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Release of Sites from Regulatory Control on Termination of Activities in Planned Exposure Situations

Draft Safety Guide

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FOREWORD

By
Director General

[standard text to be added]

CONTENTS

1. INTRODUCTION

BACKGROUND

1.1. An increasing number of facilities[1] have come or are coming to the end of their operational lifetime and are being, or are going to be, decommissioned with the intention of releasing the sites[2] from regulatory control. The release of a site from regulatory control may be contingent on measures taken to clean up the site as part of decommissioning activities [1]. The extent of the cleanup[3] 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 published a number of safety standards on decommissioning [2–4], management of the associated radioactive waste (including its transport) [2, 5–9], radiation protection [10], legal and governmental infrastructure [11] and the removal of regulatory control from radioactive material [12]. This Safety Guide provides recommendations on meeting the requirements for the release of sites from regulatory control, as established in IAEA Safety Standards Series No. GSR Part 6, Decommissioning of Facilities [2].

OBJECTIVE

1.3. The objective of this Safety Guide is to provide recommendations on the release of sites (or parts of sites) from regulatory control in planned exposure situations. Such release from regulatory control may necessitate the cleanup of contamination, and this publication provides recommendations on cleanup activities for both remaining structures and soils and subsequent release from regulatory control.

1.4. This Safety Guide is intended for use by operating organizations, regulatory bodies, policy makers, service providers and other parties involved in cleanup and site release activities, to assist in applying the requirements of GSR Part 6 [2] on the completion of decommissioning and on release of sites from regulatory control. This Safety Guide also provides recommendations on applying the relevant requirements of IAEA Safety Standards Series No. GSR Part 3, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards [10].

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[1] The term ‘facility’ includes: nuclear facilities; irradiation installations; some mining and raw material processing facilities such as uranium mines; radioactive waste management facilities; and any other places where radioactive material is produced, processed, used, handled, stored or disposed of — or where radiation generators are installed — on such a scale that consideration of protection and safety is required [1].

[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. In many cases, decommissioning activities include the decontamination of land, ponds, and buildings and other structures such as underground pipes and tanks that have become contaminated as a result of an authorized practice. The term also includes associated adjacent off-site areas, i.e. areas outside a site that might be contaminated above acceptable levels as a consequence of the operation or decommissioning of the facility.

[3] The term ‘cleanup’ means any measures that may be carried out to reduce the radiation exposure due to existing contamination of land areas through actions applied to the contamination itself (the source) or to the exposure pathways to people [1].

SCOPE

1.5. This Safety Guide applies to planned exposure situations (see para. 1.20(a) of GSR Part 3 [10]) in which sites have (or may have) become contaminated as a result of the conduct of a practice[4], and which are being considered for release from regulatory control as part of an overall decommissioning process.

1.6. This Safety Guide focuses on radiation protection aspects, the required legal and regulatory framework, the development and implementation of cleanup activities, and the unrestricted or restricted use of released sites thereafter, and the reuse of a released site for a new facility or activity.

1.7. This Safety Guide applies to sites associated with all types of facility, including nuclear power and research reactors, fuel cycle facilities, manufacturing plants, medical facilities, research and education laboratories, and other research facilities for which a graded approach to regulation is appropriate. It does not apply to tailings from processing of ores or to radioactive waste disposal sites; however, it may apply to auxiliary facilities at such sites.

1.8. In the context of this Safety Guide, 'release of sites from regulatory control' refers only to the release of sites from regulatory requirements for radiation protection and safety. This does not preclude that other regulations may still apply at the sites. Such sites might pose significant non-radiological hazards to workers, the public and the environment that should be addressed. 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 (see para. 1.21 of GSR Part 6 [2]).

1.9. This Safety Guide does not apply to the remediation of large off-site areas contaminated as a result of past activities or as a result of accidents; that is, it does not apply to remediation situations. Remediation 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. Remediation situations are the subject of other publications (e.g. see [10, 13, 14]).

[4] The term 'practice' means any human activity that introduces additional sources of exposure or additional exposure pathways, or that 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 [1].

STRUCTURE

1.10. Section 2 of this Safety Guide provides recommendations in relation to the key concepts used in the release of sites from regulatory control. Recommendations on the key radiation protection principles and criteria to be applied to the cleanup and release of sites are provided in Section 3. Recommendations on the legal and regulatory framework, together with the corresponding responsibilities of the government, regulatory body and operating organizations, are provided in Section 4. Section 5 provides recommendations on the planning of cleanup activities for the release of a site, while recommendations on the implementation of these activities are provided in Section 6. Section 7 provides recommendations on the release of a site, either with or without restrictions on its future use. Section 8 provides recommendations on specific situations, such as the release of part of a site and the release of a site containing multiple facilities.

1.11. Annex I provides an example of the release of a site without restriction to its future use, whereas Annex II provides an example of the release of a site with restrictions. Annex III provides additional details on the process of balancing different factors during selection of a cleanup option and end state. Annex IV provides information on the management system. Annex V provides an illustrative example of considerations for selecting the best cleanup option. Annex VI provides example content of a cleanup plan.

2. KEY CONCEPTS FOR RELEASE OF SITES FROM REGULATORY CONTROL

END STATE

2.1. The end state of a site (or part of a site) is the state after the completion of decommissioning actions, leading to radiological and physical conditions that allow release from regulatory control with or without restrictions on future use.

2.2. The initial decommissioning plan should include an outline description of the intended site end state. The starting point for the intended end state should be the release of the site without any restrictions. The outline description of the end state in the initial decommissioning plan may also give an indication of the assumed future use of the site after its release from regulatory control.

2.3. The site's radiological and physical conditions will evolve over the lifetime of the site. The description of the site end state should be refined over time to include a level of detail proportionate to the available characterization results for the soils and structures of the site. The evolution of the site should be reflected in updates and revisions of the decommissioning plan during the operation and decommissioning of the facility.

2.4. Decommissioning actions (procedures, processes and work activities) and the associated end state are required to be described in the final decommissioning plan, which is then required to be submitted to the regulatory body (See Requirement 11 and para. 7.10 of GSR Part 6 [2]). In the final decommissioning plan, the operating organization should identify the site cleanup actions that are necessary to achieve the end state and, where necessary, any restrictions on the future use of the site.

2.5. If the description of the end state has been refined to reflect the physical and radiological conditions attained at the end of cleanup activities, the radiological component of the end state can still be considered to be achieved provided that the site dose release criterion remains below the dose constraint (see paras 2.6–2.8) and there is no need for any new or modified restrictions on future uses. However, if there is a need to implement additional or modified restrictions on future use, then it should be considered that the end state has been modified from a radiological perspective.

SITE DOSE RELEASE CRITERION AND SITE RELEASE LEVELS

2.6. The site dose release criterion is an effective dose criterion on the radiological conditions for the end state, as part of the set of end state criteria needed for completion of decommissioning. The site dose release criterion should not exceed the dose constraint established by the regulatory body and should be derived using an optimization process, as explained in paras 3.5–3.14.

2.7. The site dose release criterion should be converted into operational quantities that can more readily be compared with the results of field measurements. For example, in this publication the term 'release levels' (generic or site specific) is used for operational quantities that can be expressed in Bq/g or in Bq/cm^2. Further recommendations on site release levels are provided in paras 5.33–5.47.

2.8. The site dose release criterion and the corresponding release levels should be proposed by the operating organization and should then be submitted to the regulatory body for review.

PLANNING FOR SITE CLEANUP

2.9. During operation of a facility, there may be buildings, structures, materials and/or areas of land that have become activated or contaminated and should be addressed through a site cleanup[5] process as part of the decommissioning process to meet the end state criteria.

2.10. Site cleanup activities need to be planned by the operating organization as part of the overall decommissioning planning. A site cleanup plan should be developed (see paras 5.48–5.50), which is a detailed description of the selected cleanup activities and related processes to achieve the end state. The site cleanup plan should be developed gradually from the conceptual stage to more a detailed plan, taking into account the progress of the ongoing dismantling and decommissioning activities. During the

[5] In the context of this Safety Guide, 'site cleanup' refers to the removal of residual contamination or activation on remaining buildings, structures, materials and land to a level that will allow release of the site from regulatory control. Site cleanup usually starts after completion of dismantling activities.

implementation of site cleanup activities, revisions to the site cleanup plan may be needed as the work progresses.

RESTRICTIONS ON FUTURE USE AND INSTITUTIONAL CONTROL

2.11. Release of the site from regulatory control without any restriction on its future use should be the preferred option, and the end state should be selected accordingly. An example of release without restrictions is provided in Annex I.

2.12. When unrestricted use is not acceptable, restrictions on future use should be introduced to assure compliance with the site dose release criterion. These restrictions should be reviewed on a periodic basis, in accordance with regulatory requirements. An example of release with restrictions on future use is provided in Annex II.

2.13. Restrictions on the use of the site after its release should typically be expressed in the form of limitation or prohibition of particular activities (e.g. access, construction, excavations, residential use, cultivation of crops, raising livestock) or in the form of particular procedures to be followed, including monitoring (e.g. groundwater monitoring, visual inspections, maintenance, reporting).

2.14. Institutional controls may be necessary to ensure that the specified restrictions on future use of the released site are properly implemented. These controls may be active (e.g. monitoring, surveillance) or passive (e.g. signage, demarcation, record keeping, fencing). The responsibility for implementing and maintaining the restrictions and controls should be clearly assigned to an authority or institution with adequate expertise, resources and legal authority.

GRADED APPROACH TO REACHING THE END STATE FOR SITE RELEASE

2.15. The government, regulatory body and operating organization should all apply a graded approach to their activities (including site cleanup) to reach the end state and site release. The approaches used should be commensurate with the hazard potential and complexity of the site, and the likelihood and magnitude of exposures, to ensure that workers, the public and the environment are adequately protected. These hazards and the need for protective actions should be balanced against the risks incurred during the implementation of the cleanup activities themselves, as well as the hazard potential of the resulting end state. In practice this means that for more contaminated sites or sites contaminated with long-lived radionuclides the level of detail of the site characterization and cleanup planning should be higher, and the extent of the cleanup and final survey activities should be larger, comparing to less contaminated sites or to sites contaminated with short-lived radionuclides. Also, the rigour of the regulatory control should be adapted to the hazard potential and complexity of the site.

2.16. The government should ensure that a graded approach is taken to the implementation of the national policy and strategy for safety, in accordance with national circumstances and with the radiation risks associated with facilities and activities, including during the cleanup and release of sites.

2.17. The regulatory body should ensure that a graded approach is taken, whereby its performance of regulatory functions in relation to cleanup and site release is commensurate with the radiation risks associated with facilities and activities.

2.18. The operating organization should ensure that it takes a graded approach to the development of the site cleanup plan and the proposed end state, commensurate with the radiation risks associated with the site and with site cleanup activities.

3. RADIATION PROTECTION AND SAFETY ASPECTS OF THE RELEASE OF SITES FROM REGULATORY CONTROL

3.1 Arrangements for radiation protection are required to be applied during decommissioning activities (see Requirement 1 and paras 2.1–2.3 of GSR Part 6 [2]): the principles of justification, dose limitation and optimization of protection (see Requirements 10–12 of GSR Part 3 [10]) are applicable to the entire decommissioning process, including site cleanup. This section provides recommendation of the application of dose limits, dose constraints and the site dose release criterion, all of which are considered in relation to prospective effective doses to members of the public above the natural (baseline) background levels that would be received after the site is released. These dose criteria are applied to 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.

