard's duties. In a collision situation the closest available (oil spill / environmental accident) response vessels and other available and feasible resources would be used for life saving activities. The Search and Rescue Mission Coordinator (SMC) for the accident would have complete decision rights on the use of all available ships, boats and other resources needed for the life-saving part in the beginning of the overall operation. The oil spill response part of the situation will fully begin only when the SAR-operation allows it, this may take up to 24 hours depending on the location, weather conditions, number of people involved etc. During this time, if the spreading of the oil to the Gulf of Finland starts from the middle of the gulf, it will almost certainly reach the closest parts of the shoreline.

In one of the drift modellings by the Finnish Environmental institute (SYKE), using a software called the SpillMod, the oil would be reaching

the shores of Helsinki in 30 hours from its release in the sea lanes crossing area in the middle of the Gulf of Finland.



FIGURE 7. Oil spillage spreading according to drift modelling by SYKE in 2012. (Jolma 2014)

The oil spill response authorities use drift modellings to simulate different options of oil spillages spreading and possible the effects of them. Simulation in figure 7 shows how a large, 30 000 tonnes spillage would in average weather conditions reach the shores of Helsinki in 30 hours. The starting point is at the sea lanes crossing area where the worst case has been identified as possible. (Jolma 2014.) The drift modellings give a good overview for preparedness planning, the same modelling may give a lot of variable results if even a smallest value in the base information for the modelling is changed. This equals to what would happen in reality, minor changes in the environmental factors have a significant impact on where and how quickly an oil spill will spread.

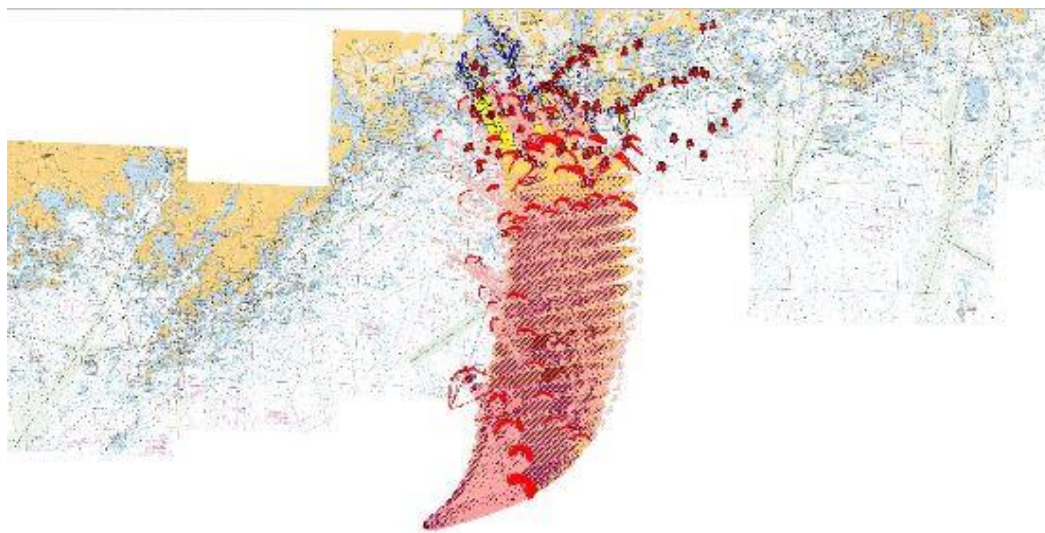


FIGURE 8. The same spill as in FIGURE 7 but with simulated oil containment and restriction booms laid out in the pre-planned locations in front of Helsinki. (Jolma 2014)

In figure 8 the simulation has been run with the same parameters as in figure 7, oil booms have been added to discover the effect they could have if deployed successfully and timely. This would practically mean that all the needed resources would be in immediate readiness and weather condition also favourable.

The probability for an accident of this scale happening in the shipping lanes crossing area in front of Helsinki is remarkably high (Ympäristöministeriö 2011, 9.); with this in mind the authorities and other entities responsible for different aspects of preparedness have to find cost efficient solutions to restrict and minimize the possible effects of an oil spill accident at sea.

3.5.1 Examples of an oil spill contaminating a shoreline

The Finnish Environmental Institute has listed accidents during the period 1969 – 2017 where Finnish state owned response vessels have been used, in the list there are also a few cases where Finnish resources have been used abroad, but the majority have happened in Finnish territorial waters (Suomen Ympäristökeskus 2018). The number of these cases, basically larger scale accidents is 102, the largest quantity of oil spilled

into Finnish territorial waters has so far been the accident of M/T Antonio Gramsci in the year 1979 – 5500 tonnes of crude oil was released. In this case only 650 tonnes of oil was reportedly collected from the shores of Åland area, what happened to the remaining 4900 tonnes remains unclear, because the accident itself happened in the waters of Latvia.(Nissinen 2000, 21.)

Another good bad example of a spillage accident was the grounding of M/S Eira, a 169 meters long bulk carrier ship in year 1984. The ship grounded with a full cargo of timber in August the 31st 1985 at 3 o'clock at night in the Kvarken area on Gulf of Bothnia, the grounding caused a rupture on the bow section of the ship where some of the so called bunker oil or fuel tanks were. The ship was carrying about 877 tons of heavy fuel oil, HFO, and 80 tons of diesel oil. (Kauppinen 2014, 33.) Approximately 300 tons of bunker oil, in this case HFO, was released to sea (Suomen Ympäristökeskus 2018).



