Version 6.0

Dated: 2017-07-06

Arrangements for the Termination of a Nuclear or Radiological Emergency

Jointly sponsored by the
XXX

General Safety Guide
No. GSG-x

Draft DS474

Status: STEP 12 – Review of the draft publication by the CSS

(Draft publication submitted to the Publication Committee as well. Reviewed in NSOC (Technical Editor: K. Asfaw))

Action: For final endorsement

IAEA
International Atomic Energy Agency

CONTENTS

1

1. INTRODUCTION

BACKGROUND

1.1. Under Article 5(a)(ii) of the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (the 'Assistance Convention') [1], one function of the IAEA is to collect and disseminate to States Parties and Member States information concerning methodologies, techniques and available results of research relating to response to such accidents or emergencies.

1.2. In March 2015, the IAEA's Board of Governors approved a Safety Requirements publication, Preparedness and Response for a Nuclear or Radiological Emergency, issued as IAEA Safety Standards Series No. GSR Part 7 [2], which was jointly sponsored by thirteen international organizations. GSR Part 7 [2] establishes requirements for an adequate level of preparedness and response for a nuclear or radiological emergency, irrespective of the initiator of the emergency; it is a revised and updated version of IAEA Safety Standards Series No. GS-R-2[1] issued in 2002.

1.3. Requirement 18 of GSR Part 7 [2] requires the government to ensure that arrangements are made for the termination of a nuclear or radiological emergency, with account taken of the need for resumption of social and economic activity. Most States pay particular attention to ensuring adequate preparedness to respond effectively to a nuclear or radiological emergency in order to protect human life, health, property and the environment early in the response. However, less attention has been devoted, at the preparedness stage, to practical arrangements for dealing with the challenges associated with the termination of an emergency and the transition to the 'new normality'[2]. Past experience has clearly demonstrated the importance of being prepared to address these challenges. To assist Member States in addressing these challenges, this Safety Guide provides guidance and recommendations on emergency arrangements for the termination of a nuclear or radiological emergency and the subsequent transition to either a planned exposure situation or an existing exposure situation for meeting the relevant safety requirements established in GSR Part 7 [2].

1.4. The term nuclear or radiological emergency and the three situations of exposure mentioned in paras 1.2 and 1.3 are defined in GSR Part 7 [2] and in Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, IAEA Safety Standards Series No. GSR Part 3 [3] and for clarity are reproduced in the following:

- Emergency: A non-routine situation or event that necessitates prompt action, primarily to mitigate a hazard or adverse consequences for human life, health, property or the environment.

---

[1] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANIZATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, UNITED NATIONS OFFICE FOR THE COORDINATION OF HUMANITARIAN AFFAIRS, WORLD HEALTH ORGANIZATION, Preparedness and Response for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GS-R-2, IAEA, Vienna (2002).

[2] The 'new normality' is a new situation compared with the situation prior to the emergency. In the context of this Safety Guide, the new normality represents either an existing exposure situation or a planned exposure situation.

- ⓘ This includes nuclear and radiological emergencies and conventional emergencies such as fires, release of hazardous chemicals, storms or earthquakes.
- ⓘ This includes situations for which prompt action is warranted to mitigate the effects of a perceived hazard.

− Nuclear or radiological emergency[3]: An emergency in which there is, or is perceived to be, a hazard due to:

(a) The energy resulting from a nuclear chain reaction or from the decay of the products of a chain reaction; or
(b) Radiation exposure.

− Planned exposure situation: The situation of exposure that arises from the planned operation of a source or from a planned activity that results in an exposure due to a source.

− Emergency exposure situation[4]: A situation of exposure that arises as a result of an accident, a malicious act or other unexpected event, and requires prompt action in order to avoid or reduce adverse consequences.

− Existing exposure situation: A situation of exposure that already exists when a decision on the need for control has to be taken.

- ⓘ Existing exposure situations include exposure to natural background radiation that is amenable to control; exposure due to residual radioactive material that derives from past practices that were never subject to regulatory control or exposure due to residual radioactive material deriving from a nuclear or radiological emergency after an emergency has been declared to be ended.

1.5. Requirement 46 of GSR Part 3 [3] addresses the arrangements to be in place, as part of overall emergency preparedness, and to be implemented as appropriate for the transition from an emergency exposure situation to an existing exposure situation. This Safety Guide provides guidance and recommendations on arrangements to be made at the preparedness stage for such a transition, in the context of a broader discussion of the arrangements necessary for the termination of a nuclear or radiological emergency.

OBJECTIVE

1.6. The objective of this Safety Guide is to provide guidance and recommendations to States on developing arrangements, at the preparedness stage as part of overall emergency preparedness efforts,

---

[3] However, and notwithstanding the definitions of these terms, for reasons of brevity, the term 'emergency' as used in this Safety Guide is intended to mean a nuclear or radiological emergency, unless otherwise specified.

[4] From the definitions, it is obvious that each emergency exposure situation takes place within a nuclear or radiological emergency; however, in a nuclear or radiological emergency an emergency exposure situation might not apply for any individual. There may be situations in which conditions indicative of a nuclear or radiological emergency have been identified at a site and the appropriate emergency class has been declared (i.e. an adequate level of emergency response has been activated) before any exposures occur as a result of these conditions.

for responding to a nuclear or radiological emergency for the transition to either an existing exposure situation or a planned exposure situation, as appropriate, and the termination of the emergency. This Safety Guide also provides guidance and recommendations on the primary objective and the general and specific prerequisites that are to be met in order to enable the termination of the emergency and to support the development of the arrangements for achieving this objective and prerequisites.

1.7. This Safety Guide should be used in conjunction with GSR Part 7 [2], with due account to be taken of the recommendations provided in Arrangements for Preparedness for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GS-G-2.1 [4] and Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GSG-2 [5]. This Safety Guide provides guidance for meeting Requirement 18 of GSR Part 7 [2] and Requirement 46 of GSR Part 3 [3] on the termination of a nuclear or radiological emergency and the transition from an emergency exposure situation to an existing exposure situation, respectively.

1.8. The guidance and recommendations provided in this Safety Guide form the basis for achieving the goals of emergency response outlined in para. 3.2 of GSR Part 7 [2], particularly the goal of preparing for the resumption of normal social and economic activity.

SCOPE

1.9. The guidance and recommendations provided in this Safety Guide are applicable to any nuclear or radiological emergency, irrespective of its cause, in relation to the transition to either a planned exposure situation or an existing exposure situation and the termination of the emergency. Considering the full range of potential nuclear or radiological emergencies[5], these recommendations necessitate the application of a graded approach[6] in their implementation.

1.10. The guidance and recommendations provided in this Safety Guide have been developed on the basis of objective considerations of radiation protection, including factors such as the health risks associated with exposure levels and relevant attributes of various characteristics of the exposure situation. In addition, this Safety Guide also recognizes the influence of, and addresses, social, economic and political attributes, as well as national, local and site-specific characteristics. Such attributes and characteristics are generally unrelated to radiation protection; however, they usually influence the final decision on the termination of a nuclear or radiological emergency.

1.11. This Safety Guide is intended to help in decision making that is based on scientific considerations regarding radiation protection, lessons learned from experience and established best

---

[5] Examples of such emergencies include, but are not limited to: a general emergency at a nuclear power plant, an emergency involving a lost dangerous source, an emergency arising from an accidental overexposure of patients, an emergency involving a release (irrespective whether intentional or not) of radioactive material to the environment or an emergency arising from a transport accident involving nuclear or radioactive material.

[6] "(1) For a system of control, such as a regulatory system or a safety system, a process or method in which the stringency of the control measures and conditions to be applied is commensurate, to the extent practicable, with the likelihood and possible consequences of, and the level of risk associated with, a loss of control. (2) An application of safety requirements that is commensurate with the characteristics of the facilities and activities or the source and with the magnitude and likelihood of the exposures" [2].

practices. It is also intended to serve as an input into a comprehensive decision making process concerning the termination of a nuclear or radiological emergency. As a nuclear or radiological emergency may lead to long term exposures owing to residual radioactivity in the human habitat and in the overall environment, it is anticipated in this Safety Guide that the decision making process will not only include emergency planners, decision makers at various governmental levels and radiation protection specialists, but will also involve consultation with the public and other interested parties[7].

1.12. The guidance and recommendations provided in this Safety Guide take into account lessons learned from past experience, including the Fukushima Daiichi accident (2011) [6, 7], the radiological accident in Nueva Aldea (2005) [8], the fuel damage incident at the Paks nuclear power plant (2003) [9], the radiological accident in Lia (2001) [10], the radiotherapy accident in Panama (2000/2001) [11], the radiological accident in Goiânia (1987) [12], the accident at the Chernobyl nuclear power plant (1986) [13, 14], and the accident at the Three Mile Island nuclear power plant (1979) [15]. Annex I of this Safety Guide provides case studies for several past emergencies.

As the full range of potential nuclear or radiological emergencies is considered in this Safety Guide, the following distinctions have to be made in relation to the way in which the emergency will be terminated and the situation to which the emergency will transition:

(a) An emergency that does not involve a significant release of radioactive material to the environment, and thus does not result in exposures of the public in the longer term due to residual radioactive material (e.g. the fuel damage incident at Paks nuclear power plant, the accidental overexposures in Panama and the radiological accident in Nueva Aldea), might not necessarily result in an emergency exposure situation. Such emergencies can be terminated in a way in which the facility, the activity and the source can ultimately be managed as a planned exposure situation. The planned exposure situation may be associated either with normal operation or a clean-up, decommissioning or ending of the operational life of the source. In terms of public exposures, such emergencies are not expected to result in an exposure situation that is different from the one that existed prior to the emergency. The decision to terminate an emergency of this type delineates also the beginning of a planned exposure situation. In such cases, within the context of this Safety Guide, the phrase “transition to a planned exposure situation” is used.

(b) An emergency involving a significant release of radioactive material to the environment (such as the Chernobyl nuclear power plant accident, the Fukushima Daiichi accident and the Goiânia radiological accident) will result in an emergency exposure situation. In such emergencies, the public may be exposed in the longer term due to the presence of residual radioactive material in the environment. Such situations are eventually managed as existing exposure situations. The termination of such emergencies is possible after a period of time that allows for the transition to an existing exposure situation to take place. The decision to terminate an emergency of this type

[7] An interested party is a person, company, etc. with a concern or interest in the activities and performance of an organization, business, system, etc. [2].

also means entering into an existing exposure situation. In such cases, within the context of this Safety Guide, the phrase “transition to an existing exposure situation” is used.

1.13. The guidance and recommendations provided in this Safety Guide are not to be applied to:

(a) The termination of an exposure situation in which contamination has occurred due to a human activity but which is not an emergency exposure situation. This would include, for example, situations arising from planned discharges of radioactive material to the environment or legacy sites.

(b) Arrangements for managing existing exposure situations and long term remediation, as well as arrangements for the decommissioning of accident damaged facilities warranting permanent shutdown; relevant guidance can be found in Refs [16–19]. However, the basic concepts and approaches contained in this Safety Guide will support, within the context of overall emergency preparedness, the planning for the management of the existing exposure situation following the termination of the nuclear or radiological emergency.

1.14. This Safety Guide does not provide guidance or recommendations on meeting the requirements set forth in GSR Part 7 [2] in relation to ensuring that arrangements are made for taking urgent protective actions, early protective actions and other response actions during the emergency response phase; relevant guidance can be found in GS-G-2.1 [4] and GSG-2 [5]. However, this Safety Guide provides guidance for the integration and coordination of activities from the declaration of the emergency until its termination.

1.15. This Safety Guide does not provide recommendations on communication with the public in preparedness for and response to a nuclear or radiological emergency in relation to the termination of the emergency including the transition phase.[8]

1.16. This Safety Guide does not provide guidance concerning nuclear security considerations in relation to the termination of a nuclear or radiological emergency, irrespective of whether the emergency was initiated by a nuclear security event. However, relevant authorities may need to give considerations to nuclear security implications, as appropriate, prior to the termination of the emergency. Relevant information relating to nuclear security can be found in the IAEA Nuclear Security Series [21 −23].

1.17. Terms are used in this Safety Guide as defined in GSR Part 7 [2] and the IAEA Safety Glossary [23]. The terminology for the various phases of a nuclear or radiological emergency in the context of this Safety Guide is clarified in Section 2.

[8] A Safety Guide on Arrangements for Public Communication in Preparedness and Response for a Nuclear or Radiological Emergency is in preparation. Further practical guidance on public communication in emergency preparedness and response can also be found in INTERNATIONAL ATOMIC ENERGY AGENCY, Communication with the Public in a Nuclear or Radiological Emergency, EPR-Public Communications, IAEA, Vienna (2012) and INTERNATIONAL ATOMIC ENERGY AGENCY, Method for Developing a Communication Strategy and Plan for a Nuclear or Radiological Emergency, EPR-Public Communication Plan, IAEA, Vienna (2015).

STRUCTURE

1.18. Section 2 describes the various phases of a nuclear or radiological emergency. It focusses on the concept of the 'transition phase' and the meaning of the termination of a nuclear or radiological emergency and the beginning of either a planned exposure situation or an existing exposure situation. Section 3 provides the primary objective for terminating a nuclear or radiological emergency and elaborates on the general and specific prerequisites that need to be met in order to terminate an emergency. Section 3 also provides generic guidance on the timeframes in which a nuclear or radiological emergency is to be terminated. Section 4 describes the arrangements to be made at the preparedness stage, as part of the overall emergency preparedness, in order to facilitate the implementation of activities in the transition phase that will enable the termination of the emergency. The Appendix provides considerations for adjusting or lifting protective actions and other response actions during the transition phase. Annex I provides case studies of several past nuclear or radiological emergencies that support the guidance and recommendations provided in this Safety Guide. Annex II presents factors that need to be considered when justifying and optimizing the protection strategy at the national level.

2. PHASES OF A NUCLEAR OR RADIOLOGICAL EMERGENCY

GENERAL

2.1. This section describes the various phases of a nuclear or radiological emergency, and explains the concept of the 'transition phase'. This concept refers to the process and the time period during which there is a progression to the point at which an emergency can be terminated. During this period, the relevant prerequisites (set out in Section 3) that should be fulfilled before the termination of the emergency can be declared are gradually addressed. In this context it is generally assumed that the transition phase commences as early as possible when the source has been brought under control and the situation is stable[9]; it ends when all the necessary prerequisites for terminating the emergency have been met. The termination of a nuclear or radiological emergency marks the end of the emergency and therefore, the emergency exposure situation, and the beginning of either an existing exposure situation or a planned exposure situation.

2.2. The various phases of a nuclear or radiological emergency are distinguished on the basis of the different timescales in which specific protective actions and other response actions are to be undertaken in order to achieve the goals of emergency response (see para. 3.2 of GSR Part 7 [2]) and to fulfil the prerequisites that would allow the declaration of the end of the emergency. The transition phase may last from a day to a few weeks for a small scale emergency (e.g. a lost or stolen dangerous source) but could take months to a year for a large scale emergency (e.g. an emergency at a nuclear installation resulting in significant off-site contamination).

2.3. In this Safety Guide, the distinction among the various phases of a nuclear or radiological emergency is intended to support the planning efforts for each phase at the preparedness stage as well as to facilitate communication and a common understanding among those involved in the planning. These efforts depend on the characteristics of each phase, including the information available and the specific activities to be carried out.

2.4. The response to a nuclear or radiological emergency is a continuous effort; therefore, during the response, it is not intended that a distinction be made between the various phases of the emergency (see para. 2.13).

