IAEA Safety Standards

for protecting people and the environment

Release of Sites from Regulatory Control on Termination of Practices

Safety Guide

No. WS-G-5.1

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RELEASE OF SITES FROM REGULATORY CONTROL ON TERMINATION OF PRACTICES

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IAEA SAFETY STANDARDS SERIES No. WS-G-5.1

RELEASE OF SITES FROM REGULATORY CONTROL ON TERMINATION OF PRACTICES

SAFETY GUIDE

INTERNATIONAL ATOMIC ENERGY AGENCY
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Sales and Promotion, Publishing Section
International Atomic Energy Agency
Wagramer Strasse 5
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fax: +43 1 2600 29302
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FOREWORD

by Mohamed ElBaradei
Director General

The IAEA's Statute authorizes the Agency to establish safety standards to protect health and minimize danger to life and property — standards which the IAEA must use in its own operations, and which a State can apply by means of its regulatory provisions for nuclear and radiation safety. A comprehensive body of safety standards under regular review, together with the IAEA's assistance in their application, has become a key element in a global safety regime.

In the mid-1990s, a major overhaul of the IAEA's safety standards programme was initiated, with a revised oversight committee structure and a systematic approach to updating the entire corpus of standards. The new standards that have resulted are of a high calibre and reflect best practices in Member States. With the assistance of the Commission on Safety Standards, the IAEA is working to promote the global acceptance and use of its safety standards.

Safety standards are only effective, however, if they are properly applied in practice. The IAEA's safety services — which range in scope from engineering safety, operational safety, and radiation, transport and waste safety to regulatory matters and safety culture in organizations — assist Member States in applying the standards and appraise their effectiveness. These safety services enable valuable insights to be shared and I continue to urge all Member States to make use of them.

Regulating nuclear and radiation safety is a national responsibility, and many Member States have decided to adopt the IAEA's safety standards for use in their national regulations. For the Contracting Parties to the various international safety conventions, IAEA standards provide a consistent, reliable means of ensuring the effective fulfilment of obligations under the conventions. The standards are also applied by designers, manufacturers and operators around the world to enhance nuclear and radiation safety in power generation, medicine, industry, agriculture, research and education.

The IAEA takes seriously the enduring challenge for users and regulators everywhere: that of ensuring a high level of safety in the use of nuclear materials and radiation sources around the world. Their continuing utilization for the benefit of humankind must be managed in a safe manner, and the IAEA safety standards are designed to facilitate the achievement of that goal.

CONTENTS

1. INTRODUCTION

BACKGROUND

1.1. An increasing number of facilities[1] have come or are coming to the end of their useful lifetimes and are at present being, or are going to be, decommissioned with the intention of removing the sites[2] from regulatory control. In many cases decommissioning activities include the decontamination of land, ponds and buildings and other structures such as underground pipes and tanks at a site that have become contaminated as a result of an authorized practice[3] [1]. The release of a site from regulatory control may be contingent on measures taken to clean up[4] the site as part of the decommissioning activities at the end of an authorized practice conducted at a facility or part of a facility. The extent of the cleanup is a function of the size, complexity and hazard potential of the site and the potential future uses envisaged for it.

1.2. The IAEA has developed a number of safety standards on safety during decommissioning [2–5], management of the associated radioactive waste (including its transport) [2, 6–12], radiation protection [1], legal and governmental infrastructure [13] and the removal of radioactive material from regulatory control [14]. This Safety Guide supports the Safety Requirements publication on decommissioning [2] and supplements the guidance in this area with recommendations on meeting the requirements for the release of sites from regulatory control on the termination of practices.

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[1] The term 'facility' as used in this Safety Guide means a facility with its associated land, buildings and equipment in which radioactive material is used, processed, handled or stored on such a scale that consideration of safety is required.

[2] The term 'site' as used in this Safety Guide means land together with any buildings or other structures being considered for release from regulatory control.

[3] The term 'practice' means any human activity that introduces additional sources of exposure or exposure pathways or extends exposure to additional people or modifies the network of exposure pathways from existing sources, so as to increase the exposure or the likelihood of exposure of people or the number of people exposed.

[4] The term 'cleanup' as used in this Safety Guide means any measures that may be carried out to reduce the radiation exposure from existing contamination through actions applied to the contamination itself (the source) or to the exposure pathways to humans.

OBJECTIVE

1.3. The objective of this Safety Guide is to provide guidance to the regulatory body and operators on the release of sites or parts of sites from regulatory control after a practice has been terminated. Such release from regulatory control may require the cleanup of contaminated sites, and this publication provides guidance in this area also.

SCOPE

1.4. This Safety Guide applies to sites that have become contaminated as a result of activities relating to the conduct of a practice and that are being considered for release from regulatory control as part of an overall decommissioning process [2]. All activities covered in this Safety Guide are considered part of a practice and meet the requirements [1] for such a practice.

1.5. This Safety Guide applies to all types of facility, including nuclear power and research reactors, fuel cycle facilities, manufacturing plants, medical facilities, research and university laboratories, and other research facilities that require a graded approach to regulation [2]. It does not apply to tailings from processing or to radioactive waste disposal sites. However, it does apply to auxiliary facilities at such sites. This publication focuses on radiation protection aspects, the required legal and regulatory framework, the development and implementation of cleanup activities, the unrestricted and restricted use of sites, and the introduction of a new practice on a released site.

1.6. In the context of this Safety Guide, 'release of sites from regulatory control' refers only to the release of sites from the requirements for radiation protection of the appropriate regulatory body, which does not preclude that other regulations may still apply at the sites.

1.7. This Safety Guide does not apply to the remediation of large sites contaminated as a result of past activities that were not conducted under the requirements of the Basic Safety Standards (BSS) [1], or as a result of accidents; that is, it does not apply to remediation in intervention situations[5].

[5] The term 'intervention' means any action intended to reduce or avert exposure or the likelihood of exposure to sources that are not part of a controlled practice or that are out of control as a consequence of an accident.

Intervention might be needed at sites that have been contaminated as a result of unauthorized activities, such as inadequate activities for radioactive waste management and disposal, accidental radioactive discharges to the environment, nuclear accidents, nuclear weapon tests and past activities that were not adequately controlled. Intervention situations are the subject of other safety standards [1, 15–17].

1.8. Such sites may pose significant non-radiological hazards to workers, the public and the environment that should be addressed during decommissioning activities. The protection of human health and the environment against such non-radiological hazards is outside the scope of this Safety Guide. However, in the context of decommissioning, these hazards are required to be given due consideration during the planning and implementation process, in the safety assessments and environmental assessments, and in the estimation of costs and the provision of finance for the decommissioning project (Ref. [2], para. 2.2).

