WESTERN FINLAND
ENVIRONMENTAL PERMIT AUTHORITY

Helsinki

PERMIT DECISION

No 83/2009/2
Dno LSY-2009-Y-143
Issued after the public notice 2 October 2009

ISSUE

Permit application concerning munitions clearance within the Finnish EEZ as part of the natural gas pipeline project from Russia to Germany, and application for starting the construction activities before the decision becomes lawful and binding

PERMIT APPLICANT

Nord Stream AG

APPLICATION

In its application submitted to the Environmental Permit Authority on 2 June 2009, and its application it has later supplemented, Nord Stream AG has requested a permit for clearing munitions in the Finnish EEZ as part of the Russia–Germany natural gas pipeline project, and a permit for starting the work before the decision becomes lawful and binding.

The application concerns the clearance of munitions from the seabed. Besides the munitions specified in more detail in the application, it is possible that other munitions will be found in the installation corridor or its immediate vicinity during the clearance and related surveys. The intention is also to clear such munitions.

BASIS FOR APPLYING FOR THE PERMIT

Chapter 1, Sections 15 and 19 of the Water Act

EXECUTIVE POWERS OF THE PERMIT AUTHORITY

Section 18 of the Act on the Exclusive Economic Zone of Finland

ENVIRONMENTAL IMPACT ASSESSMENT PROCEDURE

An Environmental Impact Assessment Report (completed in February 2009) has been prepared for the entire gas pipeline, and the assessment also includes munitions clearance. The Uusimaa Regional Environment Centre, acting as the co-ordinating authority, issued its statement on the Assessment Report on 2 July 2009.

On 7 August 2009, the applicant provided the Environmental Permit Authority with a response for the views expressed by Estonia regarding the Environmental Impact Assessment procedure concerning munitions clearance. On 13 August 2009, the Environmental Permit Authority sent the aforementioned response to the Ministry of the

Environment to be further delivered to Estonia. On 15 September 2009, Estonia provided the Western Finland Environmental Permit Authority with a statement on the further clarifications.

PLAN

Purpose of the project

The pipeline system of approximately 1,220 kilometres that consists of two pipes will travel from Russia, the Vyborg / St. Petersburg area to Germany. The pipelines will be laid on the continental shelves of Russia, Finland, Sweden, Denmark, and Germany outside territorial waters, and within the territorial waters of Russia, Denmark, and Germany. The project is not connected to the Finnish gas grid. The pipelines will pass through the Finnish continental shelf and EEZ and will not extend to Finnish territorial waters or land areas. It is intended that the pipeline runs for 375 kilometres in the Finnish EEZ.

The intention is to start the pipeline construction works in 2010. The intended lifespan of the pipeline is 50 years. To ensure the safe installation and long-term integrity of the pipeline, clearance of standard munitions will be necessary. This is why the intention is to clear a total of 27 munitions in the installation corridor located in the Finnish EEZ. The corridor extends to a distance of 25 metres from the respective median line of both pipeline routes.

Project benefits

The 27 munitions intended to be cleared from the seabed constitute a risk for the construction and use of the pipeline, and also otherwise for safety and the environment. The munitions may be detonated in connection with anchoring, bottom trawling, extraction of natural resources from the seabed or other means of seabed utilisation. If a munitions object (mine) detonates in an uncontrolled manner in connection with such activities, the munitions object may pose an immediate danger to people nearby. Furthermore, uncontrolled detonation will increase the risk of avoidable environmental impact, such as the risk of death of large fish schools and/or marine mammals, such as seals. Munitions clearance will offer clear benefits for the general public.

The immediate financial benefits to the gas pipeline project will be significant. The applicant will collect approximately EUR 500 million per year in transfer fees.

Europe currently imports natural gas mainly from Russia, Norway and Algeria. The vast Russian sources are situated in geographical proximity to the EU. Thus, it will in principle secure the supply of natural gas to the EU, provided that there is sufficient transfer infrastructure.

The gas market and the need for natural gas is growing in the EU. According to EU estimates, natural gas demand in the EU will increase from 543 bcm in 2005 to approximately 629 bcm in 2025. The share of natural gas in the overall primary energy mix is also expected to increase, in addition to the general increase in the demand for energy. According to the European Commission, it is expected that the natural gas energy share among energy sources will increase by about 25% between 2005 and 2025. This increase in demand cannot only be covered by the EU's own energy sources, and it is estimated that in 2020 approximately 80% of natural gas used in the EU will be imported from elsewhere. The Baltic Sea pipeline can provide a substantial part of this need. In order to fill the looming EU import gap of 195 bcm per year, several projects are planned to secure gas supplies. According to the European Commission, all of these projects are needed to meet the growing demand. The gas pipeline project is particularly pivotal, because it will supply more than a quarter of the import gap: the most of any of the envisaged projects. The gas pipeline project is of importance for Europe's gas supply.

Munitions clearance

General

Historically, the dumping of munitions at sea has been a typical means of destroying munitions that no longer have any military value. The Baltic Sea was used as a dumping ground for conventional and chemical munitions during and subsequent to both World War I (WWI) and World War II (WWII).

Thousands of sea mines were deployed in the sea during both WWI and WWII as a defence mechanism against attack from naval ships and submarines. The mouth of the Gulf of Finland was of special interest, and therefore the largest quantities of sea mines were deployed there. The mines were laid in barrages to prevent enemy ships from approaching the coasts and entering harbours. The mines were mainly deployed by the German, Finnish and Russian navies.

During WWI and WWII, munitions types such as artillery ammunitions, depth bombs, torpedoes and grenades were also used and dumped. Large amounts of chemical munitions have also been dumped in the Baltic Sea since WWII. It is estimated that approximately 40,000 metric tons of chemical munitions, containing approximately 13,000 metric tons of chemical compounds, have been dumped in the Baltic Sea. Chemical munitions have mainly been dumped in the southern part of the Baltic Sea and therefore they do not affect the gas pipeline in the Finnish EEZ.

Today, systematic munitions clearance is carried out in different parts of the Baltic Sea with the aim of minimising damage and harm due to munitions. In recent decades, the naval forces of the Baltic Sea states have developed safe and effective methods of clearing mines and other underwater ordnance that contain explosives. The navies of other countries around the world have applied these methods to dispose of ordnance.

According to the German navy, more than 410 mines have been cleared from the Baltic Sea between 1996 and 2006. The largest munitions clearance operations include the Baltic Sweep (1996–1999), including all the Baltic Sea states, as well as the Open Spirit project, which started in 1997 and is still ongoing, including all the Baltic Sea states as well as Belgium, Denmark, Finland, France, Germany, the Netherlands, Norway, Poland, Russia, Sweden and the United Kingdom. Between 1996 and 2008, the Baltic Sweep and Open Spirit operations cleared a total of 501 munitions from the Baltic Sea. In addition to this, several minor munitions clearance operations have been carried out.

After both WWI and WWII, the known mine fields in the Gulf of Finland have been cleared. However, individual mines remain to this day in the sea. The applicant performed a number of munitions surveys in 2006–2008 in co-operation with the Finnish Navy. A total of 27 munitions in 26 different locations must be cleared in the pipeline installation corridor. The estimated duration of the clearance is about two months.

All mines to be cleared are located within the Finnish EEZ, the closest distance being 3.3 kilometres from the Finnish territorial waters boundary. The easternmost munition to be cleared is located near Porvoo, and the westernmost is located near Kemiönsaari.

The largest charge in the munitions to be cleared is 350 kg, and the smallest is 0.8 kg. If the specific charge of a munitions object is unknown, the charge has been estimated as the highest possible charge for the munitions type in question.

The munitions to be cleared, and their location

Munition ID	Munition description	Kilometre post, approximately	Charge (kg)	Distance to municipal boundary (km)
R-06-003	No conclusion reached due to bad visibility on video. Maximum found charge assumed.	181	350	3.8/Porvoo
R-E7B-10466	German burst buoy (Spreng buoy).	206	0.8	3.3/Helsinki
R-07-004	Contact mine, Russian origin.	211	150	4.4/Espoo
R-07-2655	Contact mine, Russian origin.	213	150	4.6/Espoo
R-8AG-W-014	German EMC mine.	223	300	3.9/Kirkkonummi
R-8AG-W-009	German UMA contact mine.	237	30	4.2/Kirkkonummi
R-E8C-10223	German UMA contact mine.	237	30	4.7/Kirkkonummi
R-W8A-10317	German UMA mine.	239	30	3.8/Kirkkonummi
R-8CG-E-004	German UMA mine.	239	30	4.4/Kirkkonummi
R-8CG-E-003	German UMA mine.	239	30	4.2/Kirkkonummi
R-W8A-10312	German UMA mine.	240	30	3.9/Kirkkonummi
R-W8A-10313	German UMA mine.	240	30	3.9/Kirkkonummi
G-08-009	German UMA mine.	240	30	3.9/Kirkkonummi
R-W8A-10005	German UMA mine.	240	30	3.9/Kirkkonummi
R-8CG-E-002	German UMA mine.	240	30	4.2/Kirkkonummi
R-8CG-E-001	German UMA mine.	240	30	4.2/Kirkkonummi
R-08-2805	German EMF mine.	243	350	4.5/Kirkkonummi
R-08-159	Russian contact mine M-08.	245	115	5.0/Kirkkonummi
R-09-27	Russian contact mine M-08.	248	115	5.4/Kirkkonummi
S-09-3135	German EMC mine.	256	300	8.3/Inkoo
R-09-04	German burst buoy (Spreng buoy).	257	0.8	8.8/Inkoo
R-09-192	Russian contact mine M-08.	264	115	10.3/Inkoo
R-11-3395	Finnish S-40 mine.	319	100	11.5/Hanko
R-11-5167	Russian contact mine.	334	250	15.0/Hanko
R-12-008	Possible 2 air dropped bombs. No mine.	361	64	9.3/Kemiönsaari
R-12-3463	German EMC II mine.	366	300	9.2/Kemiönsaari

Carrying out the work

Based on competitive bidding, the applicant has chosen Bactec International Ltd (United Kingdom) to complete the work.

