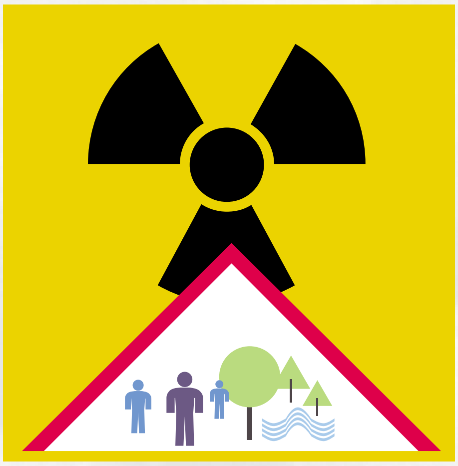
European Commission

Radiation protection 124

Radiological considerations with regard to the remediation of areas affected by lasting radiation exposure as a result of a past or old practice or work activity



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Radiological considerations

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Directorate-General
Environment
2001

Foreword

Title IX of the Basic Safety Standards (Directive 96/29/EURATOM) introduces for the first time provisions applying to intervention in cases of lasting exposure resulting from the after-effects of a radiological emergency or a past or old practice or work activity.

A working party of the Group of Experts established under Article 31 of the Euratom Treaty has prepared guidance with regard to the restoration of areas affected by lasting exposure. This guidance is based on radiological considerations but addresses also different approaches to the incorporation of other factors. Social factors are very important in this context but it is beyond the scope of the present guidance to make recommendations how these should be taken into account by national governments, although these are dealt with in general terms in the overall approach. The present document was approved for publication by the Group of Experts at their meeting in November 2000.

The practical guidance offered in this document is essentially in agreement with international recommendations by ICRP and IAEA but it is oriented towards situations prevailing in the European Union.

The Basic Safety Standards provide the overall framework for implementation in national legislation. The responsibility for the development of an adequate approach is with Member States competent authorities.

Competent authorities of Member States will benefit from the guidance offered by the Group of Experts, and this may contribute to a harmonized approach within the European Union.

S. Kaiser
Head of Unit

Table of Contents:

1. INTRODUCTION AND SCOPE

1) This document addresses the remediation of radioactively contaminated sites in Europe from the viewpoint of practical experience. Council Directive 96/29/Euratom, laying down the basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation (BSS), constitutes its legal framework. This document is intended to supplement documents produced by international bodies such as the ICRP and the IAEA, approaching problems associated with radioactively contaminated sites based on fundamental radiation protection considerations. Considerations and experiences are presented in this document in order to provide guidance for the practical implementation of radiation protection standards. A further goal is to assist responsible organisations in different Member States to apply similar criteria and methodologies if they are faced with comparable situations.

2) As a result of mining activities or industrial processes involving materials with elevated contents of naturally occurring radionuclides (NORMs), areas can become contaminated, giving rise to radiation exposures of people living or working in these areas or in their vicinity. As a result of past or old practices or work activities a large number of such sites exists in Europe.

3) There are also sites contaminated with artificial radionuclides in Europe. Most of these are parts of nuclear installations. Since the clean-up and release from regulatory control of such sites have been dealt with extensively in other publications, these are not considered within the scope of this document. However, to some extent sites have become contaminated with artificial radionuclides outside nuclear facilities through accidents. A radioactive contamination of sites also has been caused by research as well as medical and certain industrial activities. Such sites are considered within the scope this document.

4) Most of the considerations presented in this document are applicable to sites contaminated with artificial or with natural radionuclides. For this reason, the common term contaminated sites is used in the following. However, some differences exist which may affect remediation strategies. An important example is the existence of a natural background. Since within the Member States of the European Union the number and extent of sites contaminated with natural radionuclides dominate by far, the main examples and numerical values in this document are given for this category of sites.

5) Attention and efforts devoted to contaminated sites vary considerably between European countries and even within individual countries. It is desirable, however, to develop common approaches dealing with these problems throughout Europe. This requires the development of a methodological framework suitable for the different situations encountered in the Member States. This document intends to provide a basis for this development.

6) In order to address the radiological exposures and possible remedial action at contaminated sites, suitable methodologies and criteria are required to identify sites of

concern and to determine required intervention measures. The document gives an overview of the radiological problems arising and describes elements of an adequate protection philosophy. General criteria are derived and their practical implementation is discussed. An outline of the whole process encompassing

- the identification of remediation requirements,
- the assessment of the radiological situation,
- the evaluation of remedial measures, and
- the decision-making process

is presented.

7) This document addresses a variety of sites and situations. Accordingly, measures to reduce radiological exposures will vary in nature and extent, ranging from simple passive protective measures to site remediation programmes with large impacts on landscape and population. Depending on the nature of the measures taken, different terminologies, such as “remediation”, “rehabilitation”, or “restoration”, would be appropriate for individual sites. However, a document dealing with such situations on a generic level cannot make a meaningful distinction between these terms. Therefore, this document consistently uses the term “remediation”, meant to address all means allowing a reduction of the exposure of the population. By using this term it is not intended to imply anything about the actual nature and extent of measures taken to achieve this goal.

8) The document addresses past or old practices or work activities; it does not apply to situations still under control of the responsible operator. However, many of the methodologies and techniques presented may also be applicable to such situations.

9) Current work activities or practices, being conducted under strict application of the European BSS, should not give rise to long-term problems of the kind dealt with in this document. Nevertheless, some elements of decisions required in the future may have similarities with situation discussed here. An example could be a change in land-use requiring the assessment of associated risks and possibly decisions about remedial action. In these cases the considerations outlined in this document would be applicable.

10) Some aspects concerning remediation options for sites contaminated with NORMs are discussed further in Appendix A of this document. Throughout the document, the term remediation option is meant in a broad sense, addressing different remediation alternatives for one object as well as remediation strategies, consisting of a set of individual remedial measures, for complex situations.

2. BACKGROUND

11) Title IX of the European Basic Safety Standards Directive (BSS) [EUR 1996] lays down a framework for intervention in cases of lasting exposures in Article 48:

1. This Title shall apply to intervention in cases of radiological emergencies or in cases of lasting exposure resulting from the after-effects of a radiological emergency or a past or old practice or work activity.