FIGURE 9. M/S Eira in a port in 1977. (Sjöhistoriska museet 1998)

When the grounding happened, the weather conditions were very demanding for any kind of spillage response, also at the time the Finnish authorities' preparedness to cope with such a situation was very limited compared to the present day situation. The seemingly small spillage had

spread already to a 15 kilometers long area by the evening of same day the accident happened. Despite the deployed oil booms, the authorities were unable to hold the oil at sea, it contaminated 1500 square kilometers of coastal areas and shoreline –including more than a hundred islands in the Kvarken. In most cases the shores were contaminated by a one to two meters wide stretch, but in places prone to high waves the oil was spilled further away from the waterline. (Kauppinen 2014,.34.) As a result of the response and cleaning operation, approximately 60 tons of oily waste was taken away directly from water and 150 tons from the shores. Some 1500 volunteers participated in the shoreline cleaning operation, which lasted over one month, the result was not acceptable even by the standards of the time. (Kauppinen 2014, 34. Ympäristöhallinnon ohjeita 6/2012, 14.)

The two spillages described above were quite small by the quantity of released oil, still the effect on the environment – both built and natural - was significant. The response capacity and preparedness is currently much better than that of over thirty years ago, the authorities at all levels have built systems to better handle the consequences of accidents. At the same time also the risk for a lot worse accident is higher and thus the need for new solutions for minimizing spillages effects is real.

3.6 The regulatory basis for oil spill response and preparedness in Finland

The law for oil spill response and preparedness, *Öljyvahinkojen torjuntalaki 1673/2009*, describes the basic responsibilities for different authorities in oil spill response and preparedness in Finland. The state council decree on oil spill response, *Valtioneuvoston asetus öljyntorjunnasta 249/2014*, amending the law sets the demands for authorities and certain businesses' oil spill response and preparedness planning. In the law and the decree the biggest emphasis is on reactive capabilities and preparedness. These include operational plans, equipment and the resources that are going to be used when an oil spill

accident happens, there is no reference to structural protection needs or the need to consider such solutions in high risk areas.

The overall responsibility is geographically divided between different authorities. Rescue departments' area of responsibility is the land area including lakes and rivers and it extends out to the outer archipelago at sea, there are currently 22 rescue departments in Finland. The Finnish Environmental Institute, SYKE, is responsible for oil spill response and preparedness at open sea in Finnish territorial waters. The main operators for the SYKE's governmental oil spill and environmental protection units, mainly multipurpose ships, are the Finnish Border Guard, the Navy and a Finnish state owned maritime service and shipping company called Meritaito Oy.

The shorelines are without exception the responsibility of rescue departments during an oil spill accident, the existing means to protect the shorelines are described in the next chapter.


3.7 Helsinki's preparedness for an oil spillages at sea

Helsinki City Rescue Department (HCRD) is the only rescue department in Finland working in the area of one municipality, HCRD is an administrative part of The City of Helsinki and as such it is one of the City's Departments. There are 22 regional rescue departments in Finland, the autonomous area of Åland has its own municipal rescue department system. All the rescue departments that have a sea or a lake shoreline with commercial cargo traffic, are legally obliged to have preparedness and response plans for an oil spillage caused by vessel or vessels. The Finnish southern coast rescue departments, Länsi-Uusimaa, Helsinki, Itä-Uusimaa and Kymenlaakso have the biggest need for maritime spillage preparedness, the shipping traffic in the Gulf of Finland is nearly double as dense as in the other sea areas of Finland. Helsinki having the busiest commercial vessel traffic in Finland is in the center of the biggest risk and the most probable area for a major maritime accident.

Pelastuslaitokset

1. Helsinki
2. Länsi-Uusimaa
3. Keski-Uusimaa
4. Itä-Uusimaa
5. Varsinais-Suomi
6. Kanta-Häme
7. Päijät-Häme
8. Kymenlaakso
9. Etelä-Karjala
10. Etelä-Savo
11. Keski-Suomi
12. Pirkanmaa
13. Satakunta
14. Etelä-Pohjanmaa
15. Pohjanmaa
16. Keski-Pohjanmaa ja Pietarsaaren alue
17. Pohjois-Savo
18. Pohjois-Karjala
19. Jokilaaksot
20. Kainuu
21. Oulu-Koillismaa
22. Lappi

Suomen pinta-ala: 338000 km²
 Väkiluku: 5 435 497 (23.5.2013)
 Asukastiheys (31.12.2012):
 koko maa 17,9 as/maakm²
 Uusimaa 172,2 as/maakm²
 Lappi 2,0 as/maakm²

 Ahvenanmaalla on pelastustoimessa oma maakunnallinen lainsäädäntönsä.