Alternatives for eliminating munitions by exploding them onsite have been studied in connection with the project. The alternatives included removing the munitions and eliminating them on land, or transferring the munitions to an open seas location and then eliminating the munitions by detonating them. The alternative of eliminating the munitions by removing them and not detonating them onsite was rejected due to safety concerns. Removing or transferring the munitions is dangerous to people and may result in damage to equipment and vessels since, as time passes, old munitions become more and more sensitive to accidental detonation in comparison to their original state. Furthermore, accidental or unplanned detonation would increase the environmental risks (such as risks to mammals, fish, cultural heritage, external infrastructure and vessels) because harmful-impact-related mitigation measures planned for the intended clearance could not be effectively utilised.

The clearance will be carried out by placing a small charge next to the identified or suspected munitions object on the seabed with a ROV (remote operating vehicle) especially designed for this purpose. The charge will then be detonated at sea level from a safe distance from the munitions object onboard a support vessel.

Special sites of interest will be studied before and after clearance. This will ensure that no harmful impact occurs to cultural heritage sites, cables, barrels and other observed containers.

All munitions clearance works will be performed in a safe and controlled manner following all national and international laws regulating detonation of underwater explosives. The risks related to the methods used in the clearance have been assessed.

Mitigation measures related to harmful impact

In order to minimise the impacts on marine flora and fauna, the works are planned to be carried out during the ice-free period, avoiding fish spawning seasons as well as marine mammals' and birds' migration routes and migratory periods. Furthermore, gradually increasing turbidity is avoided by, for example, avoiding consecutive clearing of munitions objects located close to each other.

Acoustic devices have proven to be an effective means of dislodging marine mammals. However, the dislodgment area around the device may be small, and it may be necessary to place acoustic devices at several distances from the clearing site. The safety area radius (for marine mammals) will be adjusted in accordance with the munitions type. If the charge is 300 kilograms, the marine mammal safety area extends to two kilometres. When using the dislodgment devices, the fact that the dislodgment signal may be associated with dead fish and damaged fish which may lure mammals is taken into account. This may occur when mammals associate the acoustic signal, for example, with dead or damaged fish. In order to minimise the impact, fish that have died during the clearing will be removed whenever possible.

Since the impact prevention measures concerning marine mammals, fish and sea birds mainly consist of visual and acoustic observations and monitoring, the conditions under which the observations are made will be taken into account. The amount of light and the weather will influence the effectiveness of observations, for example. This is why clearing will be performed only when the weather conditions allow safe clearing and effective mitigation of impact, and only during the day when there is enough light (the work will begin an hour after sunrise and end an hour before sunset). Observation will begin at the latest thirty minutes before each detonation. Observation of marine mammals and birds will begin at the earliest 20 minutes after sunrise.

The size of the ammunition affects the ammunition-specific use of the measures. Usually the measures include the following:

1) Observations are carried out to determine, when possible, whether there are any marine mammals, shoals of fish, or sea birds in the safety zone surrounding the detonation site. Observation will begin at least 30 minutes before the intended detonation. The observation methods are as follows:

• Visual observations for the presence of marine mammals and sea birds in the area, carried out by qualified marine mammal observers from a survey vessel. To carry out the observation in an effective way, the measures are taken in daytime when the sea is calm, or the swell of the sea is minor.

• Sound monitoring for identifying sounds made by marine mammals. The sound monitoring buoy has one underwater listening device for low frequencies, and one underwater listening device for high frequencies. The sound monitoring buoy will be placed at a 200-metre distance from the munition before the munition is cleared, and the signals from the device are transmitted to a radio receiver set on a survey vessel.

• Active acoustic fish surveying will be carried out with an echo sounder to identify shoals of fish. Acoustic fish surveying will always be carried out from a support vessel before the munition is detonated.

If sea mammals, sea birds, or shoals of fish are identified within the safety zone, the detonation will be postponed.

2) After carrying out the observing in the safety zone of the detonation site, measures are taken to deter animals. The following methods will be used:

• Sound dislodgment devices ("seal deterrents") for deterring seals and harbour porpoises from the clearance area before the detonation. It is anticipated that the devices will have an effect on seals at a radius of about 300 metres. The number of devices used depends on the size of the munitions. A maximum of four devices will be used for a large munition.

• Sound dislodgment devices for fish, based on small explosive charges (50–500 g). The devices will be placed about 20 metres deep from the support vessel, and detonated 30 seconds before detonating the munition to be cleared.

3) After munitions detonation, any dead or injured fish in the clearance area may lure marine mammals. To minimise this, the contractor will remove fish killed during the clearance by using a surface trawl from a support vessel.

Ecological monitoring will be carried out during the clearance to be able to ensure that the dislodgment measures have duly been carried out.

Clearance work stages

The mine clearance performer will deploy a method pursuant to the aforementioned principles during the clearance works. The clearance work will include the following stages:

1) The vessel will move to the target area, and a TMS (Tether Management System) will be lowered onto the seabed up to a distance of 100 metres from the target. Observers of marine mammals will be on standby during the whole clearance operation.

2) The vessel will withdraw to a distance of one kilometre from the site.

3) The Remote Operated Vehicle (ROV) will withdraw from the TMS and will check the target. The video material based on the check will be delivered to the vessel crew to identify the munitions object and verify its condition. The ROV will also check the other objects on the seabed that have been identified in the previous studies (up to a distance of one kilometre). After this, the ROV will withdraw into the TMS.

4) The TMS will be lifted to the surface. After this, PAM (Passive Acoustic Monitoring System), a target marker and deterrent devices for fish and seals will be deployed.

5) The vessel will withdraw to its position. The clearance plan will be finished off, and the calculations regarding the detonation will be verified. The equipment required for the clearance work will be prepared for use. The local authorities will be informed of the schedules, and the clearance work to be carried out will be verified.

6) When all equipment and plans are finished, and the finishing works have been verified, the vessel will move to the target. The TMS will be positioned up to a distance of 100 metres from the target. When the TMS is laid on the seabed, the vessel will withdraw to its position. As the vessel retreats, it will lay the blasting cable on the seabed. The ROV will collect the explosives and the frames to which the explosives are attached from the TMS, and will move them to their final destination for the clearance work.

7) The ROV will withdraw into the TMS. After this, there will be a waiting period of 30 minutes. The vessel will move to the target area and lift the TMS to the surface. After this, the vessel will return to its point of origin.

8) After the vessel has returned, the authorities will be informed of the verified schedules. After this, a Rigid Inflatable Boat (RIB) will be deployed to observe fish and to remove marine mammals from the target area. After this, the RIB will move to a safe distance which has been defined in advance.

9)The clearance stage will be initiated after the clearance director has been ensured that all procedures have been followed and has checked with the vessel captain, the head observer of marine mammals and the clients' representatives that there are no obstacles to continuing the clearance. All vessels will be warned as agreed with the authorities. After this, the fish deterrent device will be detonated. The main charge will be exploded no later than 30 seconds after exploding the deterrent device. The area will then be checked with the RIB based on a visual inspection.

10) When the clearance director has ensured that there is no immediate danger, the vessel will move to the target area. The TMS will be lowered into the water and the vessel will withdraw. After this, the ROV will check the target area and ensure that the mine has been destroyed. Possible leftovers resulting from the explosion will be lifted from the seabed, and the crater will be checked. The vessel will move to the target area and lift the TMS to the surface.

These measures will be repeated with every mine that is to be cleared.

PROJECT AREA

General

The Baltic Sea water is brackish water, which is the result of freshwater mixing with sporadic saltwater inflows through the very narrow Danish Straits. In addition, temperature differences that cause stratification of the water masses contribute to the creation of brackish water by isolating the bottom water layers from the upper layers.

The water turnover in the Baltic Sea is very slow. It might take up to 30 years for the entire water volume to be changed. Because the Baltic Sea is also almost totally surrounded by land, considerable amounts of contaminants and nutrients have accumulated on the seabed, especially in areas with soft sediments rich in organic matter. Furthermore, stratification together with eutrophication due to human activity have resulted in extensive depletion of oxygen in the deep waters. At present, large seabed areas in the Baltic Sea are without living organisms. Eutrophication has also increased cyanobacterial blooms in recent decades, particularly in the Gulf of Finland.