2. The implementation and extent of any intervention shall be considered in compliance with the following principles:

- *intervention shall be undertaken only if the reduction in detriment due to radiation is sufficient to justify the harm and costs, including social costs, of the intervention,*
- *the form, scale and duration of the intervention shall be optimised so that the benefit of the reduction in health detriment less the detriment associated with the intervention, will be maximised,*
- *dose limits, as laid down in Articles 9 and 13, shall not apply to intervention; however, the intervention levels established in application of Article 50(2) constitute indications as to the situation in which intervention is appropriate; furthermore in cases of long-term exposure covered by Article 53, the dose limits set out in Article 9 should normally be appropriate for workers involved in interventions.*

12) Article 50 of the BSS requires intervention plans to be set up by the Member States:

2. Each Member State shall ensure that appropriate intervention plans, taking account of the general principles of radiation protection for intervention referred to in Article 48(2) and of the appropriate intervention levels established by the competent authorities, are drawn up at national or local level, including within installations, in order to deal with various types of radiological emergency and that such plans are tested to an appropriate extent at regular intervals.

13) The intervention measures in cases of lasting exposure are outlined in Article 53 of the BSS:

Where the Member States have identified a situation leading to lasting exposure resulting from the after-effects of a radiological emergency or a past practice, they shall, if necessary and to the extent of the exposure risk involved, ensure that:

(a) the area concerned is demarcated;

(b) arrangements for the monitoring of exposure are made;

(c) any appropriate intervention is implemented, taking account of the real characteristics of the situation;

(d) access to or use of the land or buildings situated in the demarcated area is regulated.

14) ICRP states in their Recommendation 60 [ICRP 1990] (Paragraph S14) that

A system of radiological protection should aim to do more good than harm, should call for protection arrangements to maximise net benefits, and should aim to limit the inequity that may arise from a conflict of interests between individuals and society as a whole.

15) This System of Protection for interventions should be based on the following general principles according to ICRP (Paragraph 113 in [ICRP 1990]):

- *The proposed intervention should do more good than harm, i.e. the reduction in detriment resulting from the reduction in dose should be sufficient to justify the* *harm and the costs, including social costs, of the intervention. [Justification of interventions]*

- *The form, scale, and duration of the intervention should be chosen so that the net benefit of the reduction of dose. i.e. the benefit of the reduction in dose less the costs of intervention, should be as large as reasonably achievable. [Optimisation of Protection in interventions]*

According to ICRP (Paragraph 131), the use of dose limits as the basis for deciding on intervention might involve measures that would be out of all proportion to the benefits obtained and would then conflict with the principle of justification. The Commission therefore recommends against the application of dose limits for deciding on the need for, or the scope of, intervention.

16) ICRP provides in Recommendation 82 [ICRP 2000] guidance on the Application of the Commission's System of Protection to prolonged exposure situations. Relevant sources of prolonged exposure include natural radiation sources involving relatively high levels of exposure and the contamination of land by radioactive residues that remain from the operation and decommissioning of practices, past activities conducted under less stringent radiation protection requirements than those applied today, or accidents that had released long-lived radionuclides to the environment. For such situations ICRP considers that an "extant annual dose"[1] of the order of 10 mSv may be used as a generic reference level below which intervention is optional but rarely justifiable (Paragraph 55). Above this level of extant annual dose intervention would be, according to ICRP, probably justifiable, the form, scale and duration of intervention being determined by the case-by-case optimisation of remedial measures (Paragraph 57).

17) The IAEA has published in 1997 clean-up criteria for contaminated land as an interim report for comment [IAEA 1997]. The basic radiation protection principles as recommended by ICRP in Publication 60 have been applied by the IAEA to determine whether clean-up is justified, and to optimise any clean-up actions. To provide some indication of the range of likely results of such analyses, a set of generic criteria – referred to as "clean-up levels" – are proposed, based on general consideration of the justification/optimisation principles of protection, the need to protect individuals, and the acceptability of different levels of risk. For exposures from natural sources, incremental doses in the order of a few mSv per annum, representing normal variations in levels of background radiation, are considered as routinely accepted and not changing people's behaviour. Remediation is considered almost always needed if incremental doses above background are above 10 mSv per annum. For doses between 1 and 10 mSv per annum, clean-up is seen by IAEA as being likely required.

18) The IAEA is currently preparing a Safety Requirement and Safety Guide [IAEA 2000] on the Cleanup of Contaminated Areas in Intervention Situations. The main aim is to develop the objectives of remediation, the related legal and regulatory framework, and

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[1] In ICRP 82 actually the term "existing annual dose" is used, referring to the dose at a given location from all sources of prolonged exposure, including natural background. This concept of basing decisions on the total dose has to be distinguished from the other possible approach to consider only incremental exposures from the contaminated site in question.

the considerations that have to be taken into account when establishing criteria, assessing the situation, selecting strategies, implementing remediation, and verifying compliance with criteria. As important aspects, the decision making process and involvement of the relevant bodies and population are also considered.

19) Details on national policies in several countries developed in the area of contaminated sites are given in [EC 2000].

3. PAST OR OLD PRACTICES AND WORK ACTIVITIES

20) Sites can become contaminated with NORMs as the result of, inter alia, the following industrial activities [EC 2000]:

- uranium mining and milling;
- metal mining and smelting, phosphate industry;
- coal mining and power production from coal;
- oil and gas drilling;
- rare earth and titanium oxide industry;
- zirconium and ceramics industry;
- application of radium and thorium.

21) Sites can become contaminated with artificial radionuclides outside nuclear installations mainly by the following causes:

- contamination of off-site areas in the course of nuclear accidents,
- use of artificial radionuclides in research and medical facilities,
- manufacturing, use, and deposition of radioactive sources, smoke detectors etc.

22) Numerous sites exist throughout Europe with levels of NORMs elevated above normal background. In most cases, activity concentrations are moderate, with values in the order of 1 Bq/g for each radionuclide of the ^{238}U decay chain and usually lower activities of the nuclides of the ^{232}Th decay chain. Nevertheless, such sites may give rise to significant individual and collective doses because of the large volume of material typically involved. In some cases, such as residues from uranium mining and milling, activity concentrations of these nuclides can be in the order of 10 Bq/g or even higher. Some particular materials, such as scales from oil and gas drilling and sludges from certain metallurgical processes, arising only in small quantities, however, may have activity concentrations in the order of 100 Bq/g for all or some of these nuclides.

23) Inventories of radiologically relevant sites have been set up for certain areas and certain industries. However, a complete overview of sites and contamination levels in Europe does not exist. In many cases available information is limited, so that extensive characterisation work is required before systematic inventories can be prepared.

24) Relevant radiological exposures usually arise through several pathways. Most important are, in general:

- inhalation of radon gas and its progeny;

- inhalation of contaminated dust;
- drinking of contaminated water;
- ingestion of contaminated foodstuff;
- direct ingestion of contaminated soil (e.g. by playing children);
- external irradiation.