STRUCTURE

1.9. Section 2 of this Safety Guide describes the key radiation protection principles and criteria that should be applied to the cleanup and release of sites. The legal and regulatory framework, together with the corresponding responsibilities of the government, the regulatory body and operators, are discussed in Section 3. Section 4 provides guidance on the development of cleanup activities for the release of a site, while guidance on implementation of these activities, together with considerations for restricted use, is presented in Section 5. Section 6 discusses the introduction of a new practice on a released site. The Appendix provides a list of subjects that should be included in a cleanup plan.

2. RADIATION PROTECTION ASPECTS

GENERAL

2.1. The release of sites from regulatory control is the final stage in the decommissioning process and is also the final stage of the practice [2]. Therefore, the radiation protection requirements of the BSS [1] are required to be enforced during all decommissioning activities (Ref. [2], paras 2.4–2.6), and the principles of justification, dose limitation and optimization of protection [1]

are therefore applicable to the entire decommissioning practice. Their application to the release of sites from regulatory control is the subject of this section. The dose criteria discussed in this section apply to prospective effective doses to members of the public above the pre-practice background levels that would be received after the site has been released. These doses are the summed effective doses arising from the site (considered as one source), including land and buildings and other structures. The uncertainties associated with knowledge of the site and its potential uses after its release should be taken into account in the estimation of prospective doses.

2.2. The requirements of the BSS are required to be enforced during all decommissioning activities (Ref. [2], paras 2.4–2.6), including during cleanup and site release, in order to protect workers, members of the public and the environment during the cleanup and after release of the site.

JUSTIFICATION

2.3. Decommissioning and the release of sites from regulatory control should not be regarded as separate practices requiring justification in their own right. The consequences of both decommissioning and the subsequent release of a site from regulatory control should be considered within the initial justified decision on the adoption of the practice as a whole [1, 2]. The principle of justification requires that the net benefit of the practice be positive.

DOSE LIMITATION

2.4. "The normal exposure of individuals shall be restricted so that neither the total effective dose nor the total equivalent dose to relevant organs or tissues, caused by the possible combination of exposures from authorized practices, exceeds any relevant dose limit" (Ref. [1], para. 2.23). The dose limit of 1 mSv in a year for members of the public represents an upper bound on the sum of effective doses from all possible combinations of exposures arising from practices [1].

OPTIMIZATION OF PROTECTION

2.5. Optimization of protection should include evaluation of the exposure of workers during cleanup activities (i.e. including material characterization and

radioactive waste management) and evaluation of long term exposure of the public arising from the residual site contamination after site release. This evaluation will need to ensure that the protection of workers and the public is optimized below the dose constraints defined by the regulatory body.

2.6. Cleanup and release from regulatory control of a site is one of the sources of exposure for which a dose constraint should be applied as for an authorized practice [1]. This dose constraint should take into account multiple pathways of exposure and should not exceed 300 μSv in a year above background [17].

2.7. Before commissioning a new facility, therefore, the operator should ensure that a baseline survey of the site, including obtaining information on radiological conditions, is performed to define the levels of background radiation at the facility site. These levels will be further used at the end of the practice as a basis for comparison with the levels used to release the site. For existing facilities for which no such baseline survey was carried out in the past to determine these background levels, data from analogous, undisturbed areas with similar characteristics should be used for this purpose. These analogous areas should be areas that have similar physical, chemical, radiological and biological characteristics to those of the site considered for release, but they should not have been contaminated with radioactive material as a result of activities at the site. Such areas are not limited to natural areas undisturbed by human activities.

2.8. The applicable dose constraint for the public after the release of a site should be expected to be no higher than that applied for the operational phase of the practice. However, the two phases do not necessarily share a common set of circumstances (in particular, they do not necessarily have the same critical groups) on the basis of which to prescribe equality between the dose constraints applied before the termination of a practice and those applied afterwards.

2.9. In accordance with the BSS [1] and the recommendations of the International Commission on Radiological Protection (ICRP) [17], dose constraints should be applied prospectively to exposure from radioactive residues expected to remain in human habitats after the termination of a practice. The site dose release criteria should thus be based on an optimization of protection under this constraint, with account taken of the fact that optimization below the order of 10 μSv in a year might not be warranted on radiological protection grounds.

2.10. For the unrestricted use of a site, it should be ensured by means of the optimization of protection that the effective dose to a member of a critical group is kept below the dose constraint of 300 μSv in a year. For the restricted use of a site it should be ensured that, with restrictions in place, the effective dose should not exceed the dose constraint of 300 μSv in a year and that if the restrictions were to fail in the future the effective dose should not exceed 1 mSv in a year. The application of dose limitation to the unrestricted and restricted use of a site is shown in Fig. 1.

2.11. It is reasonable and appropriate to have different dose constraints for the release of sites than for the clearance of material from regulatory control. Clearance of material may take place frequently over the lifetime of a practice, as well as at the termination stage. The cleared material may enter into trade with a broad range of potential uses and therefore should comply with clearance criteria, which are of the order of 10 μSv in a year [1, 14]. The dose criteria for the release of land from regulatory control should be optimized and can be higher than those for the clearance of material, because land remains in

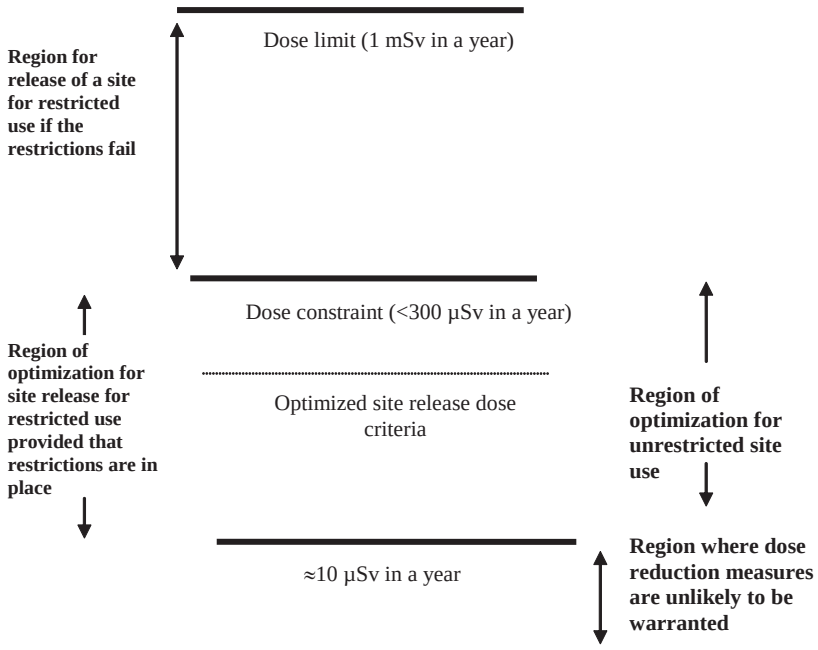

FIG. 1. Constrained optimization and regions of effective dose for members of the critical group in the release of sites.

place and hence the degree of certainty about the potential uses of the land is higher than the degree of certainty associated with the uses of material after its release from regulatory control. Thus it is reasonable to allow a larger fraction of the individual dose limit for the release of sites (i.e. the dose constraint (less than 300 μSv in a year)) than for the clearance of material (of the order of 10 μSv or less in a year) (Ref. [14], para. 3.4).