In the Finnish EEZ, the pipeline route runs through the central and deep areas of the Gulf of Finland and the northern Baltic Proper. The water depth along the surveyed pipeline corridor varies from about 40 to 200 metres.

Seabed

According to the information based on the geotechnical surveys, the morphology of the seabed of the eastern Gulf of Finland is very rugged and uneven. In several areas, 1–2% of the seabed consists of slopes. This alternating and undulating seabed of drowned glacial and pre-glacial landscapes has caused a rather complex pattern of zones of recent sedimentation. The dominant classes of sedimentation are: 1) a zone of sedimentation dominated by very soft clay, 2) a mixed zone of sedimentation and non-sedimentation consisting of clay with coarse sediments, and 3) a zone of non-sedimentation with crystalline bedrock, diamicton and coarse sediments and scattered local sedimentation—very soft clay, silt and fine sand, sand and gravel.

The seabed geology in the eastern Gulf of Finland is dominated by outcrops of glacial and pre-glacial origin. The outcrops are dominated by coarse sediments, till and crystalline bedrock. Recent sediments are deposited in numerous depressions between highs and banks and in a few larger depressions. These sediments are dominated by very soft clay, silt and fine sand. There are no very coarse recent sediments in the eastern Gulf of Finland. Clay deposits in the east change to more silty and sandy deposits further to the west. In the westernmost end of the eastern Gulf of Finland, the recent sediments are dominated by very soft clay.

The dominant classes of sedimentation in the western Gulf of Finland are 1) zone of sedimentation dominated by very soft clay, and 2) mixed zone of sedimentation and non-sedimentation consisting of clay with coarse sediments. The area can be divided into two subareas: eastern part, with a smooth seabed forming a gentle trough, and the western part, with a rough seabed with many hills and outcrops of glacial and pre-glacial deposits. The eastern part is mainly comprised of recent sediments dominated by very soft clay and a few ridges consisting of sand, gravely sand, gravel and crystalline bedrock (of glacial and pre-glacial origin). There are minor channels between the glacial outcrops. The infilling in the channels is comprised of very soft clay.

The seabed of the western part of the western Gulf of Finland is altering and undulating, with many hills with glacial or pre-glacial outcrops and intervening depressions with recent sedimentation. Very soft clay is the dominant sediment, with patches of coarser sediments, silt and fine sand. Few large topographic elements are found in this part of the western Gulf of Finland. These elements are dominated by crystalline bedrock and gravely sand.

The predominant classes of sedimentation in the Finnish part of the Baltic Proper are 1) zone of sedimentation dominated by very soft clay, 2) mixed zone of sedimentation and non-sedimentation consisting of clay with coarse sediments, and 3) zone of non-sedimentation consisting of coarser sediments, till and bedrock with thin, scattered local surface layers of recent very soft clay. The area is dominated by several hills and depressions, which create a rough and strongly undulating seabed. Generally, the seabed in this section dips against the centre of the Baltic Sea. The entire section is dominated by deep, narrow valleys that cross the pipeline route. The slope gradient of the hills and outcrops exceeds 15 degrees in several locations. The glacial landscape elements in part of the section are very large. Gravely sand and coarse sediments comprise the surface in the highs in this part. The surface sediments in the valleys and depressions are dominated by very soft clay.

Currents

The currents in the Baltic Sea are weak. Surface current velocities strongly correlate with wind speed. Together with inflows, large amounts of water flow towards the east near the coast of Estonia. A compensating strong westward outflow occurs in the northern parts of the Gulf of Finland approximately 20–30 km offshore. The Finnish coast is shallow and rich with islands. The currents are slowed down by these factors, and the westward outflow occurs in the offshore areas.

About 95% of the pipeline in the Finnish project area is located at a water depth of more than 60 m. The estimated average flow velocity at this depth of 60 m is 0.01–0.02 m/s. The pipeline route is located in the proximity of the main outflow area of the Gulf of Finland, to the north of the central axis of the Gulf of Finland. In this zone, the outflow is quite homogenous from the uppermost layers down to depths of 30 m. The width of this outflow is approximately 10 km and the typical speed is 2–5 cm/sec. Near the bottom, the effects of bathymetric topography create more eddies than are found in the upper layers.

Salinity

The salinity in the Baltic Sea and Finnish project area is variable. These variations are due to the inflow of high-saline and oxygen-enriched water from the North Sea via the Danish Straits.

The inflow causes a vertical gradient in salinity because the saline water does not easily mix with less saline, less dense water. This is why the more saline water flows to the seabed. A boundary, known as the 'halocline' (a thermocline of salinity), is formed between these two water masses, resulting in a strong vertical salinity gradient. In the western and central Gulf of Finland, the halocline is weak and seasonal and lies at a depth of approximately 60–70 m. In the northern Baltic Proper, the halocline is permanent at a depth of approximately 80 m. In areas with a weak halocline and rather shallow bathymetry, waters may mix vertically every year in late autumn or winter. This is especially the case in the eastern Gulf of Finland. In the northern Baltic Proper, as well as the central and the western Gulf of Finland, this phenomenon is constrained by greater depths and a stronger halocline.

Water temperature

Annual and seasonal temperature variation is an essential physical feature of the Gulf of Finland. In winter, the mean temperature of the surface waters varies between approximately 5°C and 7°C. In spring, the surface waters start to warm up. The annual mean maximum surface temperature of 16.5°C to 17.5°C is reached in July/August. The surface layer is mixed by the wind, due to which the water temperature remains the same at all depths of the layer, but beneath this layer a boundary (a thermocline) develops between the cool, dense bottom water and the less dense surface water. The upper edge of the thermocline is typically at a depth of 30–40 m in the Gulf of Finland.

During summer, the layer between the thermocline and the halocline is usually colder and denser than the water layers over and below it, ranging between 2°C and 4°C. Under the halocline, temperature variations are small and the temperature usually ranges between 4°C and 6°C. The temperature in near-bottom waters, however, shows stronger horizontal variations due to the widely varying bathymetry.

Water quality

Water transparency in the Gulf of Finland is considerably low. During summer, water transparency is lowest, and varies between about 3 and 5 metres. Water transparency usually decreases towards the eastern Gulf of Finland. Over the last 100 years, the decrease in summertime water transparency has been most pronounced in the northern Baltic Proper and in the Gulf of Finland. The primary cause of decreased transparency, especially in the Gulf of Finland, is the increase in phytoplankton biomass, which is a result of increased nutrient concentrations and is a sign of continuous eutrophication in the Baltic Sea.

The Gulf of Finland is the most eutrophised sub-basin of the Baltic Sea. The nutrient concentrations in the Gulf of Finland are the highest in the east. The high nutrient levels in the Gulf of Finland are a result of both external and internal loads.

Inorganic and organic contaminants

The Baltic Sea receives inorganic and organic contaminants from several different sources. The origin of the organic contaminants is anthropogenic, while the main sources of metals in the Baltic Sea are forest and agricultural soils, and industrial and municipal waste, which are either discharged directly into the sea or transported via rivers and atmospheric deposition. Hazardous substances from industry are emitted at all stages of the product chain. A significant part of the waterborne metal input into the Baltic Sea is transported via rivers from the catchment area.

Total phosphorus concentrations in the sediments along the pipeline route in 2007 and 2008 were between 410 and 5,400 mg/kg. Concentrations of nitrogen were 350–13,000 mg/kg. In the surveys carried out in 2009, the concentrations of nitrogen and phosphorus were at the same level as in the surveys conducted in 2007 and 2008.

Metal surveys related to the gas pipeline project have been conducted in the Finnish project area in 2005–2007. In 2008, environmental field investigations were carried out in the Kalbådagrund area. The Instructions for dredged sediments (Ympäristöopas 117, 2004) by the Ministry of the Environment classify two concentration limits. Concentrations of harmful substances below the lower level (limit 1) indicate background concentrations of the aquatic environment. Concentrations above the lower level indicate contaminated sediments. Concentrations above the upper level (level 2) indicate slightly contaminated sediments.

According to the concentration limits for dredged sediments applicable in Finland, the metal concentrations in recent sediments (0–2 cm) for arsenic, cadmium, chromium, copper and zinc were in excess of the lower level (limit 1). The upper limit values (limit 2) of the investigated metals were not observed to be exceeded. These concentrations represent average concentrations of recent sediments along Finnish coastal areas. However, the effect of the munitions clearance cannot be compared to the effects of dredging and dumping, because the re-suspended sediments settle down practically in the same area where they originate.

According to the OSPAR ecotoxicological assessment criteria (EAC), the mean concentrations of all studied metals except mercury, nickel and lead exceed the threshold value. Metal concentrations are in line with previous studies of metals in the sediments. Concentrations of metals in the sediment in the Finnish project area are in the mid-range compared with the overall concentrations along the pipeline route.

