Background to the Consultation on Transboundary Impacts

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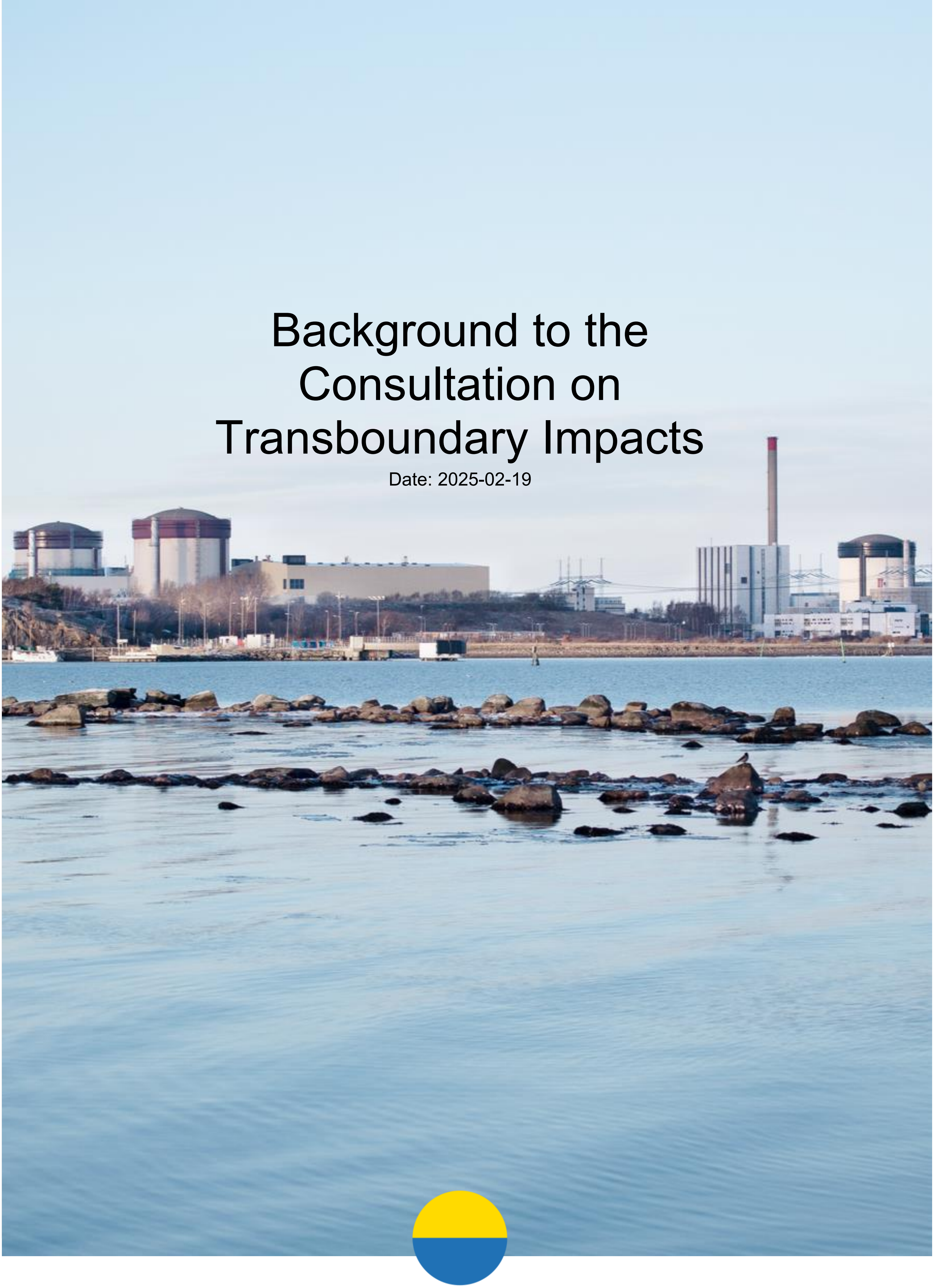

VATTENFALL

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Summary

Vattenfall is planning to build a new nuclear power plant on the Värö peninsula in the Varberg local authority area. The nature of the planned operations is such that, under the Espoo Convention, they require consultation with the neighbouring countries concerned. This report provides Vattenfall with a basis for assessing which countries could be affected and should therefore be notified. Vattenfall takes the view that only a hypothetical accident involving a core meltdown could give rise to consequences outside Sweden’s borders. The report is therefore based on such a hypothetical accident, allowing an assessment of the consultation group to be made on the basis of a hypothetical worst-case scenario.

