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CONSEQUENCES IN SWEDEN OF THE CHERNOBYL ACCIDENT

IAEA General Conference, Scientific Programme for Safety, 1986-10-02--03

Abstract

It summarizes the consequences in Sweden of the Chernobyl accident, describes the emergency response, the basis for decisions and countermeasures, the measurement strategies, the activity levels and doses and countermeasures and action levels used. Past and remaining problems are discussed and the major investigations and improvements are given.

Keywords (chosen by the author)

Nuclear accident, emergency preparedness, radiation doses, countermeasures, measurement, activity levels.

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11

Consequences in Sweden of the Chernobyl accident

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Emergency response

In the morning of April 28 1986 workers arriving to the Forsmark nuclear power station were stopped by the normal entrance activity control because they were contaminated. Activity was also found on cars, ground and in puddles. Even if there were no technical indications of an accident at the station, actions were taken as if it were, including evacuation of workers from the station and notification to the local and central authorities responsible for emergency preparedness and countermeasures.

That was the start of an operation that should rapidly increase in manpower, time, cost and efforts to unforeseen and unimaginable levels. Within about an hour after the notification from Forsmark the emergency organization was set into operation at the National Institute of Radiation Protection (SSI), Swedish Nuclear Power Inspectorate (SKI) and other authorities concerned. A special preplanned emergency task force was convened at the SSI headquarter in Stockholm. It was reinforced by extra personell from other authorities up to about hundred people and it was in operation 24 hours a day during the first months. A large number of policy decisions were taken the first days on activity levels, counter-measures, restrictions etc and information was given to several ten thousands of individual members of the public, to the mass media, to local authorities and to politicians and the government. There was a great need of information reflecting the widespread concern and worry, the unfamiliarity with the situation and the shock that such an accident and its consequences could occur.

Basis for decisions and countermeasures

In an accident situation the system of dose limitation used for normal conditions does not fully apply. The principles for countermeasures are that serious nonstochastic effects should be avoided, that risk from stochastic effects should be limited as to achieve a positive net benefit to the individuals involved and finally that the overall incidences of stochastic effects should be limited as far as reasonably practicable, by reducing the collective dose equivalent.

As concerns the values of doses to individuals for the introduction of countermeasures those given in Table 1 served as general guidance in the policy decision-making process. It was concluded already the first day, April 28, that evacuation, sheltering and iodine administration was not justified. The maximum doses the first year was anticipated to be less than 10 mSv. For other measures the guidance in Table 1 was applied by the following general principles:

1. It is highly justified to avoid long term doses above 500 mSv

2. It is not justified to take measures with great social and economical impact for society or the individuals concerned to avoid long term doses less than 50 mSv

3. The dose during the first year should be less than 5 mSv and in the long term perspective less than 1 mSv a^{-1} in average.

Other bases for judgements and decisions were reasonable cost of saved collective dose, radiation risks in perspective of other risks, public's confidence in responsible authorities and common sense.

Measurement strategies

On the basis of the first rough measurements of ground deposition and air activity it was decided that evacuation, sheltering and iodine administration was not justified. Continued high altitude air measurements by military jet fighter aircraft and sampling stations on ground in combination with meteorological information were used to trace new incoming activity. The ground deposition was measured using a network of 25 permanent continously registering gamma monitoring stations, by mobile equipments on ground and by low-speed airplanes, scanning from a height of 150 m. By this scanning the ground deposition and gamma dose rates were measured in the whole of Sweden in a few days. In order to limit the contamination of milk, the farmers were recommended to keep the cows indoors until the ground contamination was checked, the first weeks on radioiodine and later radiocesium. The assumed activity of grassamples or the total ground deposition corresponding to a given activity of milk are seen in Table 2. The measurements started in the south where the outdoor grazing season had just begun and these measurements were given higher priority than measurements in the more contaminated areas in the north of Sweden. That met later on some criticism from those living in these areas.