2.12. As part of the decision making process for the release for unrestricted use of land and associated buildings or structures, consideration should be given to the potential circulation of material arising from any future modification of the buildings, including demolition after release of the site. Material originating from a released site needs to comply with the national requirements for radiation protection for material outside the scope of regulatory control [1, 14]. The assessment of material originating from the site should be an integral part of the optimization analysis for the cleanup process. Scenarios giving rise to exposure from sites released for unrestricted use should be realistic and should consider the potential uses of the material from the released site.

2.13. Uncertainties, such as those relating to the level of contamination and hidden buried structures and waste, should be taken into account in determining the impact of the release of the site. These uncertainties, together with the uncertainties associated with the future use of the remaining buildings on the released site, should be considered in the optimization of protection, with account taken of the level of confidence that is required for release of a site from regulatory control.

2.14. If the site complies with the appropriate release criteria when a reasonable set of potential future uses and their associated uncertainties have been considered, the site should be released by the regulatory body for unrestricted use, which is the preferred option. The decommissioning phase should then be terminated and the regulatory body does not need further involvement beyond keeping records concerning the released site. If after cleanup of the site it is demonstrated that the site meets the release criteria, it may still be released for unrestricted use (see Fig. 1).

2.15. If after cleanup the site does not meet the release criteria, the site can be considered for restricted use. The restrictions should be designed and implemented to provide a reasonable assurance of compliance with the dose constraints. The restrictions should serve to exclude or prevent exposure pathways leading to effective doses higher than the dose constraint; for example, if effective doses via food chain pathways could give rise to doses

above the dose constraint, institutional restrictions should be put in place to prevent future use of the land for agricultural purposes. The release of sites for restricted use generally requires ongoing institutional involvement and control to implement the necessary restrictions. Existing regulatory limits on the time frames for institutional control should therefore be taken into consideration in deciding whether it is appropriate and reasonable to release a site for restricted use.

3. REGULATORY AND LEGAL FRAMEWORK

GOVERNMENT

3.1. The government should formulate a policy for the release of sites, including cleanup. It should ensure that an adequate legal and regulatory framework [13], supported where necessary by appropriate guidance, is in place so that workers, the public and the environment are protected during cleanup and after the release of sites from regulatory control. It should also specify the responsibilities of the parties involved.

3.2. As required, all phases of decommissioning, from the initial plan to the final release of the facility from regulatory control, shall be regulated (Ref. [2], para. 3.4). A legislative and statutory framework is required to be established to regulate the safety of facilities and activities (Ref. [13], para. 2.2), and to address the objectives, principles and safety aspects relating to the release of sites from regulatory control. National laws and regulations on such matters as occupational and public radiation protection [1], environmental protection, waste safety [2, 6–11], the transport of radioactive material [12] and the clearance of material [14] should also be in place. Where different governmental bodies regulate and administer these aspects, their responsibilities and their involvement in the decommissioning process, including the release of sites, should be defined within a coherent regulatory process.

3.3. There should be regulatory provision for the termination of a practice, which would sustain the decision for release of a site for unrestricted or restricted use. This regulatory framework should also provide the basis for establishing any restrictions that may be placed upon the use of or access to the

site before, during and, if necessary, after cleanup. Part of the decommissioning plan should address cleanup. This may be documented in a separate cleanup plan, depending on the regulatory framework, and summarized in the decommissioning plan.

3.4. The credible and acceptable time frames for institutional control that could be considered in the formulation and implementation of the cleanup should be defined within the legal framework. It should also be ensured within the legal framework that adequate funding mechanisms are available and that responsibilities are assigned for the financing of cleanup activities, including maintaining restrictive measures. As required in Ref. [2], para. 3.9, a system shall be established to ensure that all records are maintained in accordance with the records retention requirements of the management system and the regulatory requirements. These provisions should address adequate record keeping for the cleanup activities, including: the nature and level of contamination, the decisions made and their rationale before and after cleanup of the site, and information on verification that the end point conditions have been met. Record keeping is particularly important where restrictions are imposed on the future use of sites.

3.5. There should be legal provision for the regulatory body to review and approve the proposed cleanup activities as part of a decommissioning plan developed by the operator responsible for implementing the decommissioning project. The legal framework associated with the cleanup activities should also include provision for: (a) principles, objectives and guidelines for cleanup; (b) the management of radioactive waste arising from the cleanup; (c) the development, review and approval of methodology for assessing the adequacy of the implementation of the cleanup plan and of the cleanup of the site; (d) the determination of an end point for completion of the cleanup; and (e) adequate resources to complete the cleanup.

3.6. As sites from a wide range of practices and facilities may be subject to release from regulatory control, the government, the regulatory body and the operator should develop a graded approach to decommissioning (including cleanup and site release) that considers the hazard potential and complexity of the site (e.g. nuclear power plant, research laboratory), while ensuring that workers, the public and the environment are adequately protected.

REGULATORY BODY

3.7. The regulatory body should establish safety requirements and guidelines for the planning, approval and conduct of cleanup activities, for the management of contaminated material and the waste that arises from this process, and for the release of land, buildings and structures from regulatory control. The responsibilities of the regulatory body should also include:

(a) Establishing, promoting and adopting criteria and guidance for the cleanup and release of sites as a part of decommissioning activities;
(b) Reviewing and approving submissions from operators for cleanup and release of the site from regulatory control as part of the decommissioning plan (including the proposed cleanup activities and release criteria for the site);
(c) Developing criteria and methods for assessing the adequacy of the implementation of cleanup;
(d) Issuing, amending, suspending or revoking authorization for decommissioning, including provision for cleanup and release of sites from regulatory control;
(e) Performing regulatory inspections (e.g. independent measurements) to verify that safety requirements and conditions for authorization have been met and that the site meets the approved release criteria after cleanup;
(f) Reviewing of final radiological survey documentation [4];
(g) Taking appropriate actions whenever safety requirements and conditions for authorization are not met;
(h) Evaluating and approving revised cleanup activities and/or institutional control measures if compliance with the release criteria is not achieved;
(i) Evaluating reports on unplanned occurrences and events;
(j) Coordinating the regulatory process of cleanup and release of sites with other regulatory bodies responsible for other issues such as non-radiological hazards and transport.