2.5. The period covering the management of an existing exposure situation and the long term recovery operations after the emergency is declared to have ended is excluded from the scope of this Safety Guide and is covered in Refs [16, 17].

---

[9] This means that the source has been brought under control, no further significant accidental releases or exposures resulting from the event are expected and the future development of the situation is well understood.

EMERGENCY RESPONSE PHASE

2.6. If conditions are detected in relation to a facility, an activity or a source indicating an actual or potential nuclear or radiological emergency warranting protective actions and other response actions, the emergency class is required to be declared and pre-planned response actions are required to be initiated on the site and, as necessary, off the site that correspond to the emergency class and the level of emergency response warranted (see Requirement 7 of GSR Part 7 [2]).

2.7. Early in the emergency, the response organizations focus their response actions on mitigating the potential consequences of the emergency so that undesirable conditions are either prevented from developing, or their development is delayed, making it possible to take effective protective actions on the site and, as necessary, off the site. Such mitigatory actions are accompanied by protective actions and other response actions that are aimed at the potentially or actually affected individuals. Most of these actions are taken as a matter of urgency (i.e. precautionary urgent protective actions, urgent protective actions and other response actions); however, some actions allow for more detailed assessments, primarily on the basis of monitoring, and can be taken within days or weeks and still be effective (i.e. early protective actions and other response actions).

2.8. Protective actions and other response actions are defined in GSR Part 7 [2] and for clarity are reproduced in the following:

- Protective action: An action for the purposes of avoiding or reducing doses that might otherwise be received in an emergency exposure situation or an existing exposure situation.
- Mitigatory action: Immediate action by the operator or other party:
  (a) To reduce the potential for conditions to develop that would result in exposure or a release of radioactive material requiring emergency response actions on the site or off the site; or
  (b) To mitigate source conditions that may result in exposure or a release of radioactive material requiring emergency response actions on the site or off the site.
- Urgent protective action: A protective action in the event of an emergency which must be taken promptly in the event of an emergency (usually within hours to a day) in order to be effective, and the effectiveness of which will be markedly reduced if it is delayed.
  - ⓘ Urgent protective actions include iodine thyroid blocking, evacuation, short term sheltering, actions to reduce inadvertent ingestion, decontamination of individuals and prevention of ingestion of food, milk or water possibly with possible contamination.
  - ⓘ A precautionary urgent protective action is an urgent protective action taken before or shortly after a release of radioactive material, or before an exposure, on the basis of the prevailing conditions to avoid or to minimize severe deterministic effects.
- Early protective action: A protective action in the event of a nuclear or radiological emergency that can be implemented within days to weeks and still be effective.

- ⓘ The most common early protective actions are relocation and longer term restriction of the consumption of food potentially affected by contamination.

− Other response action: An emergency response action other than a protective action.

- ⓘ The most common other response actions are: medical examination, consultation and treatment; registration and longer term medical follow-up; providing psychological counselling; and public information and other actions for mitigating non-radiological consequences and for public reassurance.

2.9. The safety requirements established in GSR Part 7 [2] and its supporting guidance and recommendations (GS-G-2.1 [4] and GSG-2 [5]) address emergency arrangements to be established and implemented in the period following the identification of the conditions leading to the declaration of a nuclear or radiological emergency, until the time the situation is brought under control and radiological conditions are characterized sufficiently well.[10] This period is called the 'emergency response phase' and is defined as the period of time from the detection of conditions warranting an emergency response until the completion of all the actions taken in anticipation of or in response to the radiological conditions expected in the first few months of the emergency. The emergency response phase typically ends when the situation is under control, the off-site radiological conditions have been characterized sufficiently well to identify whether and where food restrictions and temporary relocation are required, and all required food restrictions and temporary relocations have been put into effect (see Ref. [24]).

2.10. For the purposes of this Safety Guide, the emergency response phase is divided into an urgent response phase and an early response phase (see Fig. 1) as follows:

(a) Urgent response phase: The period of time, within the emergency response phase, from the detection of conditions warranting emergency response actions that must be taken promptly in order to be effective until the completion of all such actions. Such emergency response actions include mitigatory actions by the operator and urgent protective actions on the site and off the site. The urgent response phase may last from hours to days depending on the nature and scale of the nuclear or radiological emergency.[11]

(b) Early response phase: The period of time, within the emergency response phase, from which a radiological situation is already characterized sufficiently well that a need for taking early protective actions and other response actions can be identified, until the completion of all such

[10] This includes arrangements for the implementation of urgent protective actions, early protective actions and other response actions.

[11] For example, the urgent response phase may last just hours in the case of a small scale emergency such as a radiological emergency during transport or a radiological emergency involving a sealed dangerous source.

actions. The early response phase may last from days to weeks depending on the nature and scale of the nuclear or radiological emergency.[12]

TRANSITION PHASE

2.11. For the purposes of this Safety Guide, the transition phase is the period of time after the emergency response phase[13], when (a) the situation is under control (see footnote 9), (b) detailed characterization of radiological situation has been carried out and (c) activities are planned and implemented to enable the emergency to be declared terminated. The activities carried out during the transition phase aim at achieving the primary objective and the prerequisites elaborated in Section 3. The transition phase may last from days to months; notwithstanding that for a small scale emergency (for example, a radiological emergency during transport or a radiological emergency involving a sealed dangerous source) it may last not more than a day. The termination of the nuclear or radiological emergency marks the end of the transition phase for a particular area or a site and the beginning of either an existing exposure situation or a planned exposure situation (see Fig. 1).

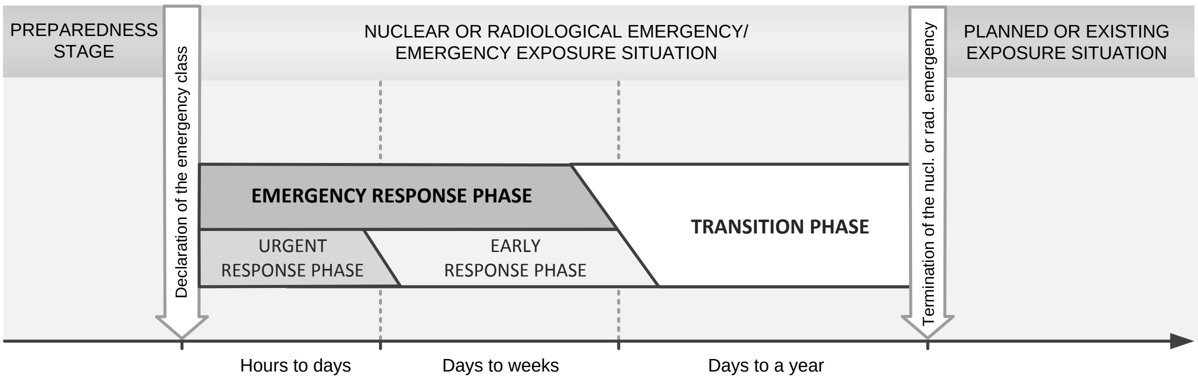

Fig. 1. Temporal sequence of the various phases and exposure situations for a nuclear or radiological emergency within a single geographical area or a single site

2.12. Compared to the urgent response phase and, to some extent, the early response phase, the transition phase is not driven by urgency and allows for adapting, justifying and optimizing protection strategies as the emergency evolves and for consultation with interested parties. Depending on the nature of the nuclear or radiological emergency, these processes may continue in the longer term after the emergency has been declared terminated. In the transition phase and in the longer term, the implementation of remedial actions might be more efficient than carrying out further disruptive public protective actions.

2.13. While the distinction between various phases of a nuclear or radiological emergency may be helpful for planning purposes, it can be difficult to clearly define a line between the various phases of an emergency during the emergency response (see paras 2.3 and 2.4), as the emergency response

---

12 For example, the early response phase may last hours to a day in the case of a small scale emergency such as a radiological emergency during transport or a radiological emergency involving a sealed dangerous source.

13 The exposure situation in the transition phase is still an emergency exposure situation although the emergency response phase is over, as presented on Figs 1 and 2.

actions are implemented on a continuous basis (see Fig. 2). This is particularly true for the early response phase and the transition phase, when the activities that are carried out may support the implementation of specific actions and activities associated with both phases. For example, a monitoring strategy implemented during the early response phase may support both decision making on early protective actions and the assessment of the radiological situation, which may in turn help to determine how protection strategies are to be further adapted.

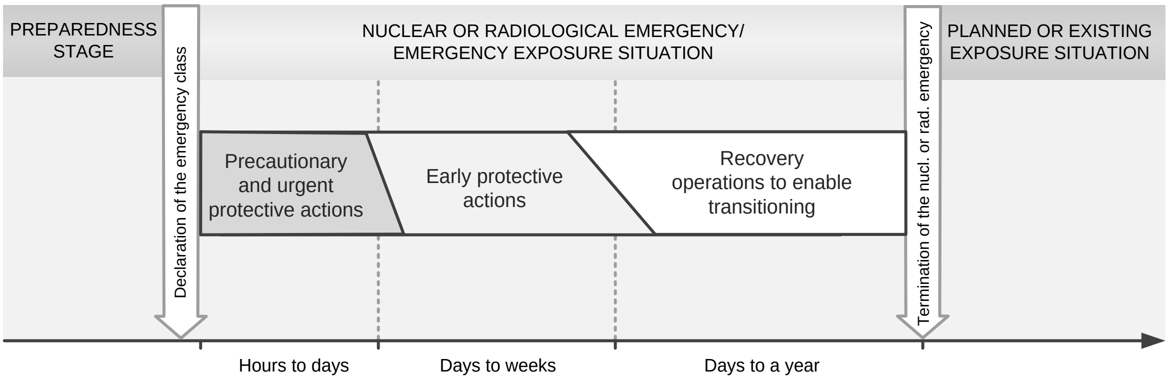

Fig. 2. Temporal sequence of various types of protective actions and recovery operations for a nuclear or radiological emergency within a single geographical area or a single site

2.14. In the case of a large scale emergency, the complexity of the radiological situation may vary greatly within an affected area and may be transient in nature. It is therefore likely that different phases and different exposure situations may coexist geographically and temporally. This challenges both the management of the situation and the communication with interested parties. The transition from the emergency exposure situation will occur gradually in specific areas within the whole affected area. In this case, the transition phase will end when the final area that was in an emergency exposure situation has transited to an existing exposure situation.[14] The transition of this final area to an existing exposure situation will also denote the overall termination of the emergency.

[14] See also paras 3.20, 3.22 and 4.98 with regard to delineation of areas.

3. PRIMARY OBJECTIVE AND PREREQUISITES FOR TERMINATING THE EMERGENCY

GENERAL

3.1 This section elaborates on the primary objective and the prerequisites to be considered in planning and decision making regarding the termination of a nuclear or radiological emergency. It provides general guidance on a broad spectrum of aspects that authorities should consider in relation to the termination of the emergency in accordance with an all-hazards approach,[15] notwithstanding the need to use a graded approach in application of the prerequisites for each specific postulated nuclear or radiological emergency and to consider national, local and site-specific circumstances.

3.2 The primary objective and the prerequisites stated in this section should guide the development and implementation of the protection strategy for the transition phase. They should, therefore, also guide the arrangements that need to be put in place during the preparedness stage to ensure that the protection strategy is implemented in an efficient and coordinated manner in the transition phase. This primary objective and these prerequisites should also serve as intermediate steps for any objectives that need to be attained in the longer term for an existing exposure situation, as applicable.

3.3 The emergency should be terminated if the relevant prerequisites set forth in this section and selected on the basis of a graded approach (see para. 3.1) have been fulfilled; the decision to terminate the emergency should be a formal decision and should be made public. The new exposure situation should then be managed as either a planned exposure situation or an existing exposure situation (see Fig. 1), as appropriate, in line with national legal and regulatory framework as required in Refs [2, 3, 25].

3.4 It should be recognized that:

- The transition from the emergency exposure situation will likely take place at different geographical areas or at different parts of the site at different points in time. The situation in some geographical areas or some parts of the site might therefore continue to be managed as a nuclear or radiological emergency, while the situation in other areas might be managed as a planned exposure situation or an existing exposure situation, as appropriate;
- Some of the prerequisites set out in this section are to be fulfilled by the operating organization in addition to responsible off-site response organizations. To great extent, the

[15] States usually have arrangements in place for returning to normal social and economic activity after any type of emergency. Such arrangements would also be expected to support the preparations for the transition to either an existing exposure situation or a planned exposure situation after a nuclear or radiological emergency. To this end, all the arrangements necessary to be put in place in accordance with this Safety Guide need to be integrated with one another in accordance with an all-hazards approach.

transition from the emergency exposure situation in areas off the site will be subject to confirmation by the operating organization that the respective prerequisites[16] have been fulfilled on the site.

PRIMARY OBJECTIVE

3.5 The primary objective of the termination of the emergency is to facilitate the timely resumption of social and economic activity.

GENERAL PREREQUISITES

3.6 A nuclear or radiological emergency should not be terminated until the necessary urgent protective actions and early protective actions have been implemented.[17]

3.7 Prior to the termination of the emergency, the exposure situation should be well understood and confirmed to be stable. This means that the source has been brought under control, no further significant accidental releases or exposures resulting from the event are expected and the likely future development of the situation is well understood.

3.8 Prior to the termination of the emergency, the radiological situation should be well characterized, exposure pathways should be identified and doses[18] should be assessed for affected populations[19] (including those population groups most vulnerable to radiation exposure, such as pregnant women and children). This characterization should consider the impact of lifting and adapting the protective actions implemented earlier in the emergency response and, where applicable, possible options for the future use of land and water bodies (e.g. imposing restrictions or identifying alternative ways in which they can be exploited).

3.9 Before any decision to terminate the emergency is made, a thorough hazard assessment should be performed in respect of the situation and its future development, consistent with Requirement 4 of GSR Part 7 [2]. The hazard assessment should provide a basis for preparedness and response for any new emergency that may occur in the future.

3.10 On the basis of the hazard assessment, those events and associated areas that may warrant protective actions and other response actions should be identified, including the actions that may be effective in mitigating the consequences of any future emergency, and the existing emergency

[16] Such prerequisites may include, as appropriate, those stated in paras 3.6, 3.7, 3.9 – 3.12, 3.19 and bullets (e), (f) and (g) of para. 3.20 of this section.
[17] At the time of deciding on the termination of a nuclear or radiological emergency, some of the urgent protective actions and early protective actions may be already under consideration to be adapted or lifted (e.g. evacuation). Other actions may remain in place in the longer term after the termination of the emergency (e.g. restrictions on food, milk and drinking water), while some actions such as iodine thyroid blocking may already have been implemented and require no further consideration in the transition phase. For more details see paras 4.70–4.101 in Section 4.
[18] Effective dose, equivalent dose to a tissue or organ, or relative biological effectiveness (RBE) weighted absorbed dose to a tissue or organ, as appropriate. See GSG-2 [5] for further details.
[19] This includes the public, workers (including emergency workers), helpers and patients, as appropriate.

arrangements should be reviewed. The review should determine whether there is a need to revise the existing emergency arrangements and/or to establish new arrangements. [20]

3.11 The emergency should not be terminated until revised or new emergency arrangements have been formulated and have been coordinated among the relevant response organizations. However, in some cases, the formal establishment of revised or new emergency arrangements may be a lengthy process. Therefore, the establishment of an interim response capability[21] in the transition phase should be considered to prevent unnecessary delay in the termination of the emergency.

3.12 Prior to the termination of the emergency, it should be confirmed that the requirements for occupational exposure in planned exposure situations[22] established in Section 3 of GSR Part 3 [3] can be applied for all workers who will be engaged in recovery operations (see para. 5.101 of GSR Part 7 [2]) and that the source is secured in a manner that is consistent with Refs [20−22].