JUSTIFICATION

3.2 Justification is the process of determining for a planned exposure situation whether a practice is, overall, beneficial; that is, whether the expected benefits to individuals and to society from introducing or continuing the practice outweigh the harm (including radiation detriment) resulting from the practice [1]. Except for situations described in para. 3.3, 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.

3.3 For some existing sites, an initial justification decision on the adoption of the practice as a whole did not take place, for example because the practice was adopted before the adoption of the principle of justification. The decommissioning and release of such sites from regulatory control should be justified, i.e. the expected benefits of completing the decommissioning of the site and releasing it from regulatory control has to outweigh the harm (including radiation detriment) arising from those activities.

DOSE LIMITATION

3.4 The exposure of individuals are required to 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 sources in planned exposure situations, exceeds any relevant dose limit (see Requirement 11 GSR Part 3 [10]). The dose limit of 1 mSv in a year for members of the public set out in Schedule III of GSR Part 3 [10] represents an upper bound on the sum of effective doses due to exposures from all justified practices and from released sites in planned exposure situations (see also para. 3.27 of GSR Part 3 [10]).

OPTIMIZATION OF PROTECTION AND SAFETY

3.5 Within the context of decommissioning and site cleanup, optimization of protection and safety is expected to ensure that radiation exposures arising from the activities undertaken to achieve an acceptable end state are as low as reasonably achievable. The process involves consideration of relevant safety, environmental and other standards, while taking into account wider economic and societal factors, and the need to manage radiological risks to non-human species, both animal and plant. In particular, the wider decision making process should address the sustainability of the site cleanup activities alongside optimization of radiation protection and other factors such as on-site conventional health and safety, and the environmental impact of off-site disposal. Optimization therefore requires that the benefits and detriments of site cleanup work are balanced in an attempt to deliver the greatest net benefit. Further information on the need to balance different factors during optimization of protection and safety in site cleanup is provided in Annex III.

3.6 Dose constraints[6] are used for optimization of protection and safety, the intended outcome of which is that all exposures are controlled to levels that are as low as reasonably achievable, economic, societal and environmental factors being taken into account (see paras 1.22 and 1.23 of GSR Part 3 [10]). Site cleanup and release of a site from regulatory control is one of the sources of exposure for which a dose constraint should be applied[7].

3.7 Optimization of protection should include evaluation of the exposure and other risks to workers during site cleanup activities (including material characterization and radioactive waste management) and demonstrate that, after site release, the long term exposures of the public arising from the residual site contamination are also as low as reasonably achievable. This evaluation should also demonstrate

[6] A dose constraint is defined as a prospective and source related value of individual dose that is used in planned exposure situations as a parameter for the optimization of protection and safety for the source, and that serves as a boundary in defining the range of options in optimization [1].

[7] For occupational exposure, the relevant dose constraint is on individual doses to workers, established and used by registrants and licensees to set the range of options in optimizing protection and safety for the source. For public exposure, the relevant dose constraint is a source related value established or approved by the government or the regulatory body, with account taken of the doses from planned operations of all sources under control [1].

that the exposures of workers and of the public are below the relevant dose constraints, as required by para. 3.25 of GSR Part 3 [10] and para. 2.1 of GSR Part 6 [2]).

3.8 Dose constraints for the release of sites are different to the criteria applied to 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 have a broad range of potential uses and therefore should comply with clearance criteria, which are of the order of 10 μSv or less in a year (see para. 1.11 of GSR Part 3 [10]. The dose criteria for the release of the site from regulatory control should be optimized and can be higher than those for the clearance of material, because the degree of certainty about the potential uses of the land after its release from regulatory control is higher than that for the uses of cleared material. However, the applicable dose constraint for the public after the release of a site should normally be expected to be lower than any constraint that had been applied for the operational phase of the practice.

3.9 Dose constraints should be applied prospectively to exposure from radioactive residues expected to remain in human habitats after the termination of a practice [15]. The site dose release criterion should thus be an optimized value below this constraint, taking into account that reducing already very low levels of exposure might not be warranted on radiological protection grounds.

3.10 For the release of a site, a dose constraint to be used in the optimization of public exposure is required to be established or approved by the government or the regulatory body (see para. 3.22 of GSR Part 3 [10]). For a site to be released without restrictions, the effective dose should be below the dose constraint. Where restrictions are necessary to keep exposures below the dose constraint, the dose limit is not to be exceeded even if the restrictions were to fail in the future. Figure 1 shows the application of optimization and dose limitation to site release, with an illustrative dose constraint of 300 μSv/year, and an illustrative optimization threshold of 10 μSv/year below which further optimization measures might not be considered necessary.

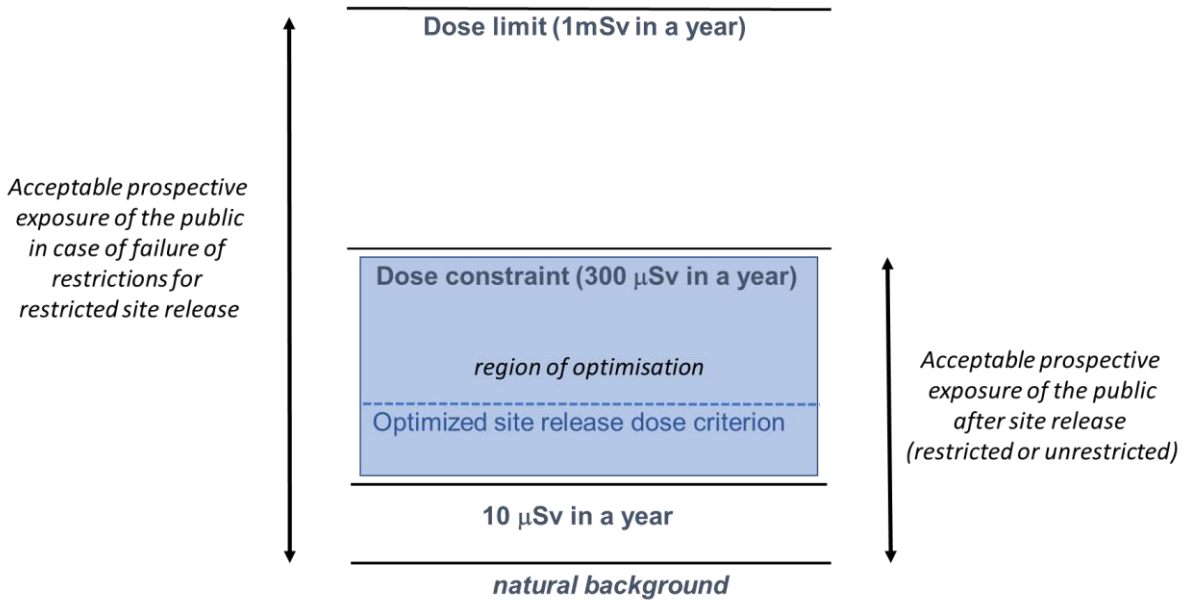

FIG. 1. The application of optimization and dose limitation to the release of a site.

3.11 Uncertainties, such as those relating to the level of contamination and the potential existence of hidden buried structures and waste, should be taken into account in determining the potential impacts 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 needed for release of the site from regulatory control.

3.12 Where a site complies with the site dose release criterion and its corresponding release levels (see paras 2.6–2.8 and Section 5), taking into account a reasonable set of potential future uses and their associated uncertainties, the regulatory body may decide to release the site for unrestricted use, which is the preferred option to terminate the decommissioning phase.

3.13 If after cleanup the site does not meet the release levels, 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 constraint and in case these restrictions fail, the public dose limit of 1 mSv/year is not to be exceeded.

3.14 Restrictions on future use of a site 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 implemented 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. A suitable time frame for institutional control should form part of the consideration on whether it is appropriate and reasonable to release a site for restricted use.

BACKGROUND RADIATION LEVELS

3.15 Before commissioning a new facility, the operating organization should ensure that a baseline survey of the site, including obtaining information on radiological conditions, is performed to determine the levels of background radiation. These levels should then be used for comparison purposes before the release of the site. For existing facilities for which no such baseline survey was carried, 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 being 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.

4. RESPONSIBILITIES FOR THE RELEASE OF SITES FROM REGULATORY CONTROL

GOVERNMENT

4.1. The government is required to establish a national policy and strategy for safety to ensure that the radiation risks associated with facilities and activities receive appropriate attention (see Requirement 1 and para. 2.4 of IAEA Safety Standards Series No. GSR Part 1 (Rev. 1), Governmental, Legal and Regulatory Framework for Safety [11]). The government is also required to establish an adequate governmental, legal and regulatory framework for safety in which responsibilities are clearly allocated (see Requirement 2 of GSR Part 1 (Rev. 1) [11]), and which includes criteria for release from regulatory control (see para. 2.5(17) of GSR Part 1 (Rev. 1) [11]). This should be supported where necessary by appropriate guidance so that workers, the public and the environment are protected during site cleanup and after the release of sites from regulatory control.

4.2. All phases of decommissioning, from the initial plan to the decision to release a site from regulatory control, are required to be subject to regulatory control (see para. 2.28 of GSR Part 1 (Rev. 1) [11]; and Requirement 5 of GSR Part 6 [2]). The legal framework is also expected to cover radiation protection of workers and the public, environmental protection, waste safety, the transport of radioactive material and the clearance of material. 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.

4.3. Within the overall legal and regulatory framework for safety (see para. 4.1), the government should establish a legal basis for the regulatory body (see paras 4.8–4.23) to develop and implement a regulatory framework for site cleanup activities and the release of sites from regulatory control. This framework should provide for decisions on the release of sites for unrestricted or restricted use, as

necessary. This should also provide the basis for establishing any restrictions that may be placed upon the use of or access to the site during and after cleanup.

4.4. The government is required to ensure that the regulatory body is provided with sufficient authority, competent staff and financial resources (see Requirement 3 of GSR Part 1 (Rev. 1) [11]). This should include the necessary authority and resources for the proper and timely discharge of its responsibilities in relation to site cleanup and release from regulatory control.

4.5. The nature and time frames for restrictions and institutional controls should be addressed within the legal and regulatory framework. The legal and regulatory framework should also contain provisions designed to ensure that adequate funding mechanisms are available and that responsibilities are assigned for the financing of site cleanup activities, restrictions on future use, and institutional controls.

4.6. The government is required to make provisions to ensure that the regulatory body coordinates its regulatory functions with other relevant authorities (see paras 2.18–2.19 of GSR Part 1 (Rev. 1) [11]). This coordination should extend to defining restrictions on the use of sites after release from regulatory control and the related institutional controls.

4.7. The government is required to make provision for the involvement of interested parties (see para. 2.5(5) of GSR Part 1 (Rev. 1) [11]), and should ensure that the regulatory body provides such parties with the necessary information on safety matters associated with the cleanup and release of sites.

REGULATORY BODY

General responsibilities

4.8. The regulatory body should establish regulatory requirements and guidance — in accordance with a graded approach — for the planning, approval and conduct of site cleanup activities; for the management of contaminated material and radioactive waste that arises from these activities; and for the release of sites (land, buildings and structures) from regulatory control.

