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Nordic Decision Conference: An Exercise on Clean-up Actions in an Urban Environment after a Nuclear Accident Arlandia Hotel, Sweden 30th–31st August, 1995

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Report of the NKS EKO 4 Programme

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ABSTRACT

The EKO 4/c working group of the environmental effects and emergency preparedness programme (EKO) of the *Nordic Nuclear Safety Research* (NKS) organised a *decision conference* on August 30th and 31st, 1995 in Stockholm, Sweden. The meeting was designed to be attended by those responsible for planning and deciding on protective actions in the Nordic countries after a nuclear accident. Issues concerning clean-up strategies in an urban environment after a hypothetical and very severe reactor accident were discussed at the meeting.

The objectives of the meeting were to provide a shared understanding between the decision makers and the radiation protection community on concerns and issues related to decisions on protective actions after a nuclear accident. Furthermore, to identify the values/attributes to be considered in setting intervention levels and to demonstrate and explore the use of Decision Conferencing as a tool for decision making on protective actions.

The conference was planned to have two phases. On the first day those who have special technical expertise in preparedness planning and in assessing the consequences of an accident and protective actions met to share their common understanding of the problem. On the second day those responsible for deciding on protective actions joined the meeting to discuss issues laid down by the groups and to produce a commitment to actions in the given scenario.

The discussion on the second day did much to address the first objective of the decision conference, namely the development of a shared understanding between government officials and the radiation protection community. There was much communication between the two groups with regard to the other's viewpoint. Many participants remarked obout the need for many more such meetings to ensure the continued growth of this shared understanding.

In terms of the second objective, to identify the values/attributes, the conference was less successful. Although it was clear that decision making would be based upon factors in addition to radiation protection issues and predicted health effects, it was not possible to elicit weights and value scales to articulate these additional factors explicitly. The model undoubtedly focused the discussion and clarified issues, but it was not explored fully.

The format of the meeting seemed effective in communicating the issues between the technical experts and the decision makers. However, it was clear that the decision makers would have taken the final decision away from the meeting in the light of the understanding they had obtained.

CONTENTS

1 INTRODUCTION

The environmental effects and emergency preparedness programme (EKO) of *the Nordic Nuclear Safety Research* (NKS) organised a *decision conference*[8] on August 30th and 31st, 1995 at the Arlandia Hotel, Stockholm. The objectives of the conference were:

1. To provide a shared understanding between the decision makers and the radiation protection community on concerns and issues related to decisions on protective actions after a nuclear accident.

2. To identify values and attributes to be considered in setting intervention levels.

3. To demonstrate and explore the use of decision conferencing as a tool for decision making on protective actions.

Objective 2 should be interpreted in the context of the event which focused on decision making for clean–up actions in an urban situation. Moreover, the format of the event was not that of a typical decision conference, at which all the participants are present during the whole event. In this case, radiation protection experts attended on the first day and were joined on the second by decision makers and their advisors from regional governments. This would correspond much more closely to the format of meetings in the event of a real accident. Thus Objective 3 should be interpreted as exploring the use of such facilitated workshops as a tool for decision making on protective actions rather than exploring the use of 'true' decision conferences.

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[8] Decision conferencing is a socially interactive approach to group decision making in order to generate a shared understanding of a problem and produce a commitment to action. Its format is a two day workshop supported by a facilitator and analyst. The decision making is supported by a decision analysis built entirely within and largely by the group. The facilitator and analyst do not contribute to the discussion of the content of the problem but attend to the process of decision making, helping the decision makers achieve a shared understanding of the issues. (French, 1996; French et al, 1993).

To achieve these objectives, the meeting focused upon a scenario developed by the project group. This concerned a serious accident at the Loviisa nuclear power plant 80km to the east of Helsinki in the Uusimaa province of Finland. A release was assumed to have occurred on the morning of August 23rd, extending for nine hours during the day. Early countermeasures included evacuation of the around 40 inhabitants in the immediate vicinity of the plant (i.e., five kilometre zone around the plant), the instruction to the public in the area over which the plume passed to shelter and to take iodine tablets, and the relocation of the town of Loviisa and surrounding area after the passage of the plume. Details of these actions are given in Annex 2. These early countermeasures were decided upon during the development of the scenario by means of a meeting involving Finnish emergency planners and radiation protection specialists held at STUK (the Finnish Centre for Radiation and Nuclear Safety), Helsinki. It was now supposed to be a week later, the 30th August. The task of the meeting was to decide upon a strategy for clean-up actions in the urban areas that had been contaminated. Decisions on actions to be taken on forests, agricultural land and livestock were not part of the discussion.

To support the meeting a detailed model of the predicted effects of possible clean-up actions was built using a spread sheet (Excel) and a geographic information system (MapInfo). This was used where necessary to answer the participants' questions and provide data for the decision model. It should be emphasised that there are inevitably many flaws and imperfections in any hypothetical exercise. In particular, there will be characteristics in real data that are not reproduced in the model based data constructed for the exercise. It should also be noted that the six areas which are identified on the map in Annex 2 and which were used during the conference to define clean-up strategies would, in a real accident, have been modified corresponding to the country's administrative structures and requirements. There would be no question of treating one side of a street and not the other, or half a village and not the rest as these areas would imply. For the purpose of the exercise they had been defined simply from an atmospheric dispersion-deposition model with no attention to other issues. In practice, they would be built developed from maps of monitoring data with attention being paid to geographic and demographic features.

In advance of the meeting, all the participants were sent the description of the scenario given in Annex 2. Radiation protection experts attended on the first day to prepare advice to be given to decision makers when they arrived on the second day. A list of participants and their affiliations is given in Annex 1.

The meeting began with a presentation of the scenario by Robert Finck and a presentation by Jørn Roed on the current view of the effectiveness of various clean-up actions. Simon French then asked the meeting to discuss the issues and concerns that were on the top of their minds as they thought about the decisions that they had to make.

2 ISSUES AND CONCERNS

During the discussion, the following issues and concerns which need to be addressed in making decisions on clean-up actions, were identified. The order in which they are presented does not reflect the chronological order in which they were raised, but rather a rough prioritisation in terms of their influence on the subsequent discussion. The Areas refer to Areas I to VI on the map in Annex 2.

* The decision will need to assign priorities to solving the following three issues:
  - What parts of the region needed to be secured for economic or strategic reasons?
  - What was to be the policy on repopulating Areas I, II, III? Could or should their populations be resettled? Is it possible to reduce the lifetime doses sufficiently for these areas to be repopulated?
  - What should be done to re-assure the population left in the affected areas, particularly Area IV? Nothing specific had been done for them after sheltering, yet their near neighbour Area III had been evacuated.
* Loviisa is economically dependent on the nuclear plant and its harbour. The plant is situated in Area I.
* Access to the plant would be needed. So the plant itself and streets needed for access would need cleaning whatever other decisions were made.
* The harbour of Loviisa is in Area III and so, whatever the decisions elsewhere, it and the streets needed for access would need some clean-up actions.
* How effective were clean-up actions? Their predicted effect in the model (up to reduction factors of 10) was based on data from carefully run experiments. In the Former Soviet Union, the effectiveness of clean-up was much less (reduction factors of less than 2). The efficiency of clean-up within the Nordic Countries would be greater. But by how much?
* The public perception of the effectiveness of countermeasures did not always correspond to the scientific evaluation. For instance, cutting grass was an

extremely cost-effective countermeasure, but few members of the public would perceive it as such *unless there was a very clear programme of advice and public information.*

* The decision would need to balance radiological and psychological factors.

* In reality, both the mood of the population and how they had reacted over the eight days following the accident would be known. But it can be assumed that the media will have carried reports from 'instant experts', disagreeing with the assessments made public by the authorities and causing confusion among the population. Again this emphasises the need for a very clear programme of advice and public information from the authorities.

* 40% of the population in the Loviisa area is Swedish-speaking, making relocation more difficult.

* At most 10,000 workers are available. The position on assistance from other countries is unclear.

* Within Finnish Law, it is possible to bury waste from scraping soil, cutting grass, pruning trees, etc. However, it may be difficult to do so in practice since pressure groups may object to any particular burial site. In other Nordic countries the legal position was less clear. It was likely that grass cuttings and prunings from private gardens could be buried at a suitable point within the garden, but the same would not be true of waste material from public areas (see annex 3).

The general discussion of these issues continued for much of the day, but during the afternoon and evening it was possible to develop a skeleton decision model.

3 DEVELOPMENT OF A DECISION MODEL

After considerable debate it was decided to build a description of clean-up strategies in terms of Areas I to VI shown on the map in Annex 2. As remarked earlier, it was recognised that the boundaries of these areas would be much more carefully defined in the event of a real accident and attention would be paid to geographic and demographic details. The form of strategies would be to prescribe the clean-up actions to be taken in each area.

It was noted that the populations in Areas I, II and III had been relocated immediately after the plume had passed.