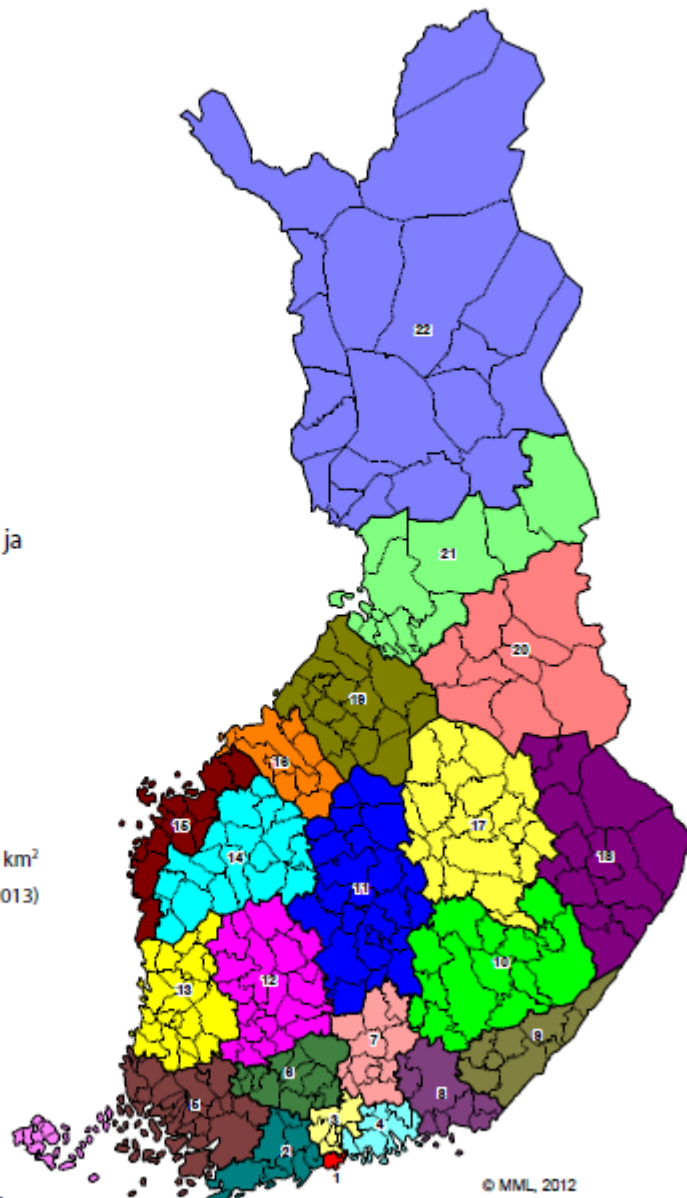


FIGURE 10. Rescue departments in Finland. (Pelastustoimi 2018)

The HCRD is the responsible authority for oil spill response and preparedness in the area of Helsinki, it uses mainly the same resources for this as for other preparedness responsibilities the department has. The majority of the HCRD's operative personnel have been trained for oil spill response activities, this includes approximately 500 out of the department's 700 employees. HCRD's material preparedness for oil spill

accidents consists of oil spill response vessels of different sizes and types and other equipment such as oil containment booms, oil collection skimmers, absorbent materials etc. The main part of the equipment is located at the oil spill response depository on Santahamina Garrison Island in Helsinki, the boats and some other equipment are located at rescue stations and their maritime bases in Helsinki. The HCRD has four maritime operation bases of its own. In addition to HCRD's own resources, the other Helsinki City departments that have activities at sea are also operating oil spill response boats owned by the HCRD and have trained personnel to work at shoreline protection. In the oil spill response plan of the HCRD are listed the Helsinki City's departments, private companies and other entities that have been trained to, or otherwise planned to be used in an oil spill response operation within HCRD's area of responsibility.

An oil spill accident would be very demanding for the HCRD to cope with, the daily operations in Helsinki require a large part of available personnel resources and also the prior described maritime rescue (SAR) operation at the same time would most likely need resourcing by the HCRD. A large scale response operation would always be a joint effort of many authorities and other, mainly contractual entities. The aim at an oil spill accident at sea is to restrict the spreading of the released oil with restriction and containment booms and to collect it away with different types of mechanical collectors – the use of dispersants is banned as an interception method in the whole Baltic Sea area by agreements under the HELCOM. As long as the oil is floating on water and away from the shores it is relatively easy and economical to remove from the water.

3.7.1 HCRD's practical solutions for oil spill response

The overall oil spillages response system of Helsinki City Rescue Department consists of overall planning for spillages preparedness,

training of personnel, special equipment for spillages and also lot of exercises with other response authorities and entities.

To enable the effective restriction of an oil spill spreading to Helsinki's shores, the HCRD has installed attachment points, so called bolts to the islands and shoals in the sea area in front of the city. The oil booms installed and attached to these points form three actual "defense lines" if the authorities are able to install them in place when the accident happens. How well this will succeed depends on the weather and other environmental factors and also the situational availability and response time of the planned resources at the time on the incident.



IMAGE 3. Oil boom attachment bolt at Liuskasaari in Helsinki. (Estlander 2016)

HCRD has approximately 14 kilometers of different sizes of oil restriction and containment booms in preparedness depositories, roughly half of this is meant to be used in the open sea area and the rest in the inner archipelago and other areas at sea which are protected from higher waves and winds. From the exercises it has been learnt, that to deploy e.g. 1 kilometer of larger oil boom, which would be needed to restrict the spreading of oil in an open sea area, it will take at least four to six hours' time on an average day and preparedness situation. On top of this, if the

wind speed would be high, more than 10 meters per second, the HCRD's own vessels' operating area at sea would be very limited.

For the collection of released oil from the sea, HCRD has brush collectors in some of the response vessels and also oil skimmers available in depository.



IMAGE 4. HCRD vessel HE 208 with oil collector equipment deployed. (Saarioinen 2016).

Oil collection from water is done mechanically mainly with skimmers and brush collectors, the equipment is often permanently installed in response vessels. The mechanical oil collection technology has been especially developed by Finnish response equipment manufacturers, the environmental factors of the Baltic Sea require this type of solutions to handle spillages. For example, the operation of a brush collector is based on oil's viscosity and other qualities that make it stick to a suitable type of bristle from where it can be swept away and pumped further to a container or other storage.

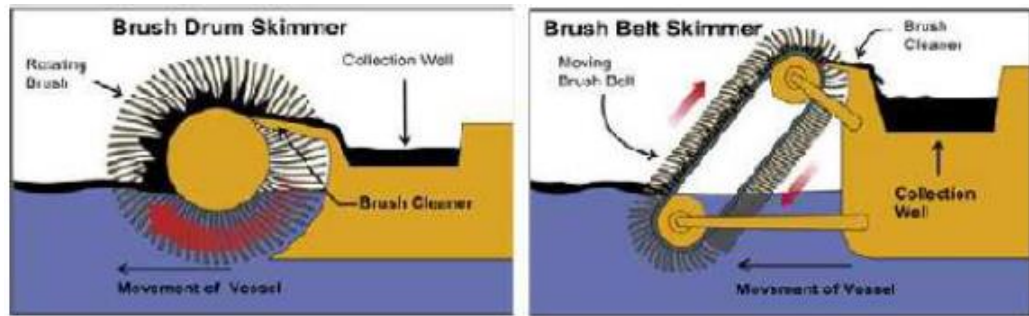


FIGURE 11. The working principle of a brush collector. (SYKE 2011)



IMAGE 5. A brush skimmer installed on an excavator. (Saarioinen 2016)

Shoreline cleaning, when applicable, can be done partially by heavier machinery when the location and structure allows the use of the machines. More often the main part of the cleaning has to be made manually using small spades, brushes and even spoons. This work is very slow and physically demanding, the non-ergonomic working positions and the workers exposure to oil and its vapours make the manual shore cleaning the least wanted duty of a spillage response operation.