The activity levels in milk in Table 2 corresponds to an effective dose equivalent of around 1 mSv in total for I-131 and somewhat less than 5 mSv a^{-1} for Cs 134+137 in the first year. Because the conversion from ground to grass activity and eventually to milk activity is uncertain and also change with time a number of special investigations were started with cows grazing outdoors at farms in various parts of Sweden. As the grass grew the conversion from ground deposition to milk decreased a factor 10-100 below the value given in Table 2 for cesium.

Measurements on other foodstuffs were started by degrees and have today included all kinds of food in the open market. External measurements were early made on the thyroid of some people living in the most contaminated areas as well as whole body measurements and measurements on mothers milk. Measurements were made to check cars and vessels from abroad, motors of airplanes, large airfilters in buildings, sewage sludge etc.

Most of the measurements needed competent experts and almost all the capacity in Sweden was engaged in measurements during the first months. Unskilled measurements with simple instruments were made occasionally and the results could cause concern and time consuming check-up. On the other hand there was also a need for simple rough and fast measurements on ground deposition, contamination of food etc to identify the high levels of activity.

Activity levels and doses

Late April 27 the first cloud of contaminated air from the Chernobyl accident reached Sweden and the air activity reached a maximum around April 29. Another cloud of contaminated air reached Sweden about 10 days later and reach a new maximum around May 9, see Figure 1. Because of rain in the end of April there was a wash out over the Northern-East of Sweden causing a 10-100 times greater fallout than in other areas. The gamma dose rates and ground deposition are shown in Figs 2 and 3. The range is from a few $kBqm^{-2}$ to about 300 $kBqm^{-2}$ of Cs 134+137 (Cs-134 is about 50 % of that of Cs-137). The total deposition was about 50.000 TBq of I-131 and 6000 TBq of Cs 134+137. That means an average deposition of about 10 $kBqm^{-2}$ of Cs-137. During the nuclear weapon atmospheric test period in early 60's the total fallout of Cs-137 in Sweden was about 4 times less and more uniformly distributed. At that time there was also a fallout of Sr-90 of the same order of magnitude as Cs-137 and plutonium a few percent of that. The relative contribution from Sr-90 and plutonium from the Chernobyl accident is much smaller, about 1 % and 0.01 % respectively.

Normal range of the concentration of Cs-137 in various foodstuffs is shown in Table 3. Extreme values 3-10 times normal range occur. No food with Cs-137 activity more than 300 $Bqkg^{-1}$ is sold in the open market in Sweden.

People are also advised to eat own food with an activity concentration above 300 $Bqkg^{-1}$ e g some fish, game etc only a few times per week or year depending on the activity level. The highest activity levels in food are found in the areas with the highest deposition. However, so-called food-basket samples i e samples made up of a mixture of representative food collected in various parts in Sweden have less than

20 $Bqkg^{-1}$. Whole body measurements on people show an increase of the Cs-137 body burden and in August 1986 it is of the order of 100-300 Bq in normal areas and about 1000 in high deposition areas. In these areas also the external exposure of the same people is measured by TLD. The results indicate external doses less than 1 mSv during 1986.

On the basis of these direct and indirect measurements of external and internal exposure the resulting doses are assessed for people in Sweden in average and for those most exposed. The assessments are still impaired by uncertainties and are continously improved. However, with this reservation, during the first year the total collective dose is about 3000 manSv, average dose 0.4 mSv and doses in most exposed groups a few mSv. A large consumption of reindeer meat (which is normal for Laplanders) could lead to 10 mSv and more per year. The total doses are mainly due to Cs 134+137 by external exposure and food consumption and less than 10 % is caused by other nuclides and routes of exposure.

Countermeasures and action levels (reference levels)

A number of decisions and recommendations were taken in order to limit the radiation exposure and to control the situation from radiation protection point of view. Some decisions implied non-actions. Some examples are given:

- Travelling people were advised not to go closer to Chernobyl than 100 km and to go within 500 km of the site only after personal judgement of the benefit of the trip.

- Drinking water from ordinary watersupplies can be used.

- Rainwater should not be used as drinking water (first week after the accident).

- There is no reason for worry for pregnant women. Breastfeeding should continue.

- Sheltering because of the accident is not justified.

- No reason to take iodine pills.