3.8. In order to fulfil these responsibilities (para. 3.7) and those established in Ref. [13], the "regulatory body shall be provided with adequate authority and power, and it shall be ensured that it has adequate staffing and financial resources to discharge its assigned responsibilities" (Ref. [13], para. 2.2), which should include the provisions previously stated (see para. 3.3). The regulatory body should also cooperate with other relevant authorities and should interact with interested parties, providing them with the necessary information on safety matters associated with the cleanup and release of the site.

3.9. If the operator is unable to fulfil its responsibilities to ensure release of the site in compliance with established regulatory criteria, the regulatory body should exercise its authority to select a competent organization to finalize the cleanup using the financial arrangements provided by the operator or an authorized party. If no funds or insufficient funds are available for completion of the cleanup of the site for unrestricted use, the regulatory body should approve the measures for restricted use and should define procedures and responsibilities for the cleanup of the site, the maintenance of restrictions, the suspension of authorization and the release of the site.

3.10. The regulatory body is required to ensure that relevant documents and records are prepared by the operator, kept for an agreed time and maintained to a specified quality by appropriate parties before, during and after decommissioning (Ref. [2], para. 3.9). In the event that the operator ceases its activities or ceases to exist, keeping records in the record system should also be considered. In addition, the regulatory body should ensure that an effective record system for the released sites is in place and is maintained for future users of the sites (see also para. 2.11 in this Safety Guide). The responsibilities for maintaining site release records should be clearly assigned, with account taken of the fact that these records could be maintained by one and the same organization, as appropriate.

OPERATOR

3.11. The operator is required (Ref. [2], para. 3.16) to have overall responsibility for safety (including the cleanup of the site). Although the performance of specific tasks may be delegated to a subcontractor, the ultimate responsibility for safety is required to remain with the operator. The operator is also responsible for the management of the cleanup activities to ensure that management of the radioactive waste generated during cleanup complies with the relevant safety requirements and criteria approved by the regulatory body. The cleanup activities and protective measures to be taken during and after the cleanup of the site should be specified by the operator and should be proportionate to the hazards at the site.

3.12. The operator's responsibilities for overall safety during the cleanup and release of sites as a part of decommissioning activities should cover:

(a) Ensuring the availability of the resources (including financial resources to guarantee decommissioning), expertise and knowledge necessary for the cleanup and release of the site.
(b) Preparing and submitting to the regulatory body details of the cleanup activities and supporting documentation; these documents will normally be part of the decommissioning plan.
(c) Performing the required cleanup activities, after their approval by the regulatory body, and demonstrating that the release criteria for the site have been met (see Section 5).

4. DEVELOPMENT OF CLEANUP ACTIVITIES FOR THE RELEASE OF A SITE

INTRODUCTION

4.1. The cleanup of a site should be part of the decommissioning process. It consists of preparation of the cleanup activities, approval of the cleanup activities, implementation of the cleanup activities, management of radioactive waste and material arising from the cleanup activities, surveillance and monitoring, and release of the site from regulatory control. The main steps of the cleanup process are shown in Fig. 2.

4.2. The overall objective of the site cleanup should be to release the site from regulatory control after optimizing radiological protection of workers, members of the public and the environment (see Section 2). Proper goals or end points for the cleanup should be set, with account taken of dose limits and constraints for workers and members of the public, uncertainties regarding the site, such as the level of contamination, and any future restrictions on the use of the site.

4.3. The development and implementation of cleanup activities for the release of a site involves: (a) characterization of the site by determining the nature and level of contamination; (b) an assessment of all significant impacts of the potential uses of the site; (c) identification and evaluation of available cleanup options; and (d) selection of the goals, the end point and the optimal cleanup option. These activities can be addressed as part of the overall decommissioning plan.