25) The relative importance of these pathways as well as the absolute value of radiological exposures are highly dependent on site conditions such as land-use, meteorological and topographic conditions, and hydrological factors. Realistic dose estimates, therefore, should be based upon site-specific analyses. Generic screening-level assessments can also be useful, in particular when dealing with large numbers of sites. However, limitations associated with the level of assessment performed always have to be borne in mind when interpreting the results and deriving conclusions. This becomes particularly important when decisions about remedial activities, usually requiring substantial financial expenditures, are to be made. This aspect, being of great practical importance, is discussed further in Section 5.

26) Doses to people living in the vicinity of such sites in most cases do not exceed 10 mSv per annum. But since many of the industrial activities giving rise to elevated levels of NORMs have been and still are taking place in or near population centres, the number of people exposed can be quite large.

4. PROTECTION PHILOSOPHY

4.1 General Aspects

27) The remediation of sites from past or old practices and work activities is governed by the radiation protection principles for intervention in cases of lasting exposure outlined in Section 2. However, there are situations for which the categorisation as intervention or practice is not straightforward. Examples are contaminated areas no longer owned by the organisation which has caused the contamination, being considered for release into the public area, or new activities commencing on sites still contaminated from past activities. Dealing with such situations can involve substantial problems, including difficulties to gain public acceptance, if the remediation requirements resulting from treating the situation as a practice or intervention are very different from each other. This aspect should be considered when setting up approaches and criteria for the remediation of contaminated sites.

28) As stated by the BSS in Article 48, for workers involved in the remedial activities the dose limits set out in Article 9 of the BSS for exposed workers should normally be appropriate.

29) The assessment of radiological impacts originating from contaminated sites and of possible remedial measures represents a complex problem. Often, many people are exposed through different pathways. Remedial activities will give rise to additional doses to workers and public and involve substantial financial efforts. In this situation, a

thorough assessment methodology is required, which can ensure a sufficient level of protection and, at the same time, take account of economic and social aspects.

30) The intervention measures must aim, above all, to maximise the net benefit from the intervention within an optimisation process. The development of remediation concepts therefore requires a methodology for the assessment of the overall radiological impact from the site or sites in question, if necessary the identification of options for reducing these impacts, the evaluation of the achievable dose reduction, and the assessment of harm and costs associated with these remediation options. Decisions taken on this basis then involve many considerations, including benefits from dose reductions, financial expenditures required and other factors of influence.

31) Contaminated sites addressed in this document usually give rise not only to radiological risks but also potentially impact on humans and the environment by the release of non-radiological hazardous substances. Therefore, benefits from remedial measures are not confined to the reduction of radiological risks alone. On the other hand, detriments associated with the remedial actions reach beyond financial expenditures and extend, for example, to additional risks, ecological damage or social problems associated with reclamation activities. Decision-making in this situation has to consider all these factors in an adequate manner. This document, therefore, uses the terms ‘cost’ and ‘benefit’ in a broad sense, incorporating all advantages and disadvantages arising from certain situations or associated with certain measures.

4.2 Action Levels

32) The optimisation process does not necessarily lead to compliance with the other important goal of radiation protection, to limit inequity potentially resulting from a conflict of interest between individuals and society as a whole. Such conflict could arise, for example, in a situation where high doses from a site are delivered only to a few individuals, so that, based on pure optimisation, a remediation does not appear to be justified. In this situation, there is a collision between the interest of society to save money and other resources and the interest of the few exposed individuals to be protected irrespective of their number. Applying equity considerations in such situations requires consideration of maximum individual doses within the decision-making process.

33) Applying such constraints to the process of defining remediation requirements and choosing a remediation option essentially means to define an Action Level in terms of individual dose, above which measures to reduce exposures are usually considered necessary. This approach is consistent with Article 48(2) of the BSS, stating that dose limits for exposed workers and general public (Art. 9 and 13 of the BSS) do not apply to intervention but interventions levels (Art. 50(2) of the BSS) constitute indications as to the situations in which interventions are appropriate. The identification of remediation requirements based upon maximum individual doses is also in agreement with the current thinking of the ICRP and IAEA.

34) The main reason of ICRP against using dose limits for practices when deciding on intervention measures is the concern that measures could result which are out of all proportion to the benefits obtained. This could also hold for Action Levels based on individual doses. Therefore, the decision-making process should be structured in a way that exceeding an Action Level does not automatically trigger site remediation programmes or other costly action. Instead, an analysis of the situation and of possible countermeasures should be initiated when Action Levels are exceeded. Physical measures should only be taken in a subsequent step following an analysis of the problem and possible solutions. This requires a two-step process discussed in more detail in the following section.

35) The site remediation and/or land-use controls should aim at reducing critical group doses significantly below the Action Levels. This will usually represent a boundary condition for the optimisation process, i.e. options or combinations of options not achieving this goal would be excluded from further consideration. However, depending on cost-benefit ratios of the available options and other factors, a possible outcome of the optimisation step can be not to carry out any remediation at all. But this decision would only be made after a detailed analysis of all relevant factors of influence.

36) There are several possibilities for the derivation of numerical values of the Action Levels. One approach is to consider exposures to natural radionuclides in general (including radon in houses) and to base Action Levels on variations of this overall natural background and on people's willingness to accept these. This leads to Action Levels in the order of 10 mSv per annum, which is broadly consistent with recent proposals from ICRP and IAEA. It has to be noted, however, that ICRP and IAEA both leave the possibility open that remedial activities are undertaken at lower doses, if they are justified.

37) Dealing with only a sector of the whole area of exposure to NORMs, e.g. sites contaminated from industrial and mining activities, leaves the possibility to derive Action Levels only based on considerations for this sector, which may yield different figures. When they refer only to the incremental dose they may be significantly lower than previously defined Action Levels for the total dose. In the case of Germany, an Action Level of 1 mSv per annum for the incremental dose caused by contaminated sites is used on the basis of such considerations, being numerically identical to the dose limit for practices in the BSS. An important advantage of this approach lies in the fact that the public acceptance usually can be achieved more easily than for the use of different criteria. A further motivation for using the same criteria as the dose limit in the BSS arises from the practical difficulty in some cases to decide whether a given situation has to be seen as an intervention or a practice (see Paragraph 27). Using the same numerical values, however, does not mean that the same requirements for the demonstration of compliance with the criteria are to be used. This aspect is discussed further in the following section.