- Cows should not be allowed to graze outdoors until a region was cleared on the basis of grass contamination measurements.

- The action level for marketing in shops of all foodstuffs including milk is 2 kBq kg^{-1} for I-131 and 0.3 kBq kg^{-1} for Cs-137.

- Special harvesting methods were recommended leaving a higher stub than usual to avoid contamination with radioactive soil.

- Sewage sludge should not be used as fertilizer if the concentration of Cs 134+137 exceeded 4 kBq kg^{-1}(wet weight) and 20 kBq kg^{-1}(dry weight)

- In replacement of airfilters used April 27 to May 5 in large buildings, breathing masks and protective gloves should be used when handling the filters.

Past and remaining problems

Besides the various problems with the radioactive contamination of the environment as such, the great problem has been to handle peoples worry and concern. Great efforts have been made to inform people and put the radiation risks in perspective. But nevertheless unjustified actions were occasionally taken e g intake of stable iodine pills.

Another problem was contradictory information and advice voluntarily given by various experts, which confused people. The role of news media was not insignificant in this connection to heighten the distrust of responsible authorities.

The problem of information was also a question of technique and organization. The communication between central and local authorities often failed because of lack of appropriate equipment or too small technical capacity. A lesson learned is that the major information burden must be laid on local authorities in such an event.

Large problems were and are connected with the action levels (or reference levels) for foodstuff. Different such levels in various countries have caused confusion and suspicion. It is a hope that these discrepancies can be internationally solved in the near future.

Another problem is that the given reference levels have been understood as absolute limits giving no margin for personal judgement of acceptable risks e g by limited consumption of own food with an activity concentration above the reference level. On the contrary, the intention of the authorities is that the reference level is to be understood as an administrative tool to control an unstable radiation situation. Now the situation is much more stabilized, there are programs for measurements and control, many local and central authorities are competent to handle the situation and there are several ways to follow the overall ambition to keep the doses to the public below given values. However, a change of reference levels will be met by suspicion and distrust and many problems will remain. A special problem in Sweden is the reindeer meat which in some parts of Sweden contains Cs-137 in concentrations of 1000-20.000 Bq kg^{-1} i e several times the reference level of 300 Bq kg^{-1}. The problem is twofold. Firstly, because of the high values reindeer meat can not be sold and secondly the doses to Laplanders who might eat about 100 kg a^{-1}, will be rather high, 10 mSv a^{-1} or more. Even if the government will pay compensation for costs incurred because of the accident, the very existence of reindeer-raising as an industry will be jeopardized. The problem of reindeer is intensively discussed in Sweden at the time being.

Another remaining problem is the contamination of peat which is planned to be used as a source of energy for central heatproduction stations. The contamination might need special cleaning system for the smoke and special treatment of the ashes as radioactive waste.

Investigations and proposed improvements in Sweden

As a result of the Chernobyl accident investigations have started and improvements are discussed, some of which are the following

- How does the accident influence the judgement of safety of Swedish reactors.

- Investigate the consequences for the environment, economy and supply of energy of an earlier than planned decommission of some reactor.

- Speed up the introduction of already decided measures to increase the safety of reactors.

- Extend the emergency preparedness to several local authorities.

- Increase the competence of local authorities in radiation protection.

- Improve the automatic alarm system in all the country.

- Improved technical communication equipment at local authorities.

- Improved education and information to the public in radiation protection.

- Extend research on consequences to man, the environment and the society of radioactive contamination of the environment.

Consequences in summary

The accident at Chernobyl has caused Sweden

- Worry and concern

- Radiation doses

- Serious economic and social problems for groups of people

- National costs of about 100 million US dollars the first year, to be paid by the tax-payers

- Decreased trust to nuclear power as a source of energy.