The results of the calculations show that radiation doses are high in the immediate area but decrease rapidly with increasing distance. The lifetime dose for a one-year-old child and adult on Läsö, which is the nearest foreign landmass located some 50 km west of the Värö Peninsula, is below 10 mSv. At distances greater than 250 km from the Värö Peninsula, no lifetime doses in any age group will exceed 1 mSv. By comparison, natural background radiation, according to the Swedish Radiation Safety Authority, gives residents in Sweden a dose of 1–2 mSv annually.

In neighbouring countries, only people living in Denmark and the coastal areas of southern Norway receive lifetime doses above the natural annual background radiation as a result of the radiological accident.

1. Introduction

Vattenfall is planning to build a new nuclear power plant on the Värö peninsula in the Varberg local authority area. The nature of the planned operations is such that, under the Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention), they require consultation with the neighbouring countries concerned. The Swedish Environmental Protection Agency is coordinating the Espoo consultation and, with this report, Vattenfall has provided a basis to enable an assessment of which countries could be affected and should therefore be notified. Vattenfall takes the view that only a hypothetical accident involving a core meltdown could give rise to consequences outside Sweden's borders. The report is therefore based on such a hypothetical accident, allowing an assessment of the consultation group to be made on the basis of a hypothetical worst-case scenario.

The land area considered is within a radius of up to 800 km from the site in question on the Värö Peninsula, please see Figure 1.

Figure 1. The land area around the site in question on the Värö Peninsula out to a radius of 800 km.

The nearest foreign land area is the Danish island of Läsö, located about 50 km west of the Värö Peninsula, please see Figure 2. Since the concentration of airborne and ground-based activities will be lower further away from the release point of a nuclear accident, other parts of Denmark and other neighbouring countries will be less affected than Läsö.

Figure 2. The map shows the distance, as the crow flies, between the Värö Peninsula and the Danish island of Läsö, taken from Google Maps. The distance between Värö Peninsula and Läsö is approximately 50 km.

The design of the proposed nuclear power plant has not been fully defined, so the calculations in this report are based on a conservative, generic source term[1]. Dispersion conditions and exposure data have been selected as far as possible in relation to the Nordic circumstances. The radiation dose caused by a radioactive release is different for children and adults because the exposure pathways are different for different age categories. For example, food intake differs between these groups. To cover the variations, this report presents results for one-year-old children and adults.

2. Evaluation criteria

Transboundary consequences of a radiological accident have not been assessed against any dose constraints or dose limits. Instead, this report makes a comparison with natural background radiation which, according to the Swedish Radiation Safety Authority, gives residents in Sweden an annual dose of 1–2 mSv. The Danish Health Authority and the Norwegian Directorate For Radiation Protection and Nuclear Safety set values for natural background radiation at the same level as the Swedish Radiation Safety Authority.

3. Method

The source term assumed to be dispersed in the surroundings as a result of the accident is presented in Table 1. It has been selected to cover emissions from a hypothetical accident involving a core meltdown in a light-water nuclear reactor. In practice, such a release means that the reactor cooling system is not working and all the cooling water has boiled away, causing the core to be exposed and melt. The source term is based on a release of 100 TBq Cs-137, which currently applies as a release requirement for existing nuclear power in Sweden in the event of highly unlikely events and situations. Emission requirements for new nuclear reactors are likely to be more stringent than this, so this should be regarded as a conservative source term covering both large and small new reactors. Other nuclides in the source term are related to the release of caesium.

[1] Source term is an accepted concept in the nuclear industry and refers to the size and composition of the release in a nuclear accident.

The release time is 24 hours and the release height is 20 metres. The analysis assumes that the release can occur on any day of the year, taking into account the weather situation on that day, i.e. 365 different weather situations are considered.

Radiation doses have been calculated for people at a distance of 1–800 km from the point of release.

Table 1. Source term assumed to be released into the environment in the event of a hypothetical accident involving a core meltdown in a nuclear power reactor on the Värö Peninsula.