In Area I, the area immediately surrounding the nuclear plant, it was felt that the contamination was so great that the only option was to resettle the three inhabitants permanently. Since the plant supplied nearly 10% of Finland's electricity, it was expected that the plant would be kept in operation. However, in the event of closure there would still be a need for work to continue at the plant for many a month to return the reactor to a safe condition to be decommissioned. Thus there was no choice but to clean-up the plant and access roads sufficiently for workers to continue to work there for the foreseeable future.

In Area II, the contamination was high with a predicted individual lifetime dose of 520 mSv. During the first three months the individual dose rate was greater than 10 mSv per month, which was the advisory intervention level for relocation and had been the criterion which had led to Areas II and III being relocated immediately after the accident. Thus for Area II clean-up actions if performed would have to be performed by workers. There was also the possibility of permanently relocating the inhabitants of Area II and only cleaning the streets sufficiently for safe access to the nuclear plant and the harbour. The column labelled Area II in Figure A2.1 indicates six increasing rigorous packages of clean-up measures and the ultimate possibility of resettlement. The different packages of clean-up actions are described in more detail in Annex 4.

Table I provides data on the various costs and benefits associated with the possible actions in Area II. The first three columns refer to costs: an estimate of the financial cost in millions of Finnish Marks (MFIM), an estimate of the number of workers needed to complete the action and an estimate of the collective dose that

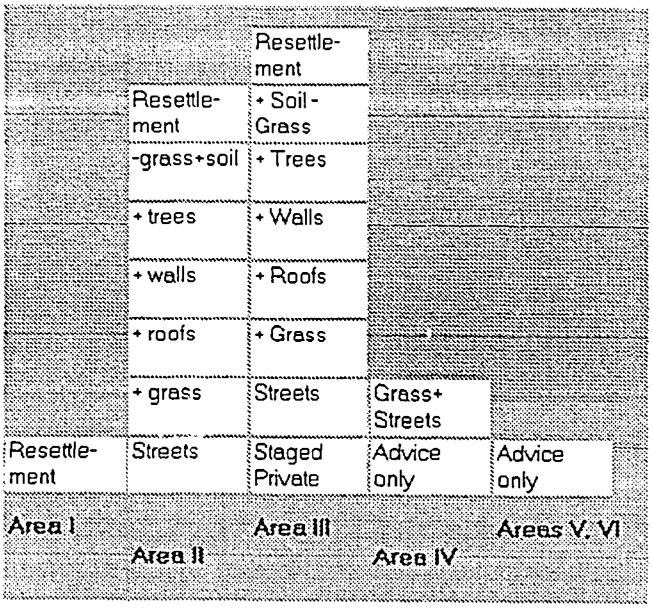

Fig. 1 The structure of the decision model

Table I. Data for the actions in Area II

Clean-up actions	Costs			Benefits		
	Cost (MFIM)	Workforce	Worker Collective Dose (manSv)	70 yr. Collective Dose Averted (manSv)	70 yr. Individual Dose Averted (mSv)	Economic Benefit (MFIM)
Streets	0	7	0.0	6	2	0.1
+ grass	0	93	0.5	1320	345	0.2
+ roofs	1	113	0.6	1385	363	0.5
+ walls	1	139	0.6	1428	375	0.6
+ trees	6	242	5.4	1580	415	2.1
-grass+soil	17	596	12.7	1740	455	6.5
Resettlement	5000	0	0.0	2000	520	-

the workers will receive in performing the clean-up actions. The second set of three columns give estimates of the benefits: the predicted reduction in the collective dose (manSv) over 70 years for the 3,815 inhabitants of Area II, the predicted mean reduction in individual dose in Area II (mSv), and an estimate of the economic benefit brought to the Finnish economy by the expenditure on the clean-up measures. It should be noted that these numbers are subject to considerable uncertainty and hence they should be interpreted with care as showing trends and qualitative patterns rather than absolute values. Note also that in the case of permanent resettlement, no attempt was made to estimate any economic benefit. The cost of permanent resettlement was estimated at 0.5 MFIM per house in the region plus two year lost GNP for resettled population.

Guidance from STUK has been issued which suggests that permanent resettlement should be *considered* if the individual lifetime dose is predicted to exceed 100 mSv. This means that clean-up actions which avert less than about 420 mSv individual dose would leave open the question of whether the inhabitants should be permanently resettled (predicted lifetime dose in Area II is 520 mSv). Moreover, some participants suggested that, since this number is in the public domain, environmental and other pressure groups would argue that 100 mSv should be a firm action level for resettlement.

In Area III, the dose rate had now fallen below 10 mSv per month, but the predicted lifetime dose was in excess of 100 mSv. It was argued, therefore, that adult members of the population of Area III should be encouraged to return for a few days to undertake certain simple measures to clean-up their homes (cutting grass, pruning plants, etc.). In addition, the state could implement various packages of actions to clean up the area. The possibility of permanent resettlement without any clean-up should also be considered. Thus there were eight possible strategies for Area III: see Figure 1 and Annex 4. Table II provides data on the various costs and benefits associated with the possible actions in Area III.

The projected 70 year individual dose in Area IV was 44 mSv, well below the level at which resettlement should be considered according to the published guidance from STUK. Indeed, the individual doses were sufficiently low that the clean-up in this area might be performed by the public themselves, i.e. grass cutting, bush pruning, etc. However, Area III had been relocated, but Area IV had not. The population in Area IV had been protected by sheltering, the intake of stable iodine and certain food bans, but by nothing so clearly protective as relocation. Thus there was a need to consider some clean-up actions by the state if only as a public calming measure. It was also noted that since the population of

Table II. Data for the actions in Area III.

Clean up actions	Costs			Benefits		
	Cost (MFIM)	Workforce	Worker Collective Dose (manSv)	70 yr. Collective Dose Averted (manSv)	70 yr. Individual Dose Averted (mSv)	Economic Benefit (MFIM)
Staged private	0	0	0.2	230	60	0.0
Streets	0	11	0.2	230	60	0.0
+ grass	1	147	0.3	460	120	0.3
+ roofs	2	177	0.3	484	126	0.7
+ walls	2	215	0.4	498	130	1.0
+ trees	10	378	3.0	554	145	3.3
–grass+soil	27	937	7.1	611	160	10.0
Resettlement	5000	0	0.0	700	184	–

Area IV was 62,000 the averted collective dose and hence the number of fatal cases of cancer saved by any protective measure would be substantial. Thus, in addition to the public cleaning their own property, the possibility of the state cleaning the streets and cutting grass, etc. in public places was considered. Table III provides data on the various costs and benefits associated with the possible actions in Area IV.

The predicted 70 yr. individual doses in Areas V and VI were so low that the only clean–up felt to be necessary was that which could be done by the public themselves. Thus it was agreed that advice on clean–up should be issued to the public.

The different possible clean–up actions indicated in Figure 1 can be put together into 112 (= 7*8*2) combinations or packages of measures. Not all of these would be acceptable, since the clean–up of Area II should clearly be at least as effective as that of Area III (unless Area II is resettled). Also it had been noted that any clean–up of Areas II and III which left a 70 yr. individual dose in excess of 100 mSv would raise questions of the need for resettlement. Thus the number of strategies to consider was certainly less than 112.

Table III. Data for the actions in Area IV

Clean-up actions	Costs			Benefits		
	Cost (MFIM)	Workforce	Worker Collective Dose (manSv)	70 yr. Collective Dose Averted (manSv)	70 yr. Individual Dose Averted (mSv)	Economic Benefit (MFIM)
Advice only	0	0	0.0	900	14	0.0
Grass + Streets	4	1140	0.6	1800	28	2.1

Several further points arose in the general discussion on the possible strategies:

* Any decision would need to include the broadcasting of clear advice to the public on cleaning up their own houses and property. This should describe simple measures: grass cutting, etc. The public should not be encouraged to fell trees, which might cause loss of life or serious injury. Moreover the broadcasting must explain in everyday terms the value of such actions. Few would intuitively think that cutting the grass could reduce the dose more than many other measures. It was vital to any strategy that such public information broadcasting be effective.

* Whatever strategy was adopted, the access to the harbour should be cleaned up.

* Further consideration needs to be given to the recommendation of grass cutting at an earlier stage in the emergency response, once the radiological situation has become clear. The effectiveness of grass cutting is greatly reduced by rain. Thus it must be implemented as soon as possible in regions in which dry deposition has occurred.

* Fallen leaves in the autumn should be collected and buried, irrespective of the other actions taken (unless an area is resettled).

It was noted that permanent resettlement was very expensive in comparison with the other measures. The estimation of the cost of resettlement was undoubtedly rough, but it was felt to be correct to within one order of magnitude. Thus it was decided that the decision makers were unlikely to choose a strategy which resettled significant numbers. If resettlement was taken out of the model it was possible to obtain further insight on the decision through a simple graph: see Figure 2. This plots the cost in MFIM horizontally, and the benefit in terms of total averted collective dose vertically.