4.3 Basis of Risk Assessments

38) Although frequently radiation protection may be the driving force for considering remedial measures, in most practical cases the impacts of remediation, in terms of benefits and detriments, reach far beyond radiological risks. Former industrial and mining activities giving rise to radiologically relevant site contaminations in most cases will also have lead to a contamination with chemically toxic substances, threatening human health as well as ecosystems. The assessment of remediation options therefore must be undertaken on a much broader basis than radiation protection alone, incorporating all relevant aspects into the decision-making process. In cases where other risk components than radiological risks are relevant, it would be desirable to perform integrated assessments on the basis of unified risk approaches. The protection philosophy should then aim at the reduction of overall risks instead of focussing on radiological risks alone.

39) Exposure conditions may change over time due to physical or chemical processes (e.g. degradation of covers or other barriers, geochemical processes altering source terms or groundwater migration properties). If such factors are relevant for the site(s) in question, it will be necessary to consider potential exposures in the dose assessment based on estimates of the effects of these processes on source term, contaminant migration or exposure parameters. In particular long-term assessments of this kind can involve substantial uncertainties, which should be adequately considered in the analysis.

40) Changes in exposure compared to the current situation may also be caused by a different land-use at some point in the future. To incorporate changes of land-use into the analysis it may be required to define hypothetical critical groups. If, however, doses are compared to Action Levels only on the basis of the current situation it may be necessary to perform a new analysis if the land-use is to be changed in the future.

41) Given the long half-lives of the relevant natural radionuclides, it is apparent that hazards associated with sites contaminated with NORMs can extend for very long-time scales. Uncertainties about future developments, however, limit time periods for meaningful quantitative assessments. When collective doses are used as an input into the decision making process, ICRP guidance in Recommendation No. 77 [ICRP 1998] should be considered, stating that *forecasts of collective dose over times longer than several thousand years and forecasts of health detriments over times longer than several hundred years should be examined critically.*

42) In cases where radionuclides are released into the atmosphere or surface waters, radiological impacts from a site can, in principle, extend over large distances. Because of natural dilution, however, associated doses rapidly become very small. When collective doses are used within the decision-making process they should be presented in individual dose rate bands. It is particularly useful to present separately the fraction of the collective dose that is delivered at levels of individual dose rate below those commonly regarded as trivial, ~10 microSievert per year. Such doses represent trivial individual risks and could be weighted differently to higher doses in the

decision-making process. This is consistent with ICRP recommendations in Publication 77.

4.4 Goals of remediation

43) Ideally, the reduction of exposures should be achieved by removing contaminated material from the site, leaving only the natural background behind. In this case, no further use restrictions are necessary. However, in many cases this will not be possible:

- Removing all contaminated material may be neither technically feasible nor economically sound. In this case, the existence of residual radioactive material on the site may require restriction on land-use after completion of the remediation programme (e.g. restriction on the use of groundwater in case of contaminant plumes in the ground).
- Contaminated wastes arising from the remediation process such as waste rock or tailings from mining and milling operations, excavated soils or building rubble have to be managed safely. However, solutions requiring no further above ground restrictions like deep geologic disposal are usually too costly for large volumes of low-level wastes. Therefore, near-surface waste management facilities have to be used in many cases, usually requiring ongoing activities (e.g. surveillance and, if necessary, maintenance of barriers) as well as long-term restrictions on land-use (e.g. prevention of building houses or other burrowing activities that could affect the integrity of covers).

In both cases, some degree of long-term institutional controls may be necessary, being the total of all long-term measures and restrictions which are required to ensure that the protection objectives of the site remediation program will be met in the future. Institutional controls can only be expected to work if their scope and purpose is adequately documented and if a competent entity is assigned the responsibility for their enforcement.

44) The goals of the institutional control are

- the protection of people against residual exposures and
- the protection of structures (e.g. covers) against damage caused by human activities (e.g. building of roads) or natural processes (e.g. erosion).

Elements of institutional controls are passive measures like record-keeping and land-use restrictions and active measures like monitoring and surveillance.

45) As a part of the planning and decision-making process it is required to balance the extent and costs of remedial measures with the remaining long-term restrictions and requirements. Since usually more extensive and expensive remedial measures will reduce long-term requirements, such decisions should be part of the optimisation of the overall concept.

46) A particular situation can arise in the case of a nuclear accident. If large areas have become contaminated, the removal of the contamination may not be feasible or at least

take a long-time. In this case, the only viable option to reduce radiological exposures may be to restrict access to certain areas and of certain resources such as groundwater. It may also be necessary to define criteria for contaminant concentrations in foodstuff in terms of intervention/action levels. Such measures may be of a short or long-term nature. In any case, the approaches outlined in this document can be and should be applied to such situations in order to find an optimal solution.

47) In accordance with Article 53 of the BSS, arrangements for the monitoring of exposures should be made for those cases where significant radiological impacts are present, but remedial action has not yet been initiated. Depending on the actual doses, interim measures like restricting access to or use of the land are required. The results of the exposure monitoring should be used as a basis for deciding about priorities of remedial measures. After the completion of a remediation programme it may also be necessary to monitor exposures in order to verify the success of the programme and to identify potential problems. The extent and duration of the monitoring program should be adequate to the potential hazards from the site(s).

5. ASSESSMENT OF IMPACTS

5.1 General Process using Action Levels

48) The protection philosophy outlined in the previous section results in a two-step process, being compliant with the fundamental radiation protection principles and practicable at the same time:

- The identification of principal remediation requirements is performed on the basis of Action Levels. These are defined in terms of individual doses for the critical group at each site above which remedial action normally is required. Based on this relatively easily accessible quantity all sites can be excluded from further consideration which do not impose a significant radiological impact on any critical group and thus, by definition, on the population as such. No decisions are made on this screening level, except to investigate those sites further which cannot be excluded as radiologically irrelevant.
- In the second assessment step, only those sites with critical group doses above the Action Level are considered. For these sites, detailed assessments of population dose distributions and options for their reduction are performed. In the case of homogeneous site conditions it may also be possible to perform a generic optimisation, reducing the extent of actual site specific assessments required [EC 2000]. The assessment efforts should, in any case, be adequate to the radiological importance of the site(s) in question. All actual decisions about remedial measures should be based on the optimisation principle.

Decisions involving actual remedial measures will only be taken within the second step of this process and thus will not be based on individual dose considerations alone. This avoids potentially unreasonable measures which could result from basing decisions only on Action Levels (see Paragraph 34).