3.13 The radiological situation should be assessed, as appropriate, against reference levels, generic criteria, operational criteria and dose limits, to determine whether the relevant prerequisite for the transition to the respective exposure situation has been achieved (see paras 3.19–3.22).

3.14 Non-radiological consequences (e.g. psychosocial and economic consequences) and other factors (e.g. technology, land use options, availability of resources, community resilience[23] and the availability of social services) relevant to the termination of the emergency should be identified and actions to address them should be considered.

3.15 A registry of those individuals[24] who have been identified, by the time the emergency is to be terminated, as requiring longer term medical follow-up (see Refs [2, 5]) should be established prior to the termination of the emergency.

3.16 Consideration should be given to the management of any radioactive waste arising from the emergency, as appropriate, prior to the termination of the emergency.

3.17 Consultation with interested parties is required prior to the termination of the emergency [2]. This process should not unduly impede the timely and effective decision making by the responsible authority in respect of termination of the emergency.

3.18 Prior to the termination of the emergency, the following should be communicated to the public and other interested parties, as appropriate:

---

[20] For example, the hazards associated with a nuclear power plant in normal operation and its associated emergency arrangements will differ from the hazards associated with an accident damaged nuclear power plant and its associated emergency arrangements.

[21] The purpose of such an interim response capability is to provide an improved response to any future emergency, postulated based on the hazard assessment, before the full emergency arrangements are put in place. This interim capability might not be optimal and would need to make use of all available means and resources with only minimal additional arrangements (e.g. training, a few revised procedures).

[22] Paragraph 5.26 of GSR Part 3 [3] requires that employers "ensure that the exposure of workers undertaking remedial actions is controlled in accordance with the relevant requirements on occupational exposure in planned exposure situations."

[23] Community resilience is the capacity of a community to be able to recover quickly and easily from the consequences of a nuclear or radiological emergency.

[24] This includes the public, workers (including emergency workers), helpers and patients, as appropriate.

(a) The basis for the termination of the emergency, including the rationale of why it is safe to end the emergency and an overview of the actions taken and the restrictions imposed;
(b) The need for adjusting imposed restrictions, for continuing protective actions or for introducing new protective actions, as well as the expected duration of these actions and restrictions;
(c) Any necessary modification in people's personal behaviours and habits;
(d) Possible options for the implementation of self-help actions[25];
(e) The need for continued environmental monitoring and source monitoring following the termination of the emergency;
(f) The need for continued efforts to restore services and workplaces;
(g) Radiological health hazards associated with the new exposure situation.

SPECIFIC PREREQUISITES

Transition to a planned exposure situation

3.19 In addition to the general prerequisites (see paras 3.6–3.18), the following prerequisites should be met in order to be able to declare the termination of an emergency and to move to a planned exposure situation:

(a) The circumstances that led to the emergency have been analysed, corrective actions have been identified and an action plan has been developed for the implementation of corrective actions by the respective authorities, as applicable, in relation to the facility, activity or source involved in the emergency. However, in some cases, the formal analysis and development of the action plan may be a lengthy process. Therefore, consideration should be given to establishing administrative procedures that limit or prevent the use or handling of the source until the circumstances that led to the emergency have been better understood with the aim of preventing unnecessary delays in the termination of the emergency.
(b) Conditions have been assessed to ensure compliance with the safe and secure handling of the source involved in the emergency[26] in accordance with the national requirements set forth for the respective planned exposure situation[27].
(c) Compliance has been confirmed with the dose limits for public exposures in planned exposure situations and with the requirements for medical exposure established in Section 3 of GSR Part 3 [3].

[25] Examples of self-help actions include, but are not limited to, avoiding prolonged visits to certain areas, changing farming practices and land use, and reducing the consumption of certain foods.

[26] A source is anything that may cause radiation exposure — such as by emitting ionizing radiation or by releasing radioactive substances or radioactive material — and can be treated as a single entity for purposes of protection and safety [23].

[27] Depending on the type of the emergency, the planned exposure situation can be associated with normal operation of the facility or activity, with clean-up and decommissioning, or with the end of the operational life of the source involved in the emergency.

Transition to an existing exposure situation

3.20 In addition to the general prerequisites (see paras 3.6–3.18), the following prerequisites should be met in order to be able to declare the termination of an emergency and to move to an existing exposure situation:

(a) Justified and optimized actions have been taken to meet the national generic criteria established to enable the transition to an existing exposure situation, with account taken of the generic criteria provided in Appendix II of GSR Part 7 [2], and it has been verified that the assessed residual doses[28] approach the lower bound of the reference level for an emergency exposure situation (see paras 4.52–4.69).

(b) Areas have been delineated that are not permitted to be inhabited and where it is not feasible to carry out social and economic activity. This delineation relates to areas that, earlier in the emergency response, were subject to evacuation and/or relocation, and/or where specific restrictions were imposed that will continue to be implemented following the termination of the emergency.

(c) For these delineated areas, administrative and other provisions have been established to monitor compliance with any restrictions imposed.

(d) Prior to the termination of the emergency, a strategy has been developed for the restoration of infrastructure, workplaces and public services (e.g. public transportation, shops and markets, schools, kindergartens, health care facilities and police and firefighting services) necessary to support normal living conditions in the affected areas, such as those areas in which evacuations or relocations were carried out.

(e) A mechanism and the means for continued communication and consultation with all interested parties, including local communities, have been put in place.

(f) Prior to the termination of the emergency, any change or transfer of authority and responsibilities from the emergency response organization to organizations responsible for the long term recovery operations has been completed.

(g) The sharing of any information and data gathered during the emergency exposure situation that are relevant for the long term planning has been organized among the relevant organizations and authorities.

(h) Development of a long term monitoring strategy in relation to residual contamination has been initiated.

(i) A programme for longer term medical follow-up for the registered individuals (see para. 3.15) has been developed.

(j) A strategy for mental health and psychosocial support for the affected population has been developed.

---

[28] The residual dose is the dose expected to be incurred after protective actions have been terminated (or after a decision has been taken not to take protective actions) [2].

(k) Consideration has been given to the compensation of victims for damage due to the emergency so as to provide for public reassurance, notwithstanding the fact that the processes for compensation will extend after the emergency is terminated.
(l) Administrative arrangements, legal provisions and regulatory provisions have been put in place or are being put in place for the management of the existing exposure situation, including provisions for the allocation of the necessary financial, technical and human resources.

3.21 Following the termination of the emergency, individual monitoring[29] of members of the public should in general no longer be necessary for radiation protection purposes. This does not rule out the fact that doses incurred by individuals may differ considerably depending on people's individual habits, that they will need to be assessed, and that they may still need to be addressed in the long term protection strategy.

3.22 There may be exceptional circumstances in which it has not been feasible, within a reasonable time, to meet the national generic criteria for enabling a transition to an existing exposure situation (see bullet (a) of para. 3.20). In such cases, a decision to terminate the emergency may still be taken, as long as it has been determined that no further justified and optimized actions are feasible, and the generic criteria for taking early protective actions and other response actions provided in Appendix II of GSR Part 7 [2] are not exceeded.

TIMEFRAMES FOR THE TERMINATION OF AN EMERGENCY

3.23 At the preparedness stage, the timeframes anticipated in which an emergency will be terminated should be assessed for a range of postulated nuclear or radiological emergencies on the basis of a hazard assessment. There may be unforeseen circumstances that would be difficult to factor in with respect to determining the timeframe for the termination of a specific nuclear or radiological emergency. However, a strategy should nevertheless be determined for coping with specific aspects of the termination within a reasonable timeframe.

3.24 Based on past experience, a timeframe in the range of several weeks to one year can be proposed for terminating a large scale emergency (for example, an emergency at a nuclear installation resulting in significant off-site contamination); however, a timeframe in the range of a day to a few weeks may be adequate for terminating a small scale emergency (for example, a radiological emergency during transport or a radiological emergency involving a sealed dangerous source).

[29] Individual monitoring is monitoring using measurements by equipment worn by individuals, or measurements of quantities of radioactive substances in or on or taken into the bodies of individuals, or measurements of quantities of radioactive substances excreted from the body by individuals [23].

4. ARRANGEMENTS FOR THE TRANSITION PHASE

GENERAL

4.1. This section provides detailed guidance on various aspects to be considered at the preparedness stage (see Fig. 1) when establishing arrangements for the transition phase of a nuclear or radiological emergency. Their implementation is intended to support meeting the prerequisites for terminating the emergency stated in Section 3.

4.2. GSR Part 7 [2] states that:

- “The government shall make adequate preparations to anticipate, prepare for, respond to and recover from a nuclear or radiological emergency at the operating organization, local, regional and national levels, and also, as appropriate, at the international level. These preparations shall include adopting legislation and establishing regulations for effectively governing the preparedness and response for a nuclear or radiological emergency at all levels” (para. 4.5 of GSR Part 7 [2]).
- “The emergency arrangements shall include clear assignment of responsibilities and authorities, and shall provide for coordination in all phases of the response” (para. 6.5 of GSR Part 7 [2]).
- “The government shall ensure that all roles and responsibilities for preparedness and response for a nuclear or radiological emergency are clearly allocated in advance among operating organizations, the regulatory body and response organizations” (para. 4.7 of GSR Part 7 [2]).
- “The government shall ensure that response organizations, operating organizations and the regulatory body have the necessary human, financial and other resources, in view of their expected roles and responsibilities and the assessed hazards, to prepare for and to deal with both radiological and non-radiological consequences of a nuclear or radiological emergency, whether the emergency occurs within or beyond national borders” (para. 4.8 of GSR Part 7 [2]).
- “The government shall ensure that a hazard assessment is performed to provide a basis for a graded approach in preparedness and response for a nuclear or radiological emergency” (Requirement 4 of GSR Part 7 [2]).
- “The government shall ensure that arrangements are in place for operations in response to a nuclear or radiological emergency to be appropriately managed” (Requirement 6 of GSR Part 7 [2]).
- “The arrangements for delegation and/or transfer of authority shall be specified in the relevant emergency plans, together with arrangements for notifying all appropriate parties of the transfer” (para. 6.6 of GSR Part 7 [2]).

4.3. In consideration of the prerequisites stated in Section 3, the government should review and revise at the preparedness stage, as appropriate:

(a) The legal and regulatory framework governing preparedness and response in respect of the transition phase of a nuclear or radiological emergency;

(b) The framework for radiation protection and safety regarding longer term issues associated with an existing exposure situation in order to ensure a smooth transition and to avoid unnecessary delays due to legal and regulatory issues.

4.4. As part of the review referred to in para. 4.3, the need for the following should be identified:

(a) The various positions to be staffed to implement the necessary activities in the transition phase and in the longer term in an existing exposure situation, as appropriate;

(b) The provision of ‘just-in-time’ training to emergency workers and helpers;

(c) The mobilization of resources among relevant organizations.

Arrangements should be established to ensure that such positions, training and resource will be in place when they are needed.

Authority, role and responsibilities

4.5. In the urgent response phase, the discharge of authority and the assumption of responsibilities in the emergency response have to be, to the extent possible, straightforward and based on pre-planned arrangements. This will allow for effective implementation of precautionary urgent protective actions and urgent protective actions. Thus, the input from other organizations into the decision making process regarding the emergency response actions warranted during the urgent response phase is expected to be limited.

4.6. As the emergency evolves, the focus of the emergency response will shift from bringing the situation under control and taking public protective actions to allowing the timely resumption of social and economic activity. At this time, radiological considerations will be only one of the many factors to be evaluated in the decision making processes. Decision making at this time will require the involvement of additional organizations, with relevant responsibilities at different levels, which might not necessarily have been directly engaged during the urgent response phase. These organizations, in order to discharge their allocated roles and responsibilities, should gradually be involved, when appropriate, in the emergency response organization. This should be done in a way that enables on-going response efforts to continue without interruption, on a routine basis in the longer term, after the emergency response organization has been relieved of its duties.

4.7. The authority, roles and responsibilities of all organizations with regard to preparation, response and recovery in the transition phase, including for oversight over the implementation of provisions within the legal and regulatory framework, as well as the necessary resources (human, technical and financial resources), should be identified at the preparedness stage. This should be undertaken on the basis of activities that are expected to be carried out during the transition phase to fulfil the prerequisites set out in Section 3. As part of these arrangements, the authority and responsibility for making a formal decision on the termination of a nuclear or radiological emergency should be clearly allocated, well understood and documented in the respective emergency plans and procedures. Consideration should be given to the fact that the authority and responsibility for deciding on the transition from an emergency exposure situation to an existing exposure situation or a planned exposure situation may differ between the on-site areas and off-site areas (see also para. 3.4).

4.8. A mechanism should be put in place at the preparedness stage that would allow for the mobilization and coordination of different organizations at different levels, provide for any necessary change in the authorities and discharge of responsibilities during the transition phase, and enable the prompt resolution of any conflicting responsibilities. This mechanism should take into account that, in the transition phase, there will be a need for multi-disciplinary contributions, including those from the operating organization, which will need to be channelled efficiently and effectively.

4.9. In the transition phase, the necessary transfer of responsibilities to different jurisdictions or different authorities (or to different units within an organization) should be carried out in a formal, coordinated and fully transparent manner, and should be communicated to all interested parties.

Management and organization

4.10. The differences in management necessary for the various phases of a nuclear or radiological emergency should be identified at the preparedness stage. During the transition phase, the emergency response organization that was established in the emergency response phase should gradually return to routine (non-emergency) duties, so that the organizations with the respective authority, roles and responsibilities can take over the activities on a routine basis within the planned exposure situation or existing exposure situation.

4.11. With the formal termination of the emergency, the structure of the emergency response organization should be deactivated. At that stage, the management structure of the various response organizations should revert to what it had been prior to the emergency to allow for an effective response to any emergency that might occur in the future; however, some of these organizations may need to assume additional responsibilities. There may also be a need for new coordination and consultation mechanisms for those organizations dealing with the consequences of the emergency in the longer term as an existing exposure situation or a planned exposure situation.

4.12. Consideration should be given to the need for the simultaneous existence of different management structures in different geographical areas, owing to the gradual change in management during the transition phase.

Transfer of information and data

4.13. The respective organizations assuming responsibility for the activities in the transition phase, and in the longer term within an existing exposure situation, as appropriate, should quickly develop an understanding of the situation. Arrangements should be established that would allow for the relevant information and data on the nuclear or radiological emergency to be made available to these organizations, including, for example, the protection strategy implemented in the emergency response phase and the rationale supporting the decisions made in the emergency response phase.

4.14. As part of the arrangements referred to in para. 4.13:

(a) The type of information and data from the emergency response phase that may be of relevance for the transition phase as well as in the longer term should be clearly identified.
(b) Relevant organizations that will need access to such information and data should be identified.
(c) A mechanism should be established to record such information and data during the emergency response phase and to exchange it efficiently among the relevant organizations, taking into account the need for continued data collection and sharing in the transition phase as well as in the longer term.

4.15. Consideration should be given to ensuring an overlap of management and technical personnel involved in the emergency response phase and those to be involved in the transition phase for an agreed period to ensure continuity between the two phases.

Hazard assessment

4.16. Requirement 4 of GSR Part 7 [2] requires the government to ensure that a hazard assessment is performed to provide a basis for a graded approach in preparedness and response for a nuclear or radiological emergency. Five emergency preparedness categories are used to group the assessed hazards in relation to facilities, activities and sources and their potential consequences and to establish a basis for developing generically justified and optimized arrangements for emergency preparedness and response. On the basis of the hazard assessment, para. 5.14 of GSR Part 7 [2] requires the establishment of a system for promptly classifying a nuclear or radiological emergency warranting protective actions and other response actions. Declaration of an emergency class initiates a coordinated and pre-planned level of emergency response on the site and, where appropriate, off the site, in accordance with the protection strategy. GS-G-2.1 [4] provides further guidance in this regard.