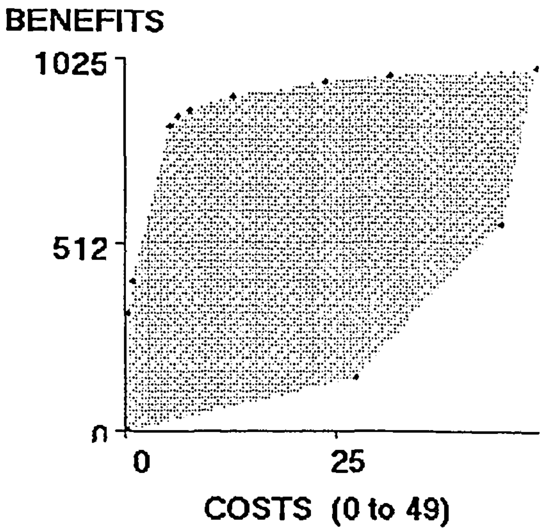

Fig 2. A cost benefit plot (not including the resettlement of Areas II and III). The small crosses on the boundary define the set of the non-dominated strategies corresponding to data presented in figure 1. The non-dominated strategies are such that there are no other strategies which would be better in all the attributes. In any situation it is only rational to make a choise among the non-dominated strategies.

A good strategy would correspond to a point on the upper boundary[9]. The software would help the decision makers do this, but before it made sense to do so the benefit scale needed defining carefully. Although total averted collective dose reflected the reduction in stochastic health effects (cancers and hereditary effects) that a strategy would bring, it did not reflect any psychological or other less tangible benefits. It was hoped that the presence of the decision makers on the next day would enable a suitable scale to be defined.

[9] i.e. the Pareto Boundary or Efficient Frontier (see French, 1986)

4 THE SECOND DAY

Early the next morning the expert group met again to discuss the points that should be made to the decision makers and how the previous days' discussion and analysis should be presented. At 10.00 am a full meeting of the technical experts and decision makers began.

To bring the decision makers 'up to speed', Robert Finck and Jørn Roed repeated their presentations, taking care to set the technical ideas in everyday language and provide the decision makers with comparisons with the public exposures after Chernobyl, during medical X-rays and arising from natural Radon. Simon French then summarised the issues and concerns listed earlier and invited the decision makers to discuss and add to them.

Several questions were asked and points raised: for instance,

* What are the normal grass cutting habits in Finland? (Grass cutting would be less effective if the usual length is very short.)

* What about tourists in the area? (It was assumed that these had been advised to leave as soon as sheltering had been lifted, and that they had done so.)

* Would the dose to workers be significant? In most cases worker doses were predicted to be low.

* What is the uncertainty in the figures? This point gave rise to much discussion during the day. Firstly, some of the experts and advisors were in a genuine disagreement about the values and accuracy of some of the data. Secondly, technical experts who work with numbers daily recognise and have a feeling for the accuracy, or rather inaccuracy, of the figures. A scientist draws qualitative conclusions from quantitative analyses. Although the decision makers do precisely the same with financial and other quantitative analyses within their daily experience, there was a danger that they would assume that science was much more precise and that there were no uncertainties. Thus, firstly, much was done during the day to convey the notion that these were 'ballpark' figures and, secondly, it was recognised that more attention must be given to the general issue of conveying to the decision makers the considerable

uncertainties which would be present in any predictions, evaluations and advice which could be provided by the technical experts in a real emergency.

The outline decision model developed the previous day was then described to the decision makers. This stimulated much discussion about the form of the strategies. One point that was discussed in detail was the following.

In practice, might advice be given to much smaller geographic areas? For instance, people might be asked to return from evacuation on a house by house or street by street basis, as the clean-up reduced the predicted doses sufficiently. The contrary view was put that one had to deal with communities to ensure that people were returned to areas with sufficient services to live reasonably and which were sufficiently clean that there was not a significant dose when they left the immediate vicinity of their property. After some debate the contrary view held and that aspect of the structure of the decision model was accepted.

The question of evaluating the benefit brought by the strategies was then discussed. First, it was noted that evaluation in terms of averted collective dose could lead to different choices regarding evaluation in terms of averted individual dose. The former might lead to efforts being directed at Area IV because of its much larger population, while individuals in Areas I, II and III faced much higher risks arising from their greater dose. On the other hand, concentrating effort on Areas I, II and III would not reduce the collective dose so much and hence lead to more cases of cancer. The decision makers indicated that they would balance such issues but were not explicit on how they would do so. During the discussion it was also pointed out that in principle the primary task in radiation protection is to protect those at the highest risk. In this case, it was noted that resettlement aside, the sums of money involved were such that all clean-up actions could be applied.

Similarly, when discussion turned to psychological factors that would need to be taken into account, the decision makers indicated that these would be very important but could not articulate their value scales explicitly. However, they were clear that cutting trees would have a very negative psychological effect. It would change the landscape and the outlook in people's gardens providing a constant reminder of the accident for many years to come. Thus it was suggested that the strategy should be to apply all the clean-up actions in Areas II and III, except the cutting and pruning of trees. It might also make sense to limit scraping of soil to public areas and close to houses relying on grass cutting, etc. further away from normal living areas. This strategy was adopted by a majority of the group, including the decision makers as a sensible compromise. Relocation was not considered a sensible option because of the cost and it was noted that the recommended strategy reduce the individual 70 yr. dose in Area II to roughly 100 mSv, avoiding a formal need to consider further relocation.

In the closing session, the above strategy and the reasons for its adoption were further explored through the drafting of a press release. In writing the outline of this, it was possible to illustrate that the strategy had internal contradictions, e.g., the individual risks left in Areas II and III were much higher than those in Area IV, so why should resources be spent on cleaning up area IV? Any strategy would have such internal contradictions and the decision makers should prepare for the public to question these. It was also noted that there could be comparisons with possibly different intervention criteria between the Nordic Countries. Further, that the individual doses in some areas after clean-up would exceed those in some regions of the former Soviet Union after Chernobyl from which people had been resettled. Would the Finnish population accept a 'less safe' criterion, e.g. for resettlement, than had been or will be applied within neighbouring countries?

The uncertainty in the effectiveness of clean-up actions had not been addressed. If they did not reduce the dose as much as predicted, there would still be a need to consider resettlement in some of the areas. How important was it to set a policy now which would still be in place in a year's time? Would the decision makers be able to deal with a significant change in policy (i.e. the resettlement of some areas) in several months' time, would the political and social cost be too great?

At the end of the meeting the decision makers and their advisors explained that they felt that they did not need more detailed information, as it was impossible to assimilate and handle all the issues. What they needed was advice on the possible actions and the problems that might arise from each possible strategy. The discussion which had illustrated the dilemmas that might arise because of the public perception of the issues and comparisons with the Chernobyl Accident had thus been particularly helpful.

5 RECOMMENDATIONS

Grass cutting, bush pruning and removal of small plants are perceived as very effective protective measures for removing dry deposition if implemented as soon as it is safe to do so. They can be implemented by the public without significant increase in their individual and collective doses in many regions after an accident.

Recommendation:

As soon as the plume has passed and the radiological situation has become clear, emergency planners should consider advising the public to cut their grass, prune bushes and remove small plants in those regions where it is safe to do so.

There is potential for the decision makers to place too much trust in the numerical predictions of technical experts and scientists.

Recommendation:

Attention should be given to ensuring that modes of communication between experts and decision makers include a clear and unambiguous statement of the uncertainty of data and predictions, both the uncertainty stemming from natural randomness and that arising because experts may quite genuinely hold different opinions about, for instance, the effectiveness of countermeasures in particular circumstances.

There was concern that the burial of waste might be legal but unfeasible in political and social terms. It was felt that this should be investigated before a real accident occurred, as there would not be time to do so afterwards.

Recommendation:

Some investigation should be made of the feasibility in social terms of burying a considerable volume of contaminated material that would be created by several of the clean–up actions.

The meeting was successful in developing communication between decision makers and technical experts, but it was too large for detailed discussion and the involvement of several countries may have had an effect. Several members suggested that smaller meetings should be held in each of the Nordic countries without involvement of other nationals.

Recommendation:

Further conferences should be held involving national representatives and technical experts only.

6 CONCLUDING DISCUSSION AND REMARKS

The discussion on the second day did much to address the first objective of the decision conference, namely the development of a shared understanding between government officials and the radiation protection community. There was much communication between the two groups concerning the others' viewpoint. Many participants remarked on the need for many more such meetings to ensure the continued growth of this shared understanding.

In terms of the second objective the conference was less successful, however. Although it was clear that decision making would be based upon other factors in addition to radiation protection issues and predicted health effects, it was not possible to elicit weights and value scales to articulate these additional factors explicitly. The model undoubtedly focused discussion and clarified issues, but it was not explored as fully as the model in the previous decision conference held in the Nordic Nuclear Safety Research Programme (French *et al*, 1993). There are several possible reasons for this.

* The format of the meeting required that the decision makers join in on the second day for only about 7 hours. This may not have been sufficient time for them to assimilate fully the issues being discussed and their context.