49) As discussed in Paragraph 37, some countries such as Germany use the same numerical value for the Action Level in the context of sites contaminated with NORMs as prescribed for practices in the BSS. However, this should not necessarily lead to applying the same assessment procedures as for practices, which are performed within a very conservative framework in some countries. Applying too conservative assumptions to intervention situations can lead to unrealistic assessments of the situation and, as a potential consequence, to decisions for measures which are disproportional to the actual risks to the population. This can only be avoided by attempting to assess risks as realistically as possible, still prudently retaining some conservative elements, though, to make sure that all exposure conditions that reasonably have to be assumed to occur are covered by the assessments.

50) The degree of conservatism of dose assessments will not necessarily be identical in the two steps of the overall process described above. Comparing critical group doses against an Action Level requires to consider living conditions and behaviours of the critical group giving rise to the highest doses. As an example, if at a site groundwater is contaminated and the possibility of the use of drinking water wells cannot be excluded, the resulting doses have to be considered in the dose assessments for the critical group. However, if the second step of the optimisation analysis is based on collective doses, results are dominated by average living conditions and behaviours. This could mean in the above example, that the groundwater pathway can be excluded from the collective dose assessment if only a small percentage of the population is concerned. Since in practical cases the difference between highest and average doses can be very substantial, it is important to clearly distinguish between different purposes of dose assessments in the overall process.

51) If people are exposed from different sites, the combined impacts of these sites have to be used in comparing doses to Action Levels. Usually, decision-making about remediation should be performed within an overall concept in these cases, ensuring that optimal solutions for the whole situation are found.

5.2 Practical Implementation of Action Levels and Optimisation

52) Action Levels as defined in the previous sections are expressed in terms of annual individual doses (critical group) below which action is normally not required. They can either address the total dose or they can be formulated only to cover the incremental dose above background caused by a contaminated site.

53) It may be desirable to convert Action Levels into criteria for activity concentrations, which can be more easily applied. This conversion requires the use of a radioecological model, relating the activity concentration in certain media (e.g. soil) to doses incurred at this contamination level.

54) An example for successfully performing the conversion of Action Levels into activity concentrations is given by the German criteria for contaminated areas in the uranium mining districts addressing the incremental dose above background caused by the

contaminated areas (see [EC 2000]). Criteria derived for the activity concentrations are only valid for relatively simple cases (small areas contaminated only with ore and waste rock, i.e. no chemically modified material like tailings from uranium extraction). Despite these restrictions, these criteria have proven to be very useful in practice, because an assessment of a large number of small contaminated areas has been possible on this basis, reducing substantially the overall assessment efforts required.

55) If site factors determining the actual radiation exposure and the potential and costs for dose reductions do not vary too much, it may be possible to perform a generic optimisation. The results can be used as screening criteria, expressed, for example, in terms of a representative activity concentration at a site, giving a first indication at which sites certain types of remedial action appear to have a favourable cost/benefit ratio. However, these generic results should never be used as an immediate basis for decisions involving actual measures, because of unnecessary elements of conservatism potentially involved on the generic level and since possibly important specific site factors have not been considered. The actual planning of these measures should only be based on a subsequent site-specific analysis of sufficient depth. A comprehensive discussion of a general approach for using Optimised Action Levels based on a generic optimisation is presented in [EC 2000].

56) At complex sites a variety of different material with different contamination levels will be present. In this situation, the definition of a representative activity concentration will be difficult and the doses incurred will depend on many additional site factors and not only the activity concentration alone. Remediation objectives, for example in terms of operational quantities such as residual contamination permitted, design of waste management facilities etc. should only be derived on the basis of a site-specific optimisation process.

5.3 Elements of Risk Assessments

57) The assessment of radiation exposures originating from sites contaminated with NORMs raises several problems, because different pathways, complex exposure situations with many factors of influence and, in many cases, large groups of people are involved. Even an assessment of critical group doses alone, not being confronted with the latter problem, usually requires substantial efforts in terms of site data acquisition and radioecological modelling. It is therefore highly desirable to develop standardised procedures (models, parameters) for cases where large numbers of sites have to be addressed.

58) Applying generic approaches, however, it must always be borne in mind that actual doses may differ substantially from such screening results because of particular site-specific factors. Therefore, such generic assessments have to incorporate sufficient elements of conservatism in order not to underestimate doses at some sites. As a consequence, decisions resulting in significant financial expenditures should not be taken on this screening basis, unless it is ensured that the potential over-estimation of doses cannot lead to unjustified measures. This is in accordance with Article 51(4) of

the BSS stating that the real characteristics of the situation should be taken into account when deciding about intervention measures.

59) At least for complex sites, a comprehensive analysis employing site-specific modelling will be necessary for the following reasons:

- In order to develop optimal remediation concepts it is necessary to identify the contaminant sources of concern and to determine their individual impact on the population. Since measurements can only provide integral results for the combined exposure from all sources, modelling is required to disentangle contributions from individual sources.
- Many processes relevant for exposures from contaminated sites only proceed slowly. Examples are the geochemical evolution of waste material properties (e.g. acidification of mining wastes), the groundwater migration of contaminants and the erosion of cover material. Future exposures can only be assessed on the basis of an evaluation of the impact of such processes, usually requiring modelling.
- An optimisation analysis has to be based upon the prediction of the possible reduction of exposures within each available remediation option. This projection usually requires the use of appropriate models.

60) Since model results can be crucial within the overall assessment process, the choice of adequate models is essential. Also, the input data for the models have to be collected and evaluated carefully. Most importantly, it should be attempted to validate the models used to the extent possible by comparing their results to actual measurements. If several sites are in close vicinity to each other, it will usually be required to perform the modelling for the overall situation, because models developed for only a segment of the whole situation cannot be validated.

61) As stated in Paragraph 41, assessment should not be carried out beyond time periods in the order of a few hundred years (see Paragraph 69), because dose estimates after this time period become increasingly meaningless. Even within this restricted assessment period important sources of uncertainties are present:

- Models will never represent reality in total. Particular limitations are to be expected in connection with screening level models.
- Many input parameters for predictive models are uncertain because of unavoidable limitations of site characterisation.
- Several important factors may change in the future. Examples are land-use, population density, living habits, climatic conditions. In addition, events like floods or earthquakes may take place which can alter exposure conditions substantially. The lack of knowledge about the occurrence of such changes in site factors leads to uncertainties of the assessment results, which usually increase with time.

62) In view of the considerable extent of uncertainties involved, it is important to appropriately address them within the assessment process. On a screening level, this is usually done by using conservative estimates for parameters that are subject to uncertainties. Within a more detailed, site-specific assessment it is possible to keep

track of uncertainties in a consistent fashion by using probabilistic methods. This is particularly advantageous in complex situations. If, for example, a certain risk is determined by a large number of parameters, setting all these parameters very conservatively results in modelling cases of a very small probability. This would become apparent in a probabilistic analysis, so that over-conservative assessments can be avoided.