4.9. The regulatory body responsibilities for decommissioning are listed in para. 3.3 of GSR Part 6 [2]. With regard to the cleanup and release of sites, these responsibilities should also include:

(a) Establishing criteria and guidance for site cleanup and release of sites;
(b) Reviewing submissions from operating organizations for the cleanup and release of sites, including site cleanup plans and their implementation, site dose release criteria, site specific release levels, radiological survey documentation, and any restrictions and institutional control measures;
(c) Developing criteria and methods for assessing the adequacy of the implementation of site cleanup;

(d) Issuing, amending, suspending or revoking authorizations for site cleanup and release of sites from regulatory control;
(e) Performing regulatory inspections and independent measurements as necessary to assess whether sites meet the site dose release criteria and the related release levels after cleanup;
(f) Assessing unplanned occurrences and events during site cleanup, and taking appropriate enforcement actions whenever safety requirements and conditions for authorization are not met;
(g) Coordinating the regulatory oversight of site cleanup and the release of sites with other regulatory authorities responsible for other issues such as non-radiological hazards and transport.

4.10. If initially the operating organization fails to achieve the release criterion, the regulatory body should request that further actions are considered, including additional site cleanup where feasible. Otherwise, the development of proposals to change the end state should be considered. If the operating organization is unable to ensure release of the site in compliance with established regulatory criteria, the regulatory body should maintain regulatory control over the site, in accordance with a graded approach.

4.11. The regulatory body is required to establish requirements for the collection and retention of records and reports, and for preserving information about the activities that have been conducted at the site (see para. 3.3 of GSR Part 6 [1]). This information should be preserved so that it is available for future users of the site.

4.12. Before releasing a site from regulatory control, the regulatory body should confirm that all regulatory obligations have been fulfilled and there are no outstanding issues.

Detailed regulatory oversight of site cleanup

4.13. The regulatory body should review the site cleanup plan to assess whether the cleanup activities can be conducted safely and whether the end state of the site will be in compliance with the site dose release criterion and related release levels.

4.14. The review of the site cleanup plan should be conducted initially as part of the review of the final decommissioning plan. At that stage, when it might not be possible to prepare a comprehensive cleanup plan (e.g. due to the complexity of the facility or insufficient information about the site contamination), the regulatory review could be based on a cleanup concept (see paras 5.4–5.6).

4.15. The main elements of a cleanup concept, supporting the later development of a cleanup plan, include:

(a) The expected radiological status of the site at the end of the dismantling activities;
(b) The expected remaining non-radiological hazardous material on site at the end of the dismantling activities;
(c) The potential contamination of areas adjacent to the site;

(d) The site release levels;
(e) The strategy for the site cleanup, and general proposals for cleanup activities and related cleanup techniques and auxiliary systems;
(f) An overview of the management of waste generated during cleanup;
(g) The anticipated necessary resources.

4.16. When the dismantling of equipment and buildings is well advanced, if the site cleanup plan has been revised by the operating organization, it should be reviewed by the regulatory body before proceeding. The review of the revised site cleanup plan should be extended to cover all components of the plan (see paras 5.48–5.50 and Annex VI) and should focus on the updated radiological characterization of the site and on any remaining uncertainties. The review should also focus on the effectiveness of the proposed cleanup technologies and on the monitoring measures that will be taken by the operating organization to verify that the release levels have been met.

4.17. If the operating organization considers that the site is not suitable for release for unrestricted use, the regulatory body should assess whether the operating organization has identified appropriate restrictions and justified their need, and then determine whether release for restricted use is appropriate.

4.18. The regulatory body should review the operating organization's approach to the selection of release levels for the site. If generic release levels are selected in the cleanup plan, the review should include a comparison of information about the site with the model and parameters used to develop the generic release levels. If site specific release levels are used in the cleanup plan, the review should cover:

(a) The adequacy of the site characterization;
(b) The quality of data used;
(c) The approach used to develop the release levels (e.g. use of site dose release criterion, scenarios and modelling, including radionuclide vectors);
(d) The evaluation of uncertainties (e.g. modelling, scenarios, input data);
(e) An evaluation of the selected release levels through verification calculations;
(f) A comparison of the information submitted by the operating organization with other information available to the regulatory body.

4.19. The regulatory body should verify the readiness of the operating organization to start site cleanup activities by checking the status of the preparatory measures taken (see para. 6.2).

4.20. The regulatory body should perform on-site inspections during implementation of site cleanup. These should include, where appropriate:

(a) Checks of the implementation of the site cleanup and monitoring procedures, and of the operating organization's conformance with its management system;

(b) Independent monitoring;

(c) Discussions with site personnel on progress towards compliance with the release levels.

4.21. During the site cleanup, the regulatory body should review any updates to the site cleanup plan (e.g. if major changes have occurred, or if the end state needs to change because of unexpected difficulties encountered, or if new restrictions are needed).

4.22. The regulatory body should review the final radiological survey report submitted by the operating organization when considering whether the objectives of the site release have been accomplished. After review of the final survey report, the regulatory body should decide if the site is ready to be released from regulatory control with or without restriction. When deciding about releasing a site, the regulatory body should involve interested parties. Section 7 provides recommendations on the process of site release.

4.23. The regulatory body should formally notify the operating organization and interested parties, including other relevant competent authorities, of the decision to release a site from regulatory control. In the event of a decision to release a site for restricted use, the notification should specify the restrictions and institutional controls needed, and the regulatory framework to be applied (see Sections 2 and 7).

OPERATING ORGANIZATION

4.24. The operating organization is required to have overall responsibility for safety throughout the lifetime of a facility and the duration of activities, including the cleanup of the site (see para. 2.14 of GSR Part 1 (Rev. 1) [11]). Although the performance of specific tasks may be delegated, for example to a contractor, the ultimate responsibility for safety remains with the operating organization (see para. 4.3 of GSR Part 6 [2]). The operating organization is also responsible for ensuring that the management of the radioactive waste generated during the site cleanup complies with regulatory requirements and any criteria specified by the regulatory body. The cleanup activities and associated safety measures to be taken during and after the cleanup of the site should be specified by the operating organization and should be commensurate with the hazards at the site, in accordance with a graded approach.

4.25. The operating organization ’s responsibilities for decommissioning are listed in para. 3.4 of GSR part 6 [2]. With regard to the cleanup and release of sites, the responsibilities of the operating organization should also include:

(a) Ensuring the availability of the resources (including financial resources), expertise and knowledge necessary for the cleanup and release of the site;

(b) Preparing and submitting to the regulatory body details of the site cleanup activities and supporting documentation (these documents may be part of the decommissioning plan);

(c) Performing the necessary site cleanup activities and demonstrating that the release levels for the site have been met (see Section 6);

(d) Involving interested parties in the discussions and decision making in relation to site cleanup and release, in accordance with regulatory requirements.

THE ROLE OF INTERESTED PARTIES IN THE RELEASE OF SITES FROM REGULATORY CONTROL

4.26. Parties other than the government, regulatory body and the operating organization may have an interest in the cleanup and release of a site. These interested parties may include the public (individuals, community groups and interest groups), other authorities (local, regional, national) and other States, especially neighbouring States. The legal and regulatory framework is required to include provision for the involvement of interested parties and for their input to decision making (see para. 2.5(5) of GSR Part 1 (Rev. 1) [11]).

4.27. Interested parties are required to be provided with an opportunity to examine the final decommissioning plan and, as appropriate supporting documents (see para. 7.16 of GSR part 6 [2]). This should include the proposed end state and how the operating organization will demonstrate that the end state has been achieved. Interested parties should have the opportunity to provide comments during the review of the site cleanup plan.

4.28. Interested parties should be involved in the decision making on the release of sites from regulatory controls, and this is particularly important if the intention is to release the site from regulatory control with restrictions on its future use (see para. 9.20 of IAEA Safety Standards Series Nos SSG-47, Decommissioning of Nuclear Power Plants, Research Reactors and Other Nuclear Fuel Cycle Facilities [3], and of SSG-49, Decommissioning of Medical, Industrial and Research Facilities [4]).

4.29. Interested parties with responsibilities for restrictions on use and for institutional controls after the release of a site (e.g. relevant authorities or institutions) should be consulted by the regulatory body on the nature and time frame of restrictions and institutional controls, and on the administrative processes to review or lift these. The site owner having obligations for the implementation of restrictions after the release of the site should also be involved in the decision making process. Other interested parties should be consulted on the restrictions and institutional controls in accordance with regulatory requirements. Following the release of a site, interested parties should be informed of any subsequent changes in site restrictions or institutional controls, and of the results of monitoring and surveillance.

5. PREPARATION FOR SITE CLEANUP

5.1. As illustrated in Fig. 2, site cleanup considerations take place throughout the lifetime of the facility.

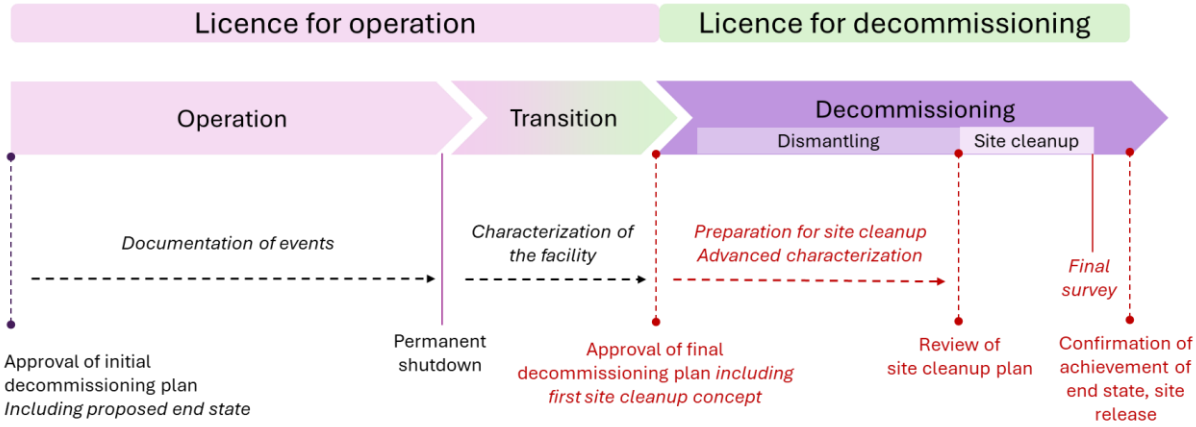

FIG.2. Site cleanup considerations and actions during the facility lifetime

5.2. At the design stage for a facility, the initial decommissioning plan should include a description of the intended end state for the site, which is likely to be general. At this stage, the objective of the end state should be release of the site without restrictions. The initial decommissioning plan may also give an indication of the assumed future use of the site. Typically, the initial decommissioning plan would only include a generic approach for the planning for site cleanup (provisions by the operating organization for recording relevant events, identification of major steps including site characterization, methodology for adopting a site dose release criterion).

5.3. During the operation of the facility, the decommissioning plan is required to be periodically reviewed and updated as necessary (see para. 7.5 of GSR Part 6 [2]). These reviews and updates should particularly consider incidents, events and situations with consequences relevant to the future site cleanup.