* The resource allocation decision model was unfamiliar to them and presented further concepts to be assimilated and understood.

* Perhaps, most importantly the format of the meeting did not sit comfortably with the decision process that they were accustomed to[10]. Currently, the

[10] In practice, in both Parliament and emergency management, advice on the decision is prepared in groups of various sizes and composition, but the decision itself is made through the *presentation of matters* to the President, Governor or maybe in a less formal way to the Director General of Rescue Services. In the later stages of the response to an accident, it may be necessary, for example, to pass a new law to allow certain costs to be incurred. A proposal for that law would first be discussed in a preliminary debate and then sent to the proper committee. After hearing evidence from various specialists and interested parties, the committee reports back on the law proposal, which is then sent back to the plenary session for three readings, the last one for passing it. The final decision is made in the presentation of the proposal to the President.

experts' role is to advise the decision makers on possible courses of action and their potential consequences, both in terms of costs and benefits. The meeting assumed that the decision makers would explore the decision in the presence of the experts.

This last point particularly raises the issue of the decision making process to be supported. If the process remains as it is currently, the format of the meeting was inappropriate. It would be better if the experts had formulated a fuller decision model, explained this to the decision makers in a shorter meeting and then withdrawn. A full decision conference would have been appropriate to help the experts formulate their model and their advice, but other structures might have been more appropriate for supporting the decision makers in their final decision. Perhaps something along the lines of the *spontaneous decision conferencing methodology* being explored by Hämäläinen and his co-workers (Hämäläinen and Leikola).

On the other hand, it should be remarked that as technology improves, we may expect that the consequences of an accident and possible countermeasures may be estimated using more and more powerful interactive software, which will allow many 'what-if' analyses. The RODOS decision support system being written by a consortium of European institutes is an example of such possibilities (Ehrhardt *et al*, 1993). The potential of such systems is such that the decision makers may have needed the experts, presence while all the possibilities and consequences are explored. Thus, in time, the decision making procedures may change, and the format of meetings will need to evolve to reflect this change.

Notwithstanding these remarks, we conclude that the conference described here seemed effective in communicating issues between the technical experts and the decision makers. However, it was clear that the decision makers would have taken the final decision away from the meeting in the light of the understanding they had obtained.

ACKNOWLEDGEMENTS

The EKO-4/c working group is grateful for the help to finalize the report to O. Walmod-Larsen, S. Magnússon and S. Pálsson.

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6 The EQUITY software which was used during the event is available from either Enterprise LSE Ltd, London School of Economics and Political Science, Houghton Street, London, WC2A 2AE, UK (Fax +44-171-955-7980) or Krysalis Ltd, 28 Derwent Drive, Maidenhead, Berkshire, SL6 6LB, UK (Fax +44-1628-38390).

ANNEX 1: Participants

Denmark

	Affiliation	Attendance
K. Ulbak Director	State Institute for Radiation Hygiene	Aug 31st

Finland

	Affiliation	Attendance
E.-R. Siitonen Governor	Provincial Government of Uusimaa	Aug 31st
M. Haranne Head of Rescue Service	Provincial Government of Uusimaa	Aug 30th and 31st
V. Peltonen Director	Ministry of the Interior	Aug 31st
J. Koivukoski Inspector General	Ministry of the Interior	Aug 30th and 31st
M. Murtomaa Special Advisor	Ministry of the Social Affairs and Health	Aug 31st
Mrs L. Eränen	Helsinki University	Aug 30th and 31st
J. Laaksonen Director	Finnish Centre for Radiation and Nuclear Safety	Aug 31st
R. Mustonen Assistant Director	Finnish Centre for Radiation and Nuclear Safety	Aug 30th and 31st

Iceland

	Affiliation	Attendance
S. Magnússon Director	Icelandic Radiation Protection Institute	Aug 31st

Norway

	Affiliation	Attendance
O. Harbitz Director	Norwegian Radiation Protection Authority	Aug 31st
E. Stranden Department Director	Norwegian Radiation Protection Authority	Aug 30th and 31st
S. Backe Head of Section	Institute for Energy Technology	Aug 30th and 31st

Sweden

	Affiliation	Attendance
C. Andersson Head of Rescue Service	Provincial Government of Malmöhus	Aug 31st
U. Bäverstam Head of Department	Swedish Radiation Protection Institute	Aug 31st
L. Moberg Secretary of Research	Swedish Radiation Protection Institute	Aug 30th and 31st
H. Svensson Principal Administrative Officer	National Board for Agriculture	Aug 31st
T. Ulvsand Senior Research Officer	National Defence Research Establishment	Aug 30th and 31st

NKS

	Affiliation	Attendance
T. Bennerstedt Secretary General	Nordic Nuclear Safety Research (NKS)	Aug 30th and 31st

EU

	Affiliation	Attendance
Dr. G.N. Kelly	DG XII, CEC	Aug 30th and 31st

Project Group

	Affiliation	Attendance
R. Finck Senior Scientist	Swedish Radiation Protection Institute, SWE	Aug 30th and 31st
S. French Professor	Leeds University, UK	Aug 30th and 31st
R. P. Hämäläinen Professor	Helsinki University of Technology, FIN	Aug 30th and 31st
K. Lundmark Secretary	Swedish Radiation Protection Institute, SWE	Aug 30th and 31st
E. Naadland Senior Scientist	Norwegian Radiation Protection Authority, NOR	Aug 30th and 31st
J. Roed Head of Group	RISØ National Laboratory, DK	Aug 30th and 31st
A. Salo Director of Dep., retired	Consultant, Finland	Aug 30th and 31st
K. Sinkko Senior Scientist	Finnish Centre for Radiation and Nuclear Safety, FIN	Aug 30th and 31st

ANNEX 2: Description of the Scenario of an hypothetical accident in a nuclear power plant and possible clean-up actions provided to the participants

General part

It has been learned from exercises that total realism could not be obtained, and many flaws in the forms of exercise and scenario have been noted. Clearly no information or papers, circulated both before and during an exercise, can simulate the level of knowledge that each participant would have in a true emergency. The data will lack realism in many respects, particularly in relation to the level of **uncertainty** that might be expected on the measurements and the distributions of dose in both time and space. The response of the public and the media to the emergency cannot be simulated. Moreover, it is a difficult task to make a scenario relevant to all participants coming from almost all corners of Scandinavia. Nonetheless, we suggest the following hypothetical accident scenario and ask you to consider it **as a real one, as it is described.**

It should be noted that only the essential events and central protective actions during the first week are described.

A serious reactor accident has happened at the Loviisa nuclear power plant in Finland and the eastern part of the province Uusimaa has been contaminated, e.g., the area from Loviisa to Lahti.

Similar areas concerning population and industry could have been ... in Denmark or ... in Iceland or ... in Norway or ... in Sweden, which is within your area of responsibility. We assume that in this exercise **you are responsible for the contaminated area in Finland**, and we further assume that you live in the area and share the problems of population. This assumption has been found useful in contemplating protective actions.

Late in the evening on Tuesday, 22nd August, information was received from the Loviisa nuclear power plant that a serious **incident** had happened at 22:00 in unit 1. The reactor was in the shutdown state, but not under full control. At that time it was assumed that the reactor could be brought under control; the probability of success was estimated to be 99%. However, at 05:00 in the next morning it was clear that a core-damaging **accident** was happening. Furthermore, at that time it was assumed that as a consequence of the accident a release of radionuclides was going to take place with a rough probability of 10%.

The weather in southern Finland on Tuesday night and Wednesday morning was stable with steady winds from the south-east. The weather forecasts indicate that there will be no rain in the area for the next two weeks.

Based on the state of the plant the reactor safety and radiation protection experts recommended evacuation in the five-kilometre zone around the plant. Evacuation of forty people who live in the area was considered applicable taking into account the time available. The weather forecast and the preliminary dose predictions made it clear that the inhabitants also had to be warned in the eastern part of the province of Uusimaa. Furthermore, as the experts predicted high doses, especially high inhalation doses, they recommended sheltering of the population for ten to fifteen hours, implementation of control of access and the taking of iodine tablets in Loviisa. It was not considered possible, although desirable, to evacuate the town of Loviisa in a couple of hours. **No deterministic health effects were predicted** to any member of the population.

Immediately, at 6:00 on Wednesday, the Director General of the Rescue Service at the Ministry of the Interior decided upon **evacuation in the five-kilometre zone, preparedness for sheltering, the intake of iodine tablets and control of access** at short notice in the whole municipality of Loviisa. People were also advised to listen to the radio and follow the orders to be given by the authorities.

Monitoring teams were sent out by car to take on-the-spot measurements and collect samples for analysis.

Shortly after 07:00 the monitors at the plant and the monitoring teams outside the plant reported a rise in the outdoor dose rate from the background reading of 0.00015 mSv/h to 5 -10 mSv/h. This indicates that a severe release has started at 07:00. In the accident a few percent of the fission products are assumed to have been released into the environment leading to a very severe contamination of the environment. Note: the real probability of this kind of accident leading to a release is estimated to be less than one in 100,000 in per year per reactor.