4.17. With account taken of the uncertainties in, and the limitations of, the information available at the preparedness stage, the hazard assessment identifies facilities and activities, on-site areas, off-site areas and locations for which a nuclear or radiological emergency might warrant implementation of protective actions and other response actions. This includes those facilities and activities, on-site areas, off-site areas and locations for which actions aimed at enabling the termination of the emergency may also be warranted.

4.18. The government, the response organizations and the operating organization should use the hazard assessment and the postulated nuclear or radiological emergencies within each emergency class to anticipate what the transition phase might encompass; they should also aim to foresee the level of response warranted in relation to the transition phase for a range of postulated nuclear or radiological emergencies and thus provide a basis for applying a graded approach as follows:

(a) For a *general emergency* at a facility in emergency preparedness category I or II (e.g. the Fukushima Daiichi accident in 2011, for which a case study is given in Annex I) leading to a significant release of radioactive material to the environment, termination of the emergency will take place through transition to an existing exposure situation.

(b) For a *site area emergency* at a facility in emergency preparedness category I or II and for a *facility emergency* at a facility in emergency preparedness category I, II, or III, termination of the emergency will take place through transition to a planned exposure situation (e.g. the Paks fuel damage incident in 2003, for which a case study is given in Annex I). In this context, the planned exposure situation may be associated with a continuation of normal operation, or with clean-up and decommissioning or end of operational life of the source involved in the emergency, as applicable. However, postulated nuclear or radiological emergencies within these classes are not expected to result in a different exposure situation for the public as compared to the situation that existed prior to the emergency.

(c) An *alert* at a facility in emergency preparedness category I, II, or III will be followed by the resumption of normal operations in a planned exposure situation.

(d) *Other nuclear or radiological emergency* covers a broad spectrum of emergencies involving activities or acts in emergency preparedness category IV and which may occur at any location [2]. In this class, depending on the type of emergency, termination of the emergency is envisaged by transition to either an existing exposure situation or a planned exposure situation. For example:

   – An emergency without a release of radioactive material to the environment is to be terminated by transition to the same exposure situation for the affected public that existed prior to the emergency (e.g. the radiological incident in Mexico 2013, for which a case study is given in Annex I). The recovered source may be brought back to normal operation, or its operational life may be ended. In the latter case, the source may be managed as radioactive waste under the requirements for a planned exposure situation.

   – An emergency with a release of radioactive material to the environment resulting in significant residual radioactivity in the environment is to be terminated by transition to an existing exposure situation (e.g. the Goiânia accident of 1987 [12], for which a case study is given in Annex I).

4.19. The insights gained through the hazard assessment should be used for the identification of options and limitations of specific emergency arrangements to be made for the transition phase, including for estimation of the timeframes in which the prerequisites in Section 3 might be fulfilled, with account taken of:

(a) The likely inability to predict accurately when, where and what the actual impact of the nuclear or radiological emergency might be;

(b) The complexity of potential recovery efforts;

(c) The potential impact of non-radiological factors, such as public concerns and the political situation, on decision making at the time of the emergency.[30]

4.20. An emergency may result in changes in the hazards applicable for the State as compared to hazards prior to the emergency. This may necessitate adjustment of the emergency arrangements (i.e. revision of existing emergency arrangements and/or introduction of new arrangements to manage the new hazards) in line with paras 4.26 and 4.27 of GSR Part 7 [2]. As a result, before a decision to terminate the emergency can be made, a thorough hazard assessment of the situation and its future development should be performed in accordance with Requirement 4 of GSR Part 7 [2]. The implications of this hazard assessment on the existing emergency arrangements should also be identified and addressed (see paras 3.9–3.11 of Section 3).

PROTECTION OF THE PUBLIC

Protection strategy

General

4.21. A protection strategy, as the concept is used in this Safety Guide, describes in a comprehensive manner what needs to be achieved in response to a nuclear or radiological emergency in all its phases and how this will be achieved through implementation of a justified and optimized set of protective actions and other response actions. In this Safety Guide, particular emphasis is placed on the protection strategy in the transition phase.

4.22. The guidance in this sub-section focuses on considerations concerning the protection of the public and society in general, while the protection of emergency workers and helpers is addressed in a paras 4.102–4.141.

Development of protection strategies at the preparedness stage

4.23. GSR Part 7 [2] states that:

– "The government shall ensure that, on the basis of the hazards identified and the potential consequences of a nuclear or radiological emergency, protection strategies are developed, justified and optimized at the preparedness stage for taking protective actions and other response actions effectively in a nuclear or radiological emergency" (para. 4.27 of GSR Part 7 [2]).

[30] For example, more detailed planning can be made for a general emergency at a facility in emergency preparedness category I (e.g. a nuclear power plant), particularly for the urgent response phase and the early response phase. In this case, aspects such as the potentially affected areas, the habits and customs of the potentially affected population and land use can be identified at the preparedness stage as part of the hazard assessment. A radiological emergency involving a dangerous source can occur at any location and, therefore, a more generic approach towards preparedness would need to be adopted.

- “The government shall ensure that the protection strategy is implemented safely and effectively in an emergency response through the implementation of emergency arrangements” (para. 4.30 of GSR Part 7 [2]).
- “The government shall ensure that interested parties are involved and are consulted, as appropriate, in the development of the protection strategy” (para. 4.30 of GSR Part 7 [2]).

4.24. The protection strategy should cover, at least, the period from the declaration of the emergency until the termination of the emergency to support achieving all the goals of emergency response stated in para. 3.2 of GSR Part 7 [2]. The primary objective and the prerequisites for the termination of the emergency stated in Section 3 of this Safety Guide should be the main drivers for development of the protection strategy for the transition phase.

4.25. For a large scale emergency, the implementation of a protection strategy could extend in the longer term within the framework of an existing exposure situation (see Refs [16, 17]). The comprehensive protection strategy developed at the preparedness stage should extend beyond the termination of the emergency, in order to support all the necessary activities for achieving any long term objectives.

4.26. The protection strategy developed at the preparedness stage for the transition phase might not be as detailed as the protection strategy for the emergency response phase. This is often due to large uncertainties in the prediction of the long term development of the radiological situation for postulated nuclear or radiological emergencies. Other uncertainties are related to social, economic, political and other aspects prevailing at the time of the emergency and the increasing importance of these non-radiological factors later in the response. Thus, the protection strategy for the transition phase should be further elaborated and adapted during the transition phase itself, as relevant information becomes increasingly available. The process for adapting the protection strategy during the emergency response should be agreed, at the preparedness stage, with all relevant authorities and interested parties and should be included in the protection strategy.

4.27. As part of the protection strategy, the processes of justification and optimization to cope with the prevailing conditions as the emergency evolves should be agreed upon. In general, this should include the following elements:

(a) Processes and methodologies to be used in the transition phase, including the designation of any particular decision aiding tools as necessary.
(b) The identification of parties that will need to be consulted on the specific inputs necessary for the process, and clearly defined roles and responsibilities for the justification and optimization processes.

4.28. As part of the processes of justification and optimization, the protection strategy should take into account the impact that emergency response actions taken during the emergency response phase may have on the actions warranted in the transition phase and in the longer term. This should be done along with an examination and considerations of the impact that emergency response actions may have on achieving the prerequisites for the termination of the emergency.[31] However, such considerations should not compromise the effectiveness of the protection strategy for the emergency response phase.

4.29. Each protection strategy should include a national reference level, expressed in terms of residual dose from all exposure pathways, to be used as a benchmark for optimization of protection and safety; generic criteria for taking protective actions and other response actions; and pre-established national operational criteria for initiating the different emergency response actions in line with Requirement 5 of GSR Part 7 [2], with account taken of the recommendations provided in this Safety Guide and in GSG-2 [5].

4.30. Public self-help actions aimed at supporting the implementation of the protection strategy should be an integral element of each protection strategy, particularly for the transition phase of a large scale emergency involving a substantial release of radioactive material to the environment.

4.31. The development of the protection strategy should involve all response organizations at all levels, as well as relevant interested parties (see paras 4.197–4.207) in order to allow for a common understanding and to enhance the acceptability, feasibility and any associated practicalities of the proposed protection strategy.

4.32. When significant radiological consequences could extend beyond national borders, every effort should be made to develop the protection strategy in consultation with neighbouring States that may be directly impacted by the emergency to ensure consistent and coordinated responses.

4.33. The protection strategies should be used at the preparedness stage as a framework to guide the establishment of adequate emergency arrangements by all response organizations.

Implementation of the protection strategy in the transition phase

4.34. As soon as the emergency has been declared, the prompt implementation of the protection strategy is paramount to provide the best level of protection under the circumstances, even if very little information is available, as may be the case during the urgent response phase. As the emergency evolves and particularly during the transition phase, more information on the circumstances that led to the emergency and its consequences becomes available. The implementation of the protection strategy should be continuously reassessed, and the protection strategy should be adapted based on the prevailing conditions [5].

4.35. The effectiveness of the protection strategy in the transition phase should be assessed against the pre-established prerequisites for the termination of the emergency (see Section 3), which includes consideration of the residual doses among affected populations against the chosen reference level.

[31] For example, if two options within the protection strategy provide the same level of protection of the public during the emergency response phase, the one that is less disruptive to society would be the preferred option, as it will support later efforts associated with the termination of the emergency and the overall recovery.

4.36. The process of reassessment and adaptation of the protection strategy during the transition phase should allow for iterative application of the processes of justification and optimization (see paras 4.39–4.51 and Fig. 3).

4.37. The rationale for adapting the protection strategy should be transparent with respect to the criteria and conditions considered (including radiological factors and other factors), documented and communicated to relevant authorities and relevant interested parties.

4.38. In the transition phase there is likely to be a gradual increase in both the need to engage with interested parties (see paras 4.197–4.207) and their interest in the decision making processes. While relevant interested parties are required to be engaged with and consulted, the process should be such that the responsibility for timely decision making clearly remains with the relevant authorities. In the transition phase, consideration should be given to the time allocated for such engagement and consultation and to the need for timely and effective implementation of the protection strategy.

Justification and optimization

General

4.39. Non-radiological factors become an increasingly important input into decision making in the transition phase as the doses tend to decrease with the effective implementation of the protection strategy. Notwithstanding the need to consider both radiological and non-radiological factors in the justification and optimization of the protection strategy, for those situations involving higher doses (approaching or exceeding an effective dose of 100 mSv per year), protective actions are almost always justified,[32] and the radiation protection considerations generally outweigh the non-radiological impacts.

4.40. The processes of justification and optimization should consider a variety of factors, examples of which are given in Table II-1 of Annex II. In order to take into account this range of factors, the processes of justification and optimization of the protection strategy should be such that input can be obtained from relevant authorities and relevant interested parties.

4.41. While some of the different factors to be considered in the processes of justification and optimization can be known or estimated at the preparedness stage, some of them cannot be known, or may be known without sufficient accuracy. Examples of such factors include seasonal and weather conditions, the occurrence of simultaneous events that may have caused a major loss of essential infrastructure (such as a conventional emergency), the actual radionuclides involved and the different lifestyles and dietary habits of the population. The processes of justification and optimization should

[32] Examples of unjustified actions at this level of dose would include the unsafe evacuation of patients (that is, for example, the evacuation of seriously ill patients without ensuring the provision of continuous medical care) from hospitals in areas where evacuation has been ordered.

recognize and allow for such uncertainties and limitations of the information available at the preparedness stage to ensure that such uncertainties are appropriately considered during the response.

4.42. In all phases of an emergency, and especially in the transition phase, the processes of justification and optimization of the protection strategy should be conducted to continuously assess the impact of the protection strategy on the overall radiological situation, including assessing the residual doses incurred by people compared to the reference levels, the impact on society and other non-radiological impacts. This should be done in order to account for the state of achieving the prerequisites for terminating the emergency. Such continuous reassessment should lead to an adaptation of the protection strategy when necessary to allow for achieving the relevant prerequisites stated in Section 3 (see Fig. 3).

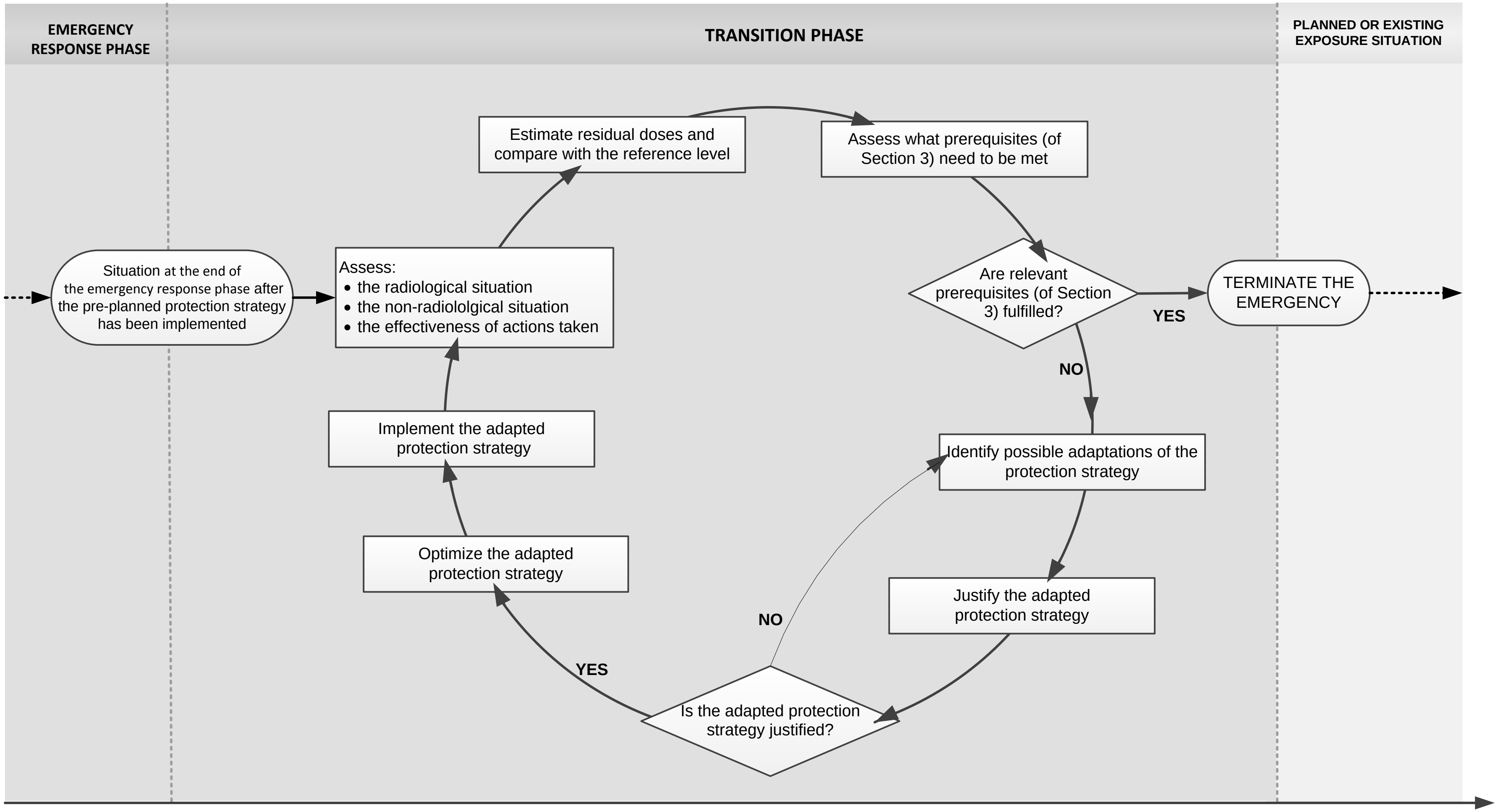

Fig. 3. The iterative process of assessment of the implementation and adaptation of the protection strategy in the transition phase.