5.4. Prior to the commencement of decommissioning actions, the operating organization is required to prepare a final decommissioning plan and submit this to the regulatory body for approval (see Requirement 11 and paras 7.9–7.16 of GSR Part 6 [2]). With regard to the cleanup and end state, the final decommissioning plan should include:

(a) A description of the end state of the site, including the radiological objectives of the end state (i.e. site dose release criterion, statement on release of the site with or without restrictions on future uses); the description should be subsequently verified on the basis of an updated site characterization before the start of site cleanup activities.

(b) The site cleanup plan or, if this is not yet available (e.g. due to the complexity of the facility or insufficient information about the site contamination), the site cleanup concept.

5.5. The site cleanup concept is a general description of the intended cleanup actions and related processes and should provide confidence that contaminated and/or activated items and materials can be removed from the site to the extent necessary to achieve the end state. The site cleanup concept should

also describe how the site cleanup plan will be prepared. The quality and the level of detail of the site cleanup concept should be sufficient to provide the necessary input to the safety assessment and to the environmental impact assessment for the decommissioning.

5.6. When only a site cleanup concept is provided in the final decommissioning plan, the operating organization should develop a site cleanup plan prior to the start of site cleanup activities. This should be based on the site cleanup concept, taking into account the results of updated information and analyses, including site characterization. In such cases, the site cleanup plan should be subject to a separate regulatory review (i.e. after the approval of the final decommissioning plan that contained only the site cleanup concept).

5.7. The site cleanup should be optimized (see paras 3.5–3.14), taking into account all relevant aspects, such as the protection of workers, members of the public and the environment, safety, management of the radioactive waste generated during cleanup, and non-radiological aspects.

5.8. The planning of site cleanup activities is not usually a linear process, and may involve several iterations, before resulting in an optimized site cleanup plan. The preparation of the cleanup plan should include:

(a) Radiological characterization of the site (updated before the start of site cleanup activities) by determining radiation levels and the nature and level of contamination and activation;
(b) An assessment of future potential uses of the site and resulting implications for the end state;
(c) Selection of the site dose release criterion and release levels;
(d) Identification and evaluation of available site cleanup options (i.e. representing different compositions and sequences of cleanup activities: see paras 5.26–5.32), and selection of the cleanup option to be used;
(e) Development of the site cleanup plan for the selected site cleanup option.

5.9. The selection of the site cleanup option should take into account factors such as the site history, the potential future uses of the site and the level of existing contamination at the site. It should also take into consideration any existing national generic or site specific release levels and the technical options available for the cleanup and their implications.

5.10. If the operating organization finds that the end state proposed as part of the final decommissioning plan cannot be met by any feasible cleanup option, the operating organization should propose a new end state. The new end state may introduce restrictions on the future uses of the site. The proposed new end state, including any proposed restrictions, should meet the recommendations for radiation protection provided in Section 3 and should be subject to review by the regulatory body.

5.11. Before start of site cleanup activities, the operating organization should consider whether there is a need to update the site cleanup plan to take into account any new information. Significant safety

related revisions to the cleanup plan should be subject to review by the regulatory body in accordance with regulatory requirements.

5.12. A simplified outline of the major steps of the cleanup process is shown in Fig. 3. This process is not always sequential and may have an iterative nature, when additional actions are necessary or certain conditions for proceeding with further steps are not met.

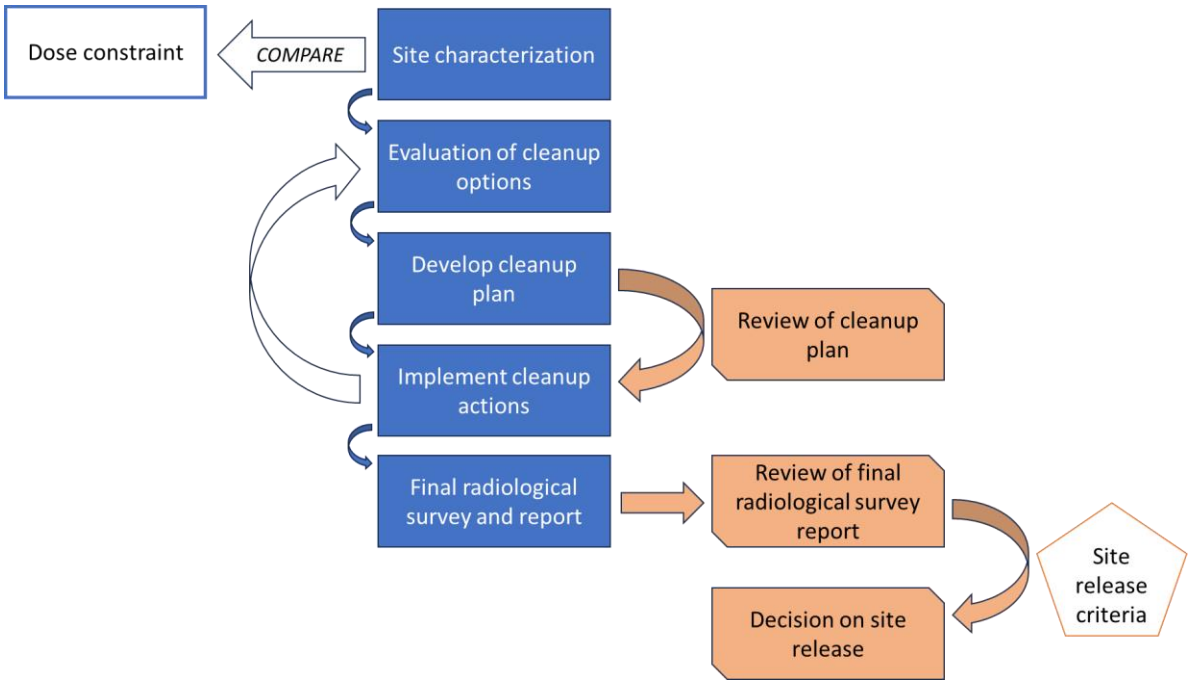

FIG. 3. Simplified flow chart of the cleanup process

5.13. The cleanup process should be covered by the management system of the operating organization. The management system should address any aspects that are specific to the site cleanup, ensuring that safety measures for cleanup are established and applied coherently and that safety is not compromised by the need to meet other requirements or demands. Further information on the management system is provided in Annex IV.

5.14. Both the operating organization and the regulatory body should establish systems for archiving, retrieving and amending records related to plans, cleanup activities, decisions, authorizations and any changes that were made during the site cleanup.

SITE CHARACTERIZATION AND DESCRIPTION OF THE END STATE

Site characterization

5.15. An appropriate assessment of the radiological impacts on workers, the public and the environment during site cleanup and after site release should be based on up-to-date information on radiological conditions on the site. Some information may already exist from the pre-dismantling characterization survey and from radiological measurements performed during dismantling. However, detailed planning of the cleanup actions usually involves additional characterization of some areas, for example those that were not accessible before and/or during the dismantling.

5.16. Depending on the size and complexity of the site to be released, and any hazards present on the site, a characterization campaign should be conducted to collect information on physical, radiochemical and environmental conditions, including:

(a) The identification of radiological contaminants and activation, the radionuclides present and their concentrations and spatial distribution in soils and buildings;
(b) The potential presence of and contamination of underground structures (e.g. pipes and tanks);
(c) Groundwater contamination and surface contamination (if any);
(d) Details of any non-radiological contaminants that might require cleanup under other legislation.

5.17. A site characterization plan should be prepared to describe the conduct of the characterization survey. Historical data for the site should be evaluated and used in the development of this plan, to help in understanding 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.

5.18. 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) Any dismantling, decontamination and radioactive waste management activities already performed at the site;
(c) Potential airborne contaminants and air quality (including amounts of suspended particulates, ease of resuspension, radon concentrations).

5.19. The radiological conditions and data for the site should then be assessed against the dose constraint (see paras 3.5–3.14) or national generic release levels (where these exist) to define the need for and scope of site cleanup.

5.20. The site characterization results should be updated as dismantling and cleanup activities progress, to ensure that relevant new information is considered in the planning for and update of site cleanup activities.

Description of the end state

5.21. The description of an end state as part of the final decommissioning plan should include information on:

(a) The dose constraint established by the regulatory body;
(b) The site dose release criterion;
(c) Site release levels, i.e. the radiological conditions to be achieved after completion of the cleanup;;
(d) Any proposed restrictions on the future use of the site after its release;
(e) Any remaining structures, systems and components of the former facility;
(f) Any remaining chemical or other hazardous contaminants, and any remaining physical risks.

5.22. After completion of decommissioning, the end state description should be updated as necessary to ensure that it remains valid and optimized. The process of optimization may consider aspects related to the evaluation of the cleanup options (see paras 5.26–5.32). If the end state description is updated, the operating organization should reassess the feasibility and effectiveness of the proposed cleanup activities to achieve the end state.

5.23. The operating organization should refine the end state as necessary if relevant information becomes available or changes during cleanup activities. The end state can be considered to be achieved provided that the site dose release criterion remains below the dose constraint (see para. 2.5).

5.24. Where the proposed site cleanup will not support unrestricted use of the site, the operating organization should determine whether additional cleanup activities could be implemented to achieve release for unrestricted use. If unrestricted use is not appropriate, restrictions on future uses will be necessary.

5.25. Before the site is released, the operating organization should demonstrate to the regulatory body that the cleanup activities have achieved the described end state and that the site meets the site dose release criterion and related release levels.

EVALUATION OF SITE CLEANUP OPTIONS

5.26. For a given end state, there may be a range of potential site cleanup options representing different combinations and sequences of cleanup activities. A simplified illustration of this is provided in Annex V.

5.27. The operating organization should evaluate the options in order to select the optimum one. In addition to the site dose release criterion and potential future use of the site, considerations to be taken into account during the evaluation of site cleanup options typically include:

(a) Exposures and other risks to the workers and to the public arising from site cleanup activities;
(b) Management of radioactive waste generated during site cleanup;

(c) Costs of the cleanup activities and associated waste management activities, including waste transport and disposal;

(d) Exposures and other risks to workers involved in waste management;

(e) Exposures to the public from waste management activities.

5.28. As part of the optimization process (see paras 3.5–3.14), the operating organization should assess the wider benefits and risks of different site cleanup options (resulting in different residual contamination and activation levels at the site), so that the best overall solution can be found for the site and its surroundings. The operating organization should consider conducting an appropriate multi-criteria analysis to assist in its optimization decision making. The operating organization should demonstrate that the approach selected represents the best overall solution for the site, the wider environment and the public.

5.29. The operating organization should ensure that the optimized cleanup option will result in a site dose release criterion which is below the dose constraint set by the regulatory body, and which can be regarded as optimized. The site dose release criterion should be reviewed by the regulatory body.

5.30. In certain situations, and when supported by an appropriate safety case, leaving contaminated structures and materials on site after release from regulatory control may represent the optimum solution for site cleanup. Where release for unrestricted use is not possible, suitable restrictions and institutional controls should be implemented.

5.31. Where the optimized site cleanup option would not result in radiological objectives that meet the specified end state, the operating organization should redefine the end state description and submit this to the regulatory body for review.

5.32. In cases where national generic release levels are available (e.g. in terms of activity concentrations), the operating organization may choose to base the evaluation of the cleanup options on a direct comparison of the residual radiological conditions (i.e. after implementation of the cleanup option) with the generic release levels. It may be more straightforward to take this approach; however, it may also result in a more conservative outcome that is not fully optimized (see also paras 5.36 and 5.37).