Based on these measurements and revised dose predictions **people were advised to shelter in more than 20 municipalities for ten to fifteen hours** as the plume moved over the area, and to take iodine tablets. The majority of the municipalities involved are shown in Figure A2.1.

The release ceased at 16:00. Then it was considered reasonable to **lift the sheltering and control of access measures** as soon as the plume had passed the area.

By Thursday morning, when all the available information was acquired, it become clear that the plume had spread and diluted in the air but left a deposition of radionuclides as is shown in Figure A2.1.

Although the information available was incomplete, it was estimated that the doses to be received by the inhabitants in the area including the population centres of Loviisa, Liljendal, Myrskylä and Hollola will be 10 to 100 mSv in the first month after the accident. Therefore it was judged that **the inhabitants, 11,000 - 12,000 people, in this area would have to be relocated from the area for several weeks.**

This time it was also clear that some urgent **actions considering foodstuffs have to be implemented.**

It was also seen that some clean-up actions should be considered, and the task was given to the expert group to give an of account and advice on possible **clean-up actions** in urban areas. This advice was required to be available by Wednesday 30.8., i.e., one week after the accident. On Thursday 31.8. the decision makers assisted by experts are invited to a meeting to decide upon the implementation of clean-up actions in urban areas in this - we are happy to say - hypothetical accident.

Detailed description of the scenario

In the following more detailed technical information is given supplementary to the scenario described above. In the tables below we have gathered all the essential data which have been **measured or predicted** and which are **assumed in this exercise to be available one week after the accident.**

Accident and dispersion

For the purpose of the analysis it is assumed that a hypothetical core–damaging and containment leaking accident has happened at a Finnish nuclear power plant leading to a very severe contamination of the environment. The probability of this kind of accident occurring, leading to a release in real life is estimated to be less than one in 100,000 per year per reactor. In the accident few percent of the fission products are assumed to have been released into the environment (Table A2.I). The release has occurred nine hours after shutdown and has also lasted for nine hours. In the dispersion calculation it is assumed that the release happened in three different phases[11]. The effective release height is 100m, which corresponds roughlyto an initial sensible–heat release rate of a few megawatts.

Table A2.I. Release fractions assumed for the hypothetical accident. Fractions are median values taken from Ref. NUREG90 (Sequoyah PWR).

Nuclide group	Release fraction
Noble gases	1
Iodine, of which 1/2 organic	0.06
Cs–group (Cs, Rb)	0.025
Te–group (Te, Se, Sb)	0.01
Sr	$3.3\ 10^{-4}$
Ru–group (Ru, Mo, Tc)	$1.5\ 10^{-5}$
La–group (Nb, Zr, Cm)	$2.2\ 10^{-5}$
Ba	$4.0\ 10^{-4}$
Ce–group (Ce, Nd, Pm, Sm, Eu, Pu, refr. ox. Nb, Zr)	$4.5\ 10^{-5}$

[11] Plume dispersion and dose predictions were calculated by Mikko Ilvonen, Technical Research Center of Finland using a novel software package which is based on the existing codes TRADOS and ARANO.

The accident happened in summer time on August 23rd in dry atmospheric conditions; wind speed 5m/s and neutral atmospheric stability. The plume spread to the north-west, 330 degrees.

Radiation situation

Table A2.II. Average individual doses during the first 15 hours, dose rates on Wednesday evening (at 22:00), and ^{137}Cs-fallout in various areas as is shown in Figure A2.1.

Area	I*	II	III	IV	V	VI
Dose for normal living conditions (mSv)**	173	101	36	8.3	1.8	0.64
Dose when sheltered (mSv)	90	53	19	3.9	0.84	0.30
Dose when sheltered and with iodine tablets (mSv)	47	28	10	1.2	0.24	0.08
Dose rate (mSv/h)***	1.6	0.93	0.33	0.078	0.016	0.0058
^{137}Cs-fallout	13	7.6	2.8	0.64	0.14	0.05
Range (MBq/m^2)	10–17	6–10	2–6	0.2–2	0.1–0.2	0–0.1

* Without evacuation. It is assumed that the dose accumulated during relocation is negligible.

** Normal living conditions, i.e., 10% outdoors and 90% indoors.

*** Outdoor.

Table A2.III. Average individual and collective doses in the first week in various areas. Normal living conditions. The dose accumulated during the first 15 hours (during the plume spread) is subtracted.

Area	**I***	**II***	**III***	**IV**	**V**	**VI**
Dose(mSv)	**33**	**19**	**6.6**	1.6	0.34	0.12
Collective dose (manSv)	**0.098**	**72**	**26**	99	14.3	6.3

* Without relocation. It is assumed that the dose accumulated during relocation is negligible.

Table A2.IV. Predicted individual doses** (individual effective dose; mSv) **for normal living conditions in the fallout areas considered for various time scales. The dose accumulated during the first week is subtracted.

Area	I*	II*	III*	IV	V	VI
1 Month	34	19.7	7.0	1.67	0.36	0.13
3 Months	73	42	15.0	3.6	0.76	0.27
6 Months	119	68	24	5.8	1.24	0.44
1 Year	186	107	38	9.1	1.93	0.69
3 Years	330	188	67	15.9	3.4	1.21
10 Years	510	290	104	25	5.3	1.88
30 Years	720	420	148	35	7.5	2.7
70 Years	900	520	184	44	9.4	3.3

* Without relocation

Table A2.V. Predicted collective doses (manSv) for normal living conditions in the fallout areas considered for various time scales. The dose accumulated during the first week is subtracted.

Area	I*	II*	III*	IV	V	VI
1 Month	0.102	75	27	104	15.3	6.8
3 Months	0.22	160	57	220	32	14.1
6 Months	0.36	260	92	360	52	23
1 Year	0.56	410	145	570	82	36
3 Years	0.99	720	260	990	144	63
10 Years	1.53	1,100	400	1,560	230	98
30 Years	2.2	1,600	570	2,200	320	140
70 Years	2.7	2,000	700	2,700	400	174

* Without relocation

Taking into account that the fallout area is relatively small we assume that **it is feasible to supply uncontaminated food to the entire contaminated area.**

Demographic data

Table A2.VI. The number of inhabitants in various areas considered and the area of the land

Area	I	II	III	IV	V	VI
Number of inhabitants	3	3,815	3,825	62,466	42,495	52,321
Area (km^2).	5	17	247	559	1,213	907

Table A2.VII. *The number of inhabitants in the municipalities in the main fallout area.*

Municipality	**Inhabitants**
Asikkala	8,800
Artjärvi	1,700
Heinola	16,300
Heinola mlk	5,900
Hollola	19,900
Lahti	93,200
Lammi	6,000
Lapinjärvi	3,300
Liljendal	1,500
Loviisa	8,400
Myrskylä	2,100
Nastola	15,100
Orimattila	14,100
Pernaja	3,700
Pukkila	1,800
Ruotsinpyhtää	3,300
Total	205,100

Clean-up techniques

The following procedures for reduction of radiation levels on various surfaces can be applied, as is indicated, on different phases of the accident and in accidents of different magnitude. **Our conference is aimed at deciding upon the implementation of clean-up actions in urban areas, which can be applied in large-scale accidents and in the early phase, i.e., within two or three weeks.**

Roofs and Walls

Water treatments

High pressure water treatment (through a turbo nozzle) is a simple method for decontamination of walls. The efficiency of the procedure has been found to be greater in the early phase after deposition, presumably due to the time-dependent fixation of the caesium ion in the structure of the material. In experiments with freshly contaminated bricks and tiles it was found that the contamination was so loosely bound on the surface that much of it could be easily removed by simply spraying with water. Therefore, it may not be necessary to use the water with high pressure in the early phase (first week). **The water hosing method for roofs and walls suggested for use immediately after deposition is simply firehosing through an ordinary nozzle.** The effect of the hosing and high pressure (HP) water methods has been investigated thoroughly in the former USSR and in other experiments with fresh contamination.

Special roof washer

A good efficiency has been obtained on roof materials, even 8 years after the contamination took place, using a newly developed device consisting of a rotating brush of a shape that follows the curves of the roof and which is driven by pressurised air at 700 l/min. (7–8 bar) and uses water at ordinary tap water pressure. The fact that the cleaning is carried out at low pressure and in a wet medium makes the method specially suitable for work in contaminated areas, as the resuspension hazard is minimised. Further, this satisfies the existing legal demands in Europe regarding treatment of asbestos surfaces. **This technique is applicable on a small scale in the later phase of the accident.**

Roads

Sweeping

The sweeping method suggested for roads is assumed to be carried out with an ordinary broom. If municipal road-cleaning machines (with rotating brushes and vacuum attachment) or just mechanical rotating brooms on tractors were available, it would be possible to sweep the streets much faster and therefore less expensively. Also efficiency would probably be greater. In a series of experiments on a freshly contaminated road wet vacuum sweeping in some cases removed twice as much as thorough sweeping with an ordinary broom. The efficiency of the method has been found to be greatly dependent on the amount of street dust per square meter. **The method is applicable in large areas during the early phase.**

Trees

Cutting

Cutting trees is a demanding and expensive, yet very effective, procedure. **It is assumed that branches of deciduous trees are cut off and conifer trees are felled.** The resulting amount of waste can be substantial. Investigations have shown that radiocontaminants such as caesium migrate into the wood tissue. This means that after a while, the contamination is not just distributed over the surface (leaves and branches), but is accumulated in the whole tree. As we know from experiments how much is on the leaves, the branches and the stem, it was possible to estimate the effect of the cutting procedure.