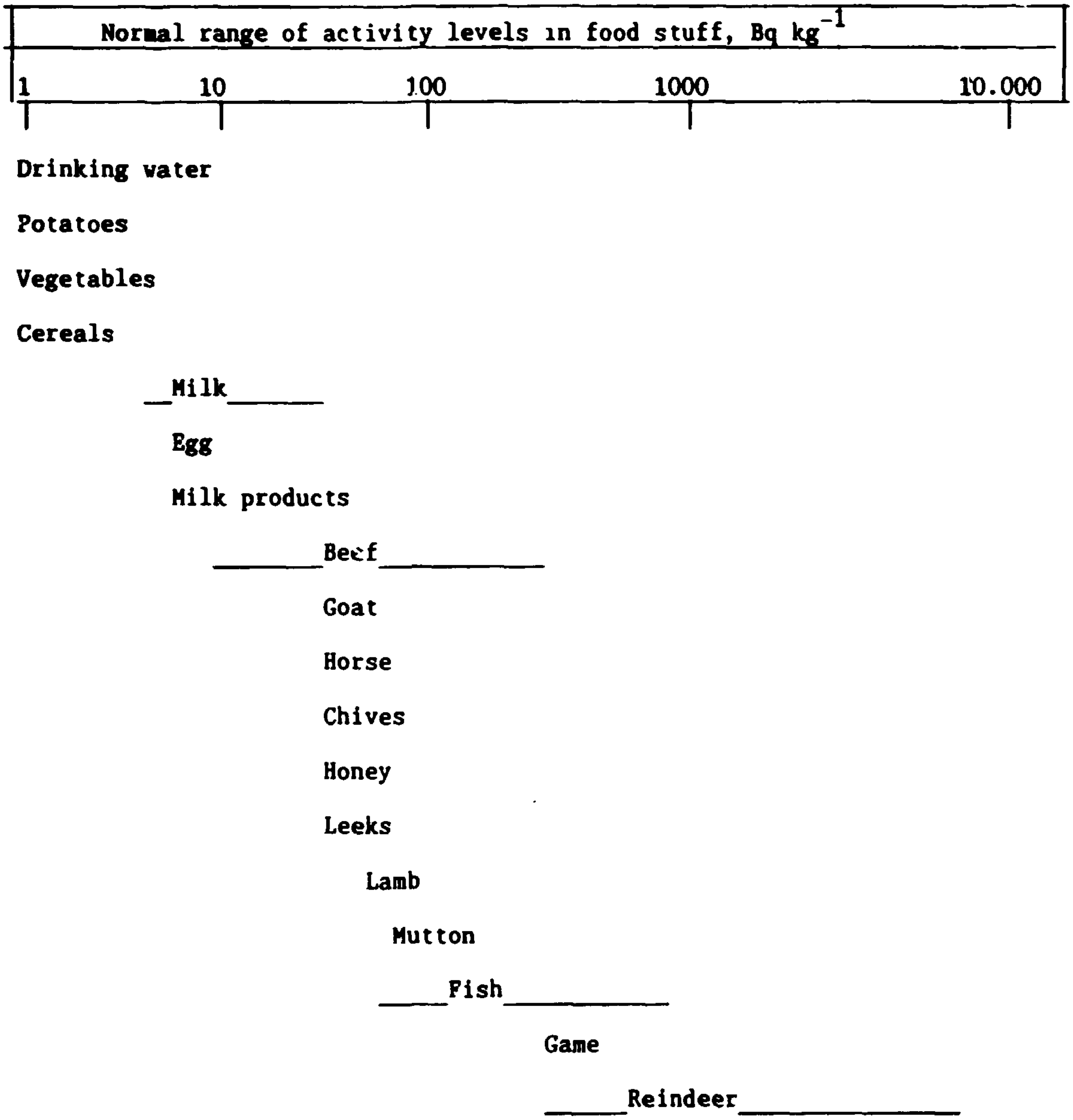
Table 1

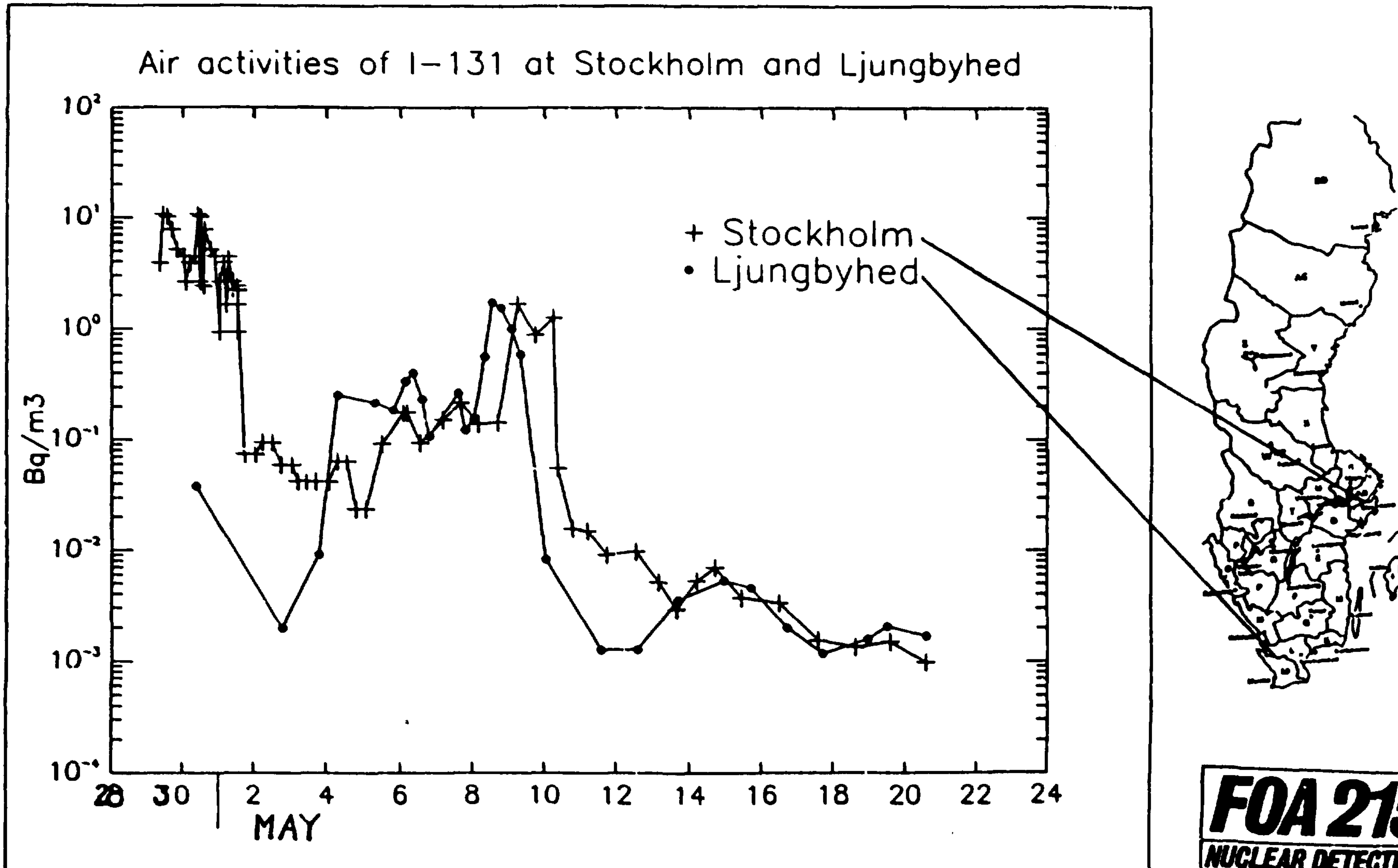
Doses to be avoided by countermeasures, mSv, effective dose equivalent		
Short term (first year)	Long term (50 years)	Countermeasures
0	0	
.	.	
.	.	Very simple measures
5	50	Simple measures
.	.	Control of foodstuffs
.	.	Stable iodine administration
50	500	Restriction of food consumption
.	.	Sheltering
.	.	Relocation
500	.	Evacuation

Table 2

	Ground deposition	Grass deposition (grass samples)	Corresponding milk acitivty
	$kBqm^{-2}$	$kBqm^{-2}$	$kBql^{-1}$
I-131	10	3	2
Cs 137	3	1	0.3

Table 3


Normal range of activity levels in food stuff, Bq kg⁻¹
1
10
100
1000
10.000
Drinking water
Potatoes
Vegetables
Cereals
Milk
Egg
Milk products
Beef
Goat
Horse
Chives
Honey
Leeks
Lamb
Mutton
Fish
Game
Reindeer



FOA 215
NUCLEAR DETECTION

Fig. 9

CONTAMINATION MAP

Estimated ground intensity on May 9, 1986, in μR/h.
The map is based on aerial surveys from May 9 to June 3, 1986.

