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Swedish Radiation Safety Authority


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# 2017:27e

# Review of Swedish emergency planning zones and distances, Appendix 5

## The central interim storage facility for spent nuclear fuel


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# Contents

# 1. Summary

Clab is a central interim storage facility for spent nuclear fuel, located since 1985 on the peninsula of Simpevarp. This is northeast of Oskarshamn. Clab is used for interim storage of all spent nuclear fuel from the Swedish nuclear power industry. At the present time, around 6,500 tonnes of spent fuel are stored here pending final disposal. The installations at this facility include storage pools located 40 m below ground surface and reception pools at ground level. Clab is operated by SKB, the Swedish Nuclear Fuel and Waste Management Company.

The facility has been classified by the Swedish Radiation Safety Authority, SSM, as belonging to emergency preparedness category II. This implies that an event at Clab is assessed as being capable of giving rise to consequences warranting urgent or early protective actions off-site. As a component of emergency preparedness planning for the purpose of enabling effective protective actions, it is recommended to have an urgent protective action planning zone (UPZ) and extended planning distance (EPD) established to surround the facility.

It is proposed by SSM to have Clab surrounded by an extended planning distance extending 2 kilometres. Within the EPD, planning should be in place for relocation based on input from measurements of ground deposition. Outside the site of the Clab facility, it has been assessed by SSM that no radiation doses can occur in connection with on-site events that justify an urgent protective action planning zone. For this reason, the present emergency planning zone should be discontinued.

The proposed design of the EPD and suggested discontinuation of the present emergency planning zone surrounding Clab are based on analyses of postulated events. Here, three postulated events were selected to serve as the basis of emergency preparedness planning. For these events, representative source terms have been defined. These source terms describe the releases assumed to follow the respective type of event. Thereafter, SSM carried out dispersion and dose calculations based on historical weather data for the purpose of estimating the distances at which it is deemed warranted to take different types of protective actions. Ultimately, on the basis of these distances, a suggested extended planning distance and a conclusion drawn on an urgent protective action planning zone were produced. This proposal was prepared in consultation with the Kalmar County Administrative Board and Swedish Civil Contingencies Agency (MSB). SSM has notified the local safety board of the Oskarshamn nuclear power plant about this ongoing project. The Kalmar County Administrative Board compiled viewpoints and comments submitted by regional stakeholders.

This appendix is part of the report *“Review of Swedish emergency planning zones and distances”.* For explanations of terms and concepts, and further information not specifically relating to a facility, please see the main report.

# 2. Postulated events

As part of this project, SSM used analyses of conceivable events having off-site consequences, as reported by SKB [1]. These events may be broken down into two categories: releases of fission or activation products due to a loss of cooling, and criticality accidents. These two categories have different characteristics depending on their respective and potential off-site consequences. Criticality events give rise to the following: direct radiation (gamma and neutron radiation), and releases of short-lived fission products in the form of iodine and noble gases. A release mainly results in inhalation dose and cloud dose while the plume passes. A loss of cooling event giving rise to a release of fission or activation products mainly results in ground deposition of caesium or cobalt. For this reason, both kinds of event are taken into account in this proposal.

The following three events serve as the basis of the proposed urgent protective action planning zone and extended planning distance to surround Clab:

- **Criticality event.** An event resulting in criticality with an immediate release of fission products. The criticality event in question is based on an event in which the bottom plate of a compact fuel element cassette loosens, whereupon the fuel becomes exposed in a disadvantageous geometry without the neutron-absorbing boron plates present in the cassette.
- **Event involving the reception pool.** An event corresponding to leakage from the reception pool owing to a severe earthquake. The total residual effect for the fuel assembly stored in the reception pool is assumed to be at the maximum level that is allowed for management (400 kW). The fuel assembly in the reception pool is exposed to the air and becomes overheated owing to a lack of cooling, which results in fuel damage and a release of fission products.
- **Event involving a transport container.** An event in which a transport container filled with water, with its cooling mantle mounted, remains hanging from an overhead crane with no cooling due to a loss of electrical power. The water in the transport container contains fission and activation products that boil off. No additional damage to the fuel assembly occurs.

In the assessment of SSM, these three events should be taken into account as part of emergency preparedness planning for Clab as they affect the dimensioning differently in terms of the period of forewarning and releases of long-lived radioactive substances. All the postulated events occur above ground in the reception building. SSM has also taken into account events in the storage pools that are located below ground level, but these have no impact on the dimensioning of the emergency preparedness planning in terms of either the period of forewarning or the magnitude of the release.

## 2.1. Selection of events

### 2.1.1. Criticality

This event, in which criticality arises owing to loosening of the bottom plate of a compact fuel element cassette, has a rapid sequence. The fuel assembly falls out of this cassette during transfer, or remains on the bottom of the pool in connection with a lifting procedure. This leaves the fuel assembly in a disadvantageous geometry without the presence of the neutron-absorbing boron plates that are inside the cassette. Since it is submerged in water in the reception pool, the fuel assembly gives rise to a criticality with subsequent releases occurring immediately. The instantaneous pulse of energy (1000 MW in 1 s) due to nuclear fission causes fragmenting of the fuel assembly, at which point the fission ceases [1].

In the assessment of SSM, this postulated event is suitable for dimensioning of the emergency preparedness planning in terms of the period of forewarning. Here, the rationale is that the duration is very brief, and a release is expected to take place instantaneously.

### 2.1.2. Reception pool

An event, corresponding to leakage from the reception pool owing to a severe earthquake, has been selected for dimensioning the emergency preparedness planning in terms of a release of long-lived caesium isotopes. This event unfolds slowly. The earthquake is postulated to result in water leakage from the reception pool. In turn, the loss of water results in overheating of the spent nuclear fuel stored in the pool. After nine days, this overheating results in fuel damage with a consequential release of fission products to the surroundings from the spent fuel [1].

In the assessment of SSM, this postulated event is suitable for dimensioning of the emergency preparedness planning in terms of a release of fission products, which might give rise to long-term ground deposition of caesium in particular.

### 2.1.3. Transport container

Spent nuclear fuel is transported inside Clab using a transport container that cools the fuel assembly with water. If there is a loss of cooling by the transport container due to a loss of electrical power, and the cooling cannot be restored, boiling temperature is reached in approximately 12 hours. The boiling water contains radioactive substances, in the form of ‘crud’, which dissolves in the water in connection with boiling. Another likely occurrence is cladding damage (pinholes) to the spent nuclear fuel. During boiling, activation and fission products are released in the reception building. Here, they are subsequently assumed to be dispersed in their entirety in the surroundings at an altitude corresponding to the height of the reception building [1].

In the assessment of SSM, this postulated event is suitable for dimensioning of the emergency preparedness planning in terms of a release of activation products, which might give rise to long-term ground deposition mainly comprising cobalt.

While this assignment was in progress, SKB implemented improvements to the transport container’s design, making it possible to carry out manual measures to avoid reaching the boiling temperature. SSM is positively inclined to this development, but has nevertheless elected to include the event involving the transport container in this assessment. Emergency preparedness planning should also take into account beyond design basis events that might affect a facility. This also implies that manual measures cannot be credited.

# 3. Representative source terms

## 3.1. Criticality

SSM has developed a representative source term for the postulated criticality event. As mentioned previously, the event is due to a loose bottom plate of a compact fuel cassette. It is assumed that the fuel assembly is unirradiated and has a degree of enrichment of 4.2 per cent U-235. The criticality sequence leads to a strong pulse of energy (1 MW) lasting one second. This ceases immediately as the fuel becomes fragmented owing to the pulse of energy. The release is expected to have a duration of one hour and pass via the stack. The source term is based on SKB's report [1]; however, SSM has also conducted sensitivity analyses based on information presented by the U.S. Nuclear Regulatory Commission (NRC) in its Regulatory Guides, Nos. 3.34 [2] and 1.183 [3].

### 3.1.1. Nuclide content

SKB has postulated that only noble gases are generated from the reception pool, where criticality arose on the assumption that all iodine, caesium and other fission products that were formed are retained in the pool's water. Certain noble gases have been omitted by SKB on the rationale that they give a negligible contribution to radiation dose to an individual in the surroundings [4]. SSM assesses that SKB's data corresponds to a representative source term for this criticality event.

The only nuclide with a long half-life that is released in the event is Kr-85, which has a half-life of around 11 years. Consequently, this nuclide may be assumed to be present in the fuel already before the criticality event. Therefore, for the purpose of including the activity from previous irradiation in the nuclear power reactor, an addition is made of the activity from Kr-85 in fuel having a degree of burnup of 55 MWd/kg U that is assumed to have decayed over the course of one year.

As the fission products decay, ingrowth of additional decay products takes place. When developing the representative source term, however, SSM did not take into account any delay in the transport of the radioactive substances between the pool and the surroundings. For this reason, decay and ingrowth are instead dealt with as part of the dispersion calculations. The nuclides characterised by ingrowth are represented by the source term (Table 1), but the activity is set at 0 Bq.

### 3.1.2. Sensitivity analysis

In one of the sensitivity analyses, SSM elected to include all the noble gases listed by the NRC. The noble gases omitted by SKB have been estimated using the source term of the NRC [2] multiplied by factor 10 in order to conservatively postulate SKB's corresponding levels of activity for the noble gases.

Iodine is also included in these sensitivity analyses. The quantity of iodine produced during the criticality event is estimated by SSM as being 10 times the quantity of the source term of the NRC [2] in the sensitivity analysis. SKB states that a decontamination factor of 50 is reasonable to assume for iodine, as this element is assumed to form deposits in the ventilation system while being released into the surroundings. At the same time, however, the NRC [3] states that a decontamination factor of 500 is reasonable to postulate for inorganic iodine, since iodine passes through 7 m of water in the pool. Consequently, since the criticality event is assumed to occur on the bottom of the pool, the iodine content of the NRC's source term is scaled using the decontamination factor

$$DF = 10 \times \frac{1}{50} \times \frac{1}{500}$$

in the sensitivity analysis. Iodine is conservatively assumed to be entirely in elemental form ($I_2$) in the sensitivity analysis, since this form gives rise to the highest radiation dose per becquerel.

### 3.1.3. Summary account of source terms

Table 1 provides a summary account of the source term for the criticality event at Clab, in addition to the source term used in the sensitivity analysis. The dispersion calculations assume a release passing via the stack (36 m) of the reception building over the duration of one hour. SSM does not anticipate the heat energy of the release to result in plume rise. These parameters are shared by both the representative source term and the sensitivity analysis.