Nuclide	Activity [Bq]	Nuclide	Activity [Bq]
Kr-87	2.8E+15	Te-132	4.5E+14
Kr-88	8.7E+15	Cs-134	1.8E+14
Xe-133	1.2E+17	Cs-137	1.0E+14
Xe-135	1.6E+16	Sr-90	1.2E+13
I-131	1.0E+15	Zr-95	1.0E+13
I-132	2.3E+14	Ba-140	2.4E+14
I-133	1.5E+15	La-140	7.5E+13
I-134	1.3E+14	Ce-144	8.2E+12
I-135	7.5E+14	Pu-238	1.5E+10
Mo-99	9.4E+12	Pu-241	8.7E+11
Ru-103	8.7E+12	Cm-242	2.6E+11
Ru-105	1.6E+12	Cm-244	1.8E+10
Sb-127	2.9E+13		

The dose calculations have been carried out using the JRODOS tool, developed by the Karlsruhe Institute of Technology. In the dispersion calculation, the radioactive substances are assumed to be released as sequential puffs and, for each time step, the transport, diffusion and deposition of radionuclides on the ground has been modelled taking into account local meteorological and topographical data.

The following exposure routes have been included:

- The short-term perspective
    - External dose when the radioactive plume passes (cloud dose)
    - External dose from radioactive substances deposited on the ground (ground dose)
    - Internal dose from inhalation of radioactive substances in the plume (inhalation dose)
    - External dose due to skin contamination

- The long-term perspective
    - External dose from radioactive substances deposited on the ground (ground dose)
    - Internal dose from inhalation of radioactive material swirled up from the ground (inhalation dose)
    - Internal dose from consumption of contaminated food

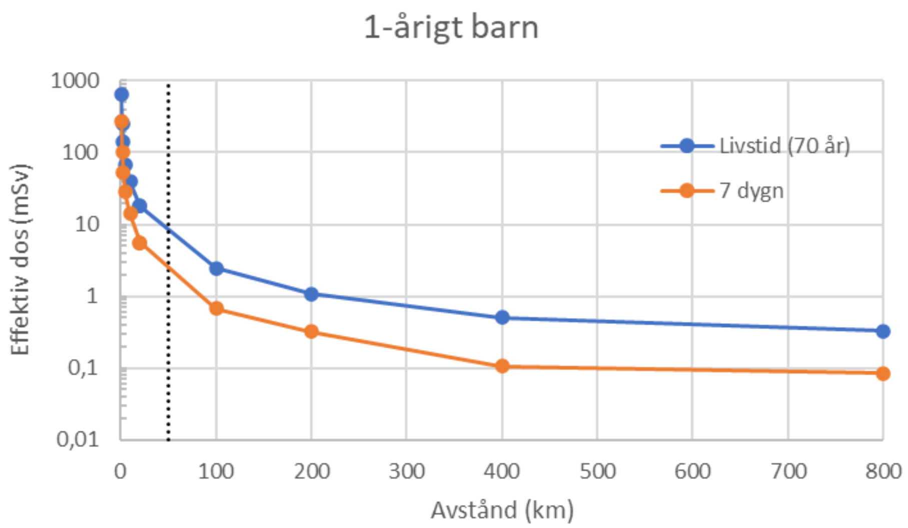
JRODOS can define how much the population in different geographical areas consumes different foods. As assumptions on land use and intake affect calculation results, the modelled area has been divided into different areas with varying food intake based on what is grown and what is statistically consumed in these areas. Depending on the area over which the radioactive plume travels, there will be different consequences via the exposure route of food intake, even if these areas are the same distance from the release point and the weather conditions in the areas would be similar. The results presented in Chapter 4 are based on the maximum dose at each distance for each of the 365 weather situations.

4. The results

The impact of the radiological release in neighbouring countries has been described in terms of effective dose to an individual. The effective dose for one-year-old children and adults is presented in Figure 3 and Figure 4. The doses are high in the immediate area but decrease rapidly with increasing distance. At Läsö, about 50 km west of the Värö Peninsula, the lifetime dose[2] for a one-year-old child and adult is less than 10 mSv. The dose after seven days' exposure is less than 1 mSv for an adult and less than 3 mSv for a one-year-old child at Läsö.