63) It is also possible, to consider potential exposures consistently in a probabilistic assessment by taking the potential doses and their probabilities of occurrence into account. In a deterministic analysis, the product of these two quantities can be used as a measure for the potential exposure [IAEA 1994]. However, this approach should not result in neglecting potentially high exposures in the decision-making process only on the grounds that their probability of occurrence is small. This is consistent with the view expressed by ICRP [ICRP 1985] (Paragraph 80) that expectation values alone are not a useful basis for decisions on optimisation of protection involving low probability events.[2] In a probabilistic analysis this problem does not arise because the dose and its probability are treated separately.

6. PROPOSED APPROACH FOR THE APPLICATION OF PROTECTION PHILOSOPHY

64) Optimising remedial measures requires in the first step to identify alternatives (including the do-nothing option). The selection will be, in many cases, constrained by boundary conditions which remedial activities have to meet. An example is the aim to reduce critical group doses to values below the Action Level (see Section 4.2). Additional requirements usually will arise from other areas, such as the protection of surface or groundwater or ecosystems. Only remediation strategies (combination of remediation options for a site) meeting these minimum requirements are to be considered in the comparative optimisation analysis. Possibly, the do-nothing option has to be excluded at this stage already because minimum requirements are not met.

65) An overview of the remediation of sites contaminated with NORMs is given in Appendix A. The practically most important remediation technique is the capping of contaminated wastes on-site or after relocation to a waste management facility. This may be supported by a pre-treatment of wastes either to extract valuable contents or to alter their chemical or physical properties. Especially as an intermediate measure the use of land-use restrictions also has to be mentioned. The costs of these different options and their long-term efficiency are discussed in Appendix A.

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[2] The latest ICRP Recommendation [ICRP 2000] on the subject of potential exposures states (paragraphs 77 and 78) that in the case of sparsely distributed hot particles the situation should be assessed on the basis of the expectation value, i.e. by combining the probability of incurring a dose with the probability of death associated with that dose. For cases of low probability events having widespread radiation consequences, however, reference is made to the broad consideration of this issue in ICRP Recommendations [ICRP 1985] and [ICRP1990]. The above statement from [ICRP 1985], therefore, is still consistent with the current thinking of ICRP.

66) An optimisation analysis should consider the following factors of influence:

- radiological and non-radiological impacts;
- long-term requirements for monitoring;
- restriction on future use of property or affected water supplied;
- costs of the various alternatives; and
- socio-economic impacts including public acceptance (important factors are anxiety, disruption, and economic prospects of using a site).

The assessments performed have to take account of the residual activity at the site and the waste management facilities.

67) A thorough optimisation analysis can only be performed if all relevant aspects are considered. As outlined above, non-radiological factors can be very important as well. Restricting the optimisation analysis only to a part of the problem, e.g. the radiological issues, might lead to inappropriate decisions in such cases. This emphasises the importance of integrated approaches.

68) In general, there are two possibilities to carry out an optimisation analysis:

- The relevant aspects can be evaluated and compared with each other on the basis of qualitative procedures based on judgement and stakeholders deliberation. This approach, of course, does not preclude the use of quantitative scales for some or all parameters involved, but eventual decisions are not based upon mathematical techniques.

- The other alternative is to express all benefits and detriments quantitatively and then to aggregate them into a single quantity by applying mathematical optimisation techniques.

69) If quantitative optimisation approaches are to be applied, different mathematical techniques can be used (see for example [ICRP 1989]). A cost-benefit analysis (CBA) is a widely used approach. If this technique is to be used the following aspects need to be defined:

- the time period over which the radiological doses and other impacts are to be integrated (taking account of the time over which meaningful predictions are possible, not exceeding the order of some hundred years according to the above discussion, see Paragraph 41);
- the spatial cut-off point within which impacts are considered (see Paragraph 42);
- the monetary value of a reduction of risks to humans and environmental damage (for radiological risks, this is the monetary value of the unit collective dose)[3].

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[3] Values used in some countries for the monetary value of avoiding a unit collective dose are in the order of 100.000 €/Sv

70) If qualitative factors such as socio-economic impacts are to be included into the quantitative analysis, different mathematical approaches such as a multi-attribute utility analysis (MAUA) or a multi-criteria outranking analysis can be applied. To the extent that quantitative comparisons of options are made, definitions of trade-offs between different factors of influence are required in analogy to a CBA. It is therefore also possible to use an extended CBA as a mathematically equivalent method to MAUA.

7. DECISION-MAKING PROCESS

71) The decision-making process should be based upon a complete analysis of the situation and an assessment of available remediation options of a sufficient depth. According to the previous section, this analysis can be carried out in a qualitative manner involving judgement of the relevant factors or by employing quantitative techniques such as CBA or MAUA. If a quantitative analysis has been performed, the results should not to be considered as a substitute but rather as an aid for the decision-making process.

72) In particular at complex sites, requiring extensive and costly remedial measures, with a potential of beneficial new uses of the site, the decision-making process is governed by numerous considerations, among which radiation risks play an important, but not necessarily a central role. In this situation, the involvement of the stakeholders (public authorities, elected representatives, experts, real estate owners, industry, environmental groups, etc.) into the decision-making process becomes very important (see [IPSN 2000]). The type and extent of consultation will depend on factors like risks prevailing or at least perceived by the public, technical complexity of the remediation, economic relevance and public interest in general. Furthermore, the legal framework may prescribe certain mechanisms for stakeholders involvement.

73) The stakeholder involvement may be faced with a variety of different views and interests, for example when the radiological impact affects several subgroups of the population at different degrees. Within the discussion with the stakeholders, social and economical considerations such as the prospects opened by changing the use of the site may play an important role to reach an agreement amongst the stakeholders as to which remediation option should be adopted.

74) In the discussion process with stakeholders, it is necessary to create conditions in which the stakeholders can express their views and interests based on a proper knowledge of the facts. They must therefore be given the means to appreciate the various components involved. In particular, the public consultation process should not be based upon a presentation only of the remedial measure which appears as optimal, but rather a set of options should be presented for discussion. The role of technical experts in this process is to enable the stakeholders to form their own judgement on the various alternative remedial measures. This requires to present and explain results on the efficiency of the options to reduce risks, financial expenditures required, nuisances associated with the remedial action and other relevant factors. Hypotheses made and remaining uncertainties in the risk assessment should be explained and their significance for the results should be indicated. Decision will result in this approach from an iterative,

analytic-deliberative process [NRC 1996], which may, but does not have to, be supported by the use of quantitative optimisation techniques.