Grass

Cutting

Cutting grass requires no explanation. It is naturally assumed that the grass is subsequently removed from the field. The transfer process of caesium contamination from grass to soil has been found to have a half-life of about 15 days. Therefore, **cutting grass to reduce the radiation level would be pointless after a few weeks.**

Soil

Peelable coatings

The point of using peelable coatings in the early phase, where all contamination is in a very thin top-soil layer, is to remove the contamination and at the same time avoid the generation of enormous amounts of waste that usually follow from soil-removal procedures. Small-scale experiments have indicated the potential of peelable coatings as a means of removing radioactive contamination from the surface of soil and grassed areas of land. The best results were obtained with coating based on polyvinyl alcohol and lignin. A very good efficiency was found and the costs are lower than those of many other procedures that have been suggested. Similar types of coating have been applied for dust control in connection with decontamination of contaminated areas of the former USSR.

Scraping

Scraping of soil is assumed to be carried out using a bulldozer, grader, front loader or some such machinery. The decontamination factor was estimated from experiments carried out in the contaminated areas by three independent Russian, Byelorussian and Ukrainian teams under the ECP/4 project. **The procedure shows great efficiency, even after many years.** The obvious problem in connection with scraping of soil is the generation of large amounts of waste (and possibly removal of the whole fertile soil layer).

Digging

Digging can of course be carried out in many ways. The most effective is probably double digging (or special digging), which is recommended. **The efficiency of this procedure will depend greatly on the soil type. In sandy soil it will be difficult to do properly**. The estimate given is a very conservative one. In fact, Monte Carlo computations have shown that the maximum achievable efficiency, if all the radioactive matter were brought to the bottom of the 40 cm deep trench, would be a dose rate reduction by a factor of about 500.

Ploughing

For larger areas ploughing may be considered. The efficiency of ploughing is based on experiments with deep-ploughing (to about 45 cm) with an ordinary plough. If one only ploughs to about 25 cm, the effect will be a dose reduction factor of about 10. The advantage of ploughing is that no radioactive waste is generated. A specially advantageous solution would be the application of the specially constructed skim-and burial plough, which has approximately the same dose reducing effect as deep-ploughing, but leaves the soil quality unaffected. **The efficiency of this procedure will depend greatly on the soil type. In stony soil the method is not feasible.**

Table A2.VIII. *The percentage dose reduction achieved by various clean-up techniques for dry deposition.*

Environment	Roofs	Walls	Streets	Trees	Grass	Soil
Technique	Hosing	Hosing	Sweeping	Prun/Cut.	Cutting	Scraping
Detached houses	3.4	2.1	0	8.0	66	74
Row houses	3.2	1.8	1.4	6.1	64	72
Block of flats	0.2	2.8	2.9	3.3	68	76

Table A2.IX. *The monetary costs of various cleanup techniques (FIM/m²).*

	Roofs	Walls	Streets	Trees	Grass	Soil
Technique	Hosing	Hosing	Sweeping	Prun/Cut.	Cutting	Scraping
Removal	5	2	0.02	4	0.1	4
Transport	0.015	0.015	0.015	0.15	0.002	4
Burying	0.0035	0.0035	0.0035	0.04	0.0175	1.3
Total	5.02	2.02	0.04	4.2	0.12	9.3

Assessment of the monetary costs of relocation

Calculation of the monetary costs arising from relocation is largely based on methods presented in the COCO-1 report. The costs of no-action are assumed to be negligible.

Transport costs:

The transport coss by road for both organised transport using buses and private cars and assuming that the average distance moved is 100 km, are estimated to be 85 FIM/person (including return; the running costs of a car per km is 1.7 FIM).

Loss of income:

It is assumed that if people are relocated, then they will also be unable to reach their workplace, and the contribution they would have made to the economy will be lost. This loss can be assessed from GDP per capita (GDP in Finland is 90,000 FIM). Note: the loss of income for farmers is included. A mean recovery time of the economy of around two years is thought to be appropriate as default value.

Food and accommodation costs:

To avoid double counting the simple approach adopted here is to estimate only the cost of lost accommodation. In choosing the time at which the costing should be stopped to be the same time as the cut-off time for loss of income, two years, and if the GDP used includes the housing component, then accommodation and food costs are included in the costs of lost income.

Costs of lost capital services:

The cost of lost capital services is caused by the acceleration of depreciation due to lack of maintenance and by loss of interest on the original investment. These costs caused by the loss of non-residential capital stock, housing and land are taken into account after the cut-off time, two years, because GDP includes the interest on capital value. Note, the loss of income is calculated for the first two years using the GDP. The GDP does not include consumer durables and therefore these costs begins at the time of the accident. The rebuilding of industry, public buildings, homes etc. is not included as costs, as these costs may be regarded as being equivalent to the costs of the lost capital value of the lost area.

It is assumed that the resettlement process takes one year and that the costs therefore continue for an extra year.

The value of land and its assets in various categories are as follows:

* non-residential capital stock; 150,000 FIM/person,

* housing; 140,000 FIM/person,

* consumer durables; 83,000 FIM/person,

* land: - urban areas; 100 MFIM/km^2

  - rural areas; 1 MFIM/km^2.

Rates of interest and depreciation:

* interest rate, 5%,

* depreciation rate:

  - stock and dwellings; 5%

  - consumer durables; 10%.

Risk perspectives

The nominal probability coefficients for fatal cancer are 5% per Sv (1000 mSv), an additional 1% per Sv for non-fatal cancer and 1.3% per Sv for severe hereditary effects. This means that the total nominal probability coefficient for stochastic effects is 7.3% per Sv (ICRP 60). Roughly, if each individual receives a dose of 1 mSv in the population of 100,000, the expected number of fatal cases of cancer is 5 **in the lifetime of that population**. Considering an individual, the exposure of 1000 mSv will cause fatal cancer risk of 5% in his/her lifetime. According to the Finnish statistics, the total lifetime cancer risk of an individual is 20%.

Table A2.X: "Normal" frequencies of cancers in Finland in a year.

	Leukaemia	Thyroid	All others
Adults	5–7/100,000	1–2/100,000	200/100,000
Children	5/100,000	0.1/100,000	100/100,000
Mortality	50%	10%	50%

Table A2.XI. Thresholds of occurrence of deterministic effects for acute exposure (IAEA Safety Series 109).

Organ or tissue	Dose in less than 2 days (mSv)	Type of effect
Whole body (bone marrow)	1000	Death
Lung	6000	Death
Skin	3000	Erythema
Thyroid	5000	Hypothyroidism
Lens of eye	2000	Cataract
Gonads	3000	Permanent sterility
Foetus	100	Teratogenesis