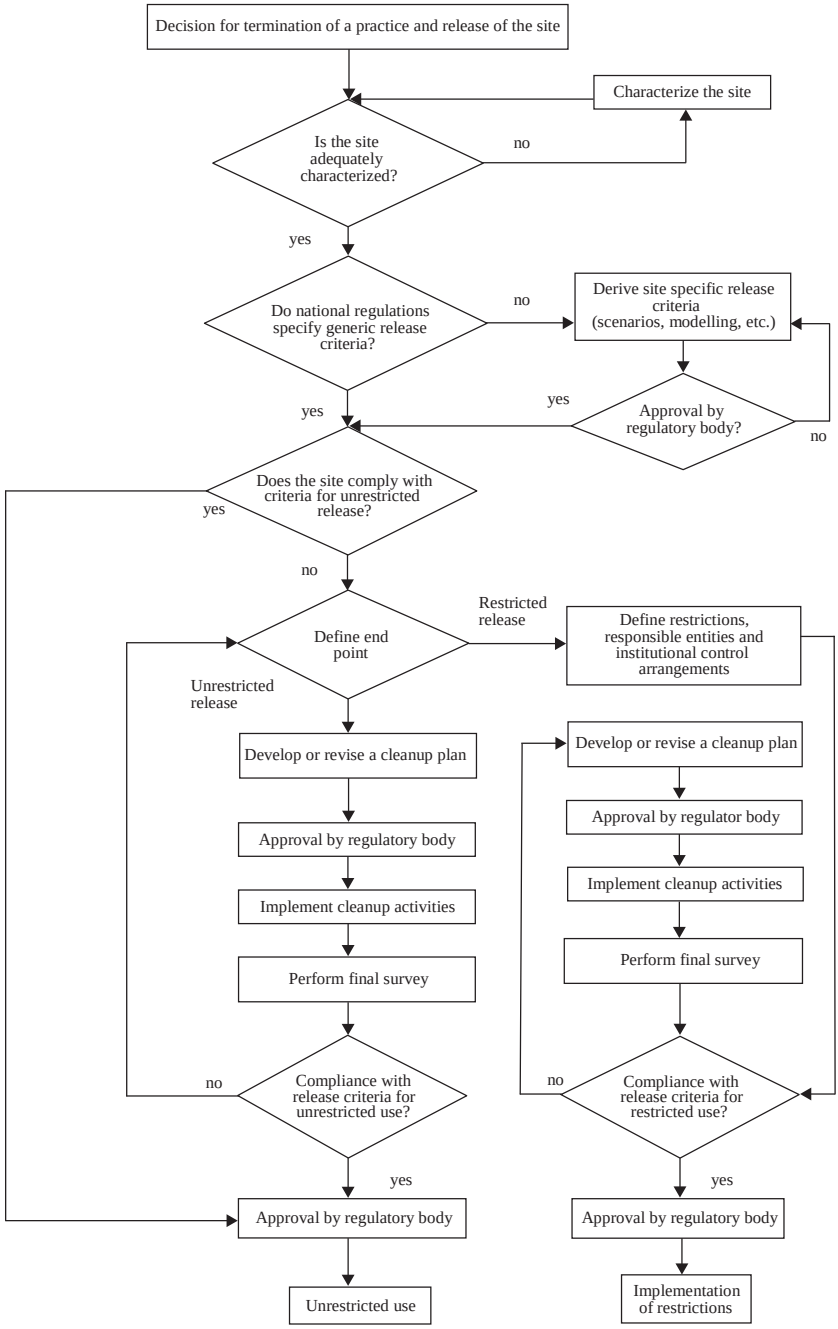

FIG. 2. Flow chart showing the cleanup process as part of the release of sites from regulatory control on termination of a practice.

4.4. Operators should usually request release from regulatory control for the entire site at the end of the decommissioning process. However, some operators may request decommissioning and cleanup for only part of the site and the release of that part of the site from regulatory control. Generally, the same approaches should be taken as for the cleanup and release of the entire site, although specific cleanup activities for the release of part of the site should be developed by the operator and submitted to the regulatory body for approval. In addition, the effective dose arising from the release of part of the site should be allocated within the framework of estimating the allowable doses resulting from decommissioning and termination of the entire practice.

4.5. The decision on the extent of the cleanup should be made with account taken of the history of the site, including the activities that were performed during operations, the potential future uses of the site, the level of the existing contamination at the site, the national generic or site specific release criteria and the options available for the cleanup and their implications.

4.6. When a decision has been made on the termination of a practice, the first step in the cleanup process is to determine whether the site has been adequately characterized and, if not, to determine the nature and amount of the radioactive material at the site.

SITE CHARACTERIZATION

4.7. The determination of what information and which data already exist and which new data will have to be acquired to permit an appropriate assessment of the radiological impacts on workers, the public and the environment from the potential uses of the released site should be part of the characterization process. Depending on the size, complexity and hazard potential of the site to be released, characterization should include the collection of physical, radiochemical and environmental data such as data on:

(a) General site conditions (e.g. chemical, physical and soil conditions);
(b) The present use and history of use of the site;
(c) The identification of radiological contaminants and their concentrations, and the spatial variability of the radionuclide distribution in soils (e.g. homogeneity);
(d) The potential presence of and contamination of underground structures (e.g. pipes and tanks);
(e) Groundwater contamination and surface contamination (if any);

(f) Other non-radiological contamination that might require cleanup under other legislation.

The historical data for the site should be evaluated and used in the development of a site characterization plan. This is important in increasing the understanding of the type and extent of the hazards and the contamination present at the site. This historical information should be obtained from available historical archives (e.g. aerial photographs, survey records, operating history, incident records) and from interviews with former employees.

4.8. In addition, for on-site structures and buildings, information on the following should be evaluated:

(a) The physical state (including the structural stability of buildings, means of access and security measures, remaining conventional hazards);
(b) Decontamination and radioactive waste management activities at the site;
(c) Airborne contaminants and air quality (including amounts of suspended particulates, ease of resuspension, radon concentrations).

4.9. The radiological conditions and data for the site should then be assessed against the existing generic release criteria established by the regulatory body or against site specific release criteria that are developed by the operator and approved by the regulatory body, to define the need for and scope of cleanup prior to release of the site.

RELEASE CRITERIA

4.10. For the evaluation of potential radiological consequences associated with the site after its release, all relevant exposure pathways should be considered. It is necessary to use dose assessment involving direct radiation, inhalation and ingestion pathways to derive release criteria (in, for example, Bq/g or Bq/cm^2). Two main approaches can be taken: either the regulatory body may develop generic release criteria for use by the operator, or the operator can derive site specific release criteria, on the basis of the optimization process described in Section 2, which the regulatory body should then approve. The former approach enables the operator to demonstrate compliance with the generic release criteria without deriving criteria specific for the site. However, this approach is likely to result in conservative release criteria because of the need to make generic assumptions in the dose assessment. This could lead to cleanup activities being more extensive and costly than necessary. The latter approach

places an additional burden on the operator and the regulatory body, but it is likely to result in a less stringent set of release criteria for the site.

4.11. An optimization process should be used to develop release criteria. This process allows for iteration between individual steps, with account taken of the optimization factors, as discussed in Section 2. The following activities should be performed on the basis of optimization of the overall decommissioning activities, the end state of the site as defined in the decommissioning plan, the associated dose criteria, the dose constraints and the site description:

(a) Definition of the scenarios and identification of the exposure pathways;
(b) Compilation of the specific data and information for the scenarios and pathways;
(c) Definition of the conceptual models for the site;
(d) Conduct of dose assessments;
(e) Determination of the release criteria.

These activities are described in more detail in the following paragraphs.

Scenarios and exposure pathways

4.12. In most situations, a number of possible scenarios arise in which members of the public could be affected in the future by residual radioactive material at the site. Scenarios should be defined as reasonable sets of human activities relating to the potential uses of the site. The scenarios should provide an adequate description of potential land uses and of human activities relating to the future uses and evolution of the site, and may include use for industrial activities, residential occupancy, agricultural production and recreational occupancy.

4.13. In accordance with the guidance of the regulatory body, the operator should determine which scenarios and which corresponding exposure pathways are most applicable for the site. Involvement of interested parties is important in the selection of the scenarios to be evaluated (e.g. in identifying the potential activities at the site after release). The selected scenarios and pathways should be used as the basis for dose assessments to develop release criteria for the site. The release criteria are derived from an iterative analysis of a set of all reasonable scenarios, with account taken of the uncertainties in relation to the characteristics of the site and its potential use.

Specific data and information

4.14. Consistent with the size, complexity and hazard potential of the site, other relevant information, such as socioeconomic and environmental data, should be collected and evaluated for the selected scenarios and exposure pathways.

Dose assessments

4.15. The goal of the dose assessment is to provide an estimate of the effective doses to individual members of a critical group[6] after the release of the site. For each of the scenarios selected, the doses via each exposure pathway should be estimated. If these pathways could lead to exposure of the same critical group, the exposures via each pathway for members of the critical group should be summed to yield the total effective dose.