**Table 1**. Nuclides and activity in the representative source term for the criticality event at Clab and as part of the sensitivity analysis. The table presents total released activity to the atmosphere.

| Release group | Nuclide | Half-life | Activity (Bq) | |
|---|---|---|---|---|
| | | | Representative source term | Sensitivity analysis |
| Noble gases | Kr-83m[1] | 110 min. | 0 | 5.9E+13 |
| | Kr-85 | 10.8 y | 1.2E+14 | 1.2E+14 |
| | Kr-85m[1] | 4.48 h | 0 | 5.6E+13 |
| | Kr-87 | 76.3 min. | 2.5E+14 | 2.5E+14 |
| | Kr-88 | 2.84 h | 3.5E+14 | 3.5E+14 |
| | Rb-88[1,2] | 17.8 min. | 0 | 0 |
| | Kr-89 | 3.15 min. | 2.1E+15 | 2.1E+15 |
| | Rb-89[1,2] | 15.4 min. | 0 | 0 |
| | Sr-89[1,2] | 50.6 d | 0 | 0 |
| | Xe-131m[1] | 11.9 d | 0 | 3.0E+10 |
| | Xe-133[1] | 5.24 d | 0 | 1.0E+13 |
| | Xe-133m[1] | 2.19 d | 0 | 6.7E+11 |
| | Xe-135[1] | 9.14 h | 0 | 1.3E+14 |
| | Xe-135m[1] | 15.3 min. | 0 | 8.1E+14 |
| | Xe-137 | 3.82 min. | 2.5E+15 | 2.5E+15 |
| | Xe-138 | 14.1 min. | 3.2E+15 | 3.2E+15 |
| | Cs-138[1,2] | 33.4 min. | 0 | 0 |
| Halogens | I-131[1] | 8.02 d | 0 | 1.3E+08 |
| | I-132[1] | 2.30 h | 0 | 1.6E+08 |
| | I-133[1] | 20.8 h | 0 | 2.4E+09 |
| | I-134[1] | 52.5 min. | 0 | 6.7E+10 |
| | I-135[1] | 6.57 h | 0 | 7.0E+09 |

1) Not included in the source term from SKB [1].

2) Decay product not stated by the NRC [2].

## 3.2. Reception pool

Based on data from SKB, SSM developed a representative source term for the postulated event involving a release of fission products from the reception pool at Clab [1]. Table 2 below presents the nuclides and activity included in the representative source term for the reception pool. The release is assumed to pass via an outlet point corresponding to the height of the reception building: 20 m. No heat content has been assumed; in other words, SSM does not anticipate the heat energy of the release to result in plume rise. SKB states that this release is expected to be in progress for several days. With this rationale in mind, SSM has postulated a release duration of 48 hours, because a shorter release duration is expected to result in a larger impact on the surroundings.

The distribution of the various chemical forms of iodine are, as stated by SKB, 92.5 per cent inorganic iodine in the form of CsI and $I_2$, in addition to 7.5 per cent organic iodine in the form of $CH_3I$ [5]. Of the inorganic iodine, it is assumed that 95 per cent is CsI, giving the activity shown in Table 2.

**Table 2**. Nuclides and activity in the representative source term for a release from the reception pool at Clab.

| Nuclide | Half-life | Activity (Bq) | Chemical form |
|---|---|---|---|
| Kr-85 | 10.8 y | 3.3E+15 | - |
| I-129 | 16.1 million y | 2.1E+08 | CsI (particulate iodine) |
| | | 1.1E+07 | $I_2$ (elemental iodine) |
| | | 1.8E+07 | $CH_3I$ (organic iodine) |
| Cs-134 | 2.07 y | 3.4E+13 | - |
| Cs-137 | 30.0 y | 1.6E+14 | - |

### 3.2.1. Sensitivity analysis

As the postulated event in the reception pool takes place due to a severe earthquake, it cannot be assumed that a possible release will pass via the ventilation system and stack. The release is assumed to pass via an outlet point corresponding to the height of the reception building, 20 m, instead of at the 36 m height of the stack, due to the failed ventilation system as a consequence of the earthquake. As the height of the release is of great significance for the air concentration of radioactive materials in the vicinity, and thereby for not only inhalation doses but also levels of ground deposition, SSM carried out sensitivity analyses assuming release heights of both 10 m and 36 m.

There is nevertheless a possibility that a de facto release takes place through an open door or the like, which would warrant estimates that take an even lower outlet point into account. However, releases at heights this low would be incompatible with the models used for the dispersion calculations (for example, effects due to buildings would be significant). For this reason, calculations for release heights lower than 10 m were not performed. The nuclide content and release duration of the sensitivity analyses are the same as for the representative source term, as shown in Table 2.

## 3.3. Transport container

SSM has developed a representative source term for the postulated event involving a release of activation and fission products from a transport container, based on data from SKB [1]. It is assumed that the fuel assembly in the transport container was removed from the nuclear power reactor nine months before the event occurs, having a degree of burnup of 60 MWd/kg U.

Here as well, an earthquake is assumed to be the root cause of this event, for which reason the release is assumed to take place via an outlet point corresponding to the height of the reception building: 20 m. This release takes place over a period of 40 hours. No heat content has been assumed; in other words, SSM does not anticipate the heat energy of the release to result in plume rise. Table 3 illustrates nuclides and activity for the representative source term in the case of the transport container at Clab. It is assumed that the relative occurrences of the different chemical forms of iodine in the release are the same as for the event occurring in the reception pool, described in section 3.2 above.

### 3.3.1. Sensitivity analysis

SKB has stated that the release from the transport container is expected to take place over a period of 40 hours. In one sensitivity analysis, SSM postulated a briefer release duration of 20 hours for the purpose of studying the impact on the surroundings. A shorter release sequence is expected to result in higher doses, as the released activity is dispersed over a smaller area due to smaller shifts in wind direction.

As in the case of the postulated event occurring in the reception pool, SSM also, in the case of the transport container, performed sensitivity analyses of how different release heights have an impact on doses in the surroundings. In these sensitivity analyses as well, the assumed release heights were 10 m and 36 m. The nuclide content and outlet point of the sensitivity analyses are the same as for the representative source term.

**Table 3**. Nuclides and activity in the representative source term for a release to the atmosphere from the transport container at Clab.

| **Release group** | **Nuclide** | **Half-life** | **Activity (Bq)** |
|---|---|---|---|
| Noble gases | Kr-85 | 10.8 y | 2.1E+08 |
| Halogens | I-129 | 16.1 million y | 1.8E+03 |
| Alkali metals | Cs-134 | 2.07 y | 4.8E+09 |
| | Cs-137 | 30.0 y | 6.2E+09 |
| Tellurium group | Sb-125 | 2.76 y | 2.5E+07 |
| Noble metals | Co-58 | 70.9 d | 3.0E+12 |
| | Co-60 | 5.27 y | 1.2E+14 |
| Cerium group | Pu-238 | 87.7 y | 9.4E+08 |
| | Pu-239 | 24,100 y | 1.3E+08 |
| | Pu-240 | 6,560 y | 2.2E+08 |
| | Pu-241 | 14.3 y | 1.8E+10 |
| Lanthanides | Am-241 | 433 y | 1.0E+07 |
| | Am-243 | 7,360 y | 1.3E+08 |
| | Cm-244 | 18.0 y | 7.3E+08 |
| Other nuclides | H-3 | 12.3 y | 2.5E+06 |
| | Mn-54 | 312 d | 7.9E+12 |
| | Fe-55 | 2.74 y | 1.2E+14 |
| | Ni-59 | 76,000 y | 3.9E+10 |
| | Ni-63 | 101 y | 5.8E+12 |
| | Sr-90 | 28.8 y | 4.2E+07 |
| | Ag-108m | 418 y | 5.5E+07 |
| | Ag-110m | 250 d | 2.2E+08 |

# 4. Dispersion and dose calculations

SSM has performed dispersion and dose calculations based on historical weather data for the purpose of estimating the distribution of the greatest distances at which dose criteria and intervention levels are exceeded. In the case of the representative source terms from Clab, weather data from the period 2006-2015 was used in the dispersion calculations. In total, the data material contains approximately 2,350 dispersion and dose calculations per representative source term. The sensitivity analyses used weather data for the period 2012-2015, which encompasses approximately 1,100 dispersion and dose calculations per representative source term. This gives a sufficient statistical basis for taking into account variations in weather conditions around Clab.

This chapter presents outcomes showing the distances at which dose criteria are exceeded for evacuation and sheltering. Intervention levels are used to estimate distances at which relocation due to ground deposition might be warranted. For more information about dose criteria, intervention levels, and dispersion and dose calculations, refer to the main report.

## 4.1. Criticality

### 4.1.1. Evacuation and sheltering

No dose criteria were exceeded outside the site of the facility on the part of the postulated criticality event, neither for adults nor children. The dose criterion for evacuation, at 20 mSv effective dose, is not exceeded when taking into account 90 per cent of the occurring weather scenarios. The greatest distance at which the dose criterion for sheltering, at 10 mSv effective dose, is exceeded is shorter than 100 m if 90 per cent of the occurring weather scenarios are taken into account (Figure 1, black curve). The distances are the same for children and for adults.

The results from the sensitivity analysis, where additional nuclides were included in the source term, give the same distances as for the representative source term shown in Figure 1 (blue curve), for children and adults alike. According to the sensitivity analysis of the postulated criticality event at Clab, radiation doses from iodine and additional noble gases are negligible.

In the assessment of SSM, direct radiation from the criticality event's fission pulse has no impact on the population outside the facility, as this event can only occur if water is present in the reception pool and the water itself constitutes an effective radiation shield.

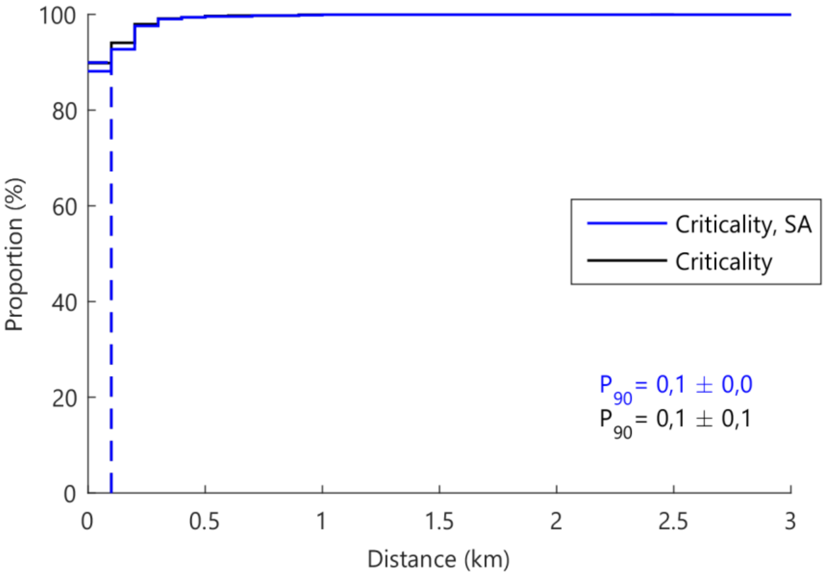


**Figure 1.** Distribution of the greatest distances at which the dose criterion for sheltering, at 10 mSv effective dose, is exceeded in the case of the postulated criticality event at Clab (black curve). The figure also illustrates the distribution shown from the sensitivity analysis, which includes a larger number of nuclides (blue curve).

### 4.1.2. Relocation due to ground deposition

It is shown from the dispersion calculations that no ground deposition occurs warranting relocation of the population outside the facility as a result of the analysed criticality event. Nonetheless, the calculations indicate that a ground deposition of Sr-89, which may lead to some concerns relating to food production, might occur following the criticality event. This topic is discussed in Chapter 7.

## 4.2. Reception pool

### 4.2.1. Evacuation and sheltering

The outcomes of the dispersion and dose calculations show that the dose criterion for relocation, at 20 mSv effective dose, is not exceeded on the part of the postulated event involving a release from the reception pool.