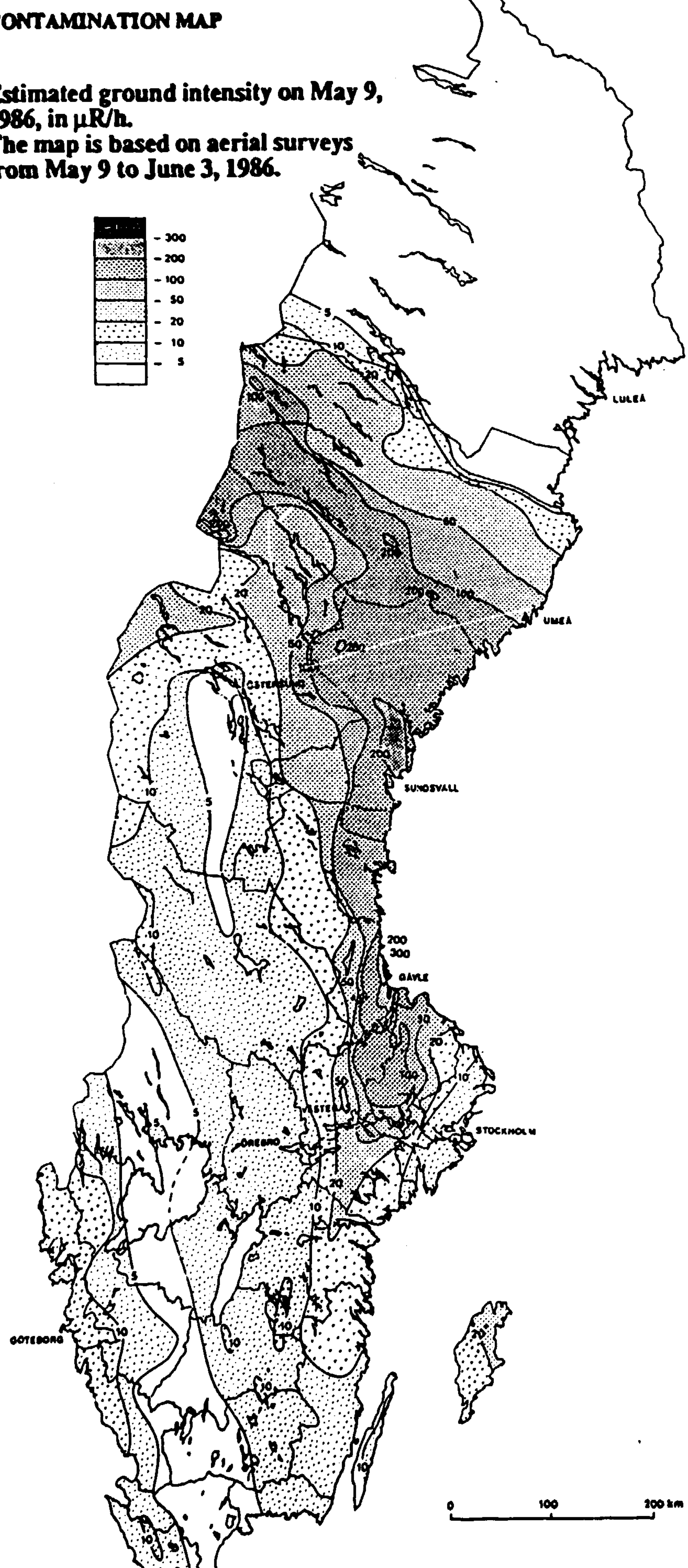


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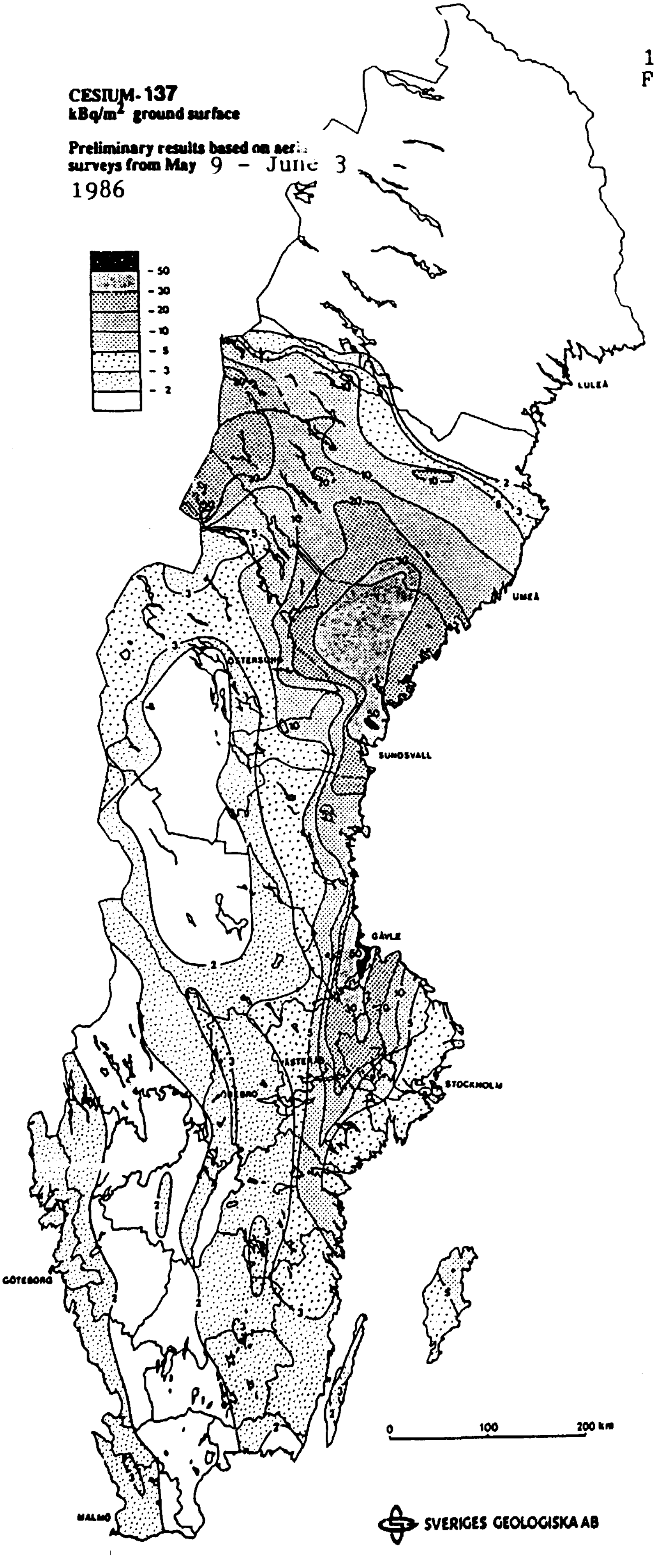
Fig 3


CESIUM-137
kBq/m² ground surface
Preliminary results based on aer
surveys from May 9 - June 3
1986
- 50
- 30
- 20
- 10
- 5
- 3
- 2
LULEÅ
UMEÅ
ÖSTERSUND
SUNDSVALL
GÄVLE
STOCKHOLM
GÖTEBORG
MALMÖ
0
100
200 km
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13	—	-
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15	Granskning av Ringhals kraftstation, block 1, 1986.	Huvudenhet för kärnenergi
16	Publikationer 1985	Informations- enheten
17	Recurrent analysis of radiation protection conditions at the nuclear power station (Översättning av 86-15)	Unit for nuclear energy

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19	Nedfall från Tjernobyl; Del I	Per-Einar Kjelle
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