4.16. A conceptual model of the site should be developed to allow the operator and the regulatory body to gain an understanding of the expected behaviour of any radioactive material remaining at the site after release of the site from regulatory control. This information is important in developing the dose assessments that are needed for determining the release criteria for the site.

DEFINITION OF END POINTS

4.17. Before release, the operator should demonstrate to the regulatory body that the site meets the release criteria. The regulatory body should review the operator's demonstration, confirm compliance with the criteria and release the site from regulatory control. If the site meets the release criteria, the site may be appropriate for release without further cleanup after the approval of the regulatory body.

4.18. If the site does not meet the release criteria, the operator should determine whether a cleanup needs to be performed or whether restrictions are necessary to meet these release criteria. If after cleanup restrictions are not needed, the selected option should be 'unrestricted use', and if restrictions are

[6] A 'critical group' is a group of members of the public that is reasonably homogeneous with respect to its exposure for a given radiation source and is typical of individuals receiving the highest effective dose or equivalent dose (as applicable) from the given source.

required, the 'restricted use' option should be selected. In both cases, the operator should develop cleanup activities for release, should obtain approval from the regulatory body, should implement these cleanup activities, should perform a survey to demonstrate that the site meets the release criteria and should submit this demonstration to the regulatory body for approval.

4.19. For restricted use, the type, extent and duration of the restrictions and controls for release of the site can range from monitoring and surveillance to restriction of access to the site. The restrictions should be proposed by the operator on the basis of a graded approach and in consideration of factors such as the type and level of residual contamination after the completion of cleanup, the relevant dose constraints and release criteria, and the human and financial resources needed to implement the restrictions and controls. The restrictions proposed by the operator should be enforceable by the regulatory body and the cleanup plan should specify which organization will ensure that the restrictions are maintained. In addition, the way in which the restrictions would be removed when they are no longer necessary should be specified in the cleanup plan.

DEVELOPMENT OF THE CLEANUP PLAN

4.20. The cleanup activities should be documented in a cleanup plan developed by the operator as part of the decommissioning plan to be approved by the regulatory body [2]. In consideration of the size, complexity and hazard potential of the cleanup, the components of the cleanup plan should include the following:

(a) A characterization of the site (including the site boundaries for cleanup agreed with the regulatory body);
(b) The objectives, end points, safety principles and criteria for the cleanup and for release from regulatory control;
(c) A description of the proposed cleanup activities and the equipment, resources and timescales for their implementation;
(d) A description of the measures taken for the protection of workers and the public;
(e) A safety assessment and an environmental impact assessment for the proposed activities and for the end state after release of the site, including information on and justification of the use of generic or site specific data;
(f) A description of the monitoring measures that will be taken to demonstrate that the release criteria have been met;

(g) A description of the activities for radioactive waste management;
(h) A description of the management system;
(i) Cost estimates for the specified cleanup activities as part of the decommissioning activities;
(j) A description of the arrangements made for emergency preparedness and response;
(k) A description of the provision for monitoring during and after cleanup.

4.21. The contents of the cleanup plan are described in the Appendix to this Safety Guide.

Optimization of the cleanup option

4.22. There may be a range of cleanup options that could lead to reductions in the exposure of a potential critical group. Cleanup options range from a 'do nothing' option to a 'complete cleanup' option. In evaluating these options and selecting an optimum one, the potential use of the site is important, as this will determine any future exposures of members of the public as well as the effective doses to workers. Optimization of various cleanup options should be performed to aid the decision making, with consideration taken of the factors discussed in para. 4.25.

4.23. Some cleanup options could involve restrictions as a means of reducing effective doses. These options should be considered in the optimization process, provided that the institutional control required to implement these restrictions is feasible, with account taken of the credible time frame for such control. Options that result in no future restrictions on the site should be favoured in the decision making process for release of the site.

4.24. Various factors relating to radioactive waste management should also be considered in determining the optimum option for cleanup, including the costs of the predisposal management, transport and disposal of the radioactive waste, the radiation exposure of the workers managing this waste and the subsequent exposure of the public that is associated with the disposal of the waste. The management of radioactive waste should comply with the international principles and requirements for waste management facilities [1, 2, 6, 7, 11, 18].

4.25. The optimum cleanup option and the corresponding dose release criteria for the site should be used to derive release criteria for the activity concentration of each radionuclide concerned, in Bq/g or Bq/cm^2, by means of

an optimization process. The release criteria for each radionuclide represent the activity concentration of that radionuclide that would give rise to the optimized dose criterion for the release of the site. If a site has been contaminated with a mixture of radionuclides, then compliance with the optimized release criteria for the site should be demonstrated by using the sum of fractions rule to derive appropriate release criteria for the particular mix of radionuclides.

Application of release criteria

4.26. The operator should provide the regulatory body with information in the cleanup plan that justifies the use of release criteria (i.e. generic or site specific criteria) for its specific case, including a recommendation of whether or not cleanup is required.

4.27. If generic release criteria are used in the cleanup plan, the regulatory body should determine the acceptability of the operator's proposal by comparing information about the site with the information used to develop the generic release criteria. If the site conditions are consistent with the conditions used to develop the generic release criteria, the operator's approach should be considered acceptable.

4.28. If site specific release criteria are used in the cleanup plan, the regulatory body should approve these criteria. The regulatory body's review of the site specific release criteria should cover such aspects as the adequacy of the level of site characterization, the quality of data, the approach of systematic assessment used to develop the release criteria (e.g. using dose constraints, scenarios and modelling), the systematic evaluation of uncertainties (e.g. the level of contamination at the site, modelling) and the proposed procedures for implementation and confirmation of the release criteria. This review of the site specific release criteria could be performed by comparing the information submitted by the operator with other data available to the regulatory body, and by means of independent assessment. If the regulatory review demonstrates consistency, the operator's approach should be considered acceptable. If there is a disparity, the operator should review and revise, as appropriate, the basis and the approach for the derivation of the release criteria.

4.29. If the operator determines that restrictions will be necessary to meet the release criteria for the site, the operator should develop measures for restricted use of the site.

4.30. The regulatory body should review and approve the cleanup plan to ensure that the cleanup activities can be conducted safely and that the end state of the site will be in compliance with the release criteria. This can be done as part of the review of the overall decommissioning plan.