For an illustration of outcomes on the part of the postulated event in the reception pool for the dose criterion for sheltering, at 10 mSv effective dose, see Figure 2. The greatest distance at which the dose criterion is exceeded is shorter than 200 m if 90 per cent of the occurring weather scenarios are taken into account (Figure 2, blue curve). As children have a lower rate of inhalation than adults, the dose criterion for children is not exceeded.

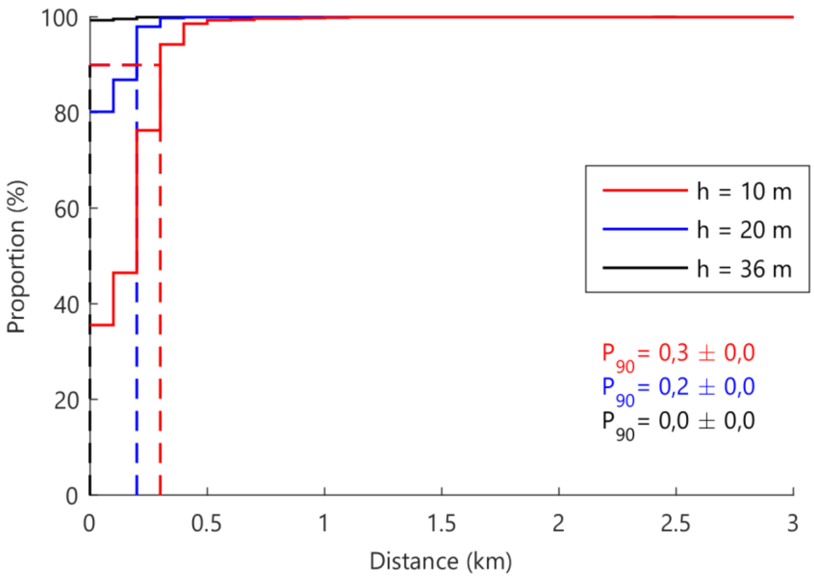


**Figure 2.** Distribution of the greatest distances at which the dose criterion for sheltering, at 10 mSv effective dose, is exceeded in the case of the postulated event at Clab's reception pool. The figure also illustrates a sensitivity analysis of release height impact (h). The 90th percentile for the distance is marked in the diagram in relation to respective heights.

The sensitivity analysis of release height impact shows that, at lower release height (10 m), there is a risk that the dose criterion for sheltering is exceeded at somewhat greater distances. The greatest distance at which 10 mSv effective dose is exceeded is thus shorter than 300 m if 90 per cent of the occurring weather scenarios are taken into account (Figure 2, red curve). In the case of higher release height (36 m), the dose criterion for sheltering is not exceeded (Figure 2, black curve). The overall conclusion, based on the dispersion and dose calculations, is that sheltering is unwarranted outside the site of the facility in the case of the postulated event if 90 per cent of the occurring weather scenarios are taken into account.

### 4.2.2. Relocation due to ground deposition

There is a risk that significant ground deposition might occur, possibly warranting protective actions off-site on the part of the postulated event involving a release from the reception pool. For an illustration of the distribution of greatest distances at which the intervention level is exceeded, warranting relocation owing to high ground deposition comprising 3,000 kBq/m$^2$ for the sum of Cs-134 and Cs-137 in the case of a release from the reception pool, see Figure 3. The dispersion and dose calculations show that the greatest distance at which 3,000 kBq/m$^2$ is exceeded is shorter than 600 m if 90 per cent of the occurring weather scenarios are taken into account.

This has also been looked into as part of a sensitivity analysis conducted by SSM, which studied the impact on distances in cases where the release height is lower (10 m) or higher (36 m) than the height of the reception building. This is illustrated in Figure 4. The greatest distance at which 3,000 kBq/m$^2$ of caesium is exceeded is shorter than 900 m and 500 m, respectively, if 90 per cent of the occurring weather scenarios are taken into account with respective release heights of 10 m and 36 m.

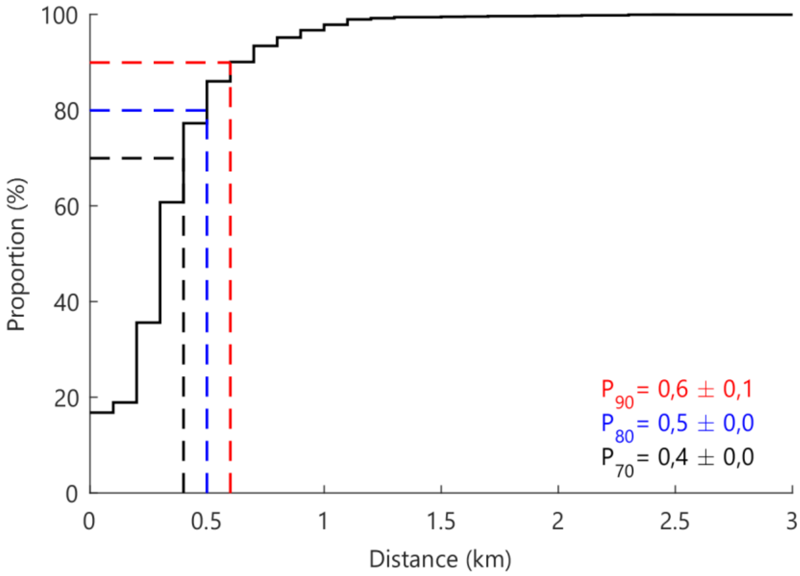


**Figure 3.** Distribution of the greatest distances at which the intervention level of 3,000 kBq/m$^2$ of total ground deposition of Cs-134 and Cs-137 is exceeded for the postulated event at Clab's reception pool.

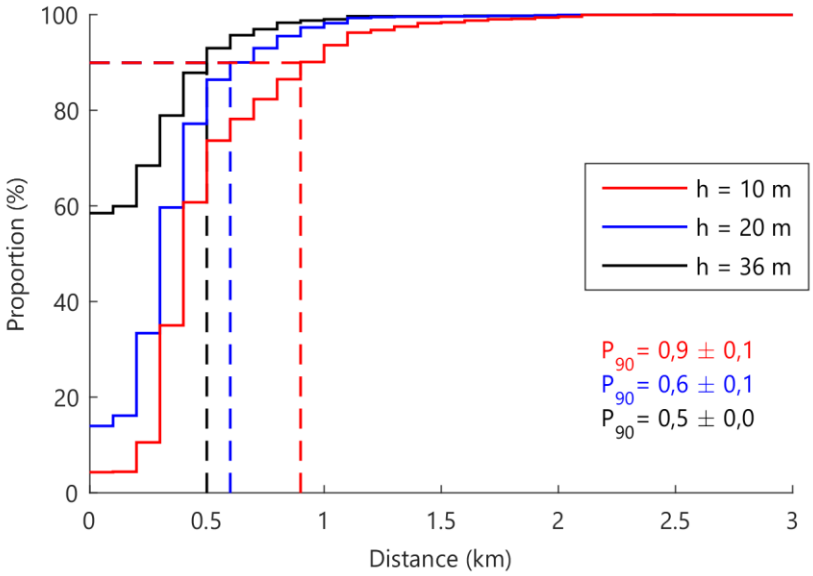


**Figure 4.** Sensitivity analysis of release height impact (h) on the greatest distances at which the intervention level of 3,000 kBq/m$^2$ of total ground deposition of Cs-134 and Cs-137 is exceeded in connection with a release from Clab's reception pool.

## 4.3. Transport container

### 4.3.1. Evacuation and sheltering

The outcomes of the dispersion and dose calculations show that the dose criterion for evacuation, at 20 mSv effective dose, is not exceeded outside the site of the facility on the part of the postulated event involving a release from the transport container. If one takes into account 90 per cent of the occurring weather scenarios, the distance is shorter than 100 m (Figure 5, blue curve).

The dispersion and dose calculations also show that the dose criterion for sheltering, at 10 mSv effective dose, may be exceeded at a distance corresponding to that of the restricted area around the facility. If one takes into account 90 per cent of the occurring weather scenarios, the distance is shorter than 300 m (Figure 6, blue curve).

This event has also been looked into as part of a sensitivity analysis conducted by SSM regarding the impact on respective distances in cases where the release height is lower (10 m) or higher (36 m) than the height of the reception building. It has been shown from the dispersion and dose calculations that the greatest distance at which evacuation may be warranted is shorter than 300 m if 90 per cent of the occurring weather scenarios are taken into account with a release height of 10 m. This is illustrated in Figure 5 (red curve). The greatest distance at which sheltering may be warranted is shorter than 400 m in the case of a release height of 10 m and where 90 per cent of the occurring weather scenarios are taken into account. This is illustrated by Figure 6 (red curve). If the release should instead pass via the stack (36 m), the dose criteria are not exceeded neither in the case of evacuation nor sheltering, even if 90 per cent of the occurring weather scenarios are taken into account (Figures 5 and 6, black curves).

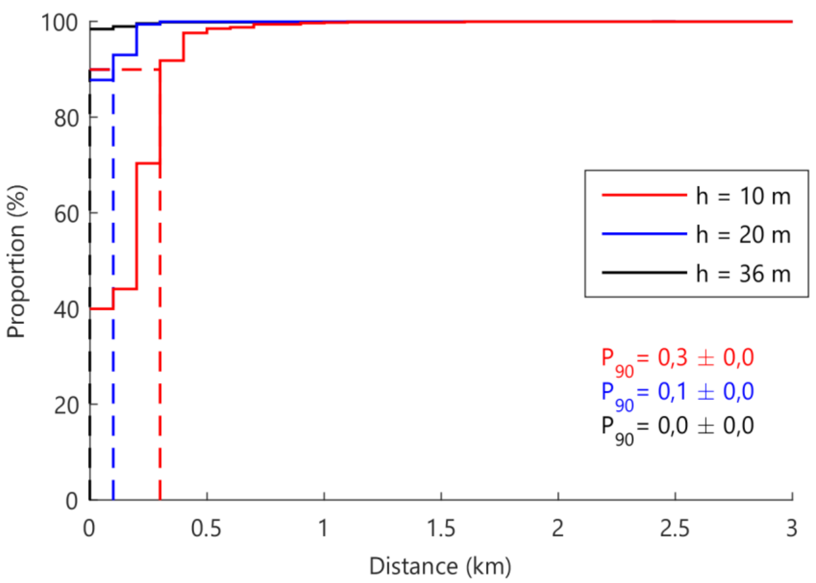


**Figure 5** Distribution of the greatest distances at which the dose criterion for evacuation, at 20 mSv effective dose, is exceeded in the case of the postulated event involving the transport container at Clab (blue curve). The figure also illustrates a sensitivity analysis of release height impact (h), where the release height is set at 36 m (black) and 10 m (red). The corresponding distribution of distances as regards doses to children yields identical distances.