DETERMINATION OF SITE RELEASE LEVELS

5.33. Depending on regulatory requirements, the operating organization should either use generic release levels set by the regulatory body or use site specific release levels derived by the operating organization.

5.34. Site specific release levels should be derived by converting the selected site dose release criterion into operational quantities that can be measured. Thus, for example, these should be expressed in terms

of the activity concentration of each radionuclide concerned (in Bq/g or Bq/cm^2). This conversion should be based on site specific models, including exposure scenarios and parameter values.

5.35. If there is only one radionuclide of radiological concern present on the site, the release level represents the activity concentration that will cause exposures to members of the public from the released site that are equal to the selected site dose release criterion. If a site has been contaminated with a mixture of radionuclides, then appropriate release levels for the particular mix of radionuclides should be derived by using the 'sum of fractions' rule (e.g. as illustrated in para. I.14 of GSR Part 3 [10]).

5.36. The operating organization should take into account that the use of generic release levels may be more restrictive due to conservative assumptions used in the related dose assessment, which need to cover a broad range of possible situations. This could lead to cleanup activities being more extensive than necessary. In addition, it might not ensure that the generation of radioactive waste is minimized and might not facilitate the potential reuse or recycling of removed material (e.g. soil).

5.37. When applying site specific release levels, the operating organization should base them on the site dose release criterion, which has been selected through an optimization process (see paras 2.6–2.8 and 3.5–3.14). The site specific release levels should be subject to regulatory review, in accordance with regulatory requirements. Compared with the use of generic release levels, the application of site specific release levels might introduce an additional burden on the operating organization and the regulatory body, but it is likely to result in a set of less conservative release levels for a particular site and in less radioactive waste to be managed.

5.38. If site release levels for unrestricted use cannot be met, restrictions will be necessary to meet the site dose release criterion. In such a case, the operating organization should propose restrictions for the future use of the site. The operating organization should derive new site release levels that are suitable for the restricted use scenarios and comply with the site dose release criterion. Such a situation would represent a modification of the decommissioning end state and should be reviewed by the regulatory body in accordance with regulatory requirements.

Determination of site specific release levels

5.39. Where site specific release levels are used, the operating organization should determine them by:

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

This should be an iterative approach, within each of the steps and of the process as a whole. The operating organization should ensure that none of the steps or the overall process introduce an unnecessary degree of conservatism (e.g. for scenarios, assumptions, data). Recommendations on the individual steps are provided in paras 5.40–5.47.

Definition of the scenarios and exposure pathways

5.40. All relevant exposure pathways should be considered in the evaluation of potential radiological consequences associated with the site after its release. This includes external irradiation, inhalation of contaminated aerosols, inadvertent ingestion of small quantities of radionuclides, ingestion of radionuclides via the food chain and skin contamination exposure pathways.

5.41. In most situations, a number of possible scenarios arise in which members of the public could be affected in the future by residual radioactivity on a released site. Scenarios should be defined as reasonable sets of human activities relating to the potential future use of the site. Based on the site dose release criterion and the selected future use of the site (restricted or unrestricted), the operating organization should consider scenarios that adequately describe potential future uses of land and associated buildings or structures, as well as human activities relating to future uses and evolution of the site (including intrusion into buried structures or waste). Such uses include industrial activities, residential occupancy, agricultural production and recreational activities.

5.42. The operating organization 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 on the site after release) and in the identification of realistic parameters. The selected scenarios and pathways should be used as the basis for dose assessments to develop the site specific release levels.

5.43. 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. For scenarios for unrestricted use of land and associated buildings and structures, consideration should be given to potential exposures from materials arising from any future modification of the buildings, including demolition after release of the site, and from excavations of soil. Scenarios should take into account that material originating from a released site needs to comply with any relevant regulatory requirements in relation to exemption and clearance from regulatory control.

Compilation of site specific data and information for the scenarios and pathways

5.44. Consistent with the size, complexity and hazard potential of the site, the operating organization should collect and, if needed, pre-process relevant information, such as historical site data, socio-economic data and environmental data, related to the selected scenarios and exposure pathways.

Definition of the conceptual model of the site

5.45. The operating organization should develop and refine a conceptual model of the site to allow it and the regulatory body to gain an understanding of the expected behaviour of any radionuclides present on the site. The conceptual model is important in developing the dose assessment that is needed for determining the site specific release levels. The central role of the conceptual model is to inform aspects of the site operations, characterization, cleanup and end state. The conceptual model of the site should ideally have been established before operation commenced, and should be updated and refined throughout the site's lifetime to inform the planning and implementation of decommissioning and site cleanup.

Conduct of dose assessments

5.46. The operating organization should perform a dose assessment to provide an estimate of the effective dose to the representative person[8] after the release of the site. For each of the scenarios selected, the doses via each exposure pathway should be estimated. If the same representative person could receive exposure via multiple pathways, the exposures via each pathway should be summed to yield the total effective dose.

Calculation of the site specific release levels

5.47. Based on the dose assessment results the operating organization should calculate nuclide and site specific release levels, taking into account the uncertainties in relation to the characteristics of the site and the scenarios for future use.

DEVELOPMENT OF THE SITE CLEANUP PLAN

5.48. The site cleanup plan should contain detailed descriptions of all technical and administrative elements needed to implement the cleanup of the site and to reach the end state (including any areas for cleanup beyond the site boundary agreed with the regulatory body). The site cleanup plan should include:

(a) Site description before the start of cleanup activities, including:
    (i) The radiological and physical status at the end of the dismantling activities, including the radionuclides that should be considered during site cleanup and radiological surveys;
    (ii) Any non-radiological hazardous material;
    (iii) Potential contamination of areas adjacent to the site.
(b) Radiological conditions to be achieved at the end of the cleanup, including:
    (iv) Compliance with applicable release levels and the basis for their selection;
    (v) In the case of site specific release levels, details of how they have been determined.

[8] The 'representative person' is an individual receiving a dose that is representative of the doses to the more highly exposed individuals in the population [1].

(c) A description of the site cleanup activities and the equipment and timescales for their implementation, including:
    (i) Prerequisites for cleanup activities;
    (ii) Planned cleanup techniques;
    (iii) The necessary auxiliary systems;
    (iv) Implementation and sequencing of cleanup activities, including management of interfaces with decommissioning processes;
    (v) Measures to avoid re-contamination.
(d) A description of the safety measures (radiological and non-radiological) to be taken during cleanup for the protection of workers and the public, including the provisions for monitoring safety relevant conditions during and after cleanup;
(e) A description of the measures to monitor the progress of site cleanup activities towards the site release levels;
(f) A description of the activities for the management of waste (radioactive and non-radioactive) generated during site cleanup;
(g) Resources necessary for the site cleanup (human, financial, technical, specific competences);
(h) A description of the relevant provisions of management system, including for record keeping and reporting;
(i) A description of the arrangements for emergency preparedness and response during site cleanup.
(j) The methodology for the final radiological survey of the site (as appropriate, the survey methodology may form part of the final decommissioning plan or the cleanup plan).

An example contents of a site cleanup plan is provided in Annex VI.

5.49. As dismantling and site cleanup progress, significant new information may be collected, and there may be a need to revise or amend the site cleanup plan. Examples of such new information are discovery of more extensive site contamination and difficulties in applying planned cleanup techniques. If the site cleanup plan is revised, depending on regulatory requirements, the operating organization should submit the revised plan to the regulatory body for review.

5.50. If changes are made to the site cleanup plan, the operating organization may need to consider a change to the end state (see para. 5.23).

6. IMPLEMENTATION OF SITE CLEANUP ACTIVITIES

SITE CLEANUP ACTIVITIES

6.1. In the implementation of the cleanup activities for the release of the site, consideration should be given to all aspects of protection and safety in accordance with the assessments undertaken during the development of the site cleanup plan (see paras 5.48–5.50). The aims should be to ensure that

radiation risks to workers, the public and the environment during the cleanup, and to the public after the termination of cleanup activities, are below dose constraints and are as low as reasonably achievable. Non-radiological hazards should be considered in a holistic manner together with radiological hazards, and addressed as appropriate in the implementation of cleanup activities.

6.2. The operating organization should undertake the preparatory measures needed to implement the planned site cleanup activities effectively. Such measures should ensure the availability of:

(a) A suitable overall organization (the operating organization and any contractors) for implementing the cleanup activities;
(b) Adequate human resources, equipment and supporting infrastructure (including accreditation of people, monitoring equipment and techniques, analytical laboratories and equipment);
(c) Sufficient funding;
(d) Arrangements for radioactive waste management;
(e) Safety procedures, including radiation protection procedures for workers and, where appropriate, safety instructions for members of the public;
(f) Quality management arrangements;
(g) Procedures for site monitoring;
(h) A process for assessing progress and record keeping;
(i) A plan for establishing the arrangements for the final site survey and preparation of the final survey report.

6.3. The operating organization should consider whether the arrangements for the dismantling phase properly take into account subsequent site cleanup activities. Where necessary, the operating organization should adapt these arrangements to ensure their suitability for site cleanup activities.

RADIOLOGICAL MONITORING DURING SITE CLEANUP

6.4. The operating organization should establish procedures for site cleanup which specify the monitoring approach and the techniques, quantities and units (e.g. Bq/g or Bq/cm^2) to be used for measurements of radioactivity. These procedures should include guidance on how to adjust cleanup activities to make progress towards achieving the site release levels. These procedures should also specify how uncertainties should be reported.

6.5. The operating organization should monitor the site during cleanup to assess the efficiency and effectiveness of the cleanup activities, and with a view to ensuring that the release levels for the site are attained. The specific monitoring measures to be used will depend on the type of facility, the nature of the contamination and the site release levels.

6.6. The operating organization should monitor and survey the site vicinity regularly during cleanup activities to determine the radiological conditions, detect possible dispersion of contamination during

cleanup activities, and to ensure compliance with radiation protection and environmental protection requirements. The operating organization should also perform monitoring to demonstrate safety during the management of radioactive waste generated during site cleanup (see paras 6.8–6.10). The operating organization should prepare a consolidated monitoring plan covering all measurement to be performed during site cleanup and in the final survey.

6.7. The operating organization should regularly assess the monitoring results in order to detect any unexpected levels or locations of contamination and use this information to update the site cleanup plan accordingly.

MANAGEMENT OF RADIOACTIVE WASTE GENERATED DURING SITE CLEANUP

6.8. Site cleanup activities may generate large amounts of radioactive waste, especially in cases where the operation of a facility resulted in extensive contamination of buildings and land. The waste from the site cleanup may be quite different from the waste typically generated during the dismantling phase of the decommissioning, in terms of types of material (soil and concrete rubble instead of metallic waste), quantities and levels of radioactivity (non-radioactive waste, very low level waste and low level waste normally predominate during site cleanup). Significant amounts of the waste generated by site cleanup might be suitable for clearance (see paras 6.11 and 6.12).

6.9. The operating organization should adapt the waste management infrastructure deployed for the dismantling phase, or else it should establish new infrastructure specific to the waste management needs during site cleanup activities.

6.10. Predisposal management of radioactive waste should be undertaken to process the radioactive waste arising from cleanup activities, including secondary waste, in accordance with regulatory requirements. Further recommendations are provided in IAEA Safety Standards Series Nos: SSG-40, Predisposal Management of Radioactive Waste from Nuclear Power Plants and Research Reactors [16]; SSG-41, Predisposal Management of Radioactive Waste from Nuclear Fuel Cycle Facilities [17]; and WS-G-6.1, Storage of Radioactive Waste [18].