5. IMPLEMENTATION OF THE CLEANUP ACTIVITIES FOR SITE RELEASE

CLEANUP ACTIVITIES

5.1. In the performance of the cleanup activities for the release of the site, consideration should be given to radiation, transport and waste safety, so as to minimize hazardous impacts on workers, the public and the environment during the cleanup, and to minimize the potential for prolonged exposure of members of the public after the termination of cleanup activities. Consideration should also be given to non-radiological hazards.

5.2. The operator should establish measures to implement the cleanup activities, including: the identification of the organizations responsible for implementing the cleanup activities; the provision of adequate human resources, equipment and supporting infrastructure; the organization and allocation of the required funding; taking measures for radioactive waste management; safety procedures and radiation protection procedures for the cleanup workers and the public; arrangements for quality management; procedures for site monitoring; and taking measures for record keeping and the transfer of information about the released site. It should be noted that such measures might have already been established earlier in the development process for the decommissioning plan.

MONITORING

5.3. The site should be monitored by the operator during cleanup to assess the efficiency and effectiveness of the cleanup activities with a view to ensuring compliance with the end state conditions for the site. The site vicinity should be monitored and surveyed regularly by the operator during the cleanup activities to determine the level of contamination and to ensure compliance with

radiation protection and environmental protection requirements [1, 2, 7, 12, 13]. The monitoring measures will depend on the type of facility and the contamination, and on the levels for release to be complied with.

5.4. The operator's procedures for cleanup should specify the monitoring approach and the techniques and units (e.g. Bq/cm^2) to be used for the relevant environmental media (soil, water, etc.), and should include guidance on detected deviations from the criteria and on the treatment of uncertainties.

5.5. Appropriate measurements such as those made in monitoring for compliance with the release criteria after cleanup should be carried out in a way that provides a sufficient level of confidence that the release criteria have been met. Monitoring for compliance should be performed in conformance with the assumptions used to derive the release criteria.

5.6. Measurements should also be performed by the operator to ensure safety during the management of the radioactive waste [2, 12] generated during cleanup.

5.7. The operator should specify and organize all measurements (see paras 5.3–5.6) in a consolidated monitoring plan to be applied during cleanup and in the final survey. The regulatory body should review the monitoring plan as part of the decommissioning plan.

5.8. Regular surveillance will also enable the operator to detect any unexpected levels of radioactive contamination and to review and modify the cleanup plan accordingly. The implementation of the cleanup plan should also be periodically reviewed during the decommissioning phase. Depending on the results of these reviews, the cleanup plan may need to be revised. Significant safety related revisions to the cleanup plan should be subject to approval by the regulatory body.

MANAGEMENT OF RADIOACTIVE WASTE

5.9. Predisposal management of radioactive waste should be undertaken, where appropriate, to process the radioactive waste arising from cleanup activities, including secondary waste, in accordance with the regulatory requirements [2, 12].

CLEARANCE OF MATERIAL DURING CLEANUP

5.10. During cleanup of a site, radioactively contaminated material that is subject to regulatory control, with no intended future use, should be managed at authorized radioactive waste facilities in accordance with the characteristics of the material and its associated hazards. Some contaminated material with a very low level of radioactivity may be suitable for release from regulatory control, for reuse in the nuclear industry or as a commodity in general industry (e.g. concrete, rubble), or for disposal in a disposal facility for non-radioactive waste, if approved by the appropriate regulatory body. Such a release from regulatory control is generally referred to as 'clearance' [1, 14] and implies that no further regulatory control of the material is required for radiation protection purposes.

5.11. The operator should ensure that the material to be cleared meets the criteria for release from regulatory control, as approved by the regulatory body. For this purpose the operator should develop a procedure that describes the approach to measurement and the activities and notifications for demonstrating compliance with the clearance requirements and criteria. This procedure should be submitted to the regulatory body for review and approval.

ENSURING COMPLIANCE WITH RELEASE CRITERIA

5.12. After completing the cleanup activities at a site, the operator should submit a final survey report to the regulatory body, demonstrating that the release criteria have been met.

5.13. The regulatory body should review the operator's final survey report to ensure that the site meets the release criteria. The regulatory body should use the information provided in this report to verify independently the operator's survey data, analyses and conclusions.

Unrestricted use of the site

5.14. If it is demonstrated that the release criteria are not exceeded, the site should be released from regulatory control on the basis of radiological protection considerations.

5.15. If it is determined after implementation of all reasonable cleanup activities for unrestricted use that the site cannot meet the release criteria for

unrestricted use, the operator should re-evaluate the approach and the plan for cleanup. This revision may lead to further cleanup activities, to a redefinition of the objectives of the cleanup or to the imposition of institutional controls and the associated monitoring and surveillance. If the cleanup plan is revised, it should be subject to review and approval by the regulatory body, as described in Fig. 2, and the steps described in Section 4 should be followed.

Restricted use of the site

5.16. If it is determined by the regulatory body that compliance with the release criteria for the site can be achieved with restrictions, the operator should implement the restrictions as approved by the regulatory body.

5.17. If it would be necessary to apply restrictions on the use of, or access to, the site to achieve compliance with the appropriate release criteria, the regulatory body should ensure that an appropriate mechanism is in place to demonstrate compliance with these restrictions. Specific restrictions should be established where necessary:

(a) To control the removal of material from the restricted site, if it is expected that the material cannot be released from regulatory control;
(b) To control the potential uses of a site or the exposure pathways, such as the production and consumption of foodstuffs and water, in order to keep prospective effective doses below the release criteria.

5.18. A surveillance and maintenance plan for the restricted site should be prepared by the operator and subject to approval by the regulatory body. This plan should then be implemented by the operator as specified in para. 5.17.

5.19. If the release criteria have not been met by using restrictions, the operator should re-evaluate and if necessary revise the cleanup plan for restricted use of the site. The revised cleanup plan should then be submitted for approval to the regulatory body (see Fig. 2).

5.20. Interested parties should be informed of any site restrictions and of the results of monitoring and surveillance, and should be invited to participate in the process of decision making on the release from regulatory control.

DECISION TO RELEASE THE SITE

5.21. The regulatory body should perform inspections of the site being considered for release from regulatory control. This will include review of the cleanup and monitoring procedures, review of the management system, independent monitoring and analysis of compliance with the release criteria for the site or review of the implementation of restrictions at the site.

5.22. When the objectives of the site release have been accomplished to the satisfaction of the regulatory body, the regulatory body should formally notify the operator, other relevant competent authorities and interested parties of the decision to release the site from regulatory control. In the event of a decision for restricted use, the notification should specify the restrictive measures and their associated time frames, and the entities responsible for the implementation, monitoring and regulatory control of these restrictions and of the release of the site for unrestricted use.