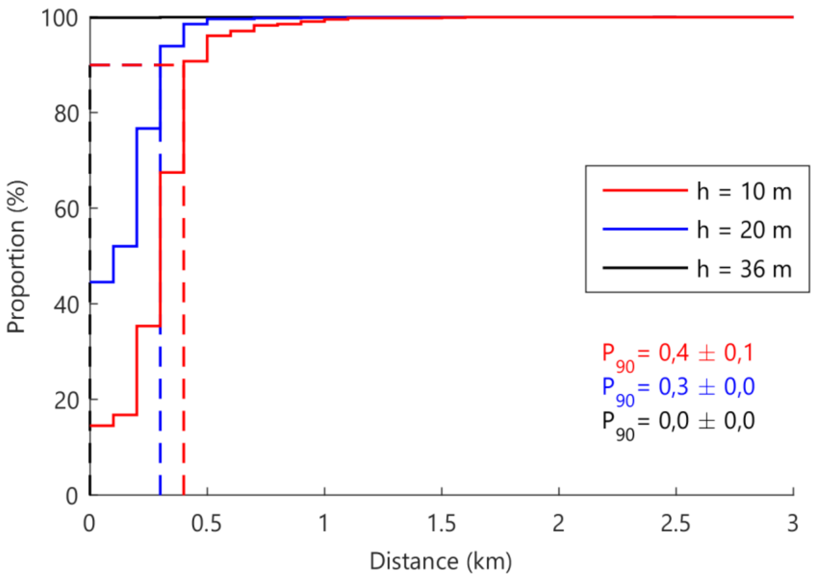


**Figure 6.** Distribution of the greatest distances at which the dose criterion for sheltering, at 10 mSv effective dose, is exceeded in the case of the postulated event involving the transport container at Clab (blue curve). The figure also illustrates a sensitivity analysis of release height impact (h), where the release height is set at 36 m (black) and 10 m (red). The corresponding distribution of distances as regards doses to children yields identical distances.

The outcomes from the sensitivity analysis based on a more rapid sequence show that briefer release duration impacts only slightly on the greatest distances where the dose criterion for sheltering is exceeded. In the case of a release height of 10 m, the greatest distance at which the dose criterion is exceeded is shorter than 500 m if one takes into account 90 per cent of the occurring weather scenarios, and at half the release duration. This is illustrated by Figure 7 (blue curve).

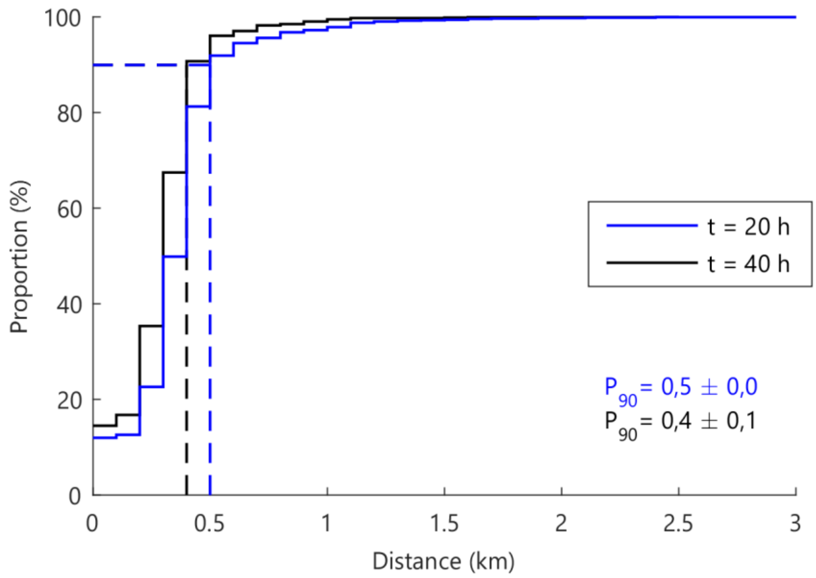


**Figure 7.** Sensitivity analysis of impact due to release duration (t) on the distribution of greatest distances where the dose criterion for sheltering, at 10 mSv effective dose, is exceeded in the event involving the transport container at the release height of 10 m. Reducing the release duration by half, from 40 hours (black curve) to 20 hours (blue curve), results in somewhat larger distances.

### 4.3.2. Relocation due to ground deposition

Significant ground deposition, which may warrant protective actions off-site, may occur on the part of the postulated event involving the transport container at Clab. Figure 8 illustrates the distribution of greatest distances at which the intervention level for relocation, at 1,000 kBq/m$^2$ of Co-60, is exceeded in the case of a release from the transport container. If one takes into account 90 per cent of the occurring weather scenarios, the distance at which the intervention level is exceeded is shorter than 1.3 km.

Figure 9 illustrates outcomes from the sensitivity analysis of release height impact. The greatest distance at which relocation due to ground deposition may be warranted is shorter than 1.6 km when taking into account 90 per cent of the occurring weather scenarios at a release height of 10 m. Correspondingly, a higher release height (36 m) yields greatest distances that are shorter (1.1 km), given the same circumstances in other respects. For an illustration of the distribution of greatest distances at which it may be warranted to carry out relocation due to ground deposition, assuming both shorter release duration (20 h) and low release height (10 m), see Figure 10. If one takes into account 90 per cent of the occurring weather scenarios, the distance is shorter than 2.1 km.

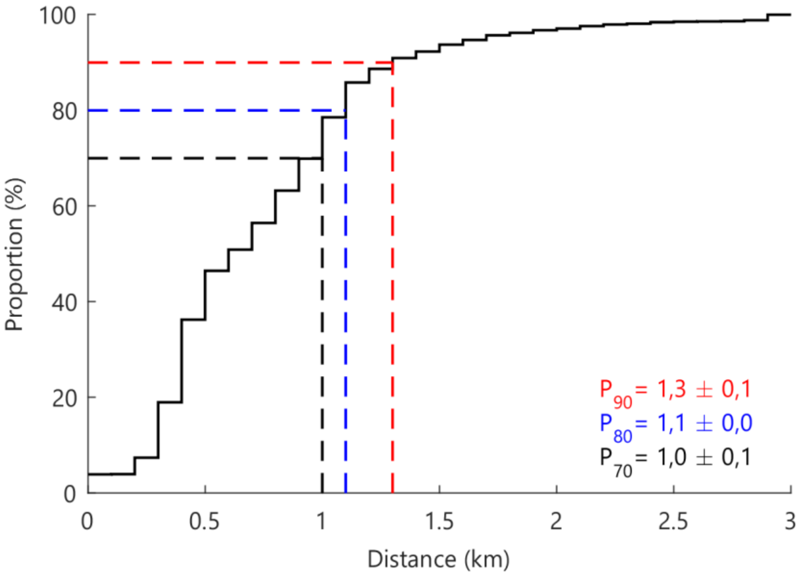


**Figure 8.** Distribution of the greatest distances at which the intervention level of 1,000 kBq/m$^2$ of ground deposition of Co-60 is exceeded during a release from the postulated event involving the transport container at Clab.

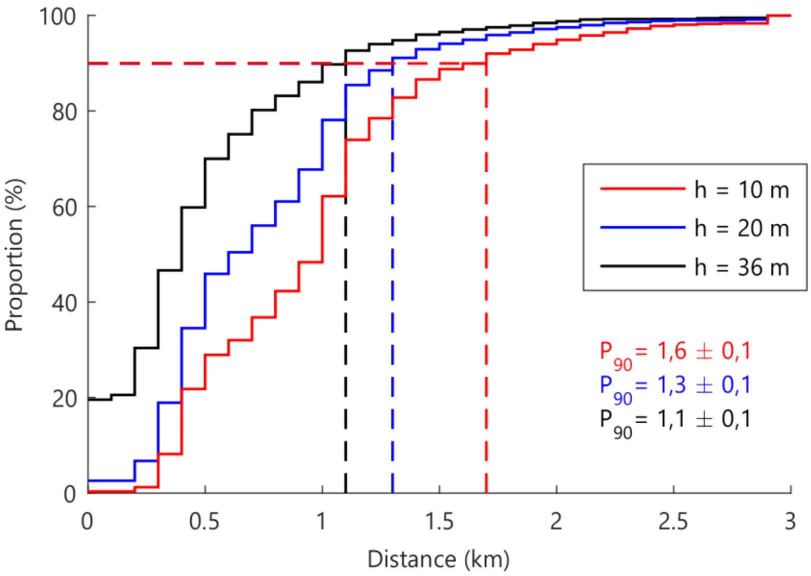


**Figure 9.** Outcome of sensitivity analysis for the impact of release height (h) on the distribution of the greatest distances at which the intervention level of 1,000 kBq/m$^2$ of ground deposition of Co-60 is exceeded during a release from the transport container at Clab.

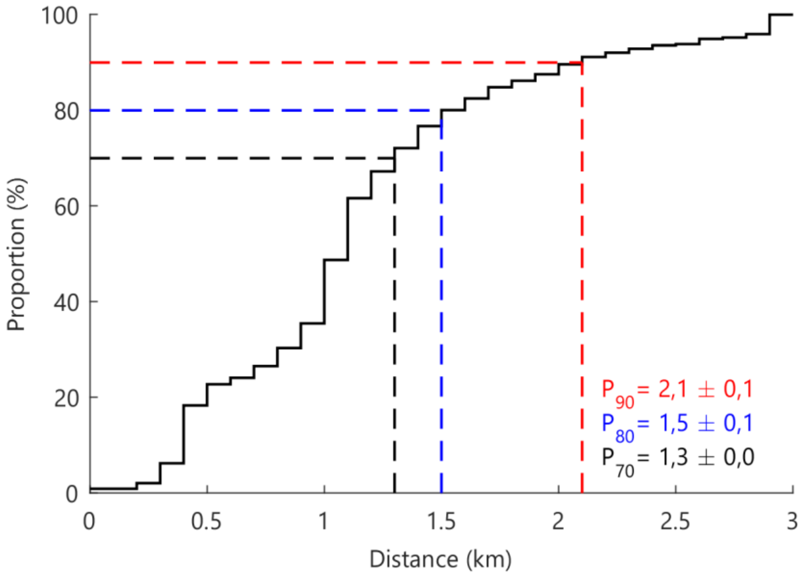


**Figure 10.** Outcome of sensitivity analysis for aggregated impact of low release height (10 m) and a shorter release duration (20 h) on the distribution of the greatest distances at which the intervention level of 1,000 kBq/m$^2$ of ground deposition of Co-60 is exceeded during a release from the transport container at Clab.

# 5. Emergency planning zones and distances

The dispersion and dose calculations show that in the case of the postulated events and representative source terms, it is unwarranted to take any urgent protective actions outside the site of the Clab facility, even if 90 per cent of the occurring weather scenarios are taken into account. On the other hand, planning is needed for radiation measurements, mainly for the purpose of giving decision-making input regarding relocation due to ground deposition. In order to dimension these emergency response measures, SSM suggests establishment of an EPD to surround Clab.

SSM's proposals:

1. Discontinuation of the present emergency planning zone.
2. Establishment of an EPD with a range of 2 km surrounding Clab.
3. The capability to carry out radiation measurements in the EPD should be dimensioned to facilitate decision-making input regarding relocation due to ground deposition within one week of the release ceasing.
4. It is advisable to have the emergency class of general emergency reviewed.
5. The authorities should be alerted in connection with events or abnormal operation having safety significance.
6. Information should be provided to the public in connection with abnormal operation and events having an impact on safety.

## 5.1. The basis for emergency planning zones and distances

### 5.1.1. Present emergency planning zone

The present emergency planning zone surrounding Clab is circular, with a radius of 2 km [6]. This zone is the location of around 30 permanent residents in addition to several summer cottages. The distance is approximately 700 m between Clab and the nearest residential building. The Oskarshamn nuclear power plant is located directly adjacent to Clab. Therefore, owing to the geographical location, there is a need for coordinated efforts between both these nuclear facilities in the case of a declared general emergency at Clab.