Currency exchange rates

FIM	DKK	ISK	NOK	SEK	USD
1	1.3	14	1.4	1.6	0.22

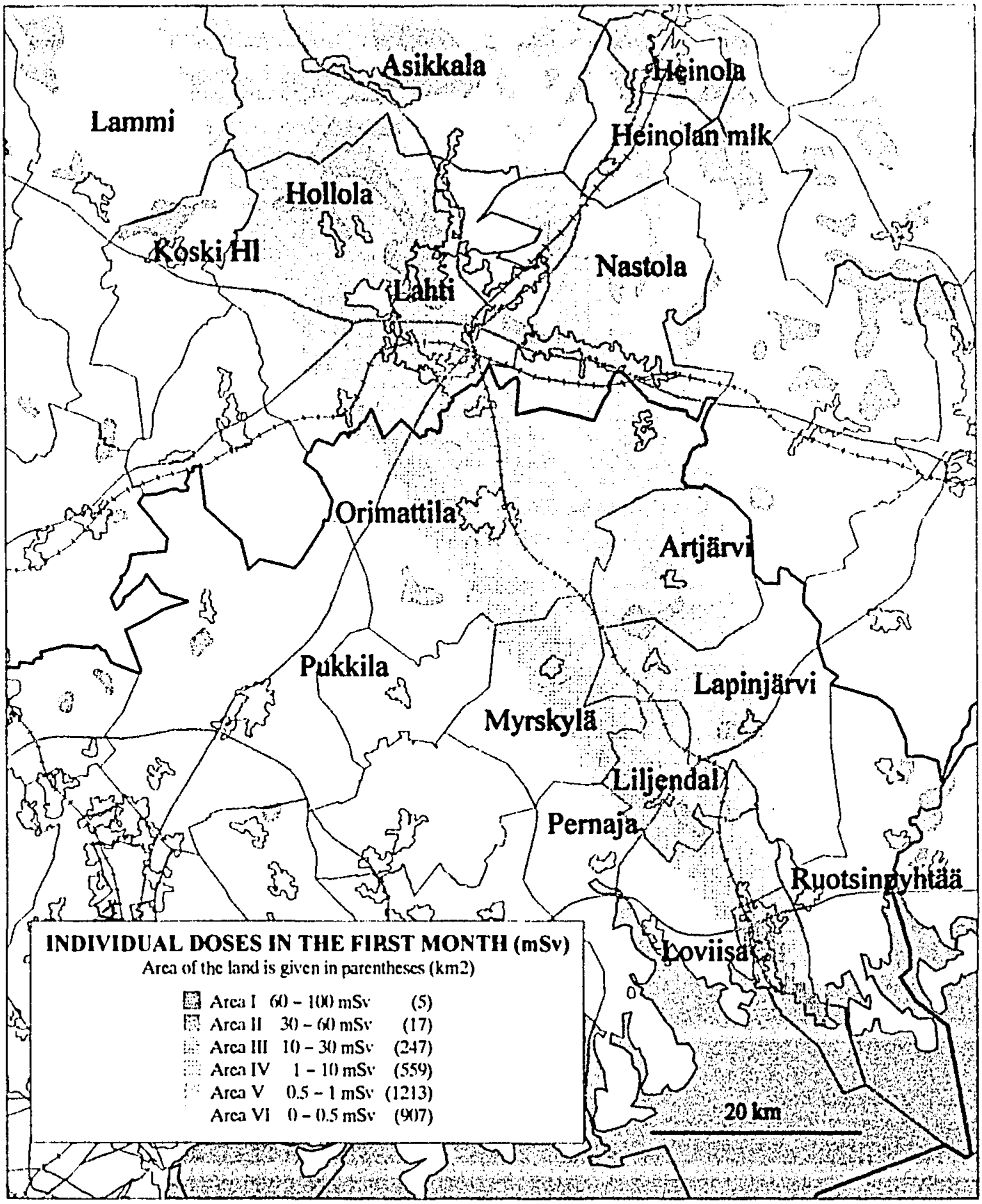

Fig.A2.1. Contaminated area and individual doses in the first month in various areas.

ANNEX 3: Legal Questions in Relation to Decontamination and Subsequent Waste Disposal in the Nordic Countries after a Nuclear Accident

Decontamination, handling of resulting large volumes of radioactive waste and compensation of damaged property after a nuclear accident may raise some legal questions depending on the accident situation. Domestic accidents are covered in more detail by nuclear energy acts, radiation safety acts and nuclear liability acts, at least in those Nordic countries which have their own nuclear energy production. Foreign accidents may create a somewhat different situation at least as regards compensation for the damage to property caused by the accident itself and by the subsequent countermeasures.

A sufficient regulatory framework seems to exist in the Nordic countries to **decide upon and to implement decontamination** measures, at least in the early phase of a post-accident situation. Large scale clean-up activities in the late phase may need some further considerations. E.g. in Finland the Fire and Rescue Services Act gives the necessary authorisation to the fire chiefs at the local level, the governors at the county level and the Ministry of the Interior at the national level to decide upon and to implement such countermeasures, radiation safety advice is given by STUK. The County administration in Sweden has the legal power to make all necessary intervention decisions in case of a nuclear accident, radiation protection advice is given collectively by authorities responsible for it. Concerning clean-up actions in particular, there is a special expert group appointed to give advice to the County administration. Also, the other Nordic countries have identified the decision makers in the early phase, the Emergency Management Agency of the Ministry of the Interior with the help of a central command centre in Denmark, the Crisis Committee for Nuclear Accidents (However, decisions on and implementation of decontamination measures by County administration and/or local fire and rescue authorities, after advice from Rad.Prot.Auth.) in Norway, and the Civil Defence Authority in Iceland.

No specific regulations seem to exist in EU or in the Nordic countries concerning the **disposal of such types of radioactive waste that may result from decontamination** operations after a major nuclear accident. However, legal restrictions that would prevent proper handling of such wastes are not foreseen. Basically, radiation protection principles are expected to be followed to improve the radiation situation for the exposed population. E.g. in Finland the Radiation Safety Act stipulates that the radiation protection principles presented in the act should be followed when limiting radiation exposure to people even in exceptional radiation situations (emergencies). In Denmark the ICRP recommendations will be followed.

Resources for implementing protective actions and recovery measures, and **Compensation** to owners for damage to private property, are expected to vary according to the type of action and the type of property and will need political decisions in the actual accident situation. In domestic nuclear accidents and in accidents in those countries which are parties to the relevant international conventions on third party liability there is a legal framework for compensation of damage caused by the accident, but there are no other regulations specific to consequences of countermeasures in nuclear accidents.

ANNEX 4: Description of differing levels of clean-up actions considered in the decision model for each of Areas I to VI.

Area I

Resettlement

Clean-up plant for continued operation and clean streets for access. Resettle the three inhabitants.

Area II

Streets WASH/BRUSH STREETS
Return from evacuation after 3 months.

+ grass Wash/brush streets, CUT GRASS.
Return from evacuation after 3 months.

+ roofs Wash/brush streets, cut grass, WASH ROOFS.
Return from evacuation after 3 months.

+ walls Wash/brush streets, cut grass, wash roofs, WASH WALLS.
Return from evacuation after 3 months.

+ trees Wash/brush streets, cut grass, wash roofs, wash walls, CUT/PRUNE TREES.
Return from evacuation after 3 months.

+ grass+soil Wash/brush streets, wash roofs, wash walls, cut/prune trees, SCRAPE SOIL (instead of cutting grass)
Return from evacuation after 3 months.

Resettlement

Resettle population in area permanently; only clean up streets that are necessary for access to harbour and plant.

Area III

Staged Private

Public return at 'weekends' to clean up houses and gardens: then full return after 2–3 months.
WASH/BRUSH STREETS.

Streets

Public return at 'weekends' to clean up houses and gardens: then full return after 2–3 months.
WASH/BRUSH STREETS.

+ grass

Public return at 'weekends' to clean up houses and gardens: then full return after 2–3 months.
Wash/brush streets, CUT GRASS.

+ roofs

Public return at 'weekends' to clean up houses and gardens: then full return after 2–3 months.
Wash/brush streets, cut grass, WASH ROOFS.

+ walls

Public return at 'weekends' to clean up houses and gardens: then full return after 2–3 months.
Wash/brush streets, cut grass, wash roofs, WASH WALLS.

+ trees

Public return at 'weekends' to clean up houses and gardens: then full return after 2–3 months.
Wash/brush streets, cut grass, wash roofs, wash walls, CUT/PRUNE TREES.

+ soil – grass

Public return at 'weekends' to clean up houses and gardens: then full return after 2–3 months.
Wash/brush streets, cut grass, wash roofs, wash walls, cut/prune trees, SCRAPE SOIL (instead of cutting grass).

Resettlement

Permanent resettlement. Only clean up necessary streets, etc. for access to plant and harbour.

Area IV

Advice only.
Advice public on how to clean up their own house and garden.

grass + streets

Advice public on how to clean up their own house and garden. CLEAN-UP OF STREETS AND CUTTING OF GRASS IN PUBLIC AREAS.

Areas V, VI

Advice only.
Advice public on how to clean up their own house and garden.

English - Nordic glossary for emergency situations

DETERMINISTIC EFFECT. A radiation effect for which generally a threshold level of dose exists above which the severity of the effect is greater for a higher dose.

DK:	FI:	IS:	NO:	SE:
Deterministiske effekter	Deterministinen vaikutus, välitön vaikutus	Vísir skaðar	Deterministiske effekter, akutte skader	Deterministiska effekter, akuta effekter/skador

STOCHASTIC EFFECT. Radiation effects, generally occurring without a threshold level of dose, whose probability is proportional to the dose and whose severity is independent of the dose.

DK:	FI:	IS:	NO:	SE:
Stokastisk effekt	Stokastinen vaikutus, satunnaisvaikutus	Tilviljunarkenndir skaðar	Stokastiske effekter	Stokastiska effekter, slumpmässiga effekter/skador

DOSE. A measure of the radiation received or 'absorbed' by a target. Depending on the context, quantities such as organ dose, effective dose, equivalent dose etc. are used but these modifying terms are often omitted when they are not necessary for defining the quantity of interest. The quantity for use in relation to deterministic effects is the **absorbed dose** expressed in gray (Gy).