The concentrations of metals in surface sediments (0–2 cm) on the basis of surveys conducted in the Finnish project area, and the limit values set out in the dredging and depositing manual by the Ministry of the Environment are as follows:

Metal	Number of samples with concentration above limits of quantification (total number of samples)	Mean concentration mg/kg, mean (Min.–Max.)	Limit value/ dredging manual (Level 1–Level 2)
Arsenic	25 (25)	11.8 (3.9–32.4)	15–60
Cadmium	25 (25)	1.2 (0.5–2.0)	0.5–2.5
Chromium	238 (238)	68 (16.5–116)	65–270
Copper	25 (25)	27.6 (6.1–50.9)	50–90
Mercury	21 (25)	0.1 (0–0.1)	0.1–1
Nickel	25 (25)	24.0 (6.1–42.8)	45–60
Lead	25 (25)	25.7 (6.2–44.7)	40–200
Zinc	25 (25)	124.4 (38.1–213.8)	170–500

The concentrations have been normalised as organic carbon content (10% of regular sediment) and clay content (25% of standard sediment).

The normalised mean concentrations, minimum and maximum concentrations between the surveys of 2007, 2008 and 2009 do not vary to a significant extent. They are practically at the same level when comparing the surveys of 2007 and 2009. Mercury and cadmium were the only difference in the results. The mean concentration in the surveys of 2009 was 0.1 mg/kg, which is more than two times higher than in the surveys or 2007 (0.04 mg/kg). The mean concentrations for cadmium were also clearly higher in the surveys of 2009 (2009: 0.82 mg/kg in comparison to 2007: 0.52 mg/kg). The concentrations of cadmium and mercury are clearly below level 2 set out in the dredging and depositing manual. This also applies to other metals.

There have been substantial inputs of organic contaminants in the Baltic Sea from numerous sources over the past 50 years. Organic pollutants reach the sea via river runoff, atmospheric deposition and direct discharge of effluents. Sources include industrial discharges, such as the organochlorines in effluent from pulp and paper mills, runoff from farmland, dumped waste and paints used on the hulls of ships and boats. Inputs of several organic pollutants, notably certain organochlorine pesticides, such as DDT and technical-grade hexachlorocyclohexanes (HCH isomers), have decreased because these substances have been banned since the 1980s. The main sources of dioxins are combustion processes, such as waste incineration and metal smelting and refining. Polychlorinated dibenzo-p-dioxins (PCDDs) and furans and dioxin-like PCBs, which are often called "dioxins" as a group, are common contaminants. The total concentration of dioxins is usually presented as a toxicity equivalent (TEQ), which is comparable to the most toxic dioxin compound, 2,3,7,8-TCDD.

Many organic contaminants are resistant to biological degradation or are only very slowly degradable, but they have a high potential for bioaccumulation in organic material. Based on these properties, the organic compounds tend to accumulate in the food chain. Hexachlorocyclohexanes (HCHs) deviate from this general observation, as they do not tend to bioaccumulate and tend to persist in the water phase rather than in sediment. In addition, polyaromatic hydrocarbons (PAHs) do not bioaccumulate due to the metabolism of the compounds in the organisms of biota. PAHs have a low water solubility and high affinity for organic matter.

Normalised concentrations of organic pollutants in young sediments along the pipeline route in a survey conducted in the Finnish project area in 2007 and 2008, and the limit values pursuant to the dredging and depositing manual by the Ministry of the Environment, are as follows:

	Number of samples with concentration above limits of quantification (total number of samples)	Mean concentration mg/kg, mean (Min.–Max.)	Limit value/ dredging manual mg/kg, mean		Number of samples exceeding level 1	Number of samples exceeding level 2
			Level 1	Level 2		
Anthracene	4 (26)	0.01 (0.005–0.02)	0.01	0.1	2	0
Benz(a)anthracene	21 (26)	0.02 (0.005–0.05)	0.03	0.4	4	0
Benz(a)pyrene	21 (26)	0.02 (0.006–0.08)	0.3	3	0	0
Benzo(g,h,i)pyrelene	22 (26)	0.04 (0.006–0.19)	0.8	8	0	0
Benzo(k)fluoranthene	21 (26)	0.02 (0.006–0.06)	0.2	2	0	0
Phenanthrene	20 (26)	0.02 (0.005–0.09)	0.05	0.5	2	0
Fluoranthene	24 (26)	0.05 (0.01–0.14)	0.3	3	0	0
Indeno(1,2,3-cd)pyrenene	24 (26)	0.04 (0.006–0.20)	0.6	6	0	0
Chrysene	21 (26)	0.02 (0.006–0.04)	1.1	11	0	0
Naphthalene	17 (26)	0.01 (0.005–0.03)	0.01	0.1	16	0
PCB 28 *)	26 (26)	1 (0.45–5)	1	30	0	0
PCB 52 *)	1 (26)	2 (0.455–8)	1	30	0	0
PCB 101 *)	3 (26)	4 (0.45–75)	4	30	2	0
PCB 118 *)	2 (26)	2 (0.45–18)	4	30	2	0
PCB 138 *)	2 (26)	6 (0.45–123)	4	30	2	0
PCB 153 *)	2 (26)	7 (0.45–158)	4	30	2	0
PCB 180 *)	1 (26)	6 (0.45–123)	4	30	1	0
Tributyltin (TBT) *)	26 (26)	106 (12–893)	3	200	26	3
DDT total	17 (26)	0.002 (0.0005–0.008)	0.01	0.03	0	0

*) µg/kg, mean

The concentrations have been normalised as organic carbon content (10% of standard sediment). The normalised concentrations have been compared to guideline values implemented to sediment dredged in Finland (DDTs and tributyltin). In all calculations, the values of the limit of quantification (LOQ) have been used when the analysed concentration was below the LOQ.

Dioxin concentrations in sediment range between 2.8 and 38 pg/g. The concentration is mainly below the Finnish concentration limit (level 1) for dredged sediment. According to the Finnish criteria, a concentration below 20 pg/g represents uncontaminated sediment, whereas 500 pg/g or higher represents contaminated sediment.

In June 2009, sediment samples were taken in a total of 33 sampling locations, of which eight positions have three sampling locations near each other (one on the centre line and two at a distance of 250 metres on each side). Four of the triple stations were located near the munitions locations. The preliminary analysis of the samples confirmed the initial assumption of the dioxin concentrations along the route of the pipelines. In the samples taken from the mine detonation sites, the highest dioxin concentration in the surface sample (0–2 cm) was 22 pg/g, and for the 0–30 cm layer, 1.2 pg/g.

Birds and mammals

The Baltic Sea is an important migrating route and breeding and resting area for birds. The northern parts of the Baltic Sea, i.e. the Gulf of Finland, the Archipelago Sea and the Gulf of Bothnia, are very important breeding areas for ducks, gulls, terns and waders. The breeding season begins in March/April and continues until early August. Some 200 bird species (migrants and breeders) can be frequently observed along the shores of the Gulf of Finland. There are about 30–40 species of seabirds (ducks, geese, waders, gulls and divers) that are common breeders or migrants. Most species nest on rocky and stony islands and islets in the outer and middle archipelago (12–20 km from the pipeline route).

Twice a year, large numbers of Arctic birds cross the Baltic Sea on their way to breeding or wintering areas. The Gulf of Finland is one of the most important migration routes for birds. Especially during the spring migrations in May, hundreds of thousands of migrating birds can be observed in a single day. Autumn migration occurs over a longer period from the end of June to the end of October.

Four sea mammal species – the harbour porpoise, the harbour seal, the grey seal, and the ringed seal are native to the Baltic Sea. Harbour porpoises and harbour seals are found primarily in the southernmost parts of the Baltic Sea, within the Danish, German and Swedish EEZs. Grey seals are found throughout the Baltic Sea, but only in small numbers in the southern region. Ringed seals are found in areas that typically have ice cover during winter, mostly in the Gulf of Bothnia and the Gulf of Riga; small populations have also been observed in the Archipelago Sea and the Eastern (Russian) parts of the Gulf of Finland. Grey seals and ringed seals are the only mammal species that have permanent populations in the Finnish project area. The harbour seal and the harbour porpoise are rarely spotted along the Finnish coastline. During ice-free periods, grey seals haul out in groups on small islands, islets and rocks in the outermost archipelago. In winter, they haul out on drift ice close to open water. Grey seals seem to migrate between haul-outs throughout the Baltic Sea Proper between the sea areas of Finland, Sweden and the Baltic states. The density of grey seals is highest close to haul-outs but varies seasonally.

Fish and fish stocks

The environmental conditions in the Gulf of Finland are unfavourable to many fish species. The Baltic Sea is host to around 70 saltwater fish species and around 30–40 brackish or freshwater species. The number of marine fish species is higher in the more saline parts, whereas in the Gulf of Finland, freshwater species are dominant. Many fish species live in the Gulf of Finland close to their ecological limits. The low oxygen content or total lack of oxygen in deeper areas limits the amount of suitable habitats for demersal fish species.

Marine fish species that are not found in inland waters but are found in the Finnish EEZ in the Gulf of Finland and in the northern Baltic Proper are: herring, sprat, straight-nosed pipefish, small sandeel, eelpout, flounder, sand goby, bullrout, lumpfish, cod, broad-nosed pipefish, great sandeel, snake blenny, sea snail, common goby, turbot, garfish, black goby, two-spotted goby, long-spined bullhead, fifteen-spined stickleback and butterfish. The open seas are dominated by sprat and herring. Migratory fish in the Finnish project area include salmon, sea trout, and whitefish. The commercially exploited fish species in the Finnish project area are mainly sprat and herring.