A general emergency is declared as follows: a shift supervisor at Clab, following consultation with the on-duty engineer at the Oskarshamn NPP, orders Clab's central alarm station to issue this alarm. Joint action is also taken with SOS Alarm, the broadcasting management of Sweden's public radio stations belonging to Sveriges Radio, and the Kalmar County Administrative Board. Outdoor warnings are communicated in the form of seven sirens to encompass the entire emergency planning zone extending 2 km from Clab, while indoor warnings (communicated via RDS radio receivers) are issued to the entire existing UPZ surrounding the Oskarshamn NPP, i.e. 12-15 km from Clab [7].

In the case of a declared general emergency, the county administrative board is in charge of implementing protective actions for the public. Important Public Announcements (IPAs) have been prepared in advance, which are used in the case of a declared general emergency to advise those present in the vicinity of Clab to stay indoors. Another action taken is to cordon off all marine vessels within a radius of 3.6 km of the facility. Initial radiation measurements are planned to be carried out along designated routes around Clab, defined in accordance with the planning of the county administrative board relating to the Oskarshamn NPP [6], [8].

### 5.1.2. Evacuation

The dose criterion for evacuation, at 20 mSv effective dose, may under unfavourable weather conditions be exceeded out to a maximum distance of approximately 100-300 m from the outlet point. For the most part, these distances are encompassed by the site of the facility. For this reason, SSM is of the opinion that it is unwarranted to conduct planning for evacuation.

### 5.1.3. Sheltering

The outcomes of the dispersion and dose calculations also show that it is unwarranted to advise sheltering outside the site of Clab. According to the estimates, the distance at which the dose criterion of 10 mSv effective dose is exceeded is shorter than approximately 300 m if 90 per cent of the occurring weather scenarios are taken into account. This distance varies somewhat depending on the parameters selected, where above all release height comprises a significant factor. It is not possible to draw conclusions on how a de facto release might manifest itself in relation to release height and prevailing weather conditions. Within the distance where the dose criterion for sheltering is exceeded, few members of the public should be present. Exceptions include visitors to the nuclear power plant or Clab. For this reason, SSM does not consider it warranted to conduct planning for sheltering.

The fact that the present emergency planning zone is 2 km signifies that, even during unfavourable conditions, estimated doses will remain below the dose criterion for sheltering in the case of all the weather scenarios analysed in most parts of this zone. Consequently, it is the assessment of SSM that the range of the present emergency planning zone is unnecessarily large. Based on the outcomes of the dose calculations, it is warranted to reduce the size of the emergency planning zone. This would also facilitate emergency management. For example, the emergency planning zone should be designed to avoid any ambiguity as to whether or not one is present in the zone. Furthermore, it should be possible to make use of limited resources to quickly establish checkpoints and provide information for the purpose of limiting non-essential entry into the emergency planning zone once a general emergency has been declared. This should be possible without having an unnecessarily negative impact on local activities and the general public.

### 5.1.4. Iodine thyroid blocking

No dose criteria are exceeded for equivalent dose to the thyroid in the cases of the postulated events at Clab, neither on the part of children or adults. Clab is located in the emergency planning zone of the Oskarshamn NPP, which means that ITB is predistributed to the population. However, SSM is of the opinion that it is unwarranted to have ITB predistributed only on the basis of potential consequences due to an event at Clab.

### 5.1.5. Relocation due to ground deposition

Following an event involving a release, the overarching objective of emergency preparedness planning for Clab should be to reduce radiation doses from ground deposition of long-lived radioactive substances. Consequently, capacity is needed to perform radiation measurements to make it possible to perform analyses of ground deposition, provide input for communicating advice and recommendations, as well as assess the need for possible remediation of contaminated land. The county administrative board is subject to the Civil Protection Ordinance (2003:789), which requires planning to be in place for radiation measurements should a release of radioactive materials take place from Clab that might warrant protective actions for the public.

Dispersion calculations show that fallout at locations possibly warranting relocation, owing to a high level of ground deposition of long-lived caesium or cobalt isotopes, may occur out to a distance of approximately 1-2 km, when also taking into account the sensitivity analyses and 90 per cent of the occurring weather scenarios.

The purpose of the extended planning distance is to define the dimensions for the pre-planned measurement capacity surrounding Clab, as recommended for the authorities in the case of an event at this site. For this reason, the extended planning distance does not constitute a maximum distance at which ground deposition might occur corresponding to the intervention levels for relocation. There are conceivable weather scenarios in which higher levels of ground deposition may occur at greater distances. However, SSM does not consider that emergency preparedness planning should be dimensioned on the basis of these scenarios.

### 5.1.6. Warnings and predistributed information

The emergency class of general emergency is to be declared at Clab if an event or abnormal operation has occurred which jeopardises safety, and a release to the surroundings, warranting protective actions for the public, is ongoing or cannot be ruled out. SSM considers it advisable to review whether the emergency class is appropriate for alerting of public authorities, warning the public, and as input for decision making concerning measures to protect the public.

Based on the outcomes of dispersion and dose calculations, SSM is of the view that it is not automatically warranted to warn the public in connection with a general emergency, because it is unwarranted to implement sheltering and other urgent protective actions. Nor is it, according to the same line of reasoning, warranted to have information predistributed to residents in the vicinity of Clab. However, should an event or abnormal operation occur at Clab, communication should be directed at the public. Consequently, it is important to alert the county administrative board and other authorities with a role in the crisis management. In the assessment of SSM, the pre-existing basic capability for providing information to the public is sufficient.

## 5.2. Conclusions concerning an emergency planning zone

The area with restricted access surrounding Clab is delineated by fencing and signage, and extends approximately 200-350 m from the centre of the reception building. The public is closed off from this area, which is designated as a protected installation under the Protection Act (2010:305). The outcomes of the dispersion and dose calculations show that it is unwarranted to carry out planning for sheltering outside the area with restricted access. Thus, in the assessment of SSM, the range of the area with restricted access offers sufficient public safety.

The IAEA recommends that facilities belonging to emergency preparedness category II should have an emergency planning zone with a range of at least 500 m [9], in other words, somewhat larger than the area with restricted access surrounding Clab. SSM and the

Kalmar County Administrative Board are nevertheless of the opinion that clear delineation is more important in this case for the purpose of facilitating effective emergency management. Consequently, SSM suggests discontinuation of the present emergency planning zone for protection of the public in the vicinity of Clab.

## 5.3. Proposed extended planning distance

The outcomes of the dispersion and dose calculations show that radiation measurement planning should be in place for mapping of potential ground deposition following an event occurring at Clab. This mainly applies to the planning and capability of the Kalmar County Administrative Board for radiation measurements to enable relocation due to ground deposition of long-lived gamma-emitting nuclides (caesium or cobalt). It may be warranted to relocate people in the nearest 1-2 km due to ground deposition, as shown by the outcomes of the dispersion calculations, if one takes into account 90 per cent of the occurring weather scenarios. Consequently, for the purpose of dimensioning the capability to conduct radiation measurements, SSM proposes establishment of an EPD with a range of 2 km.

# 6. Residual dose

SSM applies the reference level of 20 mSv effective dose as a basis for the suggested EPD to surround Clab. Reference levels refer to residual dose, which is the dose received after protective actions have been taken. The actual protective actions that can be taken in a radiological emergency also depend on circumstances other than those of the event. However, planning for emergency preparedness has the aim of keeping doses below the selected reference levels.

Reference levels are not directly applicable to dispersion and dose calculations. With this rationale in mind, SSM selected dose criteria for different protective actions applying to an unprotected person over a period of seven days, and instead used these criteria in the dispersion and dose calculations. For example, in the case of the protective action of sheltering, the dose criterion is 10 mSv effective dose to an unprotected person over a period of seven days. The distribution of the greatest distances produced using this dose criterion serves as the basis of SSM's rationale concerning the recommended distances at which sheltering should be pre-planned.

For the purpose of verifying that the emergency preparedness planning proposed by SSM makes it possible to keep doses below the selected reference levels, SSM performed calculations of residual doses, with the assumption that different protective actions are taken. As SSM has not proposed an urgent protective action planning zone to surround Clab, no urgent protective actions need to be taken. Thus, the distances at which a certain residual effective dose is received during the first week will, as a maximum, reach the estimated distributions of the greatest distances, as presented in Chapter 4.

In the case of radiation dose from possible remaining ground deposition in the proposed EPD, however, the line of reasoning is different. Relocation may be necessary after the first few days based on the outcomes of radiation measurements. This is for the purpose of keeping doses below the reference level of 20 mSv effective dose during the first year. This means that residual effective dose is linked to a decision on relocation and implementing this relocation. In the opinion of SSM, it is feasible to have adequate decision-making input ready within one week for implementing a relocation. This would imply a residual effective dose of, at most, a few mSv to the individuals affected by the release. If e.g. relocation were carried out within one month after the initiating event, the residual effective dose would be below 5 mSv for the nearest residents encompassed by the relocation.

# 7. Food production

## 7.1. Outcomes from dispersion calculations

SSM also conducted analyses of the postulated events' impacts on food production. These calculations show that during the criticality event, ground deposition of Sr-89 may occur exceeding the intervention level of 1 kBq/$m^2$ in the case of leafy vegetables. The greatest distance at which the intervention level is exceeded is shorter than 1.1 km if 90 per cent of the occurring weather scenarios are taken into account (Figure 11). However, Sr-89 has a half-life of approximately 50 days. Consequently, ground deposition of Sr-89 is not a long-term concern, though it may have a certain negative impact on local food production over a period of a few months.

For an illustration of the distributions of greatest distances at which the intervention levels are exceeded for measures in food production, at 1,000, 100 and 10 kBq/$m^2$, respectively, for the sum of Cs-134 and Cs-137 in the case of a release from the reception pool, see Figures 12-14. It is shown from the dispersion calculations that measures may be warranted within food production due to ground deposition of caesium. If one takes into account 90 per cent of the occurring weather scenarios, the greatest respective distances are shorter than 2 km, 16 km and 120 km for the intervention levels of 1,000, 100 and 10 kBq/$m^2$. In the case of the lower intervention level for food production, at 1 kBq/$m^2$ for the sum of Cs-134 and Cs-137, the distance of 500 km does not encompass 90 per cent of the weather scenarios, which constitutes the outer boundary of SSM's geographical domain applying to the dispersion calculations.

In the case of drinking water from surface-water sources, Cs-137 is instead used as a marker nuclide. The dispersion and dose calculations show that if 90 per cent of the occurring weather scenarios are taken into account, the greatest distance, at which ground deposition of Cs-137 exceeds the intervention levels for drinking water from surface-water sources, will be shorter than 1.6 km or 13 km (Figures 15 and 16), depending on assumed dilution.

Table 4 presents a summary account of outcomes, based on these intervention levels, on the part of production of specific foodstuffs. During this assignment, SSM did not develop specific intervention levels for cobalt from the postulated event involving the transport container at Clab. Instead, SSM has established that the distances presented in Table 4 in the case of caesium are larger than the corresponding distances in a case involving cobalt. Thus, the event involving the reception pool at Clab is dimensioning for the emergency preparedness planning in the case of concerns linked to production of foodstuffs.