CLEARANCE OF MATERIAL PRODUCED DURING SITE CLEANUP

6.11. A lot of materials generated during site cleanup may contain a very low level of radioactivity and may be suitable for release from regulatory control, (for reuse in the same industry or as a commodity in general industry (e.g. concrete rubble), or for disposal in a facility for non-radioactive waste, if approved by the appropriate regulatory body). This removal of regulatory control is referred to as ‘clearance’ and implies that no further regulatory control of the material is required for radiation protection purposes (see schedule I of GSR Part 3 [10], and IAEA Safety Standards Series No. GSG-18, Application of the Concept of Clearance [12]).

6.12. The operating organization should ensure that material to be cleared meets the clearance levels specified by the regulatory body. For this purpose, the operating organization should develop a procedure that describes the measurement methodology and the activities and notifications for demonstrating compliance with the regulatory requirements for clearance. This procedure should be submitted to the regulatory body for review and approval.

FINAL RADIOLOGICAL SURVEY FOLLOWING SITE CLEANUP

6.13. The final radiological survey is the concluding phase of site cleanup. After completing the cleanup activities at a site, the operating organization should perform a radiological survey of the site (and, if appropriate, the site vicinity) to demonstrate whether the site release levels have been attained. The operating organization should perform this survey in accordance with the methodology described in the site cleanup plan, and take into account the history of the site and previous site characterization results.

6.14. To confirm that the site release levels have been attained, the operating organization should compare the measurement results obtained following the completion of site cleanup activities, and the applicable generic or site specific release levels (in Bq/g or Bq/cm^2) established in the site cleanup plan. The operating organization should design and perform the final survey to provide data of sufficient quantity and quality to enable a statistically robust set of arguments that demonstrate compliance with the site release levels. The operating organization should perform a statistical evaluation to provide a sound basis for decision making regarding the radiological conditions of the site.

6.15. The operating organization should submit the methodology to be used for the final survey to the regulatory body for review prior to performing the survey, in accordance with regulatory requirements. The operating organization should take into account, as necessary, any insights obtained during the site cleanup activities which indicated a need to update the methodology (see also section 4.3 of Ref. [19]).

6.16. The operating organization should ensure that scope and level of detail of the final radiological survey and the methods used are appropriate for demonstrating that the release levels have been attained. Typically this entails accurate measurements of radionuclides at low activity concentrations and assessment of large quantities of data. The operating organization should ensure that suitable requirements on quality assurance and transparency of documentation are in place.

6.17. The operating organization should plan and implement the final radiological survey taking into consideration the site cleanup activities performed and the results of radiological monitoring performed during the cleanup. The operating organization should ensure that the design of the survey and the statistical approach used give due attention to any areas that need a greater level of detail during the performance of the final radiological survey.

6.18. The operating organization should evaluate and revise, if necessary, the radionuclide composition and the ratios of activity concentrations of different radionuclides ('radionuclide vectors') that are used during cleanup, to ensure that these are suitable for application during the final radiological survey. The radionuclide vectors to be used for the final survey might differ from the ones applied during cleanup, as the cleanup activities performed may remove some radionuclides more efficiently than others (for example, due to the radionuclide distribution in the depth of the soil or in concrete structures) or due to the different half-lives.

6.19. The operating organization should ensure that the data generated during the final survey is traceable to suitable standards and is suitable for supporting the necessary analysis and decision making. A final survey usually generates large quantity of data in different formats, which should be validated and verified by the operating organization. The operating organization should analyse and consider the uncertainties of the survey results during the decision making on attainment of the release levels, and should report these together with the survey results. Information on monitoring for compliance with remediation criteria for sites is provided in Ref. [20].

6.20. Where the final radiological survey shows that the release levels have been attained, the operating organization should document the results in a final survey report (see also section 4.4 of Ref. [19]) and submit this to the regulatory body in accordance with regulatory requirements. Before submitting the results of the final survey to the regulatory body for review, the operating organization should consider making arrangements for an independent verification of the final survey results, which may include additional sampling and measurements.

6.21. Where the survey indicates that the release levels have not been attained, the operating organization should undertake further site cleanup activities as necessary before performing a new final radiological survey. If further site cleanup is not considered feasible, the operating organization should engage with the regulatory body on defining a new end state.

7. PROCESS FOR RELEASING SITES FROM REGULATORY CONTROL

7.1. The operating organization is required to prepare a final decommissioning report to demonstrate that the end state of the site has been reached and the site is ready to be released from regulatory control; the regulatory body is then required to decide on whether the site can be released from regulatory control, and whether there is a need for restrictions on the future use of the site (see paras 9.1–9.7 of GSR Part 6 [2])

UNRESTRICTED USE OF THE SITE

7.2. Where the regulatory body determines that the final decommissioning report submitted by the authorised party has demonstrated that the end state has been attained, the regulatory body may —on the basis of radiological protection considerations — release the site from regulatory control without any restrictions or institutional control.

7.3. Unrestricted use of sites denotes that the level of residual contamination is low enough in the various environmental media and in the remaining structures to ensure that radiation exposures are in accordance with the recommendations provided in Section 3 and are compatible with the future use of the site after its release.

RESTRICTED USE OF THE SITE

7.4. Where the regulatory body determines that the final decommissioning report submitted by the authorised party demonstrates that the achieved end state necessitates the application of restrictions on specific future uses, the site may be released from regulatory control for restricted use. To implement these restrictions, some form of institutional control may be necessary (see para. 2.14). Restrictions and any institutional controls should be implemented before the site is released.

7.5. Restricted use of a site denotes that the level of residual contamination is not sufficiently low to be compatible from a radiation protection perspective with all possible future uses of the site after its release. By imposing restrictions on possible future uses, it may be possible to release the site from regulatory control and to keep doses below the site dose release criterion.

7.6. Restrictions may limit the removal of materials from the site, the potential future uses of the site and/or the exposure pathways. Examples of restrictions on use include:

(a) Limits or prohibitions on public access or use;
(b) Limits or prohibitions on excavation works, such as ensuring that prior approval is needed;
(c) Limits or prohibitions on agricultural activities;
(d) Limits or prohibitions on the extraction and use of groundwater, such as limiting its use to industrial purposes.

7.7. Responsibilities for implementing restrictions on use and institutional controls should be clearly defined. These responsibilities may be assigned to the owner of the site, the regulatory body or other authorities and institutions (e.g. for environmental protection). These responsibilities might also be assigned to a former operating organization.

7.8. The time frame for restrictions on use and institutional controls, and also the administrative process to review, revise or lift these, or to extend their duration, should be set. Where necessary,

organizations with responsibilities for restrictions should be able to seek the opinion of the regulatory body on matters relating to the restrictions.

MANAGEMENT AND PRESERVATION OF RECORDS

7.9. When a site is released from regulatory control (with or without restrictions on use), records of previous activities (including site cleanup) are required to be retained by the relevant authority or institution in accordance with regulatory requirements (see para. 9.7 of GSR Part 6 [1]).

7.10. During the period while restrictions and institutional controls are in place, the organizations responsible for maintaining the records relating to the restrictions should be clearly designated. The record keeping system should be designed and maintained so as to ensure preservation of information relevant to the restrictions for at least the intended duration of restrictions, in accordance with regulatory requirements.

NOTIFICATION OF THE REGULATORY DECISION TO RELEASE A SITE

7.11. When the regulatory body decides to release a site from regulatory control, this decision should be formally notified to the operating organization and interested parties (see para. 4.23). For release of a site with restricted use, this notification should be accompanied with the description of the restrictions and institutional controls that have been set.

8. SPECIFIC SITE RELEASE SITUATIONS

RELEASE OF PART OF A SITE

8.1. An operating organization may request release from regulatory control for only part of the site, for example to enable the progressive release of buildings from a site containing multiple facilities, or the release of land areas from larger sites. This approach can be used to achieve a reduction in the overall size of the authorized part of the site and to make the released portion of the site available for other purposes. In the event that an operating organization envisages release of part of a site, this should first be discussed with the regulatory body.

8.2. Where applicable, the operating organization should document its intention to release part of the site in the decommissioning plan, the site cleanup plan and the radiological survey methodology. The request for release from regulatory control of part of the site should take into account the radiological end state criteria for the final release of the entire site and its future use.

8.3. For that part of the site to be released from regulatory control, the recommendations provided in paras 7.2–7.8 should be followed. For the part of the site remaining under regulatory control, a revised

or new, separate authorization is required to be sought from the regulatory body (see para 9.5 of GSR Part 6 [2]).

CONTINUED USE OF PART OF THE SITE

8.4. If radioactive waste is stored on the site after completion of cleanup, a revised or new, separate authorization for the waste storage facility is required to be sought from the regulatory body (see para 9.4 of GSR Part 6 [2]). Requirements for the storage of radioactive waste are established in GSR Part 5 [7] and supporting recommendations are provided in SSG-40 [16], SSG-41 [17] and WS-G-6.1 [18].

8.5. If spent fuel remains on the site, the recommendations provided in IAEA Safety Standards Series No. SSG-15 (Rev. 1), Storage of Spent Nuclear Fuel [21] should be applied.

RELEASE OF A SITE CONTAINING MULTIPLE FACILITIES

8.6. If a site contains multiple facilities (including where there is more than one operating organization on the site), the decommissioning plan should include the overall decommissioning strategy for the site. The plan should identify and evaluate any interdependencies between the facilities, including those in operation and those that are shut down, including aspects related to the end state, site cleanup and site release. The interdependencies between facilities should be detailed in the individual facility final decommissioning plans, including the end states for each of these facilities.

8.7. A phased approach to decommissioning of a site containing multiple facilities may be preferred, whereby site decommissioning is divided into phases that are planned and implemented sequentially. The phases may relate to decommissioning of individual facilities on the site. In such a case, each phase should have its own decommissioning plan and should be reviewed by the regulatory body before the work in that phase commences. Where site cleanup is needed, it may be the last step in the decommissioning of each facility, or for the site as a whole. In either case, a consistent approach to site cleanup should be implemented.

8.8. When using a phased approach, the operating organization should keep an overview of the safety of the entire site through the coordination of decommissioning and cleanup activities performed in different phases, and to build the confidence of interested parties in the capability to achieve the defined end state of the overall site.

REUSE OF THE RELEASED SITE FOR A NEW FACILITY OR ACTIVITY

8.9. A released site may be used for the construction of a new facility. The residual activity remaining on the site after the previous cleanup and release is not part of the natural background radiation levels of that site, and should be considered an addition to the natural background radiation levels.

8.10. The impact of such residual activity should be considered when setting a dose constraint for any new authorized facility or activity to be introduced on a site that has previously been released from regulatory control. The regulatory body should ensure that the exposure of a representative person from all sources, including that residual activity, would not exceed 1 mSv in a year above the natural background.

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Annex I
EXAMPLES OF THE RELEASE OF SITES WITHOUT RESTRICTIONS ON USE

RELEASE OF THE DANISH REACTOR 1 SITE FROM REGULATORY CONTROL WITHOUT RESTRICTIONS ON USE

Site description

I–1. The Risø site to the West of the Copenhagen in Denmark originally included three research reactors, a hot cell facility, a fuel fabrication facility and a waste management plant. The site was commissioned in the late 1950s with the purpose of underpinning Danish research into application of nuclear technologies and to build experience in the operation of various types of reactor. In the early 2000's, the three research reactors were shut down and the preparation for decommissioning of all the nuclear facilities was initiated.