IMAGE 6. Oil restriction boom being rolled in to the deck of response vessel HE608, in the background other vessel, HE208 is hoisting the anchors that hold the boom in its position. (Bedda 2018).

4 POSSIBLE SOLUTIONS FOR BETTER PREPAREDNESS IN HERNESAARI AREA

As described before, the reactive response methods the response authorities are prepared to use do decrease the environmental effects of an oil spill in the Gulf of Finland in front of Helsinki may very well fail at least to some extent. This would result in shoreline contamination and a very long lasting and expensive cleaning operation. In structurally difficult shoreline types the only possible way to do the cleaning will be the replacement of the contaminated landmasses with clean ones, this will also result in a very large need for proper handling of the removed contaminated masses. The handling and logistics of these types on masses would be a demanding part of the operation, the most polluted masses would have to be handled as hazardous waste. This is very strictly regulated and requires careful procedures, including the need for an approved site for holding the material before the final handling or processing (Häkkinen 2016,17).

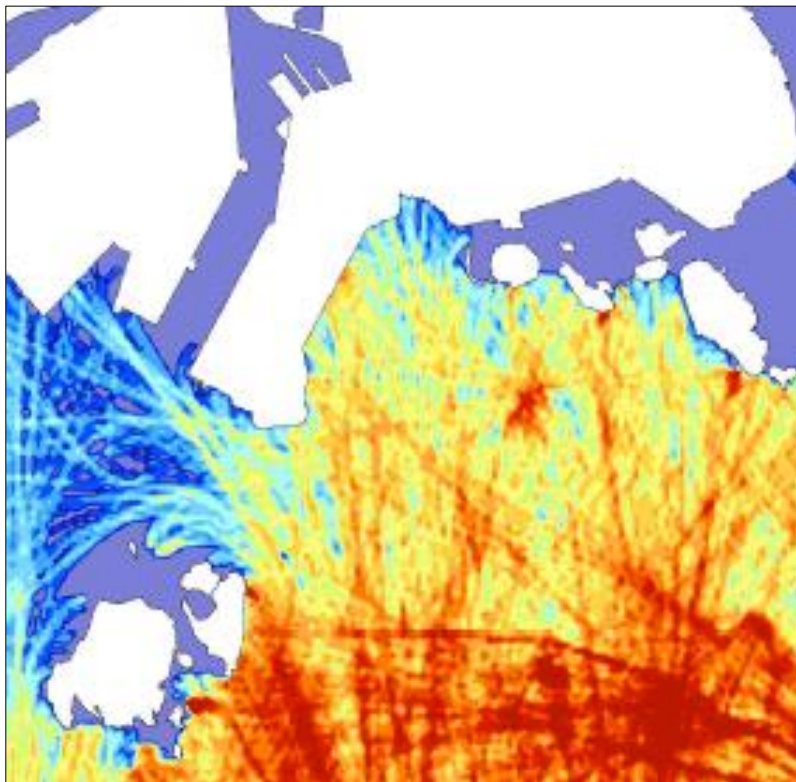


FIGURE 12. View from a wave modelling in Hernessaari partial master plan background documentation. (Ilmatieteenlaitos 2015)

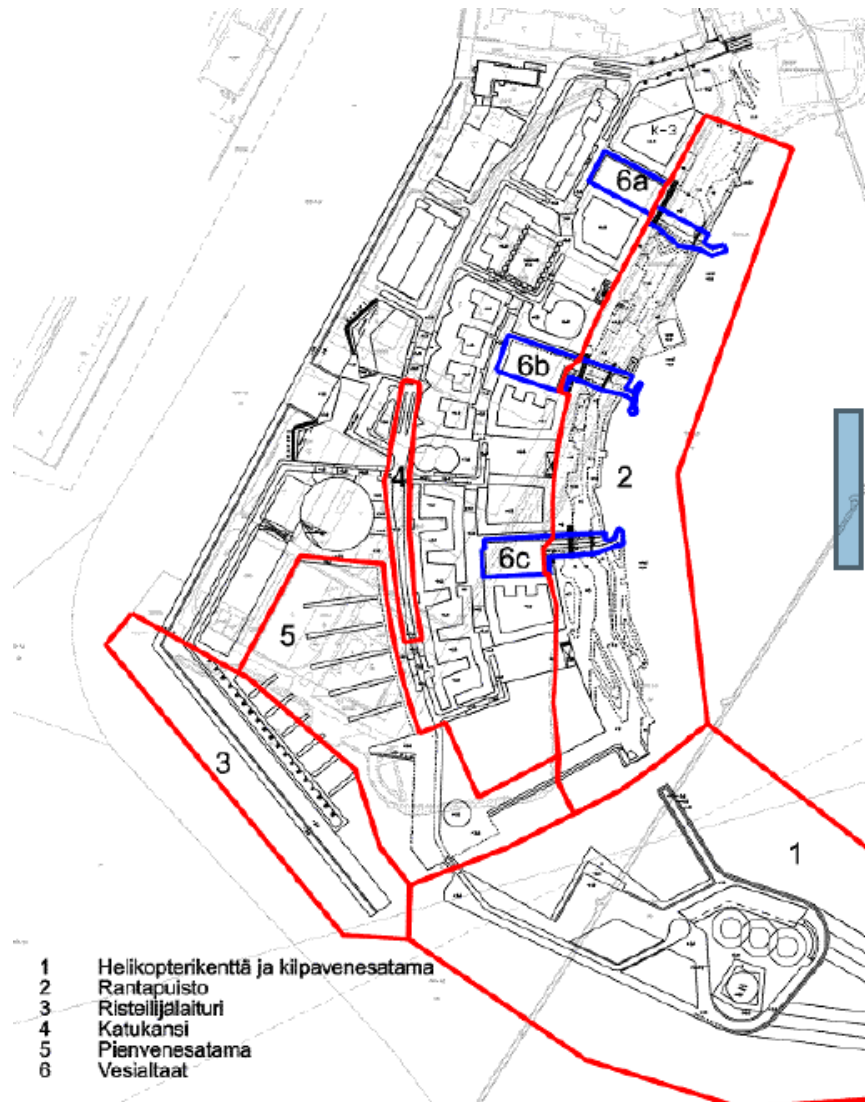


FIGURE 13. Hernesaari project area where especially the area number 2 would benefit from structural preparedness solution. (FCG Finnish Consulting Group 2017)