Justification

4.43. Paragraph 4.29 of GSR Part 7 [2] states that "Each protective action, in the context of the protection strategy, and the protection strategy itself shall be demonstrated to be justified". Application of the principle of justification allows the respective authorities to determine "whether a proposed protective action or remedial action is likely, overall, to be beneficial; i.e. whether the expected benefits to individuals and to society (including the reduction in radiation detriment) from introducing or continuing the protective action or remedial action outweigh the cost of such action and any harm or damage caused by the action" [3].

4.44. In determining whether the proposed actions and the protection strategy are justified, the reduction in radiation detriment should be weighed against the impacts in other areas such as public health, social and economic disruption, ethical considerations and the environment. Examples of such impacts include: a) possible reduced life expectancy owing to stress associated with resettlement; b) costs associated with the loss of essential infrastructure; c) loss of productivity of industrial facilities; d) the need for compensation payments to those impacted; e) societal impact owing to the loss of places of great cultural or historical importance; and f) the costs to society and its economy associated with the management of the radioactive waste generated.

4.45. A justified protection strategy and justified actions within the protection strategy should be developed during the preparedness stage, with account taken of the uncertainties in and limitations of the information available. Protective actions and other response actions implemented solely on the basis of political pressure or public concerns that do not have any scientific and technical merit should be avoided, as they may necessitate later remediation activities that are not justified in terms of their associated harm and costs , particularly in the longer term. In addition, taking such unjustified actions may give the impression to the public that the risk associated with the emergency is much greater than the actual risk, and may cause unnecessary anxiety and adverse psychological consequences.

4.46. The protective actions and the protection strategy should be periodically reassessed in the transition phase to ensure they continue to do more good than harm, with account taken of any new information that becomes available.

4.47. Paragraph 4.31(h) of GSR Part 7 [2] requires that protective actions and other response actions be discontinued when they are no longer justified.

Optimization

4.48. The process of optimization of protection and safety should be applied to protective actions and the protection strategy that have been demonstrated to be justified in accordance with paras 4.39–4.47.

4.49. Optimization of protection and safety is defined as "the process of determining what level of protection and safety would result in the magnitude of individual doses, the number of individuals (workers and members of the public) subject to exposure and the likelihood of exposure being as low as reasonably achievable, economic and social factors being taken into account" [3]. This means that the level of protection would be the best possible under the prevailing circumstances and will thus not necessarily be the option with the lowest dose.

4.50. The process for optimization should allow for all relevant factors (see Table II-1 of Annex II for examples) to be considered in making the decisions. Optimization of protection and safety should be a forward looking, iterative process that examines the available options for protection and adjusts the actions to be taken to obtain the best outcome.

4.51. Implementation of an optimized protection strategy should result in exposure levels below the reference level, and as low as reasonably achievable, as long as these reductions are justified, with account taken of the aspects indicated in para. 4.44. Optimization should be applied even if the initially projected doses are below the defined reference level, but only if actions that are justified are available to reduce exposures.

Reference levels

4.52. For emergency exposure situations, Refs [2, 3, 26] require that the typical reference level expressed in terms of residual dose be set, typically as an effective dose in the range 20 to 100 mSv, acute or annual, that includes dose contributions via all exposure pathways. Above this level, it is judged to be inappropriate to allow exposures to occur as a result of the exposure situation (i.e. an upper constraint on optimization). The residual dose expresses the accumulated exposure from the initiation of the event through a specified period of time, with account taken of the implementation of the protection strategy, if any.[33]

4.53. Reference levels are used as a tool for optimization of the protection strategy so that any optimization of protection gives priority to reducing exposures that are above the reference level; at the same time, the optimization of protection may continue to be applied below the reference level as long as this is justified, i.e. it does more good than harm. Exposures above 100 mSv are justified under some circumstances, either because the exposure is unavoidable or in exceptional situations in which the expected benefits clearly outweigh the health risks. This would apply, for example, to seriously ill patients when their evacuation would present a higher risk to their health than the dose they are likely to incur by remaining in place until their safe evacuation can be arranged.

4.54. The reference level should also serve as a benchmark for retrospective assessment of the effectiveness of the actions and the protection strategy applied in the response (see Refs [2, 26, 27]).

[33] For emergency exposure situations that may result in doses over a period of less than one year, the residual dose will be the total dose from all exposure pathways for the entire duration of the emergency. For a large scale emergency resulting in longer term exposures due to residual radioactive material in the environment, the residual dose will encompass the total dose from all exposure pathways over one year from the onset of the emergency. For residual doses to be used during the response, the total residual dose includes the doses received from all exposure pathways (received dose) and the doses expected to be received in future (projected residual dose), with account taken of the implementation of the protection strategy, if any.

This comparison should be used to identify the need for adaptation of the protection strategy in addressing the prevailing conditions. In this process, further protective actions should be determined and implemented so that they are focussed, as a priority, on those groups or individuals whose doses exceed the reference level. The available resources should then be allocated accordingly.

4.55. The decision to select specific numerical values for the national reference level remains the responsibility of the relevant national authority. Such selection will depend on a range of circumstances, including national and local conditions (e.g. prevailing economic and societal circumstances, and available national, regional and local resources and capabilities), the phase of the emergency under consideration, the practicality of reducing or preventing exposures and the availability of options to do so. The process of selecting specific numerical values for the national reference level should be based on the results of the hazard assessment and consideration of the urgent protective actions, early protective actions and other response actions implemented, as well as the projected long term development of the exposures. When selecting the values for reference levels, it should be considered that selecting a value close to the lower bound will not necessarily provide for better protection when other factors (see Annex II) are also considered in the overall processes of justification and optimization.

4.56. The following two examples aim to clarify the process for the application of the concept of the reference level for residual dose in the transition phase for a large scale emergency and for a small scale emergency:

(a) An emergency involving large scale contamination resulting in exposures of the public due to long lasting residual radioactive material in the environment will result in longer term exposures, which are expected to decrease with time. The time dependence of the reduction of the residual doses will depend on various circumstances, including the effectiveness and the efficiency of the implementation of the protection strategy. Successful implementation of the protective strategy will lead to residual doses approaching an effective dose of 20 mSv per year, which is expected to facilitate efforts aimed at enabling the transition to an existing exposure situation.
(b) An emergency involving a dangerous source that does not result in long lasting residual radioactive material in the environment will not result in a need for the residual dose to be gradually reduced, as in the example in bullet (a). As such, while the reference level for the emergency exposure situation may be selected from the range proposed (see para. 4.52) for the purpose of the response, once the source is recovered safely, the concept of the reference level will no longer apply, as the situation will return to a planned exposure situation.

4.57. In general, a reference level of the magnitude used in an emergency exposure situation will not be acceptable as a long term benchmark for an existing exposure situation (see paras 4.29 and 4.54). Termination of an emergency should not be considered if the annual effective dose (residual dose) to the affected population who remain living in an area in which they are in an emergency exposure situation would be close to upper end of the range of the reference level for the emergency exposure situation.

4.58. In exceptional cases, however, when no justified and optimized actions can be taken to further minimize the residual doses, a value for the reference level exceeding the lower end of the range of the reference level typical for an emergency exposure situation (which is the upper bound for an existing exposure situation) can be selected to terminate the emergency after consultation with all parties concerned. In this case, efforts should be continued to investigate the possible options and to further assess and minimize, as far as practicable and reasonable, the exposures of the people affected. This may include efforts to provide advice and support to individuals for minimizing their exposures (for example, advising on self-help actions).

4.59. A residual dose that is approaching the lower end of the range for the reference level for the emergency exposure situation (on the order of 20 mSv effective dose in a year (see Table 1)) should be accepted for the termination of the emergency, while continued efforts will likely be necessary to progressively reduce doses further in the longer term.

4.60. After termination of the emergency and entering an existing exposure situation, the reference level for the residual dose in an existing exposure situation should be applied in the range of 1–20 mSv per year, as required in GSR Part 3 [3] (see Table 1). The International Commission on Radiological Protection (ICRP) recommends that the reference level for the optimization of the protection strategy is selected from the lower end of the range of 1–20 mSv per year as a long term objective for existing exposure situations (see Refs [27]). Further guidance in this regard can be found in WS-G-3.1 [16] and GSG-8 [17].

TABLE 1. OVERVIEW OF THE APPLICABILITY OF REFERENCE LEVELS FOR DIFFERENT EXPOSURE SITUATIONS

RANGE FOR THE REFERENCE LEVEL FOR THE RESIDUAL DOSE	**APPLICABILITY**
20–100 **mSv** [a]	Emergency exposure situation
~ 20 mSv [b]	Transition from an emergency exposure situation to an existing exposure situation
1–**20 mSv** [b]	Existing exposure situation

[a] Acute or annual effective dose

[b] Annual effective dose

4.61. What is feasible to achieve in a given timeframe may differ from area to area. It may be necessary to apply different reference levels as benchmarks for the optimization process and for enabling the transition to an existing exposure situation in different geographical areas at the same time. Interested parties, including the public from the areas affected, should be informed about the rationale for such differences.

Generic criteria and operational criteria

4.62. Generic criteria and operational criteria are concepts within the protection strategy that are to be used to implement protective actions and other response actions in a nuclear or radiological emergency, as described in GSR Part 7 [2] and GSG-2 [5]. If the projected dose or the dose that has been received[34] in an emergency exceed the generic criteria, protective actions and other response actions, either individually or in combination, are required to be implemented.

4.63. Paragraph 4.28 of GSR Part 7 [2] requires national generic criteria to be developed for the protective actions and other response actions to be taken in an emergency response. Appendix II of GSR Part 7 [2] provides a comprehensive set of generic criteria to be considered when developing a justified and optimized protection strategy at the national level, including when establishing the national generic criteria. The generic criteria given in Appendix II of GSR Part 7 [2] are considered to be generically justified and optimized and are for taking protective actions and other response actions to avoid or minimize severe deterministic effects, to reasonably reduce the risk of stochastic effects and to mitigate the economic impact of an emergency by providing a basis for the resumption of international trade, and for guiding the actions aimed at enabling the transition to an existing exposure situation.

4.64. Appendix II of GSR Part 7 [2] establishes generic criteria for enabling the transition to an existing exposure situation to be the following projected doses:

(a) An effective dose of 20 mSv per year;

(b) An equivalent dose to a fetus of 20 mSv for the full period of in utero development.

4.65. If an emergency occurs, prompt decision making is essential to allow the necessary emergency response actions to be implemented effectively. To facilitate this implementation, operational criteria should be developed on the basis of the generic criteria to trigger specific emergency response actions, without the need for further assessments against the generic criteria and before substantial information on the situation is available. The operational criteria used in the emergency response phase include observable conditions on the site, emergency action levels (EALs), and operational intervention levels (OILs). Further guidance on the criteria to be implemented in emergency preparedness and response can be found in GSG-2 [5].

4.66. In the transition phase, OILs based on the generic criteria for taking specific protective actions and other response actions and OILs based on the generic criteria (see para. 4.64) for enabling the transition to an existing exposure situation (here-in-after referred to as OIL_T), should be used as a tool to support:

[34] For further details see GSG-2 [5].

(a) Decision making on lifting or adapting protective actions, including the determination of what protective actions may need to be lifted, when this might happen and to whom the decision may apply.

(b) Implementation of activities to enable the transition from an emergency exposure situation to an existing exposure situation by providing a basis to guide simple activities aimed at reducing the residual dose.

4.67. The Appendix of this Safety Guide provides OILs that should be taken into account when establishing the national OILs to be applied in accordance with para. 4.66. The Appendix also provides considerations as well as a methodology for deriving the OIL_T to support the implementation of generic criteria for enabling the transition to an existing exposure situation.

4.68. As for other default OILs, default OIL_T values should be developed on the basis of conservative assumptions regarding the emergency, the affected population and the prevailing conditions. However, if the characteristics of the emergency differ from those assumed in the calculations of default OIL_T values, the OIL_T values should be recalculated using the same methodology under the new available information. Paragraph 4.28 of GSR Part 7 [2] requires that arrangements be established to revise the default OILs in the course of an emergency, with account taken of the prevailing conditions as they evolve. A methodology and processes for the recalculation of the OIL_T values in the course of an emergency to address the prevailing conditions should constitute an integral part of the protection strategies.

4.69. In revising the default OILs during an emergency, it should be ensured that the situation is well understood and there are compelling reasons to do so. The public and other interested parties should be informed of the reasons for any change in the OILs applied in an actual emergency.

Adaptation and lifting of the protective actions

General

4.70. The most commonly considered urgent protective actions within a protection strategy are: a) evacuation; b) sheltering; c) iodine thyroid blocking; d) restrictions on local produce, milk from grazing animals, rain water or other open sources of drinking water; e) restrictions on the use of commodities that have the potential of resulting in significant exposures; f) decontamination of individuals when appropriate; and g) actions to prevent inadvertent ingestion. Many of these urgent protective actions may be implemented as a precaution on the basis of observable conditions or plant conditions, prior to a release of radioactive material or prior to the occurrence of radiation exposures (precautionary urgent protective actions). A decision on taking urgent protective actions is often based on limited information about the emergency and is guided by conservative assumptions on the potential development and impacts of the exposure situation.

4.71. The most commonly considered early protective actions within a protection strategy are: a) relocation; b) long term restrictions on the consumption of food, milk and drinking water; c) restrictions on the use of commodities that have the potential to result in significant exposures; d) actions to prevent inadvertent ingestion and to control the spread of contamination (including access controls for areas where evacuation or relocation is implemented); and e) decontamination of areas or commodities to further reduce the individual doses. Decisions on the adaptation of urgent protective actions and the implementation of early protective actions are taken on the basis of increasingly more detailed information and better knowledge of the exposure situation.

4.72. The transition phase is characterized by a change in approach, from a strategy predominantly driven by urgency to a strategy based on more comprehensive assessments aimed both at reducing longer term exposures and improving living conditions. The protection strategy already in place will probably need to be adjusted in order to identify where and for whom new protective actions are necessary; those protective actions that are no longer necessary are then lifted or adapted. For example, some of the urgent protective actions implemented as a precaution might be lifted if further assessment indicates that these actions are no longer justified. This might be the result of the positive evolution of the situation and the return to safe conditions, or it may be due to evidence that the protective action was not necessary because the impact of the emergency was limited.

4.73. Adaptation and/or lifting of protective actions in the transition phase should be justified and optimized on the basis of the prevailing conditions, with account taken of the results of the detailed characterization of the exposure situation and exposure pathways (see paras 4.142–4.157) and a range of radiological and non-radiological considerations.

4.74. Decisions on the adaptation and/or lifting of protective actions (such as lifting orders for evacuation, relocation or restrictions on certain foods for consumption) should be made after their impact on the residual doses among the affected population has been assessed.