75) The discussion process with the stakeholders will aim at identifying a remediation strategy which

- provides a level of protection deemed acceptable by the responsible authorities and the concerned population;
- takes into account the preferences of the local population in terms of economic and social redeployment and the cultural characteristics of the community concerned;
- makes restrictions on land-use after completion of the remediation appear acceptable to the local population in the light of the prospects that are opened up;
- is deemed acceptable to the population concerned in view of the nuisances caused by the implementation of the remedial measures;
- is compatible with an efficient allocation of national and local financial resources.

The discussion process should be managed in a way to enable the stakeholders to indicate the remedial measure (and often the use of the site) that they are ready to accept. In this context, the close association between residual risks and the use of the site should be made transparent to the public. The preferred solution results from a compromise taking into account various factors depending on the specific context.

76) If mathematical techniques are used for the comparison of remedial measures, the end result of this stakeholder involvement process can be different from the quantitative results. Even in this case, however, the quantitative analysis brings a valuable input for the deliberative process.

8. CONCLUSION

77) A two-step approach is recommended for the assessment of radiation exposures originating from sites contaminated with NORMs. Firstly, in a screening step using Action Levels, all sites are eliminated from further consideration which only give rise to individual doses below the Action Level. Secondly, in the assessment phase, the relevant sites are investigated in more detail. Available remediation strategies, including the do-nothing option, are compared with each other. Only those options which are compatible with minimum requirements defined by radiation protection criteria or other environmental standards should be considered.

78) For the first screening step, an Action Level based on the individual dose arising from a site is recommended. ICRP and IAEA recommend Action Levels in the order of 10 mSv per annum for the total dose. In Germany, an Action Level, referring only to the incremental dose above background, of 1 mSv per annum for sites contaminated with natural radionuclides is considered appropriate. Other countries may choose, according to their specific situation, different values.

79) Within the subsequent optimisation step decisions about actual remedial measures are derived. The aim is to achieve a reasonable balance between benefits and detriments that is acceptable to all stakeholders. An additional goal may be to reduce critical group doses to values well below the Action Level.

80) Optimisation considerations to determine the most appropriate remediation strategy can be carried out using different mathematical frameworks (cost-benefit analysis or multi-attribute utility analysis) or on a more judgemental basis. The application of quantitative methods requires the definition of trade-offs between different components, such as the monetary equivalent of avoiding a unit collective dose. In either approach, stakeholders should be involved into the eventual decision-making process.

81) Dose assessments should not be carried out beyond time ranges of up to a few hundred years, as estimates beyond this time period are very uncertain and usually will not represent a meaningful basis for decision-making.

82) Decision-making about site remediation usually will have to consider other factors of influence beyond radiation protection. Examples are the protection of water bodies or ecosystems. It is desirable to integrate all relevant factors, technical as well as social and economical, into the decision-making process in a consistent manner.

83) In order to assist the concrete implementation of such assessment programs in the Member States, a further development of the outlined methodology would be beneficial. A key issue of further developments should be the comparison (benchmarking) and harmonisation of models and parameters used in particular for generic assessments. Furthermore, the development of optimisation methods with particular emphasis on approaches for the definition of trade-offs between different components should be addressed. Another important area requiring further consideration are interactive processes allowing for the involvement of the stakeholders in the assessment of remediation strategies.

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Appendix A

Remediation of sites contaminated with NORMs

Remediation options for sites contaminated with NORMs are, in principle, not different from those for chemically contaminated sites. Main objectives of the remediation activities are:

- The release of contaminants from the site via aerial and aquatic pathways should be reduced.
- Exposures arising from soil ingestion and external irradiation when accessing the site or its vicinity should be reduced, if the access is not prevented by land use controls.
- If the site is to be used for agricultural purposes, exposures arising from the consumption of the produced foodstuff have to be considered.

<u>Possible remediation options</u>

The objectives outlined above can be achieved by a variety of remediation techniques:

- A common method to reduce contaminant releases as well as on-site exposures is the capping of contaminated wastes. Possible cover designs range from simple one layer covers of a certain thickness to sophisticated multi-layer covers. In the latter case, each layer serves a particular purpose. Examples are low permeability sealing layers, water storage layers, capillary breaks, biointrusion barriers, surface erosion reducing layers, and vegetation layers. Each of these layers has specific design requirements in terms of thickness, material properties and construction methods (e.g. compaction requirements). The overall design of a multi-layer cover has to be based on a detailed analysis of specific requirements for the cover, the function of individual layers and the interdependence between the different cover components. Within this analysis, it is crucial to take appropriate account of boundary conditions at the site under consideration. Examples of important site factors to be considered are the average and expected extremes of the local climate, the potential for biointrusion and the local availability of cover materials satisfying the design specifications.
- A principal alternative to covering contaminated wastes in-situ is their excavation and relocation to another site. This option has advantages in particular if the amount of contaminated material present on the site is relatively small or if the site is located in unfavourable surroundings such as densely populated areas. The site receiving the material can be an existing or a newly created waste management area (e.g. landfill), where the wastes usually will be covered in analogy to the in-situ remediation option. For small volumes it may also be feasible to use underground mines for the deposition of the excavated material.
- In some cases, the processing of the contaminated material may be possible in order to extract valuable contents. However, this option will be limited to special wastes, for example from mining activities, containing exploitable concentrations of precious metals or certain trace elements. Such operations should only be considered based on a comprehensive cost/benefit analysis taking account of profits from selling the valuable

contents as well as costs and other detriments from the extraction process. A particularly important aspect is the change in waste characteristics caused by the extraction process, which can have a substantial impact on management options for the residual wastes.

- Another purpose of the processing of contaminated materials can be the extraction of hazardous contents in order to reduce the volume of contaminated wastes. This option will only be advantageous if the residual material can be re-used or deposited of without or at least with less stringent radiological precautions than the original wastes. Furthermore, options for the deposition of the concentrated waste stream must be available. As in the previous case, a comprehensive analysis of costs and benefits should be performed before implementing this option.
- A related possibility is the pre-treatment of wastes, which can consist in an alteration of chemical or physical waste properties. Examples are mixing of lime into the wastes to raise the pH and thus decrease the mobility of contaminants such as heavy metals, the mineralisation of the wastes using phosphoric acid, reducing contaminant leachability, or the vitrification of wastes. Pre-treatment is usually only feasible, if the wastes are excavated and relocated to a disposal facility, but in some cases in-situ treatments of wastes have been performed (e.g. in-situ vitrification).