The shoreline embankment (in figure 13 area number 2) that is going to be built in Hernesaari area in Helsinki, combined with the fact that the area is prone to high winds and waves, requires extra attention (Kahma & Tikka 2016). In case the final embankment is built without any structural protection to create resilience against oil spilled and absorbed into the structure, the risk of a very large and expensive land masses changing operation to get the shoreline cleaned is evident. Also the rules and guidelines for land filling structures are very general and therefore do not give rise to any demands in this regard, the building order of Helsinki City, for example, in the only states that changing the natural shoreline requires

always a permission by Building Control Authority (Helsingin kaupungin rakennusjärjestys, 20§).

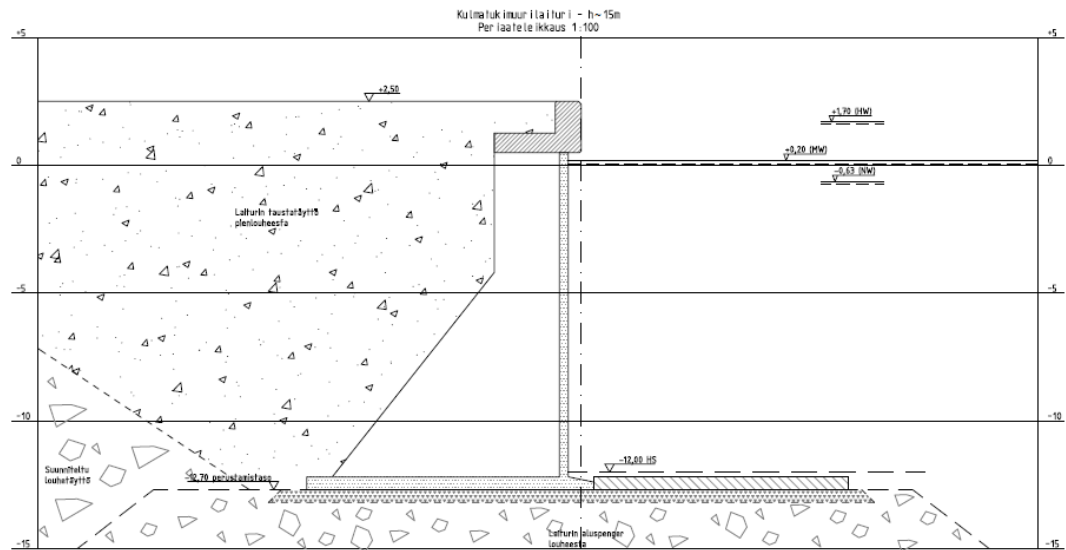


FIGURE 14. An example of a planned shore structure in Hernesaari. (Ramboll Oy 2015)

Other shoreline structures (e.g. figure 14) in the planning area of Hernesaari are to large extent possible to clean by washing if contaminated by spillages, the difficulty of cleaning to a large extent is connected with the permeability of the selected structure. The majority of the planning area's new shores are according to the present layout going to be engineered as erosion resistant embankments, the structure is in these going to include blasted stone as the top layer (Havukainen et al. 2015).

4.1 The requirements set by City planning

The most effective way to influence in this type of preparedness would be the demand for a structural solution for protection of oil spills and other possible contaminating substances to be written in the City Plan of the area; the Law on Land use and Construction – Rakennus- ja maankäyttölaki, states in its 7th chapter the possibility and requirement for this in the City Plan (Maankäyttö- ja rakennuslaki 132/1999, 7.luku, 50 ja 57§). The main subject of this study report was discussed in a meeting

with Helsinki City Planning Department (HCPD) on April 26th 2018, the aim of which was to define how the main points of need for this type of preparedness could be described in the City Plan. The city planning experts at HCPD agreed that the need for this kind of approach in the planning is new to them. To implement the idea into city planning it was agreed that HCRD would give an official written statement of the need to the head of the HCPD City Planning Division.

4.2 Examples of possible protection structures

There are very few existing examples for this type of structures in this context. Land fillings on shore embankments are mainly built either as “fully built” solutions to be used as a harbour, pier or possibly base for some buildings or just as landscape adjustment with enough resistance for environmental conditions. For the scope in this work some other example solutions might be feasible, groundwater protection structures are one option among others yet to be discovered. In the discussion with Helsinki City Planning Department’s planning group it was clear that whatever solution would be selected, it would require geotechnical engineering and a principal recognition of the basic need for this type of preparedness.

The structure in this type of location should have verifiable lifespan for at least fifty years, this is according to the Helsinki City Planning Department’s geotechnical engineer Pekka Leivo the minimum acceptable time for the solution at a location like Hernesaari. There are several different types of shore structures planned to be used in Hernesaari, the longest part, called Rantapuisto being the most difficult in scope of protection from spillages from sea (Hernesaaren osayleiskaava-alue P14965 2012).