Plankton and benthos

The species composition of the Baltic Sea phytoplankton (plant plankton) is influenced by salinity. As the salinity decreases from the south-west towards the north-east, essential variations in the phytoplankton species composition can be observed as halophilic species, which prefer saline water, are gradually replaced by brackish and freshwater species. According to the results of long-term monitoring, the biomass of phytoplankton concentration in the northern Baltic Proper and the Gulf of Finland has increased steadily since the 1970s. The increase has been most distinct in the Gulf of Finland, where the mean biomass has more than doubled since the early 1970s.

The zooplankton (animal plankton) community in the Baltic Sea consists of freshwater, brackish, and marine species. The extent of the distribution of the various zooplankton species depends on their ecophysiological tolerances and the availability of food resources, i.e. phytoplankton and microzooplankton. Moreover, both the species composition and the abundance of the zooplankton community and the phytoplankton in the Baltic Sea vary with the seasons. No significant trends in the overall biomass of zooplankton were observed in 1979–2005, but recent variations in the abundance of certain larger species have been observed. Salinity is the most important factor regulating zooplankton species composition and abundance in the Gulf of Finland. Other direct and indirect regulating factors are predation by certain fish species and human-induced eutrophication.

Macrophytes are aquatic vascular plants and algae growing on the sea floor that are large enough to be seen with the naked eye. The boundary for macrophytes in most areas of the Baltic Sea is between depths of approximately 18–20 m up to about 30 m. At greater depths, macrophytobenthos is absent. At the mouth of the Gulf of Finland, algae are present down to 27 m. In the central Gulf of Finland, the maximum depth for flora is 10–15 m, but in the easternmost parts only approximately 6 m.

In the Gulf of Finland, 93 different macroalgae species have been recorded. Filamentous algae grow from the surface to a depth of 1 m. In this zone, the seasonal succession of the composition of algae species is remarkable. Below the filamentous algae zone, there is a bladder wrack community down to a depth of about 5 m.

The deep, open areas in the Gulf of Finland have been devoid of macrofauna for most of the monitoring prgramme (established in 1964) due to hydrographical conditions and prevailing oxygen depletion. Salinity stratification disappeared and oxygen conditions improved temporarily during the prolonged stagnation during 1977–1993. However, hypoxia was re-established in the middle of the 1990s. As a result, the abundant macrobenthic communities that were recorded in the early 1990s in the deep central parts of the Gulf were almost completely absent in 1996–1997, and they have not recovered to any great extent due to continued oxygen depletion below the permanent halocline. In favourable oxygen conditions, deep bottoms can be colonised by abundant communities of amphipods and bivalves. Greater numbers of benthic fauna have been absent from the deepest parts (60–80m) of the Gulf of Finland for at least ten years. During the summers of 2006 and 2007, the situation in the deep waters of the Gulf was the worst since the beginning of the entire regular monitoring programme.

Hard-bottom habitats (bedrock, boulders, stones and gravel) below the photic zone are typically occupied by non-mobile, filter-feeding invertebrates attached directly to the substratum. These communities extend to a depth of approximately 20–40 m in the Gulf of Finland. The largest biomasses are formed by mussels and barnacles. Other groups include hydroids, bryozoans and sponges.

In the western part of the Gulf of Finland, the blue mussel may form very dense communities (more than 20,000 ind./m^2), with a biomass covering all suitable hard substrates in outer archipelago areas. The distribution of the blue mussel is limited by salinity and the species' eastern distribution boundary shifts between Helsinki and Kotka, depending on the prevailing salinity level. In the eastern Gulf of Finland, the freshwater zebra mussel becomes more abundant with decreasing salinity and reaches abundance values that are almost similar to those of the blue mussel.

Fishing

Professional fishery in the Gulf of Finland includes both coastal and offshore fishing. Offshore fishing is comprised of trawling and longline fishing. Fishery in the offshore areas of the Gulf of Finland and the northern Baltic Proper is characterised by a low number of target species. This phenomenon is a consequence of the brackish characteristics of the northern Baltic Sea and especially the Gulf of Finland. The main target species include herring and sprat. The planned pipeline route crosses the most used trawling areas over a total distance of 220 km in the Gulf of Finland.

The planned pipeline will be laid outside of a coastal band which is 12 nautical miles wide. The sea above the pipeline will be open for fishermen from other EU member states that hold an allocated catch quota.

Trawls are the principal gear type used in commercial fishery in the open waters of the Baltic Sea. Pelagic trawls, i.e. mid-water trawls, are used to capture herring and sprat. Pelagic trawls are also used by Finnish fishermen in the offshore areas of the Gulf of Finland and the northern Baltic Proper. Pelagic trawls are used in the middle water column but can also be used close to the bottom when fish schools are located in deep water. In soft-bottom areas where the seabed topography is smooth, a trawl can be towed close to or on the seabed. According to data from the Finnish Fishermen's Association, both pelagic and bottom trawling (or trawling taking place less than 4 meters from the bottom) are somewhat regularly carried out in the central and western Gulf of Finland.

Nature conservation sites

The Natura 2000 areas closest to the pipeline are the Söderskär and Långören Archipelago and the Kallbådan islets and waters. These are located within a distance of approximately 10–11 km from the pipeline. The Kallbådan islets and waters are located closest to the munitions objects to be cleared: the distance to the closest munitions objects is approximately 10 km. The Ministry of the Environment has proposes new areas to be included in the Finnish Natura 2000 network. Four of these areas are located at a distance of 3–15 km from the pipeline. Of the proposed new Natura 2000 areas, Sandkallan, at a distance of 10.7 km, is situated nearest to the munitions to be cleared.

Ship traffic

In 2002, a mandatory ship reporting system for the Gulf of Finland (GOFREP) was established between Finland, Estonia and Russia. In accordance with the system, Finland, Estonia and Russia require that all vessels exceeding 300 GT participate in the GOFREP system when sailing on the international waters of the Gulf of Finland.

There are three primary ship routes in the Finnish project area which are mainly used by commercial traffic throughout the year.

Cables

There are several electrical and telecommunications cables on the seabed of the Gulf of Finland and the Baltic Sea. The shortest distance between a cable and a munition to be cleared is about 140 metres.

Munition ID	Distance to nearest cable (km)
R-8AG-W-014	1.80
R-8AG-W-009	0.67
R-E8C-10223	0.92
R-W8A-10317	0.34
R-8CG-E-004	0.14
R-8CG-E-003	0.39
R-W8A-10312	0.98
R-W8A-10313	1.02
G-08-009	1.01
R-W8A-10005	1.02
R-8CG-E-002	0.70
R-8CG-E-001	0.83
R-08-2805	1.61 0.47 1.01
R-08-159	0.44 0.47 1.71 0.58
R-09-27	1.46 0.35 1.60
S-09-3135	1.51

Firing danger areas

The planned pipeline will pass through a stretch of a firing danger area, named Örö D52, partly situated in the Finnish EEZ. There are also a few other firing danger areas close to the pipeline route, such as firing danger area Katajaluoto D34. According to the information that the applicant has obtained from the Finnish Defence Forces, practice and firing activities are mainly limited to Finnish territorial waters.

Cultural heritage sites

An object, estimated to possibly be a whale skeleton, is located at a distance of 350 metres from the nearest munition to be cleared. Moreover, the wreck of a wooden sailing ship (estimated to date back to the late 19th century) is located at a distance of 980 metres from the nearest mine to be cleared, and the wreck of the ironclad vessel "Rusalka" (built in 1868) is located at a distance of 1.17 kilometres from the nearest munition to be cleared.

<table>
<tr><th>Munition ID</th><th>Distance to nearest cultural heritage site (km)</th><th>Description</th></tr>
<tr><td>R-07-004</td><td>0,35</td><td>A possible whale skeleton</td></tr>
<tr><td>R-07-2655</td><td>1.17</td><td>Rusalka</td></tr>
<tr><td rowspan="2">R-8AG-W-009</td><td>0.98</td><td>A wooden sailing ship</td></tr>
<tr><td>1.35</td><td rowspan="2">Wreck identified from SSS, significance of the wreck has not been assessed</td></tr>
<tr><td rowspan="2">R-E8C-10223</td><td>0.88</td></tr>
<tr><td>1.43</td><td>A wooden sailing ship</td></tr>
<tr><td>R-W8A-10317</td><td>1.41</td><td rowspan="5">Wreck identified from SSS, significance of the wreck has not been assessed</td></tr>
<tr><td>R-8CG-E-004</td><td>0.90</td></tr>
<tr><td>R-8CG-E-003</td><td>1.62</td></tr>
<tr><td>S-09-3135</td><td>1.55</td></tr>
<tr><td>R-09-04</td><td>0.54</td></tr>
<tr><td>R-11-3395</td><td>1.29</td><td>Wreck of a typical coastal vessel from the 20th century</td></tr>
</table>