4.75. To initiate discussions, in order for decisions to be made on the adaptation and/or lifting of protective actions in the transition phase, OILs should be established at the preparedness stage, with account taken of the default OILs provided in the Appendix of this Safety Guide. The pre-established OILs should be used to consider what specific protective actions may need to be lifted, and when and for whom. Following this preliminary screening, the final decision on adaptation and/or lifting of protective actions should be based on an assessment of the residual dose (see para. 4.74) from all exposure pathways against the pre-set reference level for enabling the transition (see para. 4.57).

4.76. As the prevailing conditions may vary within an affected area, consideration should be given to the fact that adaptation and/or lifting of the protective actions may take place at different times in different locations. Overly frequent changes in the protective actions applied should be avoided, unless such changes would provide significant benefits, as this could risk losing public trust in the decisions of the authorities.

4.77. Prior to the adaptation and/or lifting of protective actions, the public and other interested parties should be informed about the protective actions that are to be adapted or lifted; they should be told why, when and where the protective actions will be adapted or lifted; and they should be advised on how this adaptation or lifting will affect them.

Considerations for the adaptation or lifting of specific protective actions

Iodine thyroid blocking

4.78. Iodine thyroid blocking is a short term urgent protective action that provides protection for the thyroid against radioactive iodine; it may be implemented as a precaution, although it is not usually a stand-alone action but rather is combined with other protective actions such as sheltering. Owing to its nature, iodine thyroid blocking is not a protective action to be implemented for prolonged periods although, under some circumstances, repeated administration of stable iodine might be considered. However, whenever there is a need to implement iodine thyroid blocking for a longer duration (e.g. for several days), consideration should be given to implementing evacuation or relocation. Iodine thyroid blocking is suitable for use in the urgent response phase and is not appropriate for implementation in the transition phase. Iodine thyroid blocking is adapted or lifted in the emergency response phase.

Sheltering

4.79. Sheltering is also an urgent protective action that is relatively easy to implement in an emergency, either as a precaution or as an urgent protective action to be taken for a short time until more effective but more disruptive actions (such as evacuation) can be safely implemented. Sheltering should not be carried out for long periods (more than approximately two days). Owing to its nature, sheltering is not appropriate for implementation in the transition phase but may be lifted or adapted during this phase.

4.80. Aspects to be considered in the decision to adapt or lift sheltering imposed during the emergency response phase should include:

(a) The level of protection offered by the type of buildings used for sheltering (shielding factor and tightness against diffusion of outside atmosphere);
(b) The need for continued simultaneous implementation of iodine thyroid blocking when appropriate;
(c) The medical care and other needs of those sheltered (e.g. the availability of medicines, food supplies, clean clothing and sanitation);
(d) Any necessity to gradually increase the time recommended for members of the public to spend outdoors until sheltering is fully lifted, with account taken of the need for any instructions to be given for areas to be avoided while outdoors;
(e) The need for further protective actions based on generic criteria and OILs to replace sheltering (e.g. evacuation or relocation).

Evacuation

4.81. Evacuation may be taken as a precautionary action based on observable conditions or plant conditions (i.e. EALs), or an urgent protective action based on OILs. Owing to its temporary nature, priority should be given to lifting evacuation, with consideration given to the following (see the Appendix):

(a) In an evacuated area where the monitoring results indicate that the projected doses may exceed the generic criteria for relocation (i.e. the measurement results exceed OIL2 of GSG-2 [5]), evacuation should be substituted by relocation to provide better living conditions for evacuees.

(b) In an evacuated area where the monitoring results indicate that the projected doses do not exceed the generic criteria for relocation (i.e. the measurement results do not exceed OIL2 of GSG-2 [5]), evacuation should be lifted if no or only limited restrictions (e.g. restriction on locally produced food or limited access to certain recreational areas) would continue to be necessary for those people living normally in the area and if the pre-conditions in para. 4.101 are fulfilled.

(c) In an evacuated area where the monitoring results indicate that the projected doses do not exceed the generic criteria for relocation (i.e. the measurement results do not exceed OIL2 of GSG-2 [5]), but limited restrictions are not sufficient for the protection of the people returning to live normally in the area, or the pre-conditions in para. 4.101 are not fulfilled, evacuation should not be lifted until this area can be managed as an existing exposure situation, following fulfilment of the prerequisites in Section 3 and of the preconditions in para. 4.101.[35]

4.82. In areas with circumstances such as those referred to in para. 4.81(c), OIL_T, as provided in the Appendix, should be applied to guide remedial actions for preparing these areas so that people may live normally with limited restrictions. In deciding whether to allow people to return to these areas, the residual doses from all exposure pathways received based on the actual circumstances should be considered, with account taken of the limited restrictions continuing to be in place.

4.83. When substituting evacuation with relocation, the people evacuated should be granted access to the evacuated areas for short periods of time and in a controlled manner, in order to allow them to prepare for longer term relocation.

Relocation

4.84. Relocation is an early protective action intended for longer duration (months). Its adaptation or lifting is less urgent in comparison to evacuation, and it allows more time for planning. This action should be lifted under the same conditions as those applicable for lifting evacuation outlined in paras 4.81(b) and (c) and 4.82.

Restrictions on food, milk and drinking water

4.85. Restrictions imposed on food, milk and drinking water taken as a precaution in the emergency response phase on the basis of estimates (e.g. on the basis of EALs or OIL3 of GSG-2 [5] and

[35] In cases when the responsible authorities cannot fulfil some of relevant prerequisites in Section 3 or the pre-conditions in para. 4.102 for evacuated areas, such areas should be delineated and relocation can be considered instead of evacuation for these areas in order to allow for timely termination of the emergency.

thereafter adjusted based on OIL5 and OIL6 of GSG-2 [5] or OIL7 of Ref. [28]) should be characterized in detail in the transition phase. The purpose is to identify food production areas and foodstuffs that are justified to remain under restriction even in the longer term and to identify those restrictions that need to be lifted. OILs for restrictions of food, milk and drinking water derived on the basis of sampling and analysis, i.e. OIL6 in GSG-2 [5], should be used when considering whether to adapt or lift this protective action.

4.86. OIL6 in GSG-2 [5] has been derived on the basis of the generic criterion of a projected effective dose of 10 mSv per year and uses extremely conservative assumptions (see GSG-2 [5] for more details). In the transition phase, the actual doses received from the ingestion pathway and their contribution to the residual dose should be estimated based on actual conditions to aid in decision making on the adaptation or lifting of this protective action. Under actual conditions, the contribution of actual doses from the ingestion pathway to the total residual dose is expected to be significantly less than 10 mSv per year.

4.87. For existing exposure situations, Requirement 51 of GSR Part 3 [3] requires that specific reference levels be established for exposure due to radionuclides in commodities including food and drinking water, each of which is required typically to be expressed as, or based on, an annual effective dose to the representative person generally that does not exceed a value of about 1 mSv. In addition, the World Health Organization (WHO) has issued guidelines for drinking water quality [29] that provide guidance levels for radionuclides in drinking water for prolonged situations of exposure resulting from past emergencies. Thus, further restrictions on food, milk and drinking water extending into the longer term in an existing exposure situation might be implemented in order to eventually achieve these levels. However, this discussion goes beyond considerations concerning the termination of the emergency and is therefore beyond the scope of this Safety Guide.[36]

4.88. The implementation or adaptation or lifting of restrictions on the international trade of food, milk and drinking water should take into account established national criteria for this purpose with account taken of the guideline levels contained in Ref. [30], while ensuring consistency with GSR Part 7 [2] and GSR Part 3 [3].

4.89. In order to reassure the public of the radiation safety of food, milk and drinking water in the transition phase, the relevant authorities should provide evidence for compliance with applicable national regulations. Such evidence should include publishing of monitoring results including information that places the radiological health hazards in perspective and, where appropriate, certification.

Restriction on non-food commodities

---

[36] Further information in this regard can be found in: INTERNATIONAL ATOMIC ENERGY AGENCY, JOINT FOOD AND AGRICULTURE ORGANIZATION / INTERNATIONAL ATOMIC ENERGY AGENCY PROGRAMME NUCLEAR TECHNIQUES IN FOOD AND AGRICULTURE, WORLD HEALTH ORGANIZATION, Criteria for Radionuclide Activity Concentrations for Food and Drinking Water, IAEA-TECDOC-1788, IAEA, Vienna (2016).

4.90. Decisions on the adaptation or lifting of restrictions on non-food commodities implemented during the emergency response phase as a precaution or based on estimates (e.g. on the basis of EALs or OIL3 of GSG-2 [5]) should be based on comprehensive information and actual monitoring results. The purpose is to identify non-food commodities that are justified to remain under restriction even in the longer term and to identify those restrictions that need to be lifted. OILs for non-food commodities derived on the basis of sampling and analysis, i.e. OIL_C, should be used for this purpose. A methodology to derive default OIL_C values is given in the Appendix.

4.91. In the transition phase, the actual doses received from the use of non-food commodities and their contribution to the residual dose should be estimated based on the actual circumstances to inform the decision making on the adaptation or lifting of restrictions on the use of non-food commodities.

4.92. Requirement 51 of GSR Part 3 [3] establishes the specific reference level for commodities in the longer term in an existing exposure situation as an annual effective dose of about 1 mSv. Further restrictions on non-food commodities extending in the longer term in an existing exposure situation might be implemented in order to achieve this reference level. However, this discussion goes beyond considerations concerning the termination of the emergency and is thus beyond the scope of this Safety Guide.

4.93. The implementation, adaptation or lifting of restrictions on the international trade of non-food commodities should be determined on the basis of OILs derived from the respective generic criterion given in the Appendix II of GSR Part 7 [2]. The methodology given in the Appendix of this Safety Guide can also be used to derive OIL_C values.

4.94. In order to reassure the public of the radiation safety of non-food commodities in the transition phase, the relevant authorities should provide evidence for compliance with applicable national regulations. Such evidence should include publishing of monitoring results including information that places the radiological health hazards in perspective and, where appropriate, certification.

Dose reduction considerations in the transition phase

Prevention of inadvertent ingestion and inhalation

4.95. Actions to prevent inadvertent ingestion (such as limitations regarding playing on the ground, working in gardens or washing hands) could be advised during the urgent response phase. However, as a protective action, advice on preventing inadvertent ingestion and the inhalation of re-suspended material should also be implemented in the transition phase, on the basis of actual conditions, to reduce the residual dose among those returning to live in an affected area if evacuation or relocation is lifted.

Decontamination, control of access and other actions

4.96. Long term remediation may be needed after a large scale emergency with significant releases of radioactive material to the environment (further guidance on remediation is provided in Ref. [16]).

However, control of access, decontamination of the area or commodities and other simple dose reduction techniques should be used in the transition phase to enable the progressive lifting of protective actions such as evacuation and relocation. These actions should be considered for implementation beyond the areas where evacuation and relocation were implemented during the emergency response phase and for areas to which people are returning.

4.97. OIL_T provided in the Appendix should be used as a benchmark for screening where the actions in para. 4.96 may be warranted. Any decision on implementation of such actions should give consideration to the actual residual doses against the pre-set reference level in line with the protection strategy.

Delineation of areas

4.98. Those areas identified in the transition phase that cannot be inhabited, and where social and economic activity cannot be resumed, should be delineated. Such areas should normally not be opened for people to return to live in, and administrative measures should be put in place to control access (see the respective prerequisite in Section 3). Subject to these measures for access control, the delineation of an area as unsuitable for inhabitation should not constitute an obstacle to terminating the emergency.

4.99. Information about delineated areas and measures put in place to control access should be clearly communicated to all interested parties.

4.100. Delineation of areas as unsuitable for inhabitation should consider radiological aspects along with the other prerequisites mentioned in Section 3; in addition, social factors, such as public acceptance of their return to the area, should also be taken into account. Existing geographic or jurisdictional boundaries may also be considered when deciding on the delineation.

Additional preconditions for allowing people to return to an area

4.101. In allowing people to return to an area, their well-being should not be endangered and it should be possible for them to carry out their routine social and economic activities. However, limited restrictions on normal living habits may still need to be observed and might possibly extend into the longer term. The following preconditions should be fulfilled before allowing people to return to an area that was evacuated or from which people were relocated:

(a) Infrastructure and public services are in place (e.g. public transportation, shops and markets, schools, nurseries, health care facilities, police and firefighting services, water services, sanitation, energy supplies and telecommunication networks).
(b) Clear instructions and advice on the restrictions still in place and the recommended changes to behaviours and habits, including land use, have been provided to those returning.
(c) Public support centre(s) and informational material (e.g. leaflets, posters) for public reassurance and psychosocial support are available for those returning.

(d) A strategy has been established for the restoration of workplaces and for the provision of social support for individuals working in the area.

(e) Information on the likely evolution of the exposure situation and associated health hazards has been provided to those returning.

PROTECTION OF EMERGENCY WORKERS AND HELPERS

General

4.102. GSR Part 7 [2] and GSR Part 3 [3] define an emergency worker as "a person having specified duties as a worker in response to an emergency". Thus, any person engaged as a worker in response to a nuclear or radiological emergency at any time between the onset of the emergency and its termination is referred to as an emergency worker in the IAEA safety standards.

4.103. Emergency workers may include:

(a) Relevant employees of operating organizations (those employed directly by the operating organization and also those engaged indirectly through a contractor) engaged in an emergency response on the site, including in the activities aimed at enabling the termination of the emergency.

(b) Relevant personnel from other response organizations and services, such as response managers, rescuers, firefighters, drivers and crews of evacuation vehicles, medical personnel, law enforcement personnel, members of monitoring teams, members of decontamination teams, workers engaged in various activities on the site and off the site, including the restoration of essential infrastructure and the management of waste generated in the emergency.

(c) Relevant personnel engaged in providing support and care to the affected population (e.g. in reception centres).

4.104. Paragraph 5.49 of GSR Part 7 [2] requires that emergency workers be, to the extent practicable, designated in advance and that arrangements be made to register and integrate into operations those emergency workers who were not designated as such prior to the emergency. Emergency workers designated in advance are required to be assessed for their fitness for the intended duties prior to their engagement in an emergency response and on a regular basis thereafter.

4.105. GSR Part 7 [2] defines a helper in an emergency as a "member of the public who willingly and voluntarily helps in the response to a nuclear or radiological emergency" even though he or she is aware that he or she can be exposed to radiation while doing so. While the engagement of helpers in the urgent response phase of an emergency is less expected, helpers can be increasingly engaged as the emergency evolves, particularly in the transition phase.[37]

[37] Helpers in an emergency are members of the public and thus, they do not have a status of workers (for an employer) as defined in GSR Part 3 [3]. However, once registered and integrated into the emergency response operations, they are required to be protected in accordance with Requirement 11 of GSR Part 7 [2].

4.106. The IAEA safety standards [2, 3, 5, 32] establish the safety requirements for, and provide further recommendations and guidance on, the protection of emergency workers. GSR Part 7 [2] establishes the safety requirements for the protection of helpers in an emergency. The guidance provided in this Safety Guide addresses the specifics of protection of emergency workers and helpers in the transition phase and complements these standards.

4.107. Paragraph 5.101 of GSR Part 7 [2] states that "Once the emergency is terminated, all workers shall be subject to the relevant requirements for occupational exposure in planned exposure situations" established in Section 3 of GSR Part 3 [3]. This requirement draws on past experience, showing that the long term aspects can be subject to detailed planning that will allow for workers undertaking relevant work to be protected in accordance with the requirements for occupational exposure in planned exposure situations. Reference [31] provides further recommendations and guidance on occupational radiation protection in planned exposure situations and existing exposure situations.

4.108. Any decision to terminate a nuclear or radiological emergency and to move to a planned exposure situation or an existing exposure situation should consider the feasibility of compliance with the requirements for occupational exposure in planned exposure situations for all workers engaged in recovery operations (see Section 3).