MANAGEMENT SYSTEMS

5.23. The management requirements that apply to the decommissioning of facilities [19, 20] also apply to the cleanup of a site. A management system for cleanup activities should be prepared as part of the decommissioning process and should be implemented by the operator using a graded approach (e.g. in terms of its scope, the level of detail of the documentation, the measures taken and the resources committed) after approval by the regulatory body. The management programme could be developed as part of, or included in, the overall decommissioning plan [2].

5.24. The management system should be applied throughout the entire process [19, 20] of cleanup and release of a site from regulatory control until the final decision is made on compliance with the release criteria. The management system should be designed and implemented so as to ensure that:

(a) The objectives and the safety requirements and criteria (radiological and non-radiological) are adequately defined and met;
(b) Adequate strategies for cleanup, radioactive waste management and monitoring for compliance have been developed and implemented;
(c) Appropriate management arrangements are in place with a clear allocation of responsibilities between the operator and contractors;
(d) The required competences of staff and interfaces are in place;

(e) Adequate selection, calibration, maintenance and testing of equipment for use in appropriate monitoring techniques have been performed;
(f) Adequate control over procurement, including control over subcontractors' services, has been implemented;
(g) Appropriate sampling and measurement (in terms of locations, media, number of samples, frequency, etc.) have been performed;
(h) Verification and analysis of results have been carried out;
(i) Record keeping and reporting have been undertaken;
(j) Appropriate qualifications, experience and training of personnel involved in the cleanup and the release of sites have been ensured;
(k) Adequate financial resources are available;
(l) Adequate auditing covering internal and external audits and regulatory inspections has been performed;
(m) Measures for the detection of non-conformance, adequate corrective actions and arrangements for termination of the authorized practice have been provided.

5.25. A system for archiving, retrieving and amending records should be maintained to document the cleanup activities and the basis for decisions for authorizations or approvals of any changes in the activities that were made during their implementation. Such records should include:

(a) Characterization data of the site prior to cleanup;
(b) The cleanup plan, including the choice of cleanup options, measures and procedures;
(c) Data from monitoring and surveillance;
(d) Occupational health and safety records for the cleanup workers;
(e) Identification of radioactive waste and description of its management and disposal on and off the site;
(f) Details of abnormal occurrences;
(g) Records of equipment used for cleanup and monitoring;
(h) Cost estimates;
(i) Institutional control measures;
(j) Involvement of interested parties;
(k) Locations of released sites;
(l) An inventory of land, buildings and structures with specified restrictions for their release (e.g. restricted use of land or surface water);
(m) Final survey reports;
(n) Regulatory decisions on and authorizations or approvals for site release;
(o) Lessons learned.

This system should be commensurate with the size, complexity and hazard potential of the site to be released from regulatory control.

5.26. The organization responsible for maintaining the permanent records of the site for restricted use should be clearly designated. The archive system should be designed and maintained so as to ensure preservation of the records for at least the period of time of restricted use, unless otherwise required by the regulatory body.

5.27. Involvement of interested parties other than the regulatory body is important in the determination of the acceptable criteria and site release end point. Consultation with interested parties could be valuable in, for example, the selection of the scenarios and definition of the institutional control measures, the critical groups and the end state of the cleanup site under consideration for release. Different approaches for involving interested parties could be applied, and one of them is through the process of assessing the impact of the release of the site on the environment. The relevant interested parties (e.g. competent authorities, interested members of the public, local or governmental authorities) also need to be involved before a final decision or authorization is given by the regulatory body.

6. INTRODUCTION OF A NEW PRACTICE

6.1. In setting a dose constraint and release levels for any practice introduced on a site where a practice or practices have previously been conducted, the regulatory body should ensure that the exposure of any critical group from all sources would not exceed 1 mSv in a year above the original background. The maximum value of the annual dose constraint for practices to be introduced on sites previously released from regulatory control should be of the order of 0.1 mSv in a year but not more than 0.3 mSv in a year.

Appendix

EXAMPLE OF THE CONTENTS OF A CLEANUP PLAN[7]

Introduction

Site description

— Physical description of the site;
— Present use and history of the site, including the ways in which the site became contaminated;
— Characteristics of the site, including land, buildings and structures (including, where appropriate, structures that extend off the site);
— Characterization of the site (radiological and non-radiological).

Cleanup strategy

— Objectives;
— Cleanup options;
— Safety principles and criteria;
— Waste types, volumes and management activities;
— End points of cleanup;
— Cost estimates;
— Financial arrangements;
— Selection and justification of the selected option.

Project management

— Organization and responsibility;
— Review arrangements;
— Training and qualifications;
— Reporting and records;
— Interfaces with the regulatory body and other interested parties.

[7] The cleanup plan is part of the decommissioning plan and is not intended to cover all aspects relating to decommissioning.

Cleanup activities

— Description of cleanup activities;
— Timescales of phases of cleanup activities;
— Surveillance and maintenance.

Dose assessment

— Scenarios;
— Modelling;
— Selection of computer tools;
— Proposed release criteria;
— Operational limits and conditions;
— Demonstration of optimization of protection.

Measures for radiation protection and safety

Management of radioactive waste and radioactive material

— For example, waste management programme, procedure for clearance of material.

Management system

Environmental impact assessment

Physical protection

Emergency plan

— On-site arrangements;
— Off-site arrangements.

Monitoring and surveillance

Final radiological survey

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CONTRIBUTORS TO DRAFTING AND REVIEW

Averous, J.	Direction générale de la sûreté nucléaire et de la radioprotection, France
Barker, R.	Canadian Nuclear Safety Commission, Canada
Batandjieva, B.	International Atomic Energy Agency
Blommaert, W.	Federal Agency for Nuclear Control, Belgium
Collins, S.	Illinois Emergency Management Agency, United States of America
Cooper, J.	National Radiological Protection Board, United Kingdom
Ferch, R.	Canadian Nuclear Safety Commission, Canada
Greeves, J.	Nuclear Regulatory Commission, United States of America
Hägg, A.	Swedish Radiation Protection Institute, Sweden
Hedemann Jensen, P.	Risø National Laboratory, Denmark
Heilbron, P.	Coordenação Geral de Licenciamento e Controle, Comissão Nacional de Energia Nuclear, Brazil
Jova Sed, L.	International Atomic Energy Agency
Lareynie, O.	Direction générale de la sûreté nucléaire et de la radioprotection, France
Linsley, G.	International Atomic Energy Agency
Mobbs, S.	National Radiation Protection Board, United Kingdom
Orlando, D.	Nuclear Regulatory Commission, United States of America
Reisenweaver, D.	International Atomic Energy Agency
Selling, H.	Ministerie van VROM, Netherlands

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