IMPACT

Munition-specific circumstances and impact

Munition ID	Water depth (m)	Seabed type	Charge (kg)	Radius of the crater established (m)	Amount of sediment released (metric tons)
R-06-003	69	Sand	350	5.8	333
R-E7B-10466	68	Gravely sand	0.8	2.0	14
R-07-004	78	Clay with coarse sediments	150	4.6	165
R-07-2655	74	Very soft clay	150	5.8	329
R-8AG-W-014	41	Crystalline bedrock	300	0.0	0
R-8AG-W-009	66	Clay with coarse sediments	30	4.2	127
R-E8C-10223	66	Silt and fine sand/ some gravel	30	4.2	127
R-W8A-10317	65	Silt and fine sand	30	4.2	127
R-8CG-E-004	65	Silt and fine sand	30	4.2	127
R-8CG-E-003	66	Silt and fine sand/ some gravel	30	3.3	63
R-W8A-10312	64	Silt and fine sand	30	4.2	127
R-W8A-10313	65	Silt and fine sand	30	4.2	127
G-08-009	65	Silt and fine sand	30	4.2	127
R-W8A-10005	64	Silt and fine sand	30	4.2	127
R-8CG-E-002	65	Silt and fine sand/ gravel patches	30	3.3	63
R-8CG-E-001	65	Silt and fine sand	30	4.2	127
R-08-2805	71	Very soft clay	350	7.3	667
R-08-159	69	Silt and fine sand	115	4.3	135
R-09-27	68	Crystalline bedrock/ coarse-grained	115	0.4	0.1
S-09-3135	63	Gravely sand/ sandy clay	300	7.0	583
R-09-04	65	Gravely sand	0.8	1.6	7
R-09-192	61	Silt and fine sand	115	5.4	270
R-11-3395	81	Very soft clay	100	5.3	245
R-11-5167	80	Clay with coarse sediments	250	5.3	249
R-12-008	64	Gravely sand Large boulders	64	3.8	92
R-12-3463	78	Very soft clay	300	7.0	583

General information about the detonation

Chemically-bound energy will release and turn into heat energy, kinetic energy and pressure energy within a gas bubble when an explosive charge is detonated. A spherical explosive charge detonated from the centre and containing approximately 200 kg of TNT will change into the gas phase in 50 microseconds. Overpressure in such a gas bubble is approximately 10 GPa, with a temperature of approximately 3,000°C. Particle movement and pressure within the gas bubble will create pressure and movement in the water near the charge. Such a shock wave contains pressure and kinetic energy and will travel in water at a supersonic velocity, i.e. faster than 1,500 m/sec. Initially, the pressure wave increases radically. The boundary layer between the compacted and undisturbed water is only 10^{-7} cm thick. In free water, the shock wave will travel symmetrically in all directions and contain approximately one-third of the original energy of the charge.

Explosives usually contain fuel, oxygen and plenty of chemical energy. When a charge is blasted, water, carbon dioxide, free carbon, and gaseous nitrogen are released in proportion to the composition of the charge. The transformation of burning explosives during an explosion is more efficient in water than in the atmosphere. Therefore, burned explosive substances that have not reacted, such as nitrate, are only released to a small extent when TNT explodes underwater. The creation of released carbon shows that the explosive was underbalanced for oxygen. If the explosive contains metallic aluminium, aluminium oxide will also be created. If the explosion takes place in the atmosphere, part of the released carbon will burn into carbon dioxide when it comes to contact with the oxygen in the atmosphere. If the explosion takes place in water, there is only little air available, and the released carbon will in turn be released into particles.

The explosives contained in mines are likely to be TNT, nitrocellulose and capryl and/or a mixture of these and hexanite. TNT is toxic to fish and shellfish.

Impact on the seabed

Munitions clearance will result in a crater on the seabed. The radius of the crater will be about two to eight metres. The size of the crater created by the munition detonation, and the amount of sediment released in the process, have been calculated using an empirical formula. In the formula, the radius of the crater is comparable to the size of the charge. The calculation also takes into account the type of seabed. The amount of sediment released has been calculated with the assumption that the depth of the established crater is 50% of its radius. In the calculation, a safety factor of 1.5 has been used for the radius of the crater. The calculations are based on practical experience. All munitions to be cleared are conventional. Chemical munitions have not been found in the Finnish EEZ.

The munitions clearance will cause suspension of seabed sediments close to the detonation sites. The suspended sediments will travel with currents and mostly land back on the seabed instead of remaining in the water. The amount of sediment has been estimated as slightly below 700 metric tons for one munition at the highest. The average is about 200 metric tons. The amount will depend on the type of seabed on which the munitions object lies.

The seabed will be restored to the state before sedimentation in a period of weeks to several years, depending on the seabed type. Munitions clearance may cause permanent changes if the seabed is hard.

Impact on water quality

The suspension of seabed sediments due to munitions clearance will increase the turbidity levels in the water. Some contaminants and nutrients will be released from the suspended sediment. The Gulf of Finland normally has a background concentration of suspended solids of 1–4 mg/l.

DHI Water-Environment-Helth's MIKE3 and MIKE3PA and models have been used for sediment spreading. The grid size of the MIKE3PA model, describing the spread of particles, is 250x250 metres, and the thickness is one metre. The starting point for the modelling was that as a result of the detonation, the seabed sediment and the impurities and nutrients bonded to it will mix with the water volume above the entire site, and move farther along with currents. Besides the spreading of solids, the modelling results have been the basis for calculating the behaviour of the following substances identified in the seabed sediment: cadmium, mercury, lead, zinc, arsenic, copper, chrome, nickel, PAH compounds, and TBT.

The negative and direct impact on the water from the munitions clearance will extend throughout the whole water mass (from seabed to water surface) in the direct vicinity of the source. The duration of the impact from munitions clearance will be short-term. After the activity has ceased the suspension will be gone in less than three days. The assessment suggests that a total of approximately 5,000 metric tons of sediment will spread when all the 27 munitions objects are cleared. The assessment has been prepared according to maximum spreading.

The maximum extent of the impact is three kilometres when using an increase of 10 mg/l solids in the water. However, it must be considered that only the smallest particles move such a distance. Larger particles will re-sediment to the seabed in the immediate vicinity of the detonation point.

The organic-rich soft sediments deposited in the so-called accumulation areas of the Finnish project area contain considerable amounts of nutrients. These nutrients are typically bound to sediment particles or chemical compounds and may be released into the water in connection with the sediment spreading during munitions clearance, which could increase biological growth. However, only the dissolved parts of nutrients are directly available for biological growth. If these are utilised by vegetation (e.g. phytoplankton) then these nutrients will move further in the food chain. Nevertheless, some of the nutrients will remain attached to particles (in these cases they are not bioavailable) and will eventually re-settle on the seabed. The project will not add nutrients to the water in the Finnish project area, but only re-suspend existing nutrients from sediments. The release of nutrients will result in an increase in nutrient concentration within normal limits, and therefore, the impact on the water has been assessed to be minor.

On the seabed, contaminants typically occur in accumulation areas as bonded to the sediment particles, or are dissolved in the pore water. Metals and organic contaminants may have harmful impact on organisms in increased concentrations. The concentrations that may cause direct and negative impact vary depending on the harmful substance and on the potential impact target, i.e. the animal or plant species. In order to cause a toxicological effect, a contaminant has to be bioavailable.

The bioavailability of contaminants that are tightly bound to clay-rich sediments is usually relatively low. Contaminants that remain dissolved in the water have the capability to move into the food chain, where they may bioaccumulate. After a certain period, the contaminants typically return back to the seabed through the sedimentation process.

The amount of dioxins that may spread into the water during munitions clearance has been calculated based on the mean concentration value and the amount of sediments spreading from the surface layer. According to studies completed in the pipeline route, the sediment density close to the surface is 0.54 t/m^3 for solid matter, and the density at deeper levels is 0.60 t/m^3. It has been calculated that munitions clearance will release approximately 162 m^3 of surface sediment into the water (0–30 cm). This corresponds to approximately 88 metric tons of sediment as solid matter. Based on the surface sediment's (0–30 cm) average dioxin concentration of 37 pg WHO-TEQ/g, a total of 3.2 mg of dioxins (WHO-TEQ) may spread into the seawater with the sediment. This is 0.008% of the amount of dioxin transported by the Kymi River into the Gulf of Finland annually.

The solubility of the contaminants in water is slow, and the munitions clearance is assessed to mainly cause only a relocation of the contaminants on the seabed. The expected amount of contaminants spreading due to the munitions clearance will be low, and the duration of increased contaminant concentrations will be short.

The applicant has located six barrels on the seabed close to the munitions to be cleared. It has been assessed that the release of hazardous substances or damage to the barrels is unlikely, partly because the contents of the barrels have already leaked into the water or the contents have solidified. One of the barrels may move by up to 10–12 metres as a result of the clearance. The barrel in question is already open, however, and thus its contents have probably already spread into the water or solidified. The other barrels will transfer for shorter distances or remain completely still, and these barrels are not expected to have any major impact.