Identification and designation

Emergency workers

4.109. Emergency workers that will be engaged in the transition phase should be identified, to the extent possible, and designated as such at the preparedness stage by all relevant organizations. The relevant organizations, in this context, include response organizations, as well as other organizations[38] at the national, regional and local levels. These organizations might not necessarily be recognized as emergency response organizations, but, during the transition phase, they may gradually take over a role and assume responsibilities for long term recovery, when applicable.

4.110. Relevant organizations should use the process of designation of emergency workers that will be engaged in the transition phase:

(a) To inform emergency workers of their rights, duties and responsibilities with regard to occupational radiation protection;
(b) To recognize their responsibilities, commitments and duties as employers in occupational radiation protection, so that they can be effectively discharged at the preparedness stage and in the transition phase.

4.111. The relevant organizations that may take over a role and assume responsibilities in the transition phase might not have the necessary expertise and capabilities to provide for radiation protection of their employees (i.e. emergency workers). Examples of such organizations may include

[38] Such organizations may come from either the public sector or private sector and may provide different services.

organizations carrying out the restoration of infrastructure or dealing with conventional waste within an affected area. Thus, such organizations may need to call on a relevant institution[39] to provide such services and should make arrangements for this.

4.112. Irrespective of the arrangements referred to in para. 4.111, the responsibilities, commitments and duties in occupational radiation protection should remain with the relevant organization and cannot be transferred to the institution providing the services.

Helpers

4.113. Paragraph 5.50 of GSR Part 7 [2] requires that the response organization(s) responsible for the registration and integration of helpers into the overall response in an emergency be designated at the preparedness stage. The designated response organization should be assigned the relevant responsibilities, commitments and duties in occupational radiation protection for helpers as for emergency workers.

4.114. As part of the emergency arrangements, such designated response organizations should determine:

(a) What type of work helpers are permitted to be engaged in in the transition phase and the type of training they will need to be provided in order to safely and effectively carry out this work;
(b) A mechanism for their engagement (e.g. where and how volunteers from the public may express their interest and willingness to help, how the willingness to help will be documented, information and instructions with which helpers will be provided, and the organization(s) or tasks to which they will be assigned);
(c) The process for informing helpers about and training them in their rights, duties and responsibilities.

Specific considerations for the transition phase

4.115. For an emergency involving significant long lasting contamination of the environment that would require transition to an existing exposure situation, the protection of emergency workers and helpers in the transition phase will be challenged by:

(a) Large variations in the radiological conditions expected within the affected area in an emergency exposure situation warranting the simultaneous application of different measures for the protection of emergency workers and helpers;
(b) Severe radiological conditions having been present at the site for a longer period and, thus, challenging the on-site response efforts;
(c) Different exposure situations existing simultaneously in different areas, warranting workers undertaking the same work to be subject to different dose restrictions;

[39] Depending on the national legal and regulatory framework, technical service providers as specified in Ref. [31], for example, may be identified as relevant institutions.

(d) The large number of emergency workers involved from different organizations and services with diverse backgrounds, knowledge and expertise, some of whom might not necessarily have been identified and designated as emergency workers prior to the emergency;

(e) Numerous members of the public volunteering to help.

4.116. The arrangements to protect emergency workers and helpers should take into account the need to implement simultaneously different schemes for the protection of emergency workers and helpers. However, a consistent approach should be applied for the protection of emergency workers and helpers, to the extent possible, with account taken of the requirements established and guidance provided for this purpose in Refs [2, 3, 5, 32].

4.117. The application of different measures and dose restrictions to protect emergency workers and helpers in the transition phase could be a source of confusion among all concerned parties. Thus, any inconsistency in dose restrictions and measures to be applied for the protection of emergency workers and helpers, and its basis, should be clearly communicated to all concerned parties.

Justification and optimization

4.118. The detriment associated with doses received during the implementation of the protection strategy by the emergency workers and helpers should be taken into account when justifying the protection strategy and the specific protective actions within the strategy. This consideration should be undertaken at the preparedness stage, as well as in the transition phase when justifying and optimizing the protection strategy to meet the actual circumstances.

4.119. At the preparedness stage, the process of optimization should be applied to the protection of emergency workers and helpers and should be driven by pre-set dose restrictions (see paras 4.120 to 4.129). When implementing the protection strategy in the transition phase, the optimization process should be applied for the protection of emergency workers and helpers in the same way as for workers in planned exposure situations.

Dose restrictions for emergency workers and helpers

4.120. Paragraphs 5.54 and 5.55 of GSR Part 7 [2] stipulate that the relevant requirements for occupational exposure in planned exposure situations established in GSR Part 3 [3] are required to be applied, on the basis of a graded approach, for emergency workers, except for the following tasks: a) saving human life or preventing serious injury; b) actions to prevent severe deterministic effects or prevent the development of catastrophic conditions that could significantly affect people and the environment; and c) actions to avert a large collective dose. For these tasks, national guidance values are required to be established for restricting the exposures of emergency workers, with account taken of those given in Appendix I of GSR Part 7 [2].

4.121. Actions to save lives, prevent severe deterministic effects or avert the development of catastrophic conditions that could significantly affect people and the environment are typical for the urgent response phase of a nuclear or radiological emergency. Although the implementation of these actions should be pre-planned, it is expected that they would be driven by the prevailing conditions as the emergency evolves. They would be carried out early in the emergency response when there is a scarcity of information regarding the radiological situation where the action is to be performed. Owing to the urgency associated with implementing these actions and their importance, detailed planning of the work of emergency workers might not be possible; thus, exposures exceeding the dose limits for occupational radiation protection in planned exposure situations are justified to ensure the net benefit of the overall response efforts.

4.122. Actions to avert a large collective dose may extend through the early response phase and in to the transition phase of an emergency owing to the range of activities that are warranted to be taken to allow the timely resumption of social and economic activity. During the transition phase, the knowledge and understanding of the situation where work needs to be carried out increases, and there is no need to take urgent decisions on the deployment of workers. Thus, any work in the transition phase should be undertaken only after detailed planning. As a result, the protection of emergency workers in the transition phase should be applied stringently, in accordance with the requirements for occupational radiation protection for planned exposure situations, including the application of dose limits for occupational exposure in line with GSR Part 7 [2] and GSR Part 3 [3].

4.123. Paragraph 5.57 of GSR Part 7 [2] limits the exposure of helpers in an emergency to an effective dose of 50 mSv for the full duration of the emergency work.

4.124. Protection and safety of emergency workers and helpers in the transition phase should be optimized, with account taken of the characteristics and the necessity of the work to be carried out. The dose restrictions described in paras 4.120 to 4.123 are summarized in Table 2.

Dose restrictions for female emergency workers

4.125. The IAEA safety standards [2, 5, 32] do not limit the involvement of female emergency workers in an emergency response. However, these standards establish requirements and provide guidance for protecting the fetus in case of a possible pregnancy of a female emergency worker.

4.126. In the circumstance of para. 4.125, GSR Part 7 [2] states that female workers are required to be informed of the risk of severe deterministic effects to a fetus following exposure greater than 100 mSv equivalent dose to the fetus. Therefore, any pregnant female worker is required to be excluded from taking actions to avert a large collective dose, if this may result in an equivalent dose to the embryo and fetus exceeding 50 mSv for the full period of in utero development. Situations in which a female worker may receive doses at these levels are primarily expected early in the emergency response (i.e. in the urgent response phase).

4.127. For those activities to be carried out in accordance with the requirements for occupational radiation protection for a planned exposure situation established in Section 3 of GSR Part 3 [3], working conditions need to be ensured for a female worker who is pregnant or suspects that she is pregnant or who is breast-feeding that afford the same broad level of protection to the embryo or fetus or the breastfed infant as that required for members of the public in a planned exposure situation.

4.128. To ensure adequate protection of the fetus, a female emergency worker who is aware that she is, or who might be, pregnant should notify her employer prior to undertaking relevant work. Following notification, the employer has the responsibility to inform the female emergency worker of the associated health risks to the fetus and to ensure adequate working conditions and protective measures to ensure compliance with the dose restrictions described in paras 4.126 and 4.127.

TABLE 2. DOSE RESTRICTIONS FOR WORKERS AND HELPERS INTHE TRANSITION PHASE

Tasks	Guidance value[a]		
	$H_p(10)$[b]	***E***[c]	**AD_T**[d]
Emergency workers			
Actions to avert a large collective dose, such as: - Actions to keep the affected facility or source stable - Monitoring (environmental, source and individual monitoring)	< 100 mSv	< 100 mSv	$< \frac{1}{10} AD_{T,\ Table\ II.1}$[e]
Other activities, such as: - Remedial actions including decontamination on the site and off the site - Repairing the affected facility and restoring the relevant essential infrastructure - Management of radioactive waste and conventional waste - Monitoring (environmental, source and individual monitoring) - Medical management of contaminated patients - Implementation of corrective actions	Dose limits for occupational exposure in planned exposure situations established in Schedule III of GSR Part 3 [3]		
Helpers			
	E[c]		
Specified activities in the national arrangements such as: - Restoring essential infrastructure (e.g. roads, public transportation networks) - Management of conventional waste	≤ 50 mSv		

[a] These values apply for:

(a) The dose from external exposure to strongly penetrating radiation for $H_p(10)$. Doses from external exposure to weakly penetrating radiation and from intake or skin contamination need to be prevented by all possible means. If this is not feasible, the effective dose and the RBE (relative biological effectiveness) weighted absorbed dose to a tissue or organ have to be limited to minimize the health risk to the individual in line with the risk associated with the guidance values given here.

(b) The total effective dose *E* and the RBE weighted absorbed dose to a tissue or organ AD_T via all exposure pathways (i.e. both dose from external exposure and committed dose from intakes), which are to be estimated as early as possible in order to make it possible for any further exposure to be restricted as appropriate.

[b] Personal dose equivalent $H_p(d)$ where $d = 10$ mm.

[c] Effective dose.

[d] RBE weighted absorbed dose to a tissue or organ.

[e] Values of RBE weighted absorbed dose to a tissue or organ given in Table II.1 of Appendix II of GSR Part 7 [2].

4.129. In order to protect the embryo or fetus, all relevant organizations should make adequate arrangements for:

(a) Notification of an actual or suspected pregnancy;

(b) Informing the female worker of the associated health risks prior to her undertaking the assigned work;

(c) Assessing and monitoring the conditions in which the female emergency worker may need to undertake the assigned work;

(d) Ensuring that adequate protective equipment is provided to the female emergency worker and that she is trained in its use;

(e) Assessing the equivalent dose to the embryo or fetus following the emergency work as a basis for determining whether the further involvement of the female emergency worker needs to be restricted and whether medical consultation is warranted.

Dose management and measures to protect emergency workers and helpers

4.130. The adequate management of doses to emergency workers and helpers warrants the establishment of a comprehensive system for monitoring and controlling doses, including the use of individual dosimeters or other appropriate methods. GSG-7 [31] provides guidance regarding monitoring for the assessment of internal and external exposures relevant to occupational radiation protection.

4.131. To ensure that doses to emergency workers and helpers are adequately managed in the transition phase, all relevant organizations should make arrangements:

(a) To register the emergency workers and helpers engaged in the emergency response.

(b) To continuously monitor hazardous conditions in which emergency workers and helpers are to perform their duties.

(c) To comprehensively plan the expected work in an emergency response, while accounting for the hazardous conditions present and the time needed to complete the work.

(d) To assess the total effective dose and the RBE weighted absorbed doses to a tissue or organ for emergency workers and helpers via all exposure pathways, as appropriate.

(e) To record the doses received.

(f) To communicate to emergency workers and helpers in plain and understandable language the doses they receive, and to place the associated health hazards in perspective.

4.132. Response organizations and other relevant organizations should optimize the protection and safety of emergency workers and helpers in recognition of the limited information available at the preparedness stage and taking into account the anticipated hazardous conditions and expected duties in an emergency response. In this context, these organizations should identify:

(a) The training needs and needs for personal protective and monitoring equipment.

(b) The need for implementation of iodine thyroid blocking and/or the provision of adequate personal protective equipment to emergency workers against inhalation of radioactive iodine and other radionuclides in cases of prolonged working activities in the transition phase.
(c) Tasks during the performance of which emergency workers may be subject to exposures exceeding occupational dose limits.
(d) To whom employers need to provide comprehensive information on the risk involved as a basis for obtaining informed consent.
(e) The need for regular health surveillance to assess the initial and continued fitness of emergency workers for their intended duties.

4.133. The implementation of the arrangements set out in paras 4.131 and 4.132 for emergency workers not designated in advance and for helpers may encounter the following challenges:

(a) Emergency workers not designated in advance and helpers might not have had any recognized rights and duties in relation to occupational radiation protection prior to their involvement and thus, might not have received any training in radiation protection.
(b) The employers of emergency workers not designated in advance might not have the capacity to discharge their responsibilities, duties and commitments in the occupational radiation protection of these workers.
(c) Helpers will not have an employer who would provide for their protection.
(d) No assessment of the health condition (i.e. fitness for duty) of emergency workers not designated in advance and of helpers may be possible prior to their undertaking emergency work.

4.134. In the circumstance described in para. 4.133, para. 5.50 of GSR Part 7 [2] requires designated response organization(s), at the preparedness stage, to register and to integrate into emergency response operations those emergency workers not designated in advance and helpers and, thus, to provide for their protection. Such designated response organization(s) should be given the responsibility to implement, as appropriate, the arrangements set out in paras 4.131 and 4.132 for emergency workers not designated in advance and for helpers.

4.135. Such dedicated response organizations should also be responsible for the provision of 'just-in-time' training to emergency workers not designated in advance and to helpers before they carry out of their specified duties. Such training should include:

(a) Instructions on their assigned duties and how to carry them out under the assessed conditions.
(b) Information on the health risks associated with performing these duties.
(c) The protective measures available and how they should be implemented effectively.

4.136. These arrangements should also provide the organization with an opportunity to obtain informed consent from emergency workers assigned to perform the tasks listed in Table 2, for which the dose limits for occupational radiation protection in a planned exposure situation might be exceeded.

Provision of medical support

4.137. GSR Part 7 [2] provides a basis for a common approach in providing medical support to emergency workers and helpers. This includes a generic criterion, in terms of received dose, consistent with the criterion for members of the public (an effective dose of 100 mSv in a month) at which longer term medical actions need to be taken. Such medical actions may include, as necessary, health screening, longer term medical follow-up and counselling aimed at detecting radiation induced health effects early and treating them effectively.

4.138. In the transition phase, it is not expected that emergency workers and helpers may incur doses exceeding 100 mSv effective dose in a month or approaching the thresholds for severe deterministic effects. If this occurs accidentally, the circumstances that have led to this should be investigated, and the emergency worker or helper should be provided with adequate medical treatment in accordance with the requirements of GSR Part 7 [2].

4.139. Irrespective of the doses received, emergency workers and helpers need to have the right to psychological counselling and continuous medical care during the emergency response, including in the transition phase. Thus, the emergency arrangements should be such that both psychological counselling and continuous medical care can be provided, and the responsible organizations and facilities should be identified.

Consideration for other workers

4.140. In the transition phase, other categories of workers may carry out work within an affected area. Examples include teachers and medical staff of hospitals, working in an affected area to prepare it for the return of the population.

4.141. The workers referred to in para. 4.140 should be protected by their employers at the same level as members of the public within the area and, thus, they should be subject to the reference levels agreed to be applied for members of the public to allow for the transition to take place (see paras 4.52−4.61). The application of the reference level for the residual dose for such workers should take into account the fact that some of these workers may also reside in the affected area (and thus spend their entire time within the affected area as workers and as members of the public).