I–2. The overall objective of the decommissioning at the Risø site, as decided by the Danish Parliament, was the release of all areas and possible remaining buildings from regulatory control without any restrictions, thereby enabling reuse of the site for any other purpose.

I–3. Danish Decommissioning was established as a state-owned company in 2003 and assigned with the task of safe operation (care and maintenance) and decommissioning of nuclear facilities. Danish Decommissioning was also assigned the responsibility of managing the radioactive waste resulting from decommissioning activities at the Risø site and from the use of radioactive material in Denmark.

End state objective

I–4. Danish Reactor 1 (DR 1) was the first reactor to be decommissioned at the Risø site. DR 1 was a small homogeneous 2 kW liquid core reactor mainly used for educational purposes. It was commissioned in 1957, and taken out of operation in 2001. The aim of the decommissioning of DR 1 was to facilitate the reuse of the building and nearby surrounding area for other purposes without regulatory restrictions.

I–5. The Nuclear Regulatory Authorities specified requirements for development of a decommissioning plan and associated safety assessments. Furthermore, Danish Decommissioning was required to prepare a final decommissioning report after completion of decommissioning activities, accompanied with a final (radiological) survey report, both of which were to be submitted to the Nuclear Regulatory Authorities for approval prior to the decision for release from regulatory control.

I–6. For clearance of materials, buildings, and land areas the Nuclear Regulatory Authorities prescribed the use of:

(a) Mass specific clearance levels given by the IAEA[9] for the clearance of materials;

(b) Surface specific clearance levels given by the European Commission[10].

Decommissioning project

I–7. As a general approach, Danish Decommissioning decided that as much as possible of the decommissioning work should be performed by their own technical staff, many of whom had long experience from the operation of the facilities. However. external contractors were also used for specific demolition tasks.

I–8. In 2004, Danish Decommissioning received approval from the Nuclear Regulatory Authorities to initiate the actual decommissioning works on DR 1. Prior to that, Danish Decommissioning had conducted general post operational cleanup and other preparatory works, including removal of external parts of the cooling systems and reactor control rods. From October 2004 to January 2005 the main radioactive components were dismantled, and from May to August 2005 the reactor block was demolished, the floor in the reactor hall was removed, and all contamination above clearance levels was removed. The details of the decommissioning of DR 1 are available from the Final report of the Decommissioning of DR 1 (2006)[11].

Final cleanup activities

I–9. Following the dismantling and demolition of DR 1 and peripheral components, waste packages and demolition equipment were removed before all surfaces (floors, walls, ceiling) in the reactor hall and the surfaces on the remaining travelling crane were vacuum cleaned and washed.

Final survey and clearance

I–10. The measurements made to verify that the DR 1 building and land areas surrounding the reactor building to within a few metres could be released without restrictions were presented in the Final survey report for DR 1, Clearance of building and land (2005) [12].

I–11. All measurements were made using either a contamination monitor, a Ge-detector or a NaI-detector. Ge-detectors were used in larger rooms, as one or two measurements made it possible to monitor the entire room. Ge-detectors measurements also enabled detection and identification of radionuclides (γ-emitters) that had penetrated into the floor or walls. The building was monitored to a

[9] INTERNATIONAL ATOMIC ENERGY AGENCY, Application of the Concepts of Exclusion, Exemption and Clearance, IAEA Safety Standards Series No. RS-G-1.7, IAEA, Vienna (2004). Now superseded.

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[12] https://www.eu-alara.net/images/stories/Pdfdivers/Survey2006/SurveysForum2006/dr1-final%20survey%20report.pdf

coverage of nearly 100%. None of the measurements showed contamination above the clearance levels given by the authorities.

I–12. Outside the reactor building, all the asphalt to the north of the building was monitored for contamination: no contamination was found. A measurement using a Ge-detector on the asphalt area was performed and compared to a background spectrum measured at an area on the Risø area with a similar type and age of asphalt. The measurements on the asphalt delivered no indication of contamination by radionuclides from the operation and decommissioning of DR 1. To the East and South of the building, measurements were made using a Ge-detector. Background measurements were performed in areas at the Risø site with similar characteristics: no contamination resulting from the reactor operation and decommissioning was found. The outdoor staircase to the basement on the west side of the building was monitored: no contamination above background levels was found.

Regulatory decision

I–13. After regulatory approval of the specific decommissioning plan in 2004, DR 1 was successfully dismantled and demolished in 2005. On the basis of a detailed final decommissioning report presented by Danish Decommissioning in late 2005, and the final survey report, the Nuclear Regulatory Authorities released the building and surrounding area from regulatory control without restrictions in January 2006. The former reactor building is now used for other purposes by the Danish Technical University.

COMPLETION OF DECOMMISSIONING OF THE FIR 1 RESEARCH REACTOR

Introduction

I–14. The FiR 1 research reactor, located in Otaniemi, Espoo, Finland, was the first nuclear facility in Finland and was operational from 1962. It was used for various purposes, including research, education, isotope production, and cancer treatment studies. Due to economic reasons, the reactor was decommissioned by VTT from 2013 to 2024.

Completion of decommissioning

I–15. VTT completed the decommissioning of the FiR 1 research reactor and requested the Radiation and Nuclear Safety Authority (STUK) to verify that the remaining structures met the safety requirements for unrestricted use. The decommissioning process involved several phases, including planning, regulatory approvals, dismantling, waste management, and final site clearance. The decommissioning was conducted in compliance with STUK's guide YVL D.4[13].

Waste management

[13] https://www.stuklex.fi/en/ohje/YVLD-4

I–16. The management of radioactive waste during decommissioning involved detailed planning, waste characterization, and packaging at the facility. All nuclear waste generated during reactor operation and decommissioning was delivered in stages to the Loviisa Nuclear Power Plant Low and Intermediate Level Waste Repository for final disposal as the decommissioning progressed. VTT and Fortum applied together for transfer of the waste management obligation from VTT to Fortum, and the Ministry of Economic Affairs and Employment transferred the obligation in 2023. In practice, the waste management obligation for each transport batch was transferred between licensees upon acceptance of the contents of the shipments at the Loviisa Nuclear Power Plant.

I–17. The waste management process included also the transfer of spent nuclear fuel to the United States of America in 2020 and free release of significant amounts of non-activated materials. One significant free-release material stream was the dismantled heavy concrete from the FiR 1 Boron Neutron Capture Therapy Cancer Treatment Station in 2022.

Survey and documentation

I–18. A comprehensive survey in accordance with regulatory requirements was conducted on all surfaces within the reactor's radiation controlled area. The findings, including decontamination actions, were documented in a report. The survey confirmed that the remaining structures met the nuclear and radiation safety requirements for unrestricted use.

Regulatory approvals

I–19. In 2025, the Ministry of Economic Affairs and Employment will decide on the cessation of VTT's responsibility for the reactor on the basis of compliance with the Nuclear Energy Act. This decision will be made after verifying that all safety and environmental standards have been met. The application for the cessation of responsibility is part of the verification process.

Historical significance

I–20. The FiR 1 reactor was Finland's first nuclear facility and played a significant role in research, education, and medical studies. It was decommissioned due to economic reasons, and the process was undertaken in compliance with the current nuclear energy regulations. The reactor was used for the last time in 2015, and several fuel rods were removed during the same year from the core to ensure it remained subcritical.

Decommissioning phases

I–21. The decommissioning process included several phases such as pre-decommissioning actions, detailed planning, regulatory licensing, and the actual dismantling work. These phases were completed in stages to ensure safety and compliance with regulatory requirements. The dismantling of the reactor's internal components — including fuel racks, cryostat tube, neutron radiography tube, central irradiation tube, control rods and other parts — was completed between June and September 2023. The dismantling

of the concrete biological shield was performed between October 2023 and April 2024. These two phases were the most challenging with respect to direct radiation exposure and contamination control, respectively. Other phases included dismantling of cooling circuits, activated structures, and the reactor's auxiliary systems.

Radiation protection

I–22. Radiation protection measures were implemented throughout the decommissioning process. This included continuous monitoring, use of protective equipment, and adherence to safety protocols. Significant additional space was provided by erecting a 'portacabin village' next to the reactor building hosting personnel radiation monitors, change rooms, kitchen, meeting rooms and security arrangements. Entry and exit of personnel and materials from the controlled area were strictly separated for contamination control. Specific radiation protection measures included the use of a dismantling bridge equipped with radiation shielding, manipulators, winches, tools, and cameras for the dismantling of the reactor's internal components.

Organizational structure

I–23. The organizational structure for decommissioning was adapted from the operational phase. Clear delineation of responsibilities for project management and safety oversight were maintained throughout the process. The decommissioning project involved subcontractor organizations, but VTT as the licensee had the overall responsibility for nuclear and radiation safety.

Regulatory oversight

I–24. STUK maintained regulatory oversight through regular inspections, document reviews, and on-site monitoring. The oversight ensured that the decommissioning process complied with all safety and environmental standards. STUK conducted several mandatory inspections to verify the readiness for moving on into a new dismantling phase.

Conclusion

I–25. The decommissioning of the FiR 1 research reactor was a comprehensive process that involved various stages and regulatory approvals. The successful completion of the decommissioning ensured that the site can be used for unrestricted purposes, marking the end of an important chapter in Finland's nuclear history.

Annex II
EXAMPLE OF RELEASE WITH RESTRICTIONS AND IMPLEMENTATION OF INSTITUTIONAL CONTROLS

RELEASE OF THE WINFRITH SITE IN UNITED KINGDOM

II–1. The Winfrith site is located approximately 200 km southwest of London: the site is approximately 7 km from the sea, and the area of the site is 1.29 km^2. Construction on site started in the late 1950s with the first reactor being commissioned in 1960. The last reactor on the site was shut down in 1990. The site has since been undergoing decommissioning and cleanup, with half the site released for other uses. The current schedule is for decommissioning to be finished in the 2040s. Decommissioning has resulted in the removal of contamination from most areas to a level that would not require ongoing stewardship or regulatory control. However, proposals for the end state of the remaining reactors would mean leaving some lightly contaminated concrete and rubble in place under stewardship to allow for decay prior to full release from regulatory control.

II–2. The site is currently owned by the Nuclear Decommissioning Authority (NDA), with decommissioning and cleanup conducted by Nuclear Restoration Services (NRS, a subsidiary of the NDA). NRS is the steward of the site holding the nuclear site licence, the environmental permits, and the land-use planning permissions for the site. Consideration is being given to the ongoing stewardship of the site once the work is complete.

II–3. The UK's Office for Nuclear Regulation (ONR) regulates activities associated with nuclear safety, nuclear security, nuclear site health and safety, nuclear safeguards, and transport of radioactive material, including waste, by road and rail.

II–4. The Environment Agency regulates the disposal of waste on or from nuclear sites including setting the requirements for the condition in which an operating company can leave a site following decommissioning and the site's release from regulatory control. This will define the period for which post-cleanup stewardship is required. The intention is for the site to be eventually released from regulatory control once it meets its site reference state and then be available for any further use without restriction.