Munition ID	Distance to nearest barrel (km)	Description of barrel	Estimated horizontal displacement (m)
R-8AG-W-009	0.03	Metal debris. Small metal drum.	5.0
	0.70	Metal barrel with rope coiled around, the lid of which is loose.	1.2
R-E8C-10223	1.21		0.6
	0.54	Metal debris. Small metal drum.	0.6
R-W8A-10317	1.32		0.1
	1.77	Metal debris, 44-gallon drum	0.3
	1.73	Metal barrel with rope coiled around, the lid of which is loose.	0.3
R-8CG-E-004	1.97		0.2
	1.39	Metal debris. Small metal drum.	0.1
	1.69	Metal debris, 44-gallon drum	0.08
R-8CG-E-003	0.84		0.3
R-W8A-10312	0.43		1.0
R-W8A-10313	0.36		1.3
G-08-009	0.20		2.5
R-W8A-10005	0.30		1.6
R-8CG-E-002	0.33		1.5
R-8CG-E-001	0.08		4.6
R-11-3395	1.63	Standard oil drum in scoured hole. Probably empty as lid is missing.	0.4
R-12-008	0.71	Corroded metal barrel, slightly inclined in seabed.	1.2

Impact on benthic flora and fauna

It has been assessed that the benthos will recover quickly after the suspension of the sediments. It is likely that any benthic flora and fauna in the immediate vicinity of the munitions objects will be destroyed. It is estimated that vascular plants such as sea sandwort will be destroyed close to the munitions clearance sites. The re-suspended material will also increase the concentration of suspended matter in the water near the bottom, which may impair filtering benthic organisms. In addition, it is likely that the pressure waves from munitions clearance will damage benthos near the munitions object. The losses will be compensated for within a few months by virtue of migration. However, if long-lived species occur, complete regeneration may take a few years.

The re-suspended sediments will be transported by currents and eventually re-settle after some time (typically hours), resulting in net sedimentation. The area affected and the magnitude of the effect are influenced by a number of factors, such as the amount of re-suspended material, grain size, currents and temperature. At sites where increased sedimentation takes place, the existing benthos may be covered and impaired. The impairment and its intensity depend on the extent of cover and the existing colonisation of benthos. Most of the species that occur on soft bottoms can also survive under substantial cover, where they move upwards actively.

The re-suspension of fine-grained sediments, may also increase oxygen consumption in the lower water column. A release of organic-rich, oxygen-consuming sediments may further aggravate seabed areas with local oxygen deficiency. In pipeline route sections where benthic fauna is already stressed due to reduced oxygen concentrations, additional oxygen consumption may temporarily increase the impairment. This can be assumed only for small stretches of the pipeline route in Finnish waters. However, the amounts of re-suspended sediment are relatively small, and the effects on benthic fauna, if any, will be weak and short-term.

Considering the short time scale, the elevated values in the water and the overall behaviour of the suspended chemicals, it can be assumed that the re-suspension of contaminated sediments does not constitute a special threat to benthic fauna. Therefore, no severe impact on benthos due to an increase in the bioavailability of contaminants is expected.

Impact on plankton

Availability of light is a prerequisite for the photosynthetic activity of phytoplankton. Thus, any increase of turbidity in the photic zone due to increased concentrations of suspended matter will reduce primary production. Released nutrients may stimulate phytoplankton production and subsequently also zooplankton production, and therefore have an effect on the entire food chain. Contaminants, such as heavy metals, can have an impact on the planktonic environment. During munitions clearance, contaminants bound to sediments or dissolved in pore water may be partly dissolved in the water and, therefore, become biologically available to organisms. Dissolved contaminants without any settling velocity may be spread across the entire water column. The severity of the effect depends on the contaminants and their concentrations. Low concentrations do not pose a threat to plankton but might cause problems via bioaccumulation at higher levels of the food chain.

Impacts on birds

Underwater blasting may cause damage related to acoustic trauma and shock waves, particularly to diving sea birds. Damages may include bleeding in the lungs, rupture of the liver and kidneys, and rupture of the eardrum. These effects will, however, only ensue if there are diving sea birds in the vicinity of the munitions clearing location during the clearing.The noise and pressure waves resulting from munitions clearance may cause injury or death to sea birds present close to the explosion.

Indirect impacts via the impacts of noise and pressure waves on fish and therefore reduced prey availability can be excluded because the impact on fish will be minor. If several detonations are carried out in a small area, injured or dead fish may attract gulls and other birds close to the detonation area after previous detonations.

Higher turbidity can lead to changes in feeding conditions for birds. On the other hand, higher turbidity can also result in improved food resources because the stirred sediments may include benthic fauna. Suspended matter concentrations of more than 15 mg/l are considered to impair the vision of diving sea birds. If the concentrations of suspended solids are 15 mg/l, the visibility in water is approximately 2 metres.

Impact on mammals

Munitions clearance may cause damage or death of marine mammals. However, damage can be avoided by conducting explosion activities when no marine mammals are nearby. Although the populations of marine mammals in the Finnish project area are known to be relatively small and no known seal haul-outs are located closer than 10 kilometres from the pipelines, it is necessary to make sure that no animals are present within a two-kilometre safety zone around the blast location. If marine mammals are present in the area, they can be deterred from the area by using special acoustic devices designed for this purpose.The lethal distance from the munitions objects being cleared is only approximately 35 metres for mammals, depending on the charge size. The distance where damage occurs – where mortality is assessed at 25–35% – extends to a maximum of 240 metres from the munitions object.

Suspension of sediments may cause direct impacts on marine mammals by constraining their sight and predation. The impact may also be indirect in the form of an impact on prey fish and benthic fauna. Hunting would not, however, be significantly affected due to the relatively low increase of turbidity and because the mammals will be able to leave the area or hunt by efficiently utilising their sensitive hearing, which is their primary sense when hunting. Furthermore, the sediment plumes will mostly occur close to the seabed. Thus, increased turbidity will have no impact on marine mammals. The re-suspension of sediments and contaminants due to munitions clearance have been assessed as having no impact on marine mammals.

Impact on fish and fish stocks

The noise and pressure waves resulting from munitions clearance may cause injuries or death to some individual fish near the blasting site. Fish are the most sensitive of all sea animals to underwater explosions. According to studies, small fish are more sensitive than large ones, and fish that have a swim bladder seem more sensitive than those with no swim bladder. According to studies, newly hatched salmon and Baltic herrings may survive a pressure of 5 kPa, while fish of the same two species 3 to 6 months old and already having a swim bladder will die within 24 hours of exposure to a pressure of over 2 kPa.

Sediment suspension in excess of certain threshold values will cause reactions in fish during munitions clearance. For example, sediment suspension can impair vision and thus the ability to find prey. At high concentrations, suspended matter in the water may get stuck in gills and reduce oxygen absorption. Sharp-edged particles may also damage and irritate gills, which are very sensitive organs. Because adult and juvenile fish may be injured or killed in this way, they tend to avoid or flee from areas with too high suspension concentrations. Fish will be able to return to these areas after the suspension has returned to values that are below species-specific threshold values.

Concentrations of suspended material must be high for fish to be injured or die. However, pelagic fish are more sensitive to suspended sediment than demersal fish. Herring are assumed to have the lowest threshold value and thus are considered the most sensitive fish species with regard to suspension of sediments.

Suspended material from sediment plumes may become attached to fish eggs and cause physical and chemical irritation, which will increase mortality. When the total amount of suspended sediment attached to fish eggs reaches a certain species-specific level, the sediment prevents ionic transfer between the water and the fish eggs, causing the fish eggs to die. Pelagic fish eggs floating and drifting within the water column may also be affected if suspended matter adheres to them, causing them to sink to the bottom, where there is a risk of oxygen depletion. In general, fish eggs and fry are more sensitive to increased concentrations of suspended sediment than juvenile or adult fish. Therefore, if suspended sediment reaches eggs, it will have a negative and direct impact on fish eggs. The impact will only affect individual fish eggs, and there will be no impact at the species level, unless a large portion of eggs is lost. The importance of this impact on fish and fish stocks has been assessed as low.

Contaminants may have an impact on fish due to long-term or short-term exposure. Fish may take in contaminants either directly from the ambient water or from food. For sprat eggs, contaminants can increase mortality. Only individual fish or eggs will be affected and no impact at the species level is expected due to the small impact area. Theoretically, some portion of released contaminants may accumulate in the food chain and with other exposure sources cause potential adverse effects.

High concentrations of dioxins have been measured in Baltic herring and salmon. These dioxins are not of sedimentary origin; atmospheric deposition is suspected to be the main source of the compounds found in fish. Dioxin levels in Baltic herring are close to the allowed maximum level in Europe. It has been estimated that the amount of dioxin suspended from the sediment due to munitions clearance is approximately the same as the amount found in 200 tonnes of herring (which is approximately 0.1% of the annual herring catch in the Baltic Sea).

Fish species living in open sea areas of the Gulf of Finland are plankton feeders which get their nutrition from the pelagic environment. Plankton will not be significantly affected by sediment-released contaminants, and plankton-feeding fish will not be significantly affected, either directly or through the food chain. Furthermore, the suspension of sediments will cause fish to avoid the plume area, which will further reduce exposure to contaminants. Route selection and optimisation have mitigated the impact of contaminants on fish and fish stocks in order to limit the amount of sediment and contaminants released from it.