IMAGE 7. An example of heavy erosion protection on a manmade shore embankment at Vuosaari harbour in Helsinki. (Finnish Consulting Group 2017)

The cost – benefit ratio for the structural solution needs to be described and examined. This could in the case of Hernesaari be done for example by using other types of major landmasses change operations as reference, one such could be the former Herttoniemi oil harbour area in Helsinki which was rebuilt to Herttoniemenranta residential area in the late 1990's. The ground of Herttoniemenranta area was polluted by different types of oil products during the time that it was an oil harbour and warehousing area, when construction of the residential area begun, the polluted landmasses changing operation was the largest so far in Finland. The cost of this operation could give a rough idea of the possible cost of Hernesaari area shoreline's renovation if an oil spillage contaminates an unprotected shore embankment.

The carbon footprint of the solution to be planned was also brought up by Mr. Leivo, the materials for the structure need to be as ecologically friendly

as possible. This requirement may limit some solutions, the global agreements on greenhouse gasses limitations have a very practical effect in this case.

4.2.1 Groundwater protection structures as a possible solution

An example of possible structures already in use are groundwater protection solutions made for example at Salpausselkä or Lohjanharju areas in Finland (Liikennevirasto 2015). These locations are quite different from Hernesaari area by nature, the environmental stress – wind, waves, ice etc. – in Hernesaari is remarkably greater and hence requires more attention in planning of the structure. The same principle solutions in the structure could nevertheless be applicable.

A widely used structural solution in groundwater protection sites is one with a bentonite clay liner assembled as a protection against contaminants between ground structure layers (example in figure 15), these are also known as bentonite mats or commonly as geotextiles. The geosynthetic liners consist of a layer of high swelling sodium bentonite sandwiched between two layers of usually nonwoven geotextiles. Bentonite clay is a natural material which can absorb up to six times its volume of water, this feature makes the structures where bentonite is used nearly waterproof. The ability to absorb water causes bentonite also to swell as it gets in contact with water, for this reason the bentonite clay liner, for example, repairs small punctures in itself. The bentonite clay layer is often bonded inside the liner by needle punching through all three layers. The expected lifespan for one example of bentonite mat product, Dual Seal® is over 100 years, which also makes the material's use highly suitable in this practice (RT 38648).



IMAGE 8. Bentonite clay liner being assembled for groundwater protection in highway construction site. (Kaitos Oy 2017)

Also a bentonite clay layer in between the land filling layers of the future embankment structure could work as a solution, the insulating effect of bentonite clay in the structure would undoubtedly protect the inner parts of the filling from oil or other contaminants released on the ground.

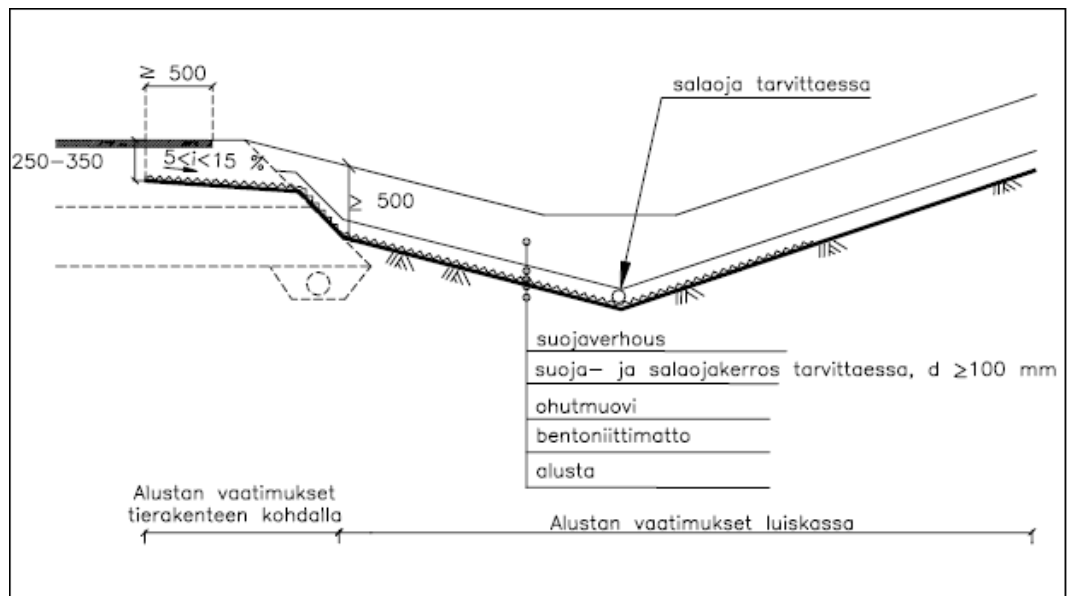


FIGURE 15. Groundwater protection structure example with bentonite clay liner. (Tiehallinto 2004)

4.2.2 Other structures

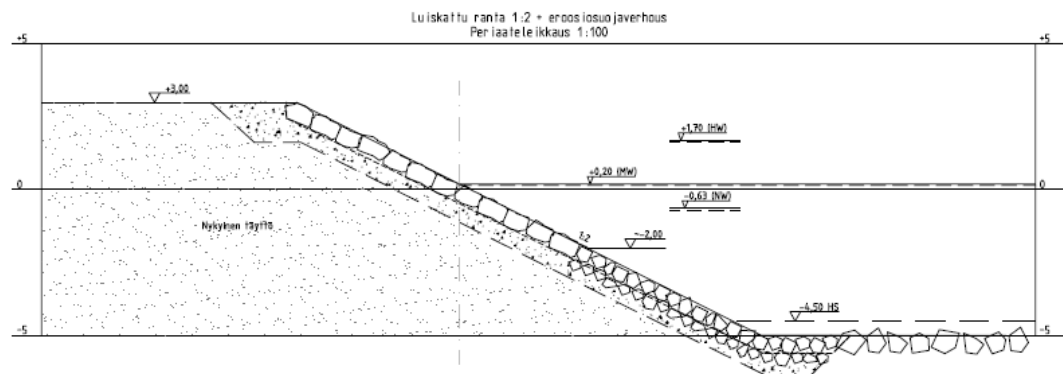


FIGURE 16. Example structure for Hernesaari Rantapuisto embankment with erosion protection layer. (Ramboll Oy 2015)