II–5. Dorset Council is the local authority responsible for land use, waste and emergency planning, transportation, development control and sustainable development. Local authorities are also key interested parties as planning authorities under the UK's land-use planning legislation.

II–6. It is proposed that during the period of stewardship, after the period of regulatory control, the site will be monitored though a combination of in-person inspections by NRS, NDA or a successor organisation which will act as steward.

II–7. The stewardship strategy identifies the relevant regulatory authorities, their roles, and how this may change over the stewardship period. The expectations of stakeholders, particularly the community and the planning conditions of the local authority will continue to be taken into account throughout the stewardship period.

II–8. The activities undertaken under the stewardship programme will include:

(a) Surveillance and environmental monitoring of groundwater levels and quality though borehole sampling to understand the performance of the disposal and the numerical models that underpin the safety case.
(b) Management of the environmental monitoring programme.
(c) Site management, including maintenance of disposal caps and habitat management such as removal of invasive species.
(d) Site surveillance though routine visits and satellite monitoring to identify incidences of interference or other physical changes.
(e) Engagement with regulatory and planning authorities.
(f) Preservation of knowledge and records.
(g) Engagement of interested parties.
(h) Preparation for the period after the site reference state is met, when stewardship will no longer be required.

II–9. The stewardship programme is funded by the UK government. This funding provides assurance that the cost of any rework at the site will be met if this is necessary.

II–10. Data and records regarding the operation, closure, decommissioning, cleanup and restoration of the site will be retained. The NDA is currently collating all information and information will also be held by:

(a) The Environment Agency until the end of the period of verification (the site reference state);

(b) The local authority (currently Dorset Council).

II–11. Records will be maintained for a minimum of 30 years beyond the point of the release of the site from regulatory control, as stipulated by the requirements of both the site licence and the environmental permit. It is possible that these records will be held for a longer period, particularly as it is anticipated nuclear decommissioning in the UK will continue long after the Winfrith site is released.

II–12. Early consideration of the stewardship process, who is responsible and how this might be achieved has helped to shape the scope of site cleanup. Active and early engagement with regulatory authorities to establish roles, boundaries and requirements has been beneficial and helped define some aspects of the site end state.

CLEANUP OF A FUEL FABRICATION PLANT IN FRANCE

II–13. After extensive cleanup of a fuel fabrication plant, on-site and off-site uranium contamination of soils and groundwater remains. The site has been released from regulatory control with restrictions on the use of soils and groundwater. Restrictions are set by local authority (local order) and apply to the owner of the site. The terms of the local order are the following:

(a) No public use of the site is allowed.
(b) Excavation works are granted upon survey submitted for approval by the local authority, based on the nuclear safety authority advice, waste from excavation are to be managed in dedicated waste routes.
(c) New construction for water extraction is forbidden (except for monitoring).
(d) The owner has to conduct groundwater monitoring twice a year; results are submitted to the local authority once a year.
(e) Access to groundwater wells outside of the site is granted to the owner of the restricted parcels of land.
(f) The groundwater monitoring plan is revised every 4 years.

II–14. The owner can ask the local authority for modifications of the restrictions by demonstrating the absence of residual contamination of soils and groundwater. The local authority is responsible for authorizing the end of the restrictions. The local authority has to be informed in case of transfer of the ownership of restricted parcels of land.

Annex III
BALANCING DIFFERENT FACTORS DURING OPTIMIZATION OF SITE CLEANUP AND THE END STATE

III–1. During decommissioning and site cleanup, significant volumes of waste can be generated. Most of the waste volume is expected to be conventional waste, in the form of rubble, concrete, brick, soil, drains and pipelines, as buildings and structures are demolished and the site cleaned up. However, a small percentage of this waste will be radioactive; mostly low level waste and very low level waste. Although the proportion of waste that is radioactive is usually small, the amounts are nevertheless significant, typically tens of thousands of cubic metres for a typical nuclear power plant site. The quantity of waste generated depends on the agreed level of cleanup.

III–2. If the only factor considered in determining the option for cleanup is radiation exposure for future users of the site, this generally results in removing virtually all the lightly radioactively contaminated foundations and substructures from a site and transporting them to disposal facilities elsewhere. For a typical nuclear power plant site, this can represent thousands of cubic metres of lightly contaminated waste. The excavation and transport of this waste for disposal elsewhere can result in a number of adverse impacts on people and the environment, including: resuspension of radioactive dust; risks to construction and demolition workers; traffic risks due to multiple movements of heavy lorries taking waste away and bringing fresh material in for filling voids; and the filling up of the limited space in radioactive waste disposal facilities. This might also result in unnecessary costs.

III–3. Applying optimization to nuclear site decommissioning and cleanup will ensure that radioactive waste and contamination are managed in a way that is safe, but might not necessarily lead to all radioactivity being removed from the site. In some cases, the risks associated with leaving lightly contaminated substructures and soils in place, where it is safe to do so, may be significantly lower than those of excavating, transporting and disposing of them elsewhere. The possible benefits of leaving some lightly contaminated foundations and substructures on the site include:

(a) Avoiding unnecessary cleanup work, and allowing substructures and soils to remain in place, where it has been demonstrated that this represents the optimum solution for the site;
(b) A significant reduction in the generation of radioactive and conventional waste and the risks to workers and the public associated with excavation and transport of these wastes;
(c) A reduction in pressure on existing disposal facilities;
(d) Cost savings from reduced excavation and transport of waste;
(e) Potentially earlier re-use of sites for recreational purposes or redevelopment.

Annex IV
MANAGEMENT SYSTEM AND DOCUMENTATION SPECIFIC FOR CLEANUP

MANAGEMENT SYSTEM

IV–1. With regard to site cleanup and release, the management system might typically be used to ensure that:

(a) Objectives, safety requirements and criteria (radiological and non-radiological) are adequately defined and met;
(b) Adequate plans for cleanup, radioactive waste management and monitoring for compliance are developed and implemented;
(c) Appropriate management arrangements are in place with a clear allocation of responsibilities between the operating organization and contractors;
(d) Adequate selection, calibration, maintenance and testing of equipment for use in appropriate monitoring techniques are performed;
(e) Adequate controls over procurement, including control over subcontractors' services, are implemented;
(f) Appropriate sampling and measurements (in terms of locations, media, number of samples, frequency) are performed;
(g) Adequate analysis and verification and of monitoring results are performed;
(h) Appropriate record keeping and reporting are undertaken;
(i) Appropriate qualifications, experience and training and competence of personnel involved in the cleanup and the release of sites are in place;
(j) Adequate financial resources are available;
(k) Adequate internal and external audits and regulatory inspections are performed;
(l) Measures for the detection of non-conformance, adequate corrective actions and arrangements for termination of the authorized practice are provided.

DOCUMENTATION

IV–2. With regard to site cleanup and release, records for archiving typically include:

(a) Characterization data of the site prior to cleanup;
(b) The site 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.

Typically, such a system is commensurate with the size, complexity and hazard potential of the site to be released from regulatory control.

Annex V
SIMPLIFIED EXAMPLE OF EVALUATION OF SITE CLEANUP OPTIONS

V–1. This annex contains a simplified example of evaluation of site cleanup options. In this example, a national dose constraint for the release of a site has been established at 300 μSv in a year.

V–2. Towards the end of a decommissioning project, the site is considered for a release from regulatory control. It contains one remaining building that is intended for reuse.

V–3. The radiological characterization of the site indicates that there are radionuclides present in the remaining building structure (C1), an underground aquifer (C2) and in the subsoil (C3), as illustrated in Fig. V –1. The contamination levels are such that the resulting exposures to people, calculated on the basis of scenario modelling, exceed the dose constraint for release of the site. Therefore, cleanup actions are needed to remove some of the contamination and, consequently, reduce the exposures.

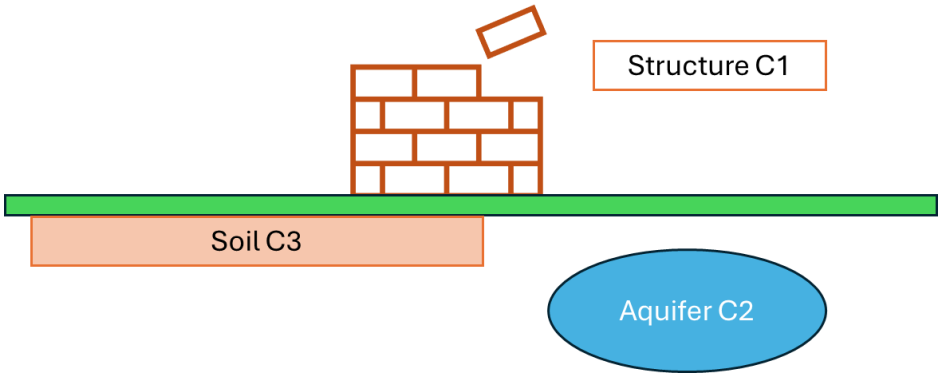

FIG. V –1. Simplified sketch of the site

V–4. If no cleanup is undertaken, then the dose calculations indicate that a dose of 600 μSv in a year might be received by members of the public, which exceeds the national dose constraint for site release. Consequently, different combinations of cleanup actions that could achieve the site release dose constraint have been identified, as shown in Table V–1.

TABLE V–1: EXPOSURES FROM DIFFERENT CLEANUP OPTIONS FOR THE SITE

	Without cleanup	**Cleanup option 1**	**Cleanup option 2**	**Cleanup option 3**
Structure (C1)	150 µSv	50 µSv	50 µSv	50 µSv
Aquifer (C2)	200 µSv	50 µSv	100 µSv	150 µSv
Soil (C3)	250 µSv	10 µSv	50 µSv	50 µSv
Total	**600 µSv**	**110 µSv**	**200 µSv**	**250 µSv**

V–5. From Table VI–1, if only the radiological parameters are considered, cleanup option #1 is the best as it will result in lower exposure levels to future users of the site, compared to the other two options considered. But to achieve such reduction of exposures, it will require large excavations, pumping and treatment of the groundwater and removal of concrete layers from the building structure, potentially impacting the structural stability. Consequently, it is possible that cleanup options #2 or #3 could be better solutions, considering all relevant aspects, such as exposures, costs, project duration, waste generated and industrial hazards. The operating organization will need to consider all of these factors for each of the options in order to select the optimum one.

Annex VI
EXAMPLE CONTENTS OF A SITE CLEANUP PLAN

VI–1. This annex provides an example outline of the possible content of a site cleanup plan. In accordance with a graded approach, the level of detail will depend on the radiological contamination and the non-radiological hazards, and complexity and extent of planned activities.

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 before use (baseline condition);
- Characterization of the current site (radiological and non-radiological).

Cleanup strategy

- Objectives.
- Cleanup options considered.
- Description of selection criteria:
    - Safety principles;
    - Radiation protection requirements;
    - Waste management;
    - Environmental impact;
    - End points of cleanup;
    - Human resource requirements;
    - Cost.
- Description of selected cleanup option and rationale for the selection.

Cleanup activities

- Description of cleanup activities;
- Timescales of phases of cleanup activities;
- Physical monitoring and surveillance of the site.

Project management

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

Dose assessment

- Scenarios;
- Modelling;
- Selection of computer tools;
- Proposed site dose release criterion and corresponding release levels;
- 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.

Environmental impact assessment

Radiological monitoring and surveillance

Security arrangements

Emergency plan

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

Final radiological survey

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