DK:	FI:	IS:	NO:	SE:
Dosis, absorberet dosis	Annos, absorboitunut annos	Skammtur, geislaskammtur	Dose, absorberte dose	Dos, absorberad dos

EQUIVALENT DOSE AND EFFECTIVE DOSE are the quantities to be used to assess risks of stochastic effects. The name for the special unit for both of them is the sievert **(Sv)**

DK:	FI:	IS:	NO:	SE:
Ækvivalent dosis, effektiv dosis	Ekvivalenttiannos, efektiivinen annos	Geislaálag	Ekvivalent dose, effektiv dose	Ekvivalent dos, effektiv dos

COLLECTIVE DOSE. An expression for the total radiation dose incurred by a population, defined as the product of the number of individuals exposed to a source and their average radiation dose. It is expressed in man–sieverts **(man.Sv)**

DK:	FI:	IS:	NO:	SE:
Kollektivdosis	Kollektiivinenannos, väestöannos	Hópálag	Kollektivdose	Kollektivdos

PROJECTED DOSE. The dose to be expected if no protective or remedial action is taken.

DK:	FI:	IS:	NO:	SE:
Forventet dosis	Ennakoitu annos	Væntanleg geislun án aðgerða	Projisert dose	Förväntad dos

AVERTABLE DOSE. The dose to be saved by a protective action; that is, the difference between the dose to be expected with the protective action and that to be expected without it.

DK:	FI:	IS:	NO:	SE:
Undgåelig dosis	Vältetty /vältettävä annos	Geislunarminnkun vegna aðgerða	Spart dose	Avstyrd/avstyrbar dos

RESIDUAL DOSE. The remaining dose from each pathway after implementation of the protective action (projected dose minus averted dose) is called residual dose.

DK:	FI:	IS:	NO:	SE:
Restdosis	Jäännösannos	Væntanleg geislun eftir aðgerðir	Restdose	Resterande dos

EXPOSURE. The act or condition of being subject to irradiation. Exposure can be either external or internal exposure depending on whether the radiation source is outside or inside the body.

DK:	FI:	IS:	NO:	SE:
Bestråling	Altistus	Geislun	Eksponering	Bestrålning

INTERVENTION. Any action intended to reduce or avert exposure or the likelihood of exposure to sources which are not part of a controlled practice or which are out of control as a consequence of an accident.

DK:	FI:	IS:	NO:	SE:
Indgreb	Interventio, torjuntatoimet	Aðgerð	Tiltak	Åtgärder

PROTECTIVE ACTION. An intervention intended to avoid or reduce doses to members of the public in **chronic or emergency** exposure situations.

DK:	FI:	IS:	NO:	SE:
Beskyttelsesforan-staltning	Suojelutoimenpide	Verndunaraðgerð	Tiltak, (beskyttelsestiltak)	Skydds åtgärder

REMEDIAL ACTION. Action taken when a specified action level is exceeded, to reduce radiation doses that might otherwise be received, in an intervention situation involving **chronic exposure**.

DK:	FI:	IS:	NO:	SE:
Afhjælpendeforanstaltning	Korjaava toimi	Gagnaðgerðir	Tiltak	Åtgärd

COUNTERMEASURE. An action aimed at alleviating the consequences of an accident.

DK:	FI:	IS:	NO:	SE:
Modforanstaltning	Vastatoimenpide	Aðgerð	Tiltak, (mottiltak)	Motåtgärd, åtgärd

AGRICULTURAL COUNTERMEASURE. Action taken to reduce contamination of food, agricultural or forestry products before they reach consumers.

DK:	FI:	IS:	NO:	SE:
Landbrugsindgreb	Vastatoimenpide maataloudessa	Gagnaðgerðir i landbúnaði	Landbrukstiltak, tiltak i landbruket	Motåtgärder inom lantbruket

RECOVERY MEASURE. Measures directed towards the return, so far as possible, to pre-accident conditions. Eg. decontamination is both a protective action and a recovery measure.

DK:	FI:	IS:	NO:	SE:
Retableringsforan-staltning	Palauttamistoi-menpide	Endurheimtur	Tiltak	Sanering

INTERVENTION LEVEL. The level of avertable dose at which a specific protective action or remedial action is taken in an **emergency exposure or a chronic exposure** situation.

DK:	FI:	IS:	NO:	SE:
Indgrebsniveau	Vastaoimenpi- detaso	Viðmiðunarmörk fyrir aðgerðir, aðgerðamörk	Tiltaksnivå	Åtgärdsnivå

ACTION LEVEL. The level of dose rate or activity concentration above which remedial actions or protective actions should be carried out in **chronic exposure or emergency exposure** situations.

DK:	FI:	IS:	NO:	SE:
Aktionsniveau	Operatiivinen toimintataso	Aðgerðamörk	Operasjonelle tiltaksnivåer	Åtgärdsnivå

GENERIC INTERVENTION/ACTION LEVEL. It is the first criterion for action to be used immediately and for a short time after the occurrence of an accident. It is based on a generic optimization of protective actions, based on a generic accident scenario calculation in the phase of planning, prior to accidents. Only radiological protection principles are considered, no sociopolitical, psychological or cultural factors are taken into account.

DK:	FI:	IS:	NO:	SE:
Generisk indgrebsniveau, generisk actionsniveau	Yleisperusteinen toimenpidetaso, yleisperusteinen operatiivinen toimintataso	Geislunarleg viðmiðunarmörk	Generiske tiltaksnivåer	Åtgärdsnivå, generisk åtgärdsnivå

SHELTERING. Sheltering refers to staying inside or moving into dwellings or to other buildings, closing doors and windows, and turning off any ventilation systems in order to reduce the dose from inhalation of radioactive material, and to reduce the direct exposure to airborne radionuclides and to shortlived surface deposits.

DK:	FI:	IS:	NO:	SE:
Gå-inden-døre	Sisällesuojautu-minen	Skýling	Innendørsopphold	Inomhusvistelse

EVACUATION. Evacuation is used to refer to the urgent moving of people from their homes, or from places of work or recreation, for a limited period of time (less than a week) in order to avert short-term exposure from an airborne plume or from deposited radioactive material due to an accident.

DK:	FI:	IS:	NO:	SE:
Evakuering	Suojaväistö	Brottflutningur	Evakuering	Utrymning, evakuering

PRECAUTIONARY EVACUATION. Evacuation taken as a precautionary measure before there has been any significant release of radioactive material.

DK:	FI:	IS:	NO:	SE:
Forebyggende evakuering	Valmiusevakuointi, suojaväistö varotoimena	Brottflutningur í varúðarskyni	Evakuering	Utrymning, evakuering

TEMPORARY RECOCATION. Temporary relocation is used to refer to the organized and deliberate removal of people from the area affected by an accident for an extended but limited period of time (typically several months but less than about a year) to avert exposures principally from radioactive material deposited on the ground and from inhalation of any resuspended radioactive particulate material.

DK:	FI:	IS:	NO:	SE:
Foreløbig flytning	Tilapäinen väes-tönsiirto	Tímabundinn brottflutningur	Midlertidig flytting, relokering	Tillfällig omflyttning, omflyttning

PERMANENT RESETTLEMENT. Permanent resettlement is the term used for the deliberate complete removal of people from the contaminated area with no expectation of return.

DK:	FI:	IS:	NO:	SE:
Permanent flytning	Väestön uudelleen-asuttaminen	Varanlegur brottflutningur	Permanent flytting, relokering	Permanent flyttning

CONTAMINATION. The presence of radioactive substances in or on a material or the human body or other place where they are undesirable or could be harmful.

DK:	FI:	IS:	NO:	SE:
Kontaminering, forurening	Kontaminaatio, saastuminen	Mengun, geislamengun	Kontaminering, radioaktiv forurensing	Kontaminering, radioaktiv förorening

DECONTAMINATION. The removal or reduction of contamination in or on materials, persons or the environment.

DK:	FI:	IS:	NO:	SE:
Dekontaminering, rensing, sanering	Puhdistus	Hreinsun	Dekontaminering	Sanering, dekontaminering

DECISION CONFERENCING. Decision conferencing is one of many decision aiding techniques. It is a technique or process which seeks to support a group facing a complex strategic problem.

DK:	FI:	IS:	NO:	SE:
Beslutningekonference	Päätöskonferenssi	Akvartanafundur	Beslutningskonfe-ranse	Beslutskonferens

OBJECTIVE. Objectives are defined to express what is desired to be achieved by the decisions. **Fundamental objectives** concern the ends that decision makers value in a specific decision context. **Means objectives** are methods to achieve ends.

DK:	FI:	IS:	NO:	SE:
Mål, målsætning	Tavoite	Markmið	Mål, målsetninger	Mål, målsetning

ATTRIBUTE. Attributes measure the degree to which the identified objectives are met.

DK:	FI:	IS:	NO:	SE:
Attributt, målepunkt	Attribuutti, kriteeri	Eáttur	Attributt	Attribut, egenskap

TRADE-OFF. Value trade-off indicates how much any change in the level of one attribute is worth in terms of a second attribute.

DK:	FI:	IS:	NO:	SE:
Analyseteknik	Vaihtoarvo			Marginalvist, marginalkostnad

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