In the present planning situation of Hernesaari the longest stretch of the future shore embankment is planned to resemble structurally what is presented in figure 16 (Havukainen et al 2015). If a bentonite clay liner would be selected as a protective solution in this example, it would be easy to assemble in between the planned filling layers. Practically the liner would have to be installed into the structure so that the surface layer would act as erosion resistant protection and the second one should work as a buffer layer protecting the bentonite mat. This way the possible contamination would reach these two upper layers and stop from deeper penetration in to the geotextile. Also a compressed layer of suitable ground material might work, certain ground materials are well known to resist the absorption of oil products. In this the bentonite clay as a separate material would be an option, the material is also used as a sealing layer itself in ground construction solutions.

The embankment's visible part could possibly also be built as only cladding to the actual structure, this way the inner part could be built even as a concrete wall – in a spillage situation the cladding could then be removed, cleaned and installed back to its original place. This option would, according to Mr. Pekka Leivo from Helsinki City Planning Department, create too large carbon footprint to be even considered and

studied as an option. The lifespan for the concrete structure would, on the other hand, be most reliably over the required minimum of fifty years.

4.3 Non-structural options as solutions

Nonstructural solution for protecting the shoreline in this case could be a pre-positioned, easily deployable oil restriction boom at a suitable location in Hernesaari. If this approach were selected, the system would have to be designed to hold even in the roughest weather conditions and to be used by either response authority i.e. the Rescue Department or by some other Helsinki City Department capable of keeping up such preparedness. Practically, the feasibility of such solution seems quite limited; the boom itself would need to be a so called Heavy Duty Boom (HDB) to reliably provide the resistance needed in most of the weather conditions. This kind of boom is quite expensive as an investment – not to mention the whole operating system needed - requires regular maintenance and exercising in its use , and it has a lifespan of approximately 20 years.

Another possibility could be some kind of rapidly deployable protection sheet or liner that would, as a response to an evident pollution threat situation be quickly spread to cover the shore embankment. The material itself would need to be heavy enough to submerge to the waterline and to hold in place in wind and waves, it would also need to be resistant to oil products. The earlier in this study mentioned bentonite clay liner might be suitable material for this purpose. Before selection of such solution, at least some testing would need to be done to verify the material's validity. One important issue about the use of a bentonite mat as a response material is the availability of the material, the only 100% certain way to ensure this would be warehousing for this purpose. Also the technology to be used for the deployment and installation of the protection liner in a spillage situation, is not available as a ready solution – this would require engineering, testing of the equipment and also constant overhauling if finally selected to be acquired and kept in readiness. The feasibility of such system in other locations make this option worth of further study.

4.3.1 Funding of the preparedness solution

The development of different types of response methods and equipment may in future solve the problems that are evident at this moment.

Whatever the solution will be, the same basic issues of the cost – benefit ratio, lifespan and the feasibility for specific locations will always have to be dealt with. The Finnish State has basically developed a well working funding mechanism for oil spillages response preparedness, the Oil Pollution Fund – Öljynsuojaarahasto. The funding for this is collected from imported and transit transported oil products, the so called oil protection fee is 0.50 euro per each full ton of oil product (Laki öljynsuojaarahastosta 2004, 5§). The oil spill response authorities get funding for their preparedness for oil spillages from the Oil Pollution Fund, most of the extra costs of equipment and also training are paid for. Also municipalities can get compensation for e.g. oil contaminated ground cleaning operations and also for the renovation procedures after an oil spillage accident. However the law for the fund does not recognize the municipality's measures for preparedness, for example the solution studied in this thesis work as a cost to be compensated is not possible (Laki öljynsuojaarahastosta 2004, 12 – 15§). This is clearly a shortcoming in the funding system and may even result in some aspects in the identification of risks regarding environmental pollution to be left without consideration.

5 RESULTS

The study was carried out to find new ways to better prepare for the effects of possible oil spillages at the shoreline of the Hernesaari area in Helsinki and other similar locations, the idea could be adopted to use also in other types of places where applicable, e.g., beach areas. Also the purpose was to create understanding of the need for this kind of approach in preparing to an oil spillage; the regulations do not demand it. It seems that the official line and scope of entities responsible for the different parts of preparedness and planning are strongly guided to stay within their respective line of legislation and rules related to it. If this way of thinking could be changed to a wider perspective at least in the most obvious cases, the long term effects would be positive in the sense of limiting the effects of spillage accidents.

5.1 Structures

The studied structures, especially the ones commonly used in groundwater protection sites, are the kinds that could be used to protect the shoreline embankment against deep contamination in an oil spillage situation, where the oil reaches the shores. The author did not find example cases where, for example, bentonite clay liner would have been used in these types of locations, even it is a quite common material in ground structures that are planned to be impermeable inside the structural layers. The function of these solutions is, nevertheless, the same as the objective of the solution suggested in this study, to prevent pollutants from going deep into the ground as demonstrated in figures 17 and 18.

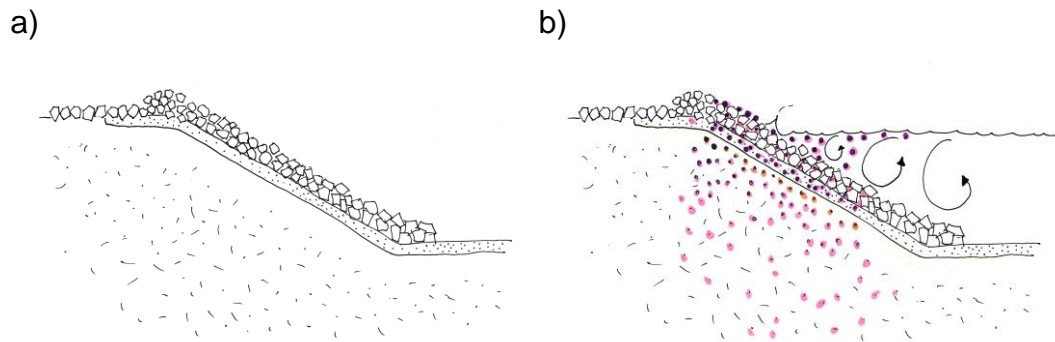


FIGURE 17. The basic shoreline embankment structure without protection layer installed (a) and the same structure with oil (red dots) contaminating the structure (b). Without structural protection the contamination will be absorbed deep in the filled ground material, only possibility to clean the contaminated ground is changing the landmasses.