Depending on the kind of foodstuff, the distances at which the intervention level for caesium is exceeded show great variability. The outcomes presented in Table 4 show that food production concerns owing to ground deposition may, depending on the event and kind of foodstuff, occur at a distance of a few kilometres up to hundreds of kilometres from Clab.

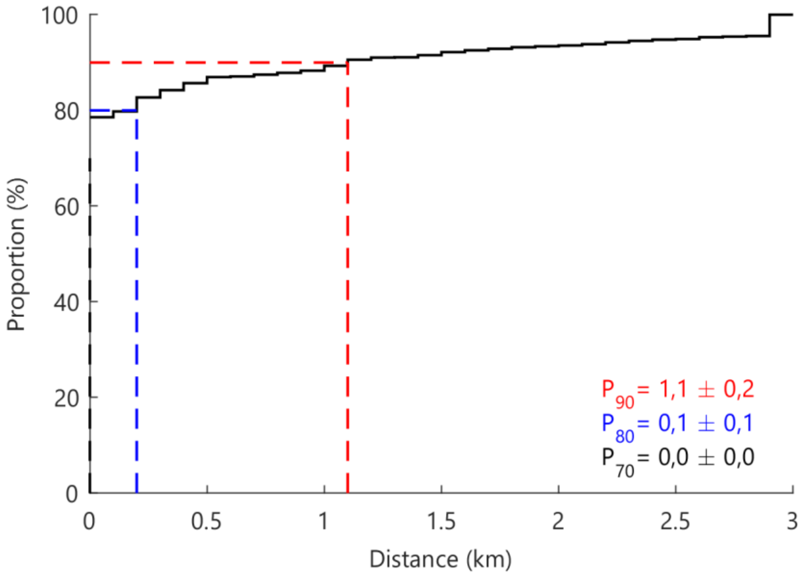


**Figure 11.** Distribution of the greatest distances at which the intervention level of 1 kBq/m² of Sr-89 is exceeded as a result of the postulated criticality event at Clab.

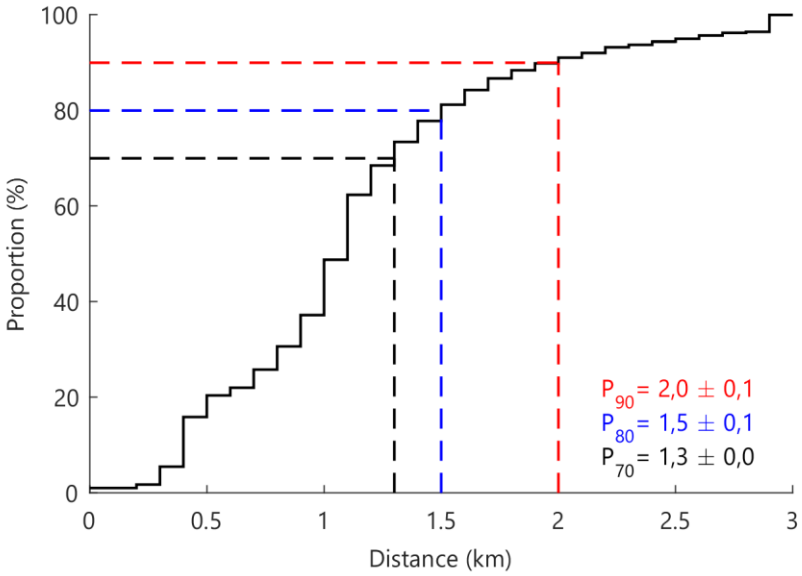


**Figure 12**. Distribution of the greatest distances at which the intervention level of 1,000 kBq/m² of total ground deposition of Cs-134 and Cs-137 is exceeded as a result of the postulated event involving the reception pool at Clab.

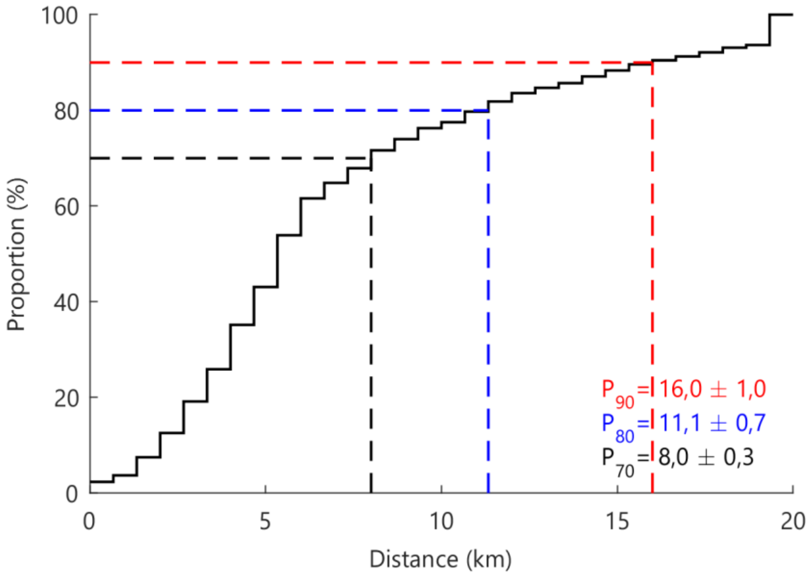


**Figure 13**. Distribution of the greatest distances at which the intervention level of 100 kBq/m[2] of total ground deposition of Cs-134 and Cs-137 is exceeded as a result of the postulated event involving the reception pool at Clab.

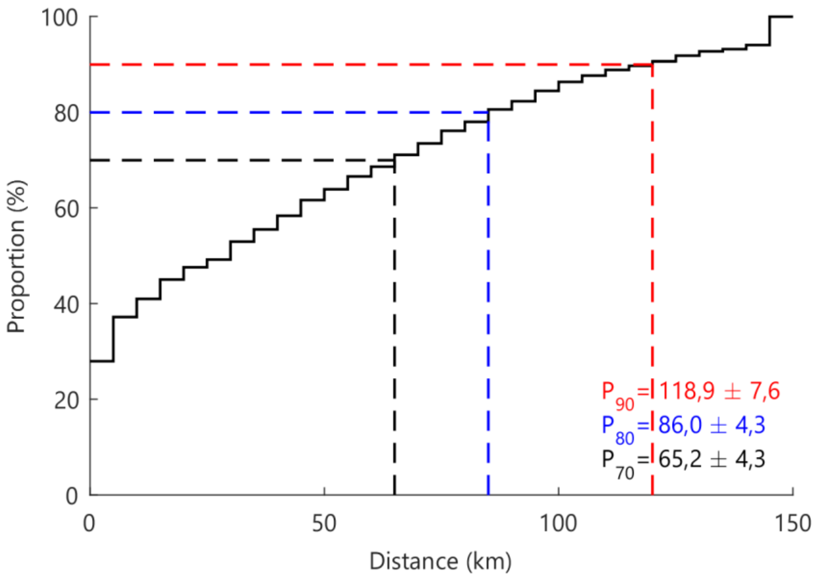


**Figure 14**. Distribution of the greatest distances at which the intervention level of 10 kBq/m[2] of total ground deposition of Cs-134 and Cs-137 is exceeded as a result of the postulated event involving the reception pool at Clab.

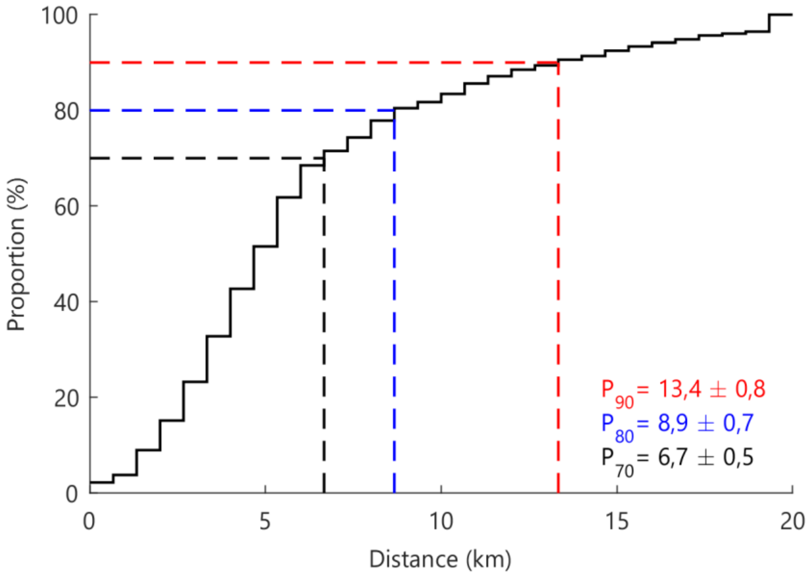


**Figure 15**. Distribution of the greatest distances at which the intervention level of 100 kBq/m$^2$ of ground deposition of Cs-137 is exceeded as a result of the postulated event involving the reception pool at Clab.

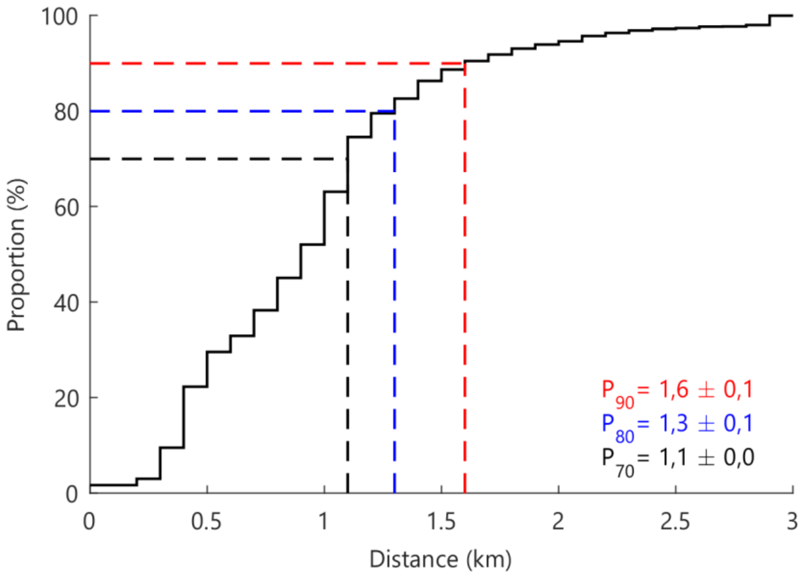


**Figure 16**. Distribution of the greatest distances at which the intervention level of 1,000 kBq/m$^2$ of ground deposition of Cs-137 is exceeded as a result of the postulated event involving the reception pool at Clab.