- An option which is considered in many cases as an interim or even a permanent solution is to not carry out any remedial action. Protection of the public will then usually require land-use controls such as restrictions of access or use of the land for dwelling purposes, monitoring and possibly closing of water supplies etc. At least as a long-term solution this option should only be adopted after a comprehensive analysis demonstrating the social and economic acceptability of the imposed land-use controls. It also has to made certain that no significant spread of the contamination from the site with wind or water can occur, which could aggravate the problems in the long-term.

<u>Costs for remediation options</u>

Costs for implementing these options vary considerably depending on site and waste characteristic as well as on legal boundary conditions and socio-economic factors. Therefore, only approximate ranges can be given here, indicating typical costs for large scale operations:

- The costs for covering wastes depend on the complexity of the cover, the amount of material required, the material specifications, and the local availability of suitable material. Typical costs range from 10 to 100 € per m^2 of surface area.

- The main cost parameters for a relocation of wastes are the distance to the new disposal site and the expenditures associated with this new site. The latter cost component can range from marginal expenditures for example in cases of existing and easily available waste dumps to costs of a few 100 €/m^3. Such high costs arise, for example, if special landfills for hazardous materials or underground disposal facilities have to be used, which may be necessary because of non-radiological hazardous constituents. The costs for the relocation of the wastes obviously depend on the distance. For large scale operations and small distances these will be in the order of a few €/m^3.

- The processing of wastes in order to extract valuable constituents or to concentrate hazardous components can be very expensive. This option will be economically viable only if at least a portion of the costs can be recovered by selling extracted contents of value or if the advantage of the volume reduction of the hazardous fraction of the wastes is substantial. Typical costs will be in the order of tens or hundreds of €/m^3.

- The pre-treatment of wastes similarly con involve substantial costs. The range is very wide depending on the chemical or physical waste properties to be changed. Simple measures such as the adding of lime to adjust the pH will require only moderate expenses, while more complex processes can incur substantial expenditures with a similar range as for the processing option.

- Direct clean-up costs do not arise for the no-remediation option. However, land use restrictions may require enforcement. Furthermore, the closing of water supplies may incur substitution costs for supplies from other sources. In addition to such cost components, economic losses may result from the restrictions of land-use.

Within all options it may be required to extend measures like surveillance and monitoring into the future. To a certain extent it may also be necessary to repair containment structures like covers. These long-term cost components also should be carefully analysed before making decisions about remediation options.

Efficiency and durability of remedial measures

The efficiency and durability of remedial measures depends on site factors and waste parameters. In general, the following statements can be made:

- The efficiency of a cover depends on its design. It is relatively easily possible to efficiently reduce exposures caused by contaminated dust and by external irradiation by just adding a relatively thin layer of any material. The radon exhalation rate can only be reduced substantially by low permeability cover materials of appropriate thickness. Requirements for a reduction of water infiltration are usually even higher. Depending on site hydrology, sophisticated cover designs using for example sealing and storage layers may be required. The long-term evolution of the cover performance is also design dependant. Simple covers are only threatened by a possible erosion of cover material, which is visible and can be reduced by appropriate design features such as flat slopes, run-off management and vegetation. In addition to such failures, complex covers may be subject to internal failures caused by changes of parameters like the permeability. Such changes can be caused by bioturbation, freeze/thaw cycles, desiccation of sealing layers or cracks induced by settlements of the wastes. Since such failures are not necessarily visible, a detection may only be possible by a periodic monitoring of seepage quantities and qualities and radon exhalation rates.

- By excavation and relocation the exposures can be reduced, depending on residual contamination, to almost zero. Long-term concerns obviously do not arise. However, impacts from the new site to which the wastes are relocated have to be considered. Since this will usually be a landfill-type waste management area, the long-term concept for this site usually will also consist in covering the wastes. For this part of the remediation activities, the same considerations as for wastes covered in-situ hold. However, since the new site usually will be chosen in more favourable site conditions in terms of, for example, hydrology and population density, requirements for cover design and for long-term surveillance may be less strict as they would have been at the original site. If an underground disposal site is chosen, long-term exposures may be close to zero and long-term surveillance requirements may not arise or be limited to the water pathway.

- The efficiency and durability of processing or pre-treatment of the wastes depends on the processes employed and the physical and chemical form of the residues and thus cannot be judged generically.

- Not carrying out any remediation can be efficient, if land-use restrictions associated with this option can be enforced. In the long-term, however, there are doubts about the effectiveness of these restrictions. A particular concern is the loss of information about the site in the future, leading potentially to a loss of institutional control over the site. It has to be noted, however, that such failures of institutional controls can also affect other remediation options. For instance, loss of information about a site with wastes covered in situ can lead to the termination of necessary inspections and repairs or even to the destruction of the cover by construction activities. Considerations of a possible long-term loss of institutional control, therefore, are not limited to the no remediation option.

Already this short description of common remediation options and relevant factors of influence demonstrates the complexity of technical and economic factors to be considered. Within the actual decision making process, it is further required to incorporate social factors like the public acceptance of certain remediation options. Comprehensive methodologies therefore have to be employed for identifying and assessing the relevant parameters and finding an optimal balance between benefits and detriments.

Abstract

Following publication of the Basic Safety Standards (Council Directive 96/29/EURATOM) and specifically Title IX, this publication is a guidance prepared by the Group of Experts Article 31. The aim is to contribute to a harmonized approach with regard to practical implementation of radiation protection standards for restoration of areas affected by lasting exposure.

Most of the considerations presented in the document are applicable to sites contaminated with artificial radionuclides or materials with elevated contents of naturally occurring radionuclides (NORMs): an overview of the corresponding radiological problems is given.

The document describes elements of an adequate protection philosophy. Among others, following matters are discussed:

- categorisation as intervention or practice,
- methodology for assessment of the overall radiological impact,
- optimisation related to defined Action Levels expressed in terms of annual individual doses to the critical group,
- performing integrated assessments on the basis of unified risk approaches instead of focussing on radiological risk only,
- definition of hypothetical critical groups in the future,
- consideration on long-term institutional controls.

General criteria are derived and their practical implementation is discussed. An outline of the whole process is presented encompassing:

- the identification of remediation requirements,
- the assessment of the radiological situation and corresponding risks,
- the evaluation of remedial measures and optimisation,
- the decision-making process and involvement of the stakeholders.

14

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