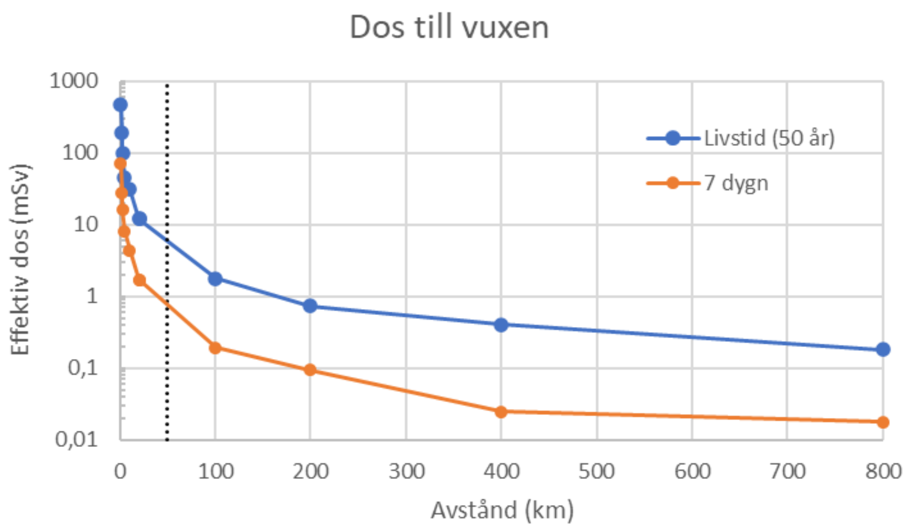
At distances further than 250 km from the Värö Peninsula, lifetime doses will be less than 1 mSv, i.e. less than the approximate level of annual dose from natural background radiation. As can be seen from the distances shown in Figure 1, only residents of Denmark and the outer part of the south-east coast of Norway may receive lifetime doses above the annual natural background radiation following the hypothetical meltdown accident described in this report.

[2] The lifetime dose describes the radiological impact on an individual from the time of the accident and for the rest of their life. For a one-year-old child, this period is 70 years after the accident and for an adult, it is 50 years after the accident.



1-årigt barn	One-year-old child
Livstid (70 år)	Lifespan (70 years)
7 dygn	7 days
Effektiv dos (mSv)	Effective dose (mSv)
Avstånd (km)	Distance (km)

Figure 3. Effective dose to a one-year-old child as a function of distance from the release. Dashed vertical line indicates the distance to Läsö (50 km).



Dos till vuxen	Dose to an adult
Livstid (50 år)	Lifespan (50 years)
7 dygn	7 days
Effektiv dos (mSv)	Effective dose (mSv)
Avstånd (km)	Distance (km)

Figure 4. Effective dose to adults as a function of distance from the release. Dashed vertical line indicates the distance to Läsö (50 km).

5. Discussion

The results presented in this report show that after a hypothetical nuclear accident with a core meltdown on the Värö Peninsula, the doses to people in neighbouring countries are relatively low. Compared to the dose from natural background radiation of 1–2 mSv that a person living in Sweden receives each year, the impact of the radiological accident is small. The calculations have consistently been made using conservative approaches, and it is reasonable to believe that the impacts in reality would be even lower. Some of the assumptions that drive the results in a conservative direction are presented below:

- For each distance evaluated, the geographical point giving the highest dose has always been selected. This means that, although this point is in the centre of the North Sea, it has been included in the evaluation.
- No crediting of protective measures[3] has been done, meaning that people evaluated have been assumed to be outdoors every second for a whole year. The considerations of sheltering for parts of the day and restrictions on food intake would further reduce the consequences.
- It has been assumed that all food eaten comes from the place where the evaluated people live. Importing food from non-contaminated sites would further reduce the impact.

6. Conclusion

The radiological impact on residents in neighbouring countries in the event of a release from a hypothetical accident involving a core meltdown at a proposed nuclear power plant on the Värö Peninsula has been evaluated. Radiation doses to a one-year-old and an adult have been calculated for distances out to 800 km from the release point. Calculated lifetime doses at 50 km, a distance corresponding to the nearest inhabited foreign landmass (Danish Läsö), are less than 10 mSv for both a one-year-old and an adult. At distances greater than 250 km from the release point, lifetime doses are less than 1 mSv, which is approximately equivalent to the normal annual background dose to the general public in Sweden.

[3] Protective measures include sheltering, taking iodine tablets, food restrictions, etc.