**Table 4.** Summary compilation of approximate distances at which intervention levels for food production are exceeded on the part of the postulated event at Clab's reception pool, if 90 per cent of the occurring weather scenarios are taken into account.

| Foodstuff | Distance (km) |
|---|---|
| | 1 kBq/m$^2$ Cs-134 + Cs-137 |
| Leafy vegetables in addition to beef, lamb and reindeer (grazing) | >500 |
| | 1 kBq/m$^2$ Sr-89 |
| Leafy vegetables | ~ 1 |
| | 10 kBq/m$^2$ Cs-134 + Cs-137 |
| Milk, grains, pork and game (elk and venison, low) | ~ 120 |
| | 100 kBq/m$^2$ Cs-134 + Cs-137 |
| Game (elk and venison, high) | ~ 15 |
| | 1,000 kBq/m$^2$ Cs-134 + Cs-137 |
| Potatoes | ~ 2 |
| | 100 kBq/m$^2$ Cs-137 |
| Drinking water from surface-water sources with a low level of dilution (0.5 m) | ~ 15 |
| | 1,000 kBq/m$^2$ Cs-137 |
| Drinking water from surface-water sources with a high level of dilution (10 m) | ~ 2 |

## 7.2. Analysis

Foodstuffs sold are subject to producer responsibility, meaning that it is the responsibility of the producer to demonstrate that the radioactive content of a product does not exceed maximum permitted levels. The responsibility for carrying out checks at producers is shared between a number of stakeholders in Sweden (municipal authorities, county administrative boards, National Food Agency, and Swedish Board of Agriculture), depending on the foodstuff in question. In Sweden, maximum permitted levels of radioactive materials in foodstuffs are only regulated in the case of Cs-137. Beyond this, there is a Council Regulation from the EU that defines maximum permitted levels of radioactive substances in food and feed. These permitted levels are intended to enter into force following a nuclear or radiological emergency that may be detrimental to food production [10].

Consequently, in the case of cobalt, there are no maximum permitted levels regulated in Sweden for levels of activity in foodstuffs. On the other hand, Co-60 and Cs-134 are to be treated similarly as Cs-137 under the Council Regulation, as the limit will apply to the total activity of these nuclides. In the assessment of SSM, it is feasible to have plans of action linked to food production that encompass all areas that might be affected by a release. In other words, this means taking into account distances encompassing a minimum of 90 per cent of the occurring weather scenarios. The rationale behind SSM’s standpoint is that the intervention levels are linked to doses exceeding the limits imposed by the EU applying to foodstuffs, which are compulsory for Sweden in the event of an accident involving a large release of radioactive materials.

The dispersion calculations for Clab underpin the proposal recommending national planning for measurements throughout Sweden that are linked to food production. However, not all the postulated events at Clab signify an impact on food production across county boundaries. In the assessment of SSM, the authorities having responsibilities linked to food production should review existing emergency preparedness planning in relation to the calculations presented in this report. Areas of key importance include sufficiently quick decision making concerning measures linked to food production, and protecting the population from intake of contaminated foodstuffs.

# 8. Remediation

## 8.1. Outcomes from dispersion calculations

For an illustration of the distribution of the greatest distances at which it may be warranted to carry out remedial action owing to a postulated event involving the reception pool or the transport container at Clab, see the respective Figures 17-20 and Figures 21-24 shown below. Ground deposition that is expected to give rise to 20 mSv effective dose during the first year coincides with the intervention level for relocation due to ground deposition, as described in Chapter 4. For this reason, no illustrations are provided below for distributions of the greatest distances at which 20 mSv effective dose is exceeded. Instead, this section presents and describes levels of ground deposition estimated to correspond to anticipated radiation doses received during the first year after the event in the interval of 1 mSv-50 mSv effective dose. In their turn, the anticipated radiation doses bring about a situation where different remedial actions may be warranted. For a more detailed description of the different intervention levels for remediation, see the main report.

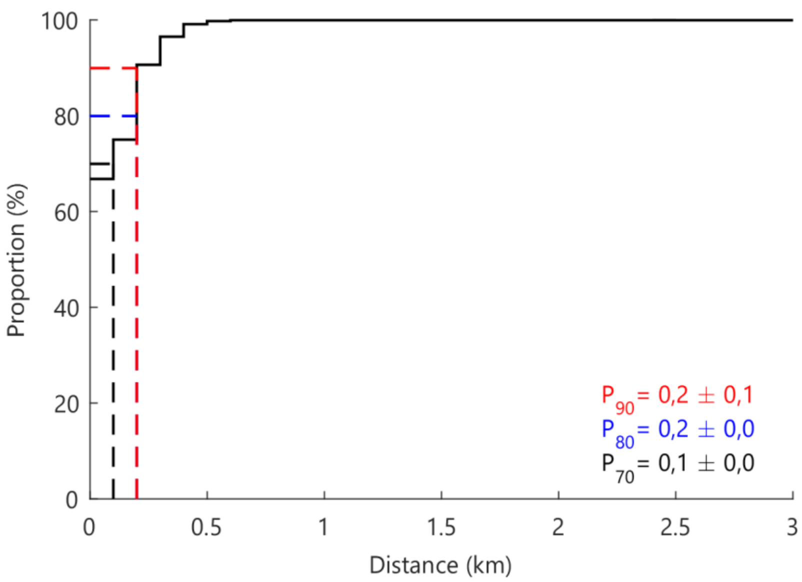


**Figure 17**. Distribution of the greatest distances at which 7,500 kBq/m$^2$ of total ground deposition of Cs-134 and Cs-137 is exceeded as a result of the postulated event involving the reception pool at Clab. The ground deposition is estimated to result in an effective dose of 50 mSv during the first year.

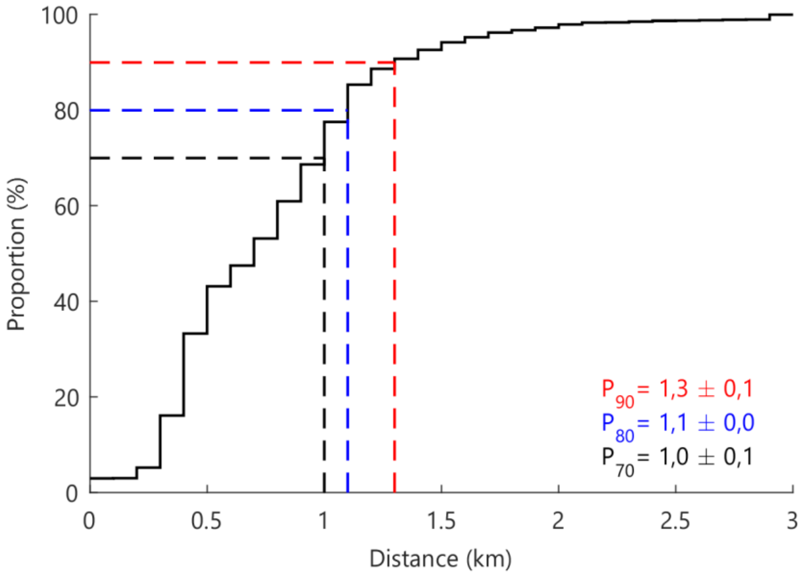


**Figure 18**. Distribution of the greatest distances at which 1,500 kBq/m$^2$ of total ground deposition of Cs-134 and Cs-137 is exceeded as a result of the postulated event involving the reception pool at Clab. The ground deposition is estimated to result in an effective dose of 10 mSv during the first year.

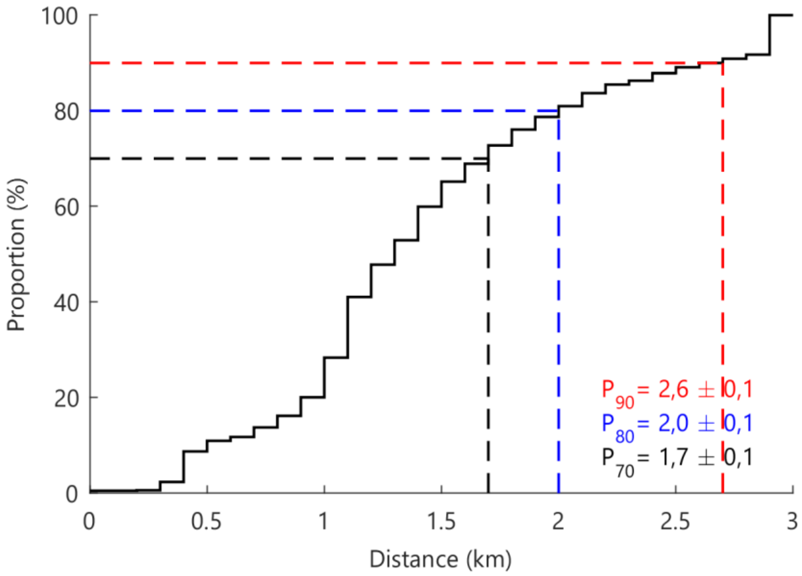


**Figure 19**. Distribution of the greatest distances at which 750 kBq/m$^2$ of total ground deposition of Cs-134 and Cs-137 is exceeded as a result of the postulated event involving the reception pool at Clab. The ground deposition is estimated to result in an effective dose of 5 mSv during the first year.

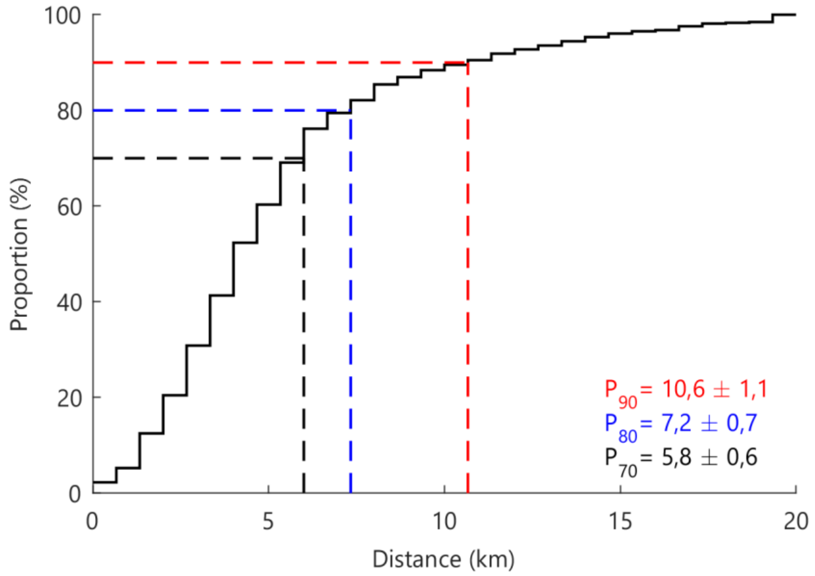


**Figure 20**. Distribution of the greatest distances at which 150 kBq/m$^2$ of total ground deposition of Cs-134 and Cs-137 is exceeded as a result of the postulated event involving the reception pool at Clab. The ground deposition is estimated to result in an effective dose of 1 mSv during the first year.

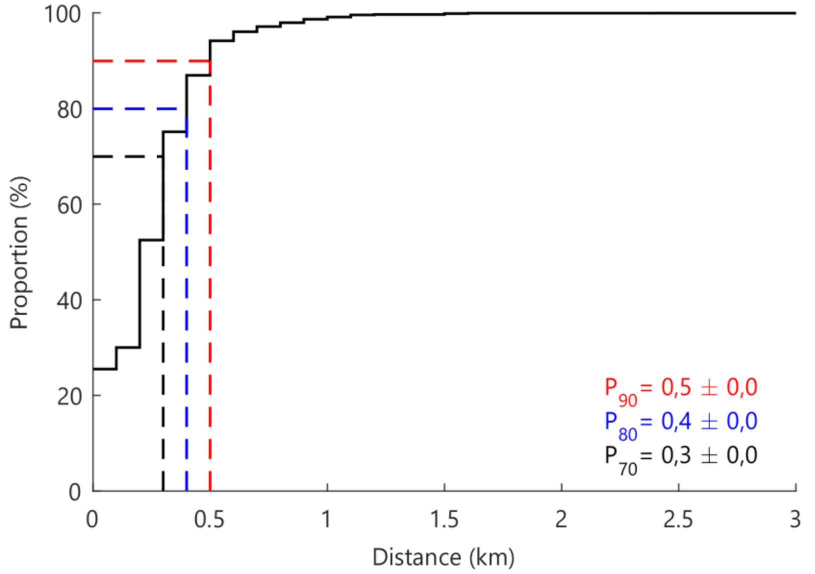


**Figure 21.** Distribution of the greatest distances at which 2,500 kBq/m$^2$ of ground deposition of Co-60 is exceeded due to the postulated event involving the transport container at Clab. The ground deposition is estimated to result in an effective dose of 50 mSv during the first year.