For fish that swim in dense schools, it has been suggested that acoustic fish finders be used to check the area before detonation. This would ensure that mortality is kept to a minimum. Furthermore, it is recommended that dead or injured fish are located and dead fish are removed when clearing the munitions. The lethal distance from the munitions objects being cleared is only approximately 35 metres for fish (the same as for mammals), depending on the charge size. The distance where damage occurs – where mortality is assessed at 25–35% – extends to a maximum of 240 metres from the munitions object.

Impact on protected areas

Suspended sediments may influence protected areas if munitions are cleared in the immediate vicinity of such areas. However, the munition objects to be cleared are relatively far away from Natura 2000
areas. The closest munitions object to be cleared is approximately 10.8 km from a Natura 2000 area. The impact of suspended sediments at a distance of 10 km, 1 mg/l, is 36 hours. Sediment suspension and reworking, or the spreading of contaminants have been assessed to have no impact on Natura 2000 areas.

Impact on shipping

The clearance activities may interfere with the regular ship traffic in the area. The munitions clearance causes a pressure wave, which might have a negative impact on vessels. The work requires that a safety zone be established around the construction area for a couple of days at a time.

Verification surveys will be carried out with a radius of 1 kilometre from the munitions object. When explosives are installed next to the munition, the safety area must be maintained at a radius of 2 kilometres from the munitions object. In this way, impact can be avoided if the explosion takes place by accident or in an uncontrolled manner. When the munitions are exploded, a safety area with a radius of 2 kilometres is required in order to avoid impact on ship traffic. Post-detonation verification surveys and waste collection will be carried out within a radius of 1 kilometre from the munitions object.

The applicant is developing the ship traffic management plan in co-operation with the Finnish Maritime Administration. There is a connection between the practices developed by the munitions clearance contractor and the GOFREP system that will ensure the safety of ship traffic. The plan will include cooperation between the VTS centres of Helsinki and Tallinn. Clear communications channels will be implemented between the VTS centres. These will be used for coordinating and managing the ship traffic in the GOFREP system.

Strict limitations are required for clearing munitions that are located within or in the immediate vicinity of the traffic separation schemes. Many simultaneous detonations might be carried out in the traffic separation scheme area south of Porkkala in order to minimise the possible interruption to westward traffic.

Impact on fishing

The safety zone established during the munitions clearance may cause harm to fishing vessels, which may have to change their courses because of the safety zones. The restrictions caused by the safety zones will be imposed only during munitions clearance. The impact from sailing restrictions due to these activities are within the range of normal navigational conditions in busy shipping routes.

Increased turbidity close to munitions clearance sites will cause avoidance reactions in fish. However, the area that fish will avoid due to sediment plumes will be limited to the vicinity of the activity at hand. The concentration that will cause avoidance reactions (the amount of suspended solids being above 10 mg/l) will not exceed a distance of 3 kilometres from the pipelines, and the duration will be less than a day. The impact is temporary, and fish will soon return to the area. The significance of the impact has been assessed as low, and no damage to be compensated for will occur to private or public fishing. All parts of munitions which might hamper bottom trawling will be removed after the clearance.

Impact on military areas

Since the clearance activities will only take a couple of days per munitions object, the munitions clearance has not been expected to cause any major disturbances to the use of military areas.

Impact on cultural heritage sites

No munitions clearance will be required within close range of cultural heritage sites, which is why no impact has been anticipated. The maximum pressure caused by munitions clearance is not expected to damage wrecks. However, loose objects on the cultural heritage object or around it may be moved by the pressure wave.

Impact on cables

No impacts on the cables near the munition objects are expected. The closest munitions objects are 140 metres away from cables. A safe distance between a munitions object to be cleared and a cable is 50 metres when a 500-kilogram charge is being used. Existing cables and pipelines will be taken into account during munitions clearance. Munitions clearance will be carried out in a manner that will not damage the cables.

Impact on other munitions

Clearance of one mine should not trigger a chain reaction down the mine line. The distance between individual mines is planned according to the safety distances specific to each type of mine. One explosion will not cause the destruction of the adjacent mine or whole barriers. Aged mines may contain even more sensitive explosive material than in the original state. The shortest distance is 32 m between two 30 kg mines. This is within the 20 m safety distance for munitions up to 50 kg TNT. Based on the presently available information it is highly unlikely that clearance of munitions will trigger other detonations and other munitions.

Transboundary impact

The shortest distance from the boundary between the respective EEZs of Finland and Estonia to a munition to be cleared is 460 metres. Moreover, ten munitions are located at a distance of 1 to 2 km, and the rest are located at a distance of 2 to 5 km. The clearance activities are not expected to have any transboundary impact. However, detailed survey information about possible cultural heritage sites and barrels in the Estonian EEZ is not available. When taking into account the small probability of unexpected incidents, their impact has been estimated as minor.

Although the impacts of the munitions clearance have been assessed as minor in the Estonian EEZ, the transboundary impact can further be mitigated by avoiding clearance when considerable current velocities prevail from the clearance sites towards the Estonian EEZ. Since the currents in the Gulf of Finland are complex and usually caused by winds, clearance should be avoided in sites located near the Estonian border during extended periods of time when winds result in southern currents. Moreover, it may be necessary to measure the profile of vertical currents before the detonations to ensure that there is no continuous current from the north.

RISK ASSESSMENT

The risk assessment has reviewed a scenario as follows:

– In activities related to the construction of the gas pipeline system, sediment mixes with water and travels along with water currents.

– Solids mainly settle on the seabed at the velocity determined by the particle size. The most coarse material settles near the activity area, but fine material may remain for a long time in the water, and the cloud formed by the fine material will disappear mainly along with diluting.

– The soluble concentration of dioxins in the water is determined according to the balance principle with the solids concentration and distribution factor values.

– The dioxins dissolved in the water are in a very bioavailable form to sea animals, and the part bonded to solids is of small significance in this regard.

– Dioxins dissolved in the water accumulate in fish, for example. The accumulation in fish varies according to different dioxin compounds and fish species. Tetrachlorodioxins and pentachlorodioxins have the highest accumulation rates. The fat concentration in fish has an impact on the accumulation, and the highest amounts of dioxins accumulate in fat-rich fish, such as herring and salmon.

– When people use the fish for food, the dioxins will accumulate in the people. Together with exposure from other sources, the dioxins accumulating from fish to people increase the dioxin concentration in the body. If a large amount of dioxins is accumulated, this may result in health issues. The impact will appear the first in the development of foetuses and small children (such as changes in children's tooth enamel).

The share of organic material in the sediment is important for dioxins' bioavailability, since the amount of organic material is inversely proportional to dioxins' dissolution in water. The amount of organic material in the sediment along the pipeline in the Gulf of Finland has been surveyed at different depths (0–0.6 m). The mean loss of ignition was 4.6%. Near the surface (0–0.3 m), the mean was 4.4% (n=14). The amount of organic carbon is about half of the loss of ignition, and for the munitions clearance situation, the share of organic carbon was specified as 2.2%.

Dioxins are bonded tightly to the organic material in the sediment and release very slowly even in sparse water. From the Kymi River sediment, for example, in ten hours, only 1.2% of the amount of 1,2,3,4,6,7,8-heptachlorofuran (the most common dioxin compound in the sediment) dissolved. No research information is available on the dioxin dissolution from the target area's sediment, and the numeric values related to the dioxin dissolution in water were specified according to the assessed worst-case scenario. In the analysed samples of the sediment in the target area, the amount of pentachlorofurans and pentachlorodioxins covers about 66% of the dioxin toxicity equivalent (TEQ). Said dioxins are more hydrophobic, and their mobility in the environment is of a smaller magnitude than that of TCDD, but reliable information about their distribution factors was not found. A normalised distribution factor, Koc, has been measured for TCDD in the desorption that occurred in the sediments in Lake Ontario. The conclusion was that log(Koc)>7.1. For the target area sediment, the distribution factor Kd was calculated with the help of TCDD's aforementioned normalised distribution factor and the concentration for organic carbon as follows:

- $Kd = foc * Koc = 0.022 * 10^{7.1} = 2.8*10^{5}$ l/kg

The concentration for the dissolved dioxin in the water was calculated as follows:

$$C_w = \frac{C_{sed} \times SS \times 10^{-6}}{K_d \times SS \times 10^{-6} + 1}$$

Where:
C_w = concentration of the dissolved dioxin in the water, ng/l
C_{sed} = concentration of the dioxin in the sediment, ng/kg dw
SS = concentration of suspended sediment in water, mg/l
K_d = distribution factor, l/kg

On the basis of the modelling results, the sediment concentration in the water will decrease below 10 mg/l within two days at the latest. This is why the soluble shares were calculated using a sediment concentration of 10 mg/l. In the munitions clearance situation, 26% of the dioxins were assumed to be in a soluble form, and thus possibly bioavailable. Thus, the total amount of dioxins (WHO-TEQ) dissolved in the water in the munitions clearance is 0.8 mg.

The concentration for dioxins dissolved in the water were calculated with the assumption that all dioxin dissolving according to the balance theory would be released immediately when the sediment mixes with water. The mean concentration in the activity area at 0 to 1 km from the pipeline was calculated on the basis of the concentra-