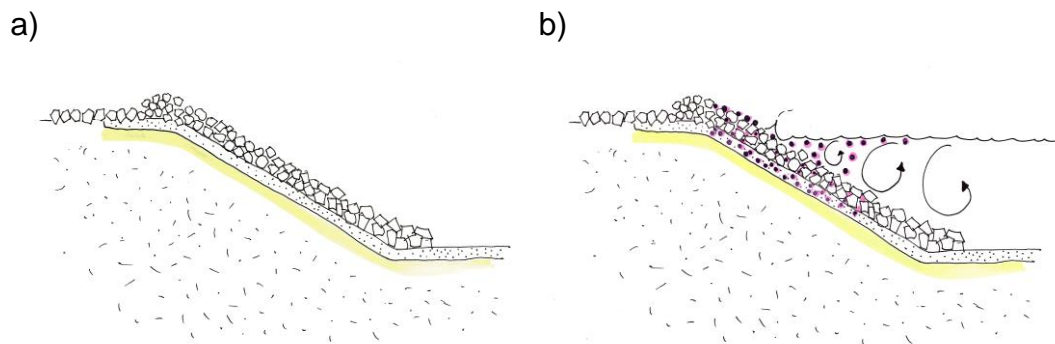


FIGURE 18. The shoreline embankment structure with a protection layer (yellow) installed (a) and the equal structure with oil spillage causing contamination (b). The protective layer prevents the deep absorption of oil into the ground, the need for landmasses changing or cleaning is significantly smaller.

5.2 Regulations concerning the planning process

The regulations that guide the planning processes in different stages do not recognize the possibility of an oil spill contaminating a shore embankment and the need for structural protection solutions. To ensure this point of view in the planning, the regulations need to be adjusted accordingly. The preparedness to respond is well regulated. When an accident happens the responding authorities use specialized equipment and trained personnel to handle the situation. The regulations requiring structural preparedness to shore embankments in locations likely to be contaminated would amend the overall preparedness for oil spillages.

6 CONCLUSIONS AND DISCUSSION

One aim of the study was to create understanding of the need for wider perspective for authorities' planning and preparing for spillage incidents. The case example area studied, Hernesaari east coast, is still under city planning process. It is yet uncertain if the idea and requirement for extra protection inside the shore embankment structure is going to be included in the plan, but a statement of the need for it is going to be made by the HCRD – this was agreed in the meeting with the City Planning Department's experts in April 26th 2018.

The study gives partial answers to the original study questions, the described factors that leave the final solutions open, such as the legally limited scope of the authorities on different aspects of risk identification is an issue to be discussed further. The reactive methods the response authorities need to be planned to cover the worst case that is seen to be possible and probable, this is what has been done actively during the last two decades. Even if the calculable response capacity would be adequate, there is a need for passive preparedness in locations where extensive pollution is likely to occur when a disaster strikes. The passive preparedness can be in the form of structures in the shorelines, which would prevent the oily waste from causing extra damage by e.g. preventing oil from penetrating deep into shore embankments. There are still issues to be studied and engineered before the solution can be implemented in more regular use, the findings and negotiations so far are encouraging and give a clear opportunity for the Hernesaari shoreline to be the first one in Helsinki where this approach may be adopted.

A big uncertainty in the responders' preparedness is the actual timeline of the procedures of a possible operation, in exercises this cannot be properly studied because all organizations need to reserve the resources for the exercises several months earlier. The timeline could be studied in practice if the Oil Pollution Fund, with the Finnish Environmental institute's approval and support would agree on financing a preparedness supervision exercise that would be launched without prior notice to the

responding authorities. Such an exercise could be planned in a small core group with representation from all the main responsible authorities, for all the participating organizations there should be a designated minimum output or procedure planned which would then indicate the reaching of the expected result in the exercise.

For the Helsinki City Rescue Department the objective in the exercise could be e.g. to deploy all the HCRD's oil spill response vessels that have been funded by the Oil Pollution Fund with adequate crews and to install 5 kilometers of restriction booms to a given location. The timing could stop for HCRD when the vessels that have oil collection equipment have deployed them and are operating with collectors after the oil boom installation. The same type of a preparedness inspection should be performed for the Governmental authorities, the Finnish Environmental Institute and the field operators that form the core of the State response capacity – The Finnish Border Guard, The Navy and the maritime service company Meditation Oy.

This type of exercising would give a realistic picture of the real state of responders' preparedness, instead of the current one which is based in many parts on estimates and calculations.

The regulations regarding the construction of land fills in the shorelines should also be adjusted, currently they do not recognize the need to take oil spills or other pollution coming from sea into consideration when these structures are being planned. As the Helsinki City Planning Department's experts agreed, the planning process would benefit from having this point

The funding of oil spill preparedness should be expanded also to structural solutions. Currently the response capacities are very well funded in Finland, the Oil Pollution Fund is financing most of the authorities' equipment and a large part of the personnel training expenses. There are 19 multifunction ships partially financed by the Oil Pollution Fund, these ships are the core of the Finnish State response fleet. The Fund's rules are laid out so, that the funding of fixed passive preparedness solutions is

impossible. There is a huge gap between the landside and the maritime preparedness funding, even though there are beneficial solutions available.

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