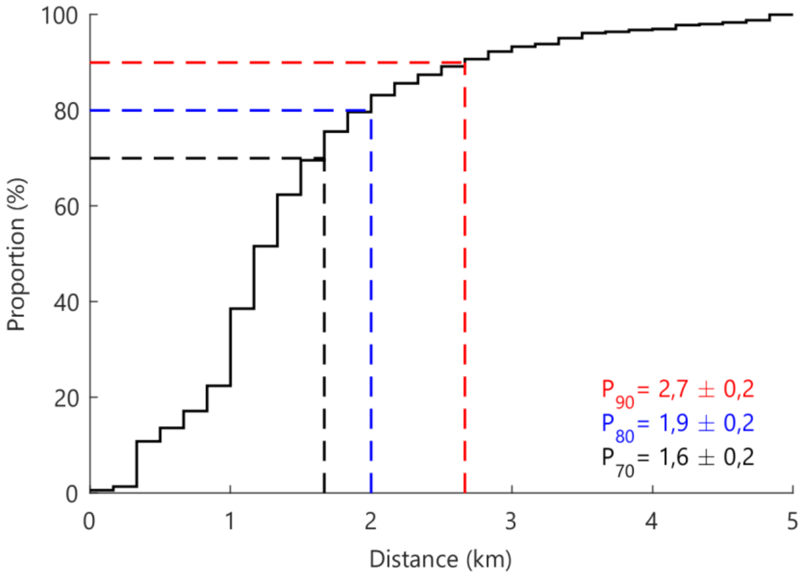


**Figure 22.** Distribution of the greatest distances at which 500 kBq/m$^2$ of ground deposition of Co-60 is exceeded due to the postulated event involving the transport container at Clab. The ground deposition is estimated to result in an effective dose of 10 mSv during the first year.

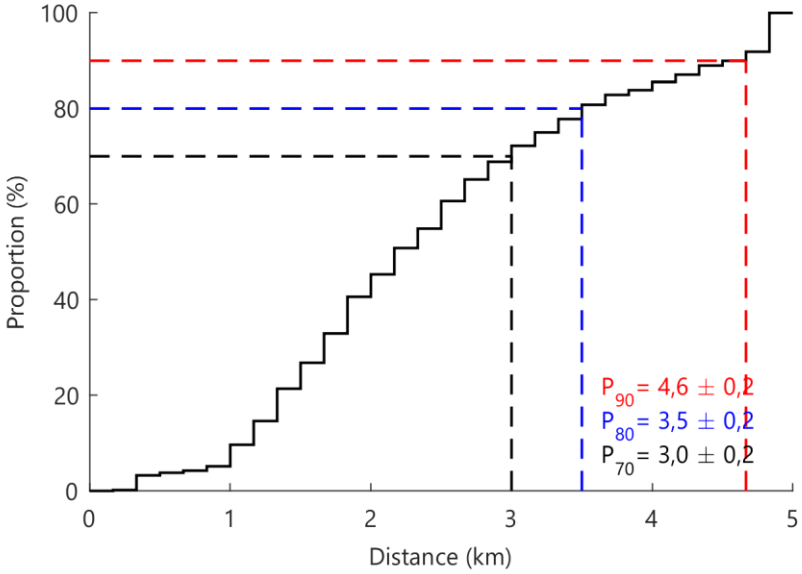


**Figure 23.** Distribution of the greatest distances at which 250 kBq/m$^2$ of ground deposition of Co-60 is exceeded due to the postulated event involving the transport container at Clab. The ground deposition is estimated to result in an effective dose of 5 mSv during the first year.

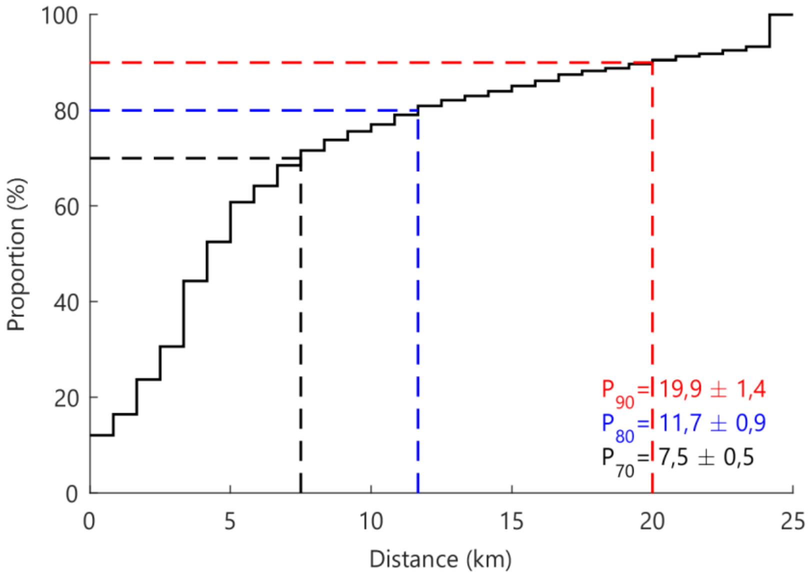


**Figure 24.** Distribution of the greatest distances at which 50 kBq/m$^2$ of ground deposition of Co-60 is exceeded due to the postulated event involving the transport container at Clab. The ground deposition is estimated to result in an effective dose of 1 mSv during the first year.

The representative source terms encompass releases of the same magnitude as for the respective events involving the reception pool or transport container. As Co-60 gives a higher radiation dose per becquerel from ground deposition during the first year than compared to Cs-137, and the release of caesium from the reception pool mainly constitutes Cs-137, the resulting distances will be larger owing to the event involving the transport container. Consequently, this is the dimensioning event for the emergency preparedness planning in terms of remedial actions. Table 5 provides a summary account of distances within which different remedial actions may be warranted due to an event occurring at Clab. For example, the greatest distance at which annual dose is expected to amount to 1 mSv effective dose from caesium (possibly warranting establishment of a remediation plan) is shorter than approximately 11 km if one takes into account 90 per cent of the occurring weather scenarios.

## 8.2. Analysis

Usually, when it comes to events involving a release of hazardous substances from non-nuclear facilities, the party conducting the activities bears the responsibility for potential remediation work. However, under the Civil Protection Ordinance, the county administrative boards have a designated responsibility in the case of an event involving a release of radioactive materials from nuclear facilities. When looking into the need for remediation, the outcomes of dispersion calculations show whether remediation is warranted as a consequence of the postulated events involving the reception pool and transport container at Clab.

In the assessment of SSM, it is likely that remediation would be applicable only after the emergency exposure situation, and thus rescue services, have been terminated. For this reason, SSM does not propose any particular measures to be taken within the EPD for Clab owing to the outcomes presented. On the other hand, SSM is of the view that all county administrative boards should review their present remediation plans on the basis of the calculations presented by SSM in this report.

**Table 5.** Summary presentation of approximate distances at which intervention levels for remediation are exceeded for different events if the respective 70, 80 and 90 per cent of the occurring weather scenarios are taken into account ("-" signifies that the intervention level is not exceeded off-site). The doses shown in the table refer to additional effective dose due to ground deposition during the first year.

| Percentile | Reception pool (km) | Transport container (km) |
|---|---|---|
| | A remediation plan should be produced and basic remediation measures may be warranted (higher than 1 mSv) | |
| 70 | ~ 6 | ~ 8 |
| 80 | ~ 7 | ~ 12 |
| 90 | ~ 11 | ~ 20 |
| | Basic remediation measures are likely to be warranted (higher than 5 mSv) | |
| 70 | ~ 1.5 | ~ 3.0 |
| 80 | ~ 2 | ~ 3.5 |
| 90 | ~ 2.5 | ~ 4.5 |
| | Advanced remediation measures may be warranted (higher than 10 mSv) | |
| 70 | ~ 1 | ~ 1.5 |
| 80 | ~ 1 | ~ 2 |
| 90 | ~ 1.5 | ~ 2.5 |
| | Advanced remediation measures are likely to be warranted (higher than 20 | |
| 70 | ~ 0.5 | ~ 1 |
| 80 | ~ 0.5 | ~ 1 |
| 90 | ~ 0.5 | ~ 1.5 |
| | Advanced remediation measures are likely to be insufficient for allowing resettlement of the area for several years (higher than 50 mSv) | |
| 70 | - | ~ 0.5 |
| 80 | - | ~ 0.5 |
| 90 | - | ~ 0.5 |

# References

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[2] U.S. Nuclear Regulatory Commission, "Regulatory Guide 3.34," 1979.

[3] U.S. Nuclear Regulatory Commission, "Regulatory Guide 1.183," 2000.

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[5] Information from SKB about iodine forms, document no. SSM2015-4786-24.

[6] Kalmar County Administrative Board, *Tilläggsprogram Clab* (Additional programme for Clab), Ref. no. 452-11132-07, 2008.

[7] Swedish Nuclear Fuel and Waste Management Company (SKB), *Initial hantering av onormal händelse* (Initial management of abnormal event), 1066100, 2013.

[8] Kalmar County Administrative Board, *Beredskapsprogram för räddningstjänst vid kärnteknisk olycka* (Emergency preparedness programme for rescue services in the event of a nuclear accident), Ref. no. 452-6935-16, 2017.

[9] International Atomic Energy Agency, "Safety Guide No. GS-G-2.1", IAEA, 2007.

[10] Council of the European Union, Council Regulation (Euratom) 2016/52 of 15 January 2016 laying down maximum permitted levels of radioactive contamination of food and feed following a nuclear accident or any other case of radiological emergency, Euratom, 2016.

2017:27e

The Swedish Radiation Safety Authority has a comprehensive responsibility to ensure that society is safe from the effects of radiation. The Authority works to achieve radiation safety in a number of areas: nuclear power, medical care as well as commercial products and services. The Authority also works to achieve protection from natural radiation and to increase the level of radiation safety internationally.

The Swedish Radiation Safety Authority works proactively and preventively to protect people and the environment from the harmful effects of radiation, now and in the future. The Authority issues regulations and supervises compliance, while also supporting research, providing training and information, and issuing advice. Often, activities involving radiation require licences issued by the Authority. The Swedish Radiation Safety Authority maintains emergency preparedness around the clock with the aim of limiting the aftermath of radiation accidents and the unintentional spreading of radioactive substances. The Authority participates in international co-operation in order to promote radiation safety and finances projects aiming to raise the level of radiation safety in certain Eastern European countries.

The Authority reports to the Ministry of the Environment and has around 300 employees with competencies in the fields of engineering, natural and behavioural sciences, law, economics and communications. We have received quality, environmental and working environment certification.

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