CHARACTERIZATION OF THE EXPOSURE SITUATION

4.142. As noted in para. 3.8, among the prerequisites to be met prior to the termination of the emergency are the detailed characterization of the radiological situation, the identification of exposure pathways and the assessment of the doses to the affected populations. The characterization of the exposure situation should be performed in the transition phase to support, as appropriate:

(a) Adjusting the implementation of the protection strategy on the basis of actual circumstances, including the adaptation or lifting of specific protective actions.
(b) Identifying measures necessary for protecting emergency workers and helpers.

(c) Identifying those individuals to be registered and needing longer term medical follow-up.
(d) Decision making on the termination of the emergency.
(e) Planning for long term recovery within the new exposure situation.

4.143. An emergency resulting in long term exposures due to residual radioactive material in the environment warrants continued monitoring in the longer term within an existing exposure situation. In accordance with the guidance provided in this Safety Guide, the development of a long term monitoring strategy should be initiated in the transition phase to enable the prerequisite in para. 3.20(h) to be met.

4.144. IAEA Safety Standards Series No. RS-G-1.8 [32] provides recommendations and guidance on environmental and source monitoring for the purposes of radiation protection in various circumstances, including in emergency exposure situations, and also considerations relating to dose assessment and the interpretation of monitoring results.

Preparedness stage

4.145. To characterize the exposure situation in detail, monitoring (environmental, source and individual monitoring, as appropriate) should be carried out. A monitoring strategy should be developed at the preparedness stage on the basis of hazards identified and the potential consequences assessed at the preparedness stage, with account taken of the available resources. The monitoring strategy should stipulate priorities for the different phases of the emergency in accordance with the protection strategy.

4.146. The monitoring strategy for the transition phase should provide for assessing doses to the affected population and should consider focussing on the following exposure pathways:

(a) External exposure from radionuclides deposited on the ground;
(b) Internal exposure due to ingestion of radionuclides incorporated in food, milk and drinking water;
(c) Internal exposure due to inhalation of resuspended radionuclides.

4.147. As part of the monitoring strategy, the available resources for monitoring should be identified to include, inter alia:

(a) The organizations, expert bodies, local and national laboratories, private institutes, universities and research centres responsible for implementing the monitoring strategy.
(b) The availability of human resources and technical capabilities (including monitoring equipment and dose assessment tools) in each of these entities for implementing the monitoring strategy.
(c) Mechanisms for ensuring the comparability and consistency of measurements and for their interpretation, including training, quality management and inter-comparison exercises.
(d) An organization designated as responsible for the validation, recording and retention of monitoring results and assessments.
(e) A mechanism for incorporating monitoring results and assessments into the decision making processes.

4.148. In the transition phase, the monitoring strategy may be supported by decision aiding tools and models in adjusting the priorities for monitoring in order to allow for the effective and efficient use of available (but usually limited) resources and capabilities. However, monitoring should ultimately be conducted in all areas and not just in those areas indicated by modelling tools. The objective of using such tools and their limitations should be clearly communicated to all concerned parties and documented in the monitoring strategy.

4.149. Monitoring data are an important basis for decision making in all phases of the emergency. However, the uncertainties associated with the results of the monitoring may impact the quality of the decision making process. These uncertainties may be of technical origin (variability of procedures for sampling, processing and measurement; spatial and temporal variability of the measured quantity; variability of calibration procedures) due to the non-representativeness of samples and/or measurements and/or human error (e.g. from a lack of training). In order to reduce as much as possible such technical uncertainties, appropriate quality assurance requirements should be agreed upon, at the preparedness stage, and should be observed by all parties providing measurements during the emergency response. To reduce human errors, the individuals involved in radiation monitoring should be periodically trained and human interference in monitoring procedures should be minimized when appropriate.

Transition phase

4.150. In an emergency involving a radioactive release to the environment, depending on the severity of the emergency, characterization of the radiological conditions may involve atmospheric modelling, wide area environmental monitoring and direct measurements, or a combination of these (see Ref. [32]). In the transition phase, reliable data from monitoring should be obtained by direct measurements to accurately characterize the nature of radioactivity in the environment.

4.151. The radionuclide composition of the release has a major impact on the doses that will be received and on the contribution of each exposure pathway. Therefore, the radionuclide composition of the release or of any contamination should be identified as early as possible.

4.152. Evaluation of the external dose, dose rate and deposition measurements should be carried out. Therefore, detailed radionuclide specific deposition maps and external gamma dose rate maps should be established as soon as possible, and should be periodically updated, with account taken of that the deposition of the radionuclides will be subjected to redistribution due to weathering effects (such as resuspension) or natural radioactive decay processes over time.

4.153. Particular attention should be given to the possibility of heterogeneity in the deposition patterns due to the variation in the spectrum of released radionuclides and the weather conditions prevailing during the emergency response phase. In this regard, a comparison of the atmospheric releases and dispersion patterns with rainfall data may help to identify areas of potentially higher deposition.

4.154. Mapping of deposition patterns and of external gamma dose rate should be prepared in the transition phase. Such maps should be shared with interested parties, and they should be accompanied with plain language explanations regarding the associated health hazards and the need for protective actions.

4.155. Exposure due to ingestion of contaminated food, milk and drinking water may result from episodic or continuous intakes. A comprehensive sampling and monitoring programme should be carried out to allow for continuous analysis and assessment of the levels of radionuclides in food, milk and drinking water, of the doses received from the ingestion pathway and of the need for any adaptation of the restrictions imposed on food, milk and drinking water. The monitoring programme should take into account local diets and food preferences as well as food production patterns. The monitoring results should be made publicly available to provide reassurance of the safety of the food, milk and drinking water intended for consumption.

4.156. In the transition phase, internal exposure due to the inhalation of resuspended material can be expected. While the contribution of this pathway to the total effective dose is usually small, particular circumstances (e.g. carrying out activities in an arid, windy environment or in a dusty environment) may lead to its contributing significantly to total doses. This should be taken into consideration and monitoring for resuspended particles should be included in the monitoring programme as appropriate.

4.157. Doses should be reassessed using the monitoring results and the dose assessment tools and models foreseen in the monitoring strategy developed at the preparedness stage. Estimations should be carried out as realistically as possible, and should focus on the doses to the representative person or groups and with account taken of realistic habits, the actual patterns of contamination and the food, milk and drinking water that are used by people in the contaminated areas. Assessed doses (either projected, received or residual doses) should be compared with the generic criteria and reference levels pre-set in the protection strategy or with dose restrictions applicable for emergency workers and helpers.

MEDICAL FOLLOW-UP AND PROVISION OF MENTAL HEALTH AND PSYCHOSOCIAL SUPPORT

General

4.158. This sub-section describes emergency arrangements to be made for implementing longer term medical follow-up and for providing mental health and psychosocial support following a nuclear or radiological emergency in the light of its perception and impact on the termination of the emergency.[40]

[40] Generic procedures for medical response in a nuclear or radiological emergency including for longer term medical follow-up and psychological counselling is provided in INTERNATIONAL ATOMIC ENERGY AGENCY, WORLD HEALTH ORGANIZATION, Generic Procedures for Medical Response During a Nuclear or Radiological Emergency, EPR-Medical, IAEA, Vienna (2005).

4.159. GSR Part 7 [2] states that

- "Arrangements shall be made to identify individuals with possible contamination and individuals who have possibly been sufficiently exposed for radiation induced health effects to result, and to provide them with appropriate medical attention, including longer term medical follow-up" (para. 5.67 of GSR Part 7 [2]).
- "Arrangements shall be made for the identification of individuals who are in those population groups that are at risk of sustaining increases in the incidence of cancers as a result of radiation exposure in a nuclear or radiological emergency. Arrangement shall be made to take longer term medical actions to detect radiation induced health effects among such population groups in time to allow for their effective treatment" (para. 5.68 of GSR Part 7 [2]).

4.160. The arrangements in para. 4.159 include:

(a) Guidelines for effective diagnosis and treatment;
(b) Designation of medical personnel trained in clinical management of radiation injuries;
(c) Designation of institutions for evaluating radiation exposure (external and internal), for providing specialized medical treatment and for longer term medical actions;
(d) Criteria for identifying the individuals referred to in para. 4.159 and for their registration (see Appendix II of GSR Part 7 [2] and GSG-2 [5]).

4.161. Before deciding on the termination of the emergency, the following prerequisites (see Section 3) should be met with regard to longer term medical follow-up and to mental health and psychosocial support:

(a) A registry has been established of those individuals who have been identified, by the time the emergency is to be terminated, as requiring longer term medical follow-up, on the basis of criteria established in Table II.1 and Table II.2 of GSR Part 7 [2] (see also GSG-2 [5] for further details).
(b) A programme for longer term medical follow-up for registered individuals has been established.
(c) For the transition to an existing exposure situation, a strategy for mental health and psychosocial support of the affected population has been developed.

4.162. The medical follow-up referred to in para. 4.161 should have the following objectives:

(a) To provide for the long-term medical care for individuals who have suffered deterministic effects and for those individuals incurring doses that exceed the threshold dose for deterministic effects;
(b) To provide for the early detection and diagnosis of stochastic effects (e.g. thyroid cancer) among the exposed population in order to allow for effective treatment.

4.163. The mental health and psychosocial support referred to in para. 4.161 should have the objective of reducing adverse psychological and societal consequences for the wider affected population, such as evacuees, and those relocated after a decision has been made to lift evacuation and/or relocation, even if radiation induced health effects are not expected to be observed among them.

4.164. The objectives of medical follow-up and mental health and psychosocial support should be clearly explained to those involved to ensure that the expectations among all relevant parties are appropriate.

Coordinating mechanism

4.165. The mechanism for coordinating the necessary arrangements to implement the medical follow-up and to provide mental health and psychosocial support following a nuclear or radiological emergency should be identified at the preparedness stage. The coordinating mechanism may involve an existing organization that is designated to act as a coordinating authority in this area or a newly established body consisting of representatives from authorities in public health, radiation protection, emergency management and epidemiology and other relevant authorities.

4.166. The coordinating mechanism established in accordance with para. 4.165 should coordinate arrangements to be put in place at the preparedness stage by the relevant organizations with responsibilities in medical follow-up and in provision of mental health and psychosocial support. The coordinating mechanism should coordinate the actions of the relevant organizations during an emergency response within a unified emergency response organization.

4.167. The responsible authority within the coordinating mechanism should, at the preparedness stage, establish criteria for identifying and registering those individuals requiring longer term medical follow-up and mental health and psychosocial support. These criteria should take into account the relevant criteria set out in GSR Part 7 [2] and GSG-2 [5] and should be subject to agreement by all relevant authorities.

Registering individuals for longer term medical follow-up

4.168. If a nuclear or radiological emergency occurs, registration of those individuals that may require longer term medical follow-up on the basis of predetermined criteria (see para. 4.160) should be an important response action in the protection strategy. National response organization(s) should be designated to maintain the registry.

4.169. The data and information to be gathered in the registry should be determined at the preparedness stage and may include: basic contact details (e.g. name, date of birth, gender, address, telephone number); information on the circumstances under which exposures occurred during the emergency (e.g. location at the time of the event, duration of exposure, activities carried out); and any relevant medical history (e.g. previous illnesses, co-morbidities, family history, workplace history, habits).

4.170. An initial registration should be carried out by employers or first responders that would allow for completion of the registry later on. Arrangements should be made for transferring information to the organization designated for the maintenance of the registry.

4.171. Registered individuals should be provided with the necessary information, including but not limited to: the reason for their selection for longer term medical follow-up; assessed doses and associated health risks; a contact point in the institution responsible for the medical follow-up; a record of the procedures and laboratory tests performed, if appropriate (e.g. radiological and clinical assessments, blood tests); a description of symptoms that may eventually present and whom to consult in case of the presentation of symptoms. Such individuals should also be given the opportunity to ask questions and be offered psychological support.

4.172. The information on a patient's dose received, as well as his or her medical history and records, should comply with the usual conditions of doctor-patient confidentiality and should be securely stored for a period of time established by the health authorities.

Medical follow-up

4.173. As part of the arrangements for the medical follow-up, the following should be considered:

(a) The initial duration of the medical follow-up.

(b) The management of the information and the reporting and sharing of results.

(c) The identification of medical specialists to be involved in the medical follow-up.

(d) The management of biological and non-biological samples.

(e) The management of mental health and psychosocial consequences.

(f) Ethical and cost-benefit aspects.

4.174. Arrangements for longer term medical follow-up should ensure that individuals are provided with access to information about the results of their medical evaluations and to adequate sources of information such as health care providers.

4.175. Decisions on the medical follow-up of individuals in relation to deterministic effects should be made by medical specialists on the basis of established clinical criteria, with consideration of the assessed doses (see GSR Part 7 [2] and GSR Part 3 [3]) and individual health risk assessment. Consideration should be given to including these individuals in screening and monitoring programmes for stochastic effects as well.

4.176. Screening and monitoring programmes for stochastic effects should be based on criteria supported by sound scientific evidence for observing an increase in the incidence of cancer among the exposed population (see GSR Part 7 [2 and GSR Part 3 [3]). The inclusion of non-cancer health effects in the monitoring programme should be carefully considered. In case of limited resources being available, the most vulnerable population groups, such as infants, children and pregnant women, should be prioritized for longer term medical follow-up.

Mental health and psychosocial support

4.177. Arrangements should be made to provide mental health and psychosocial support for people being evacuated, relocated or returning to live normally in the affected area and to support their well-being. In this, people's life styles and their need for reassurance following a nuclear or radiological emergency should be taken into account. Such arrangements should allow for facilitating two-way communication between the authorities and concerned parties.

4.178. As part of the arrangements set forth in para. 4.177, the establishment of a public support centre for the affected populations should be considered. Local doctors, nurses, pharmacists, psychologists, respective experts from public universities and associations, and others who are in positions of trust and who have the respect of the community should be considered for participation in the work of the public support centres. Information that places the health hazards in perspective and training on effective approaches to risk communication, tailored for various population groups, should also be given to local doctors, nurses, pharmacists, psychologists and other health care specialists in order to enable them to provide advice to the public in the settings of their practices.

WASTE MANAGEMENT

General

4.179. A nuclear or radiological emergency may generate radioactive waste as well as conventional waste. In particular, nuclear or radiological emergencies resulting in significant contamination of the environment (such as the Chernobyl accident, the Goiânia radiological accident and the Fukushima Daiichi accident) can be expected to generate radioactive waste with various radiological, chemical, physical, mechanical and biological properties and of a volume that can overwhelm national capabilities and resources for radioactive waste management. Thus, the generation of radioactive waste in a nuclear or radiological emergency may pose a challenge for the implementation of the national policy and strategy for radioactive waste management, as well as for overall efforts to enable the termination of the emergency and achieving long term recovery objectives.

4.180. The management of radioactive waste will not be of primary importance early in the response (especially during the urgent response phase), when the focus will be on the effective implementation of the protection strategy and on bringing the situation under control. However, the generation of radioactive waste and its management is one of many factors that should be considered in the processes of justification and optimization of the protection strategy at the preparedness stage.

4.181. As the emergency evolves and particularly during the transition phase, radioactive waste management activities will become an important and integral part of the overall emergency response effort. Therefore, adequate consideration should be given, at the preparedness stage, to waste management issues and challenges to be faced in the transition phase in order to facilitate the safe and effective management of radioactive waste following the emergency, in a manner that does not compromise the protection strategy, as required in Requirement 15 of GSR Part 7 [2].

4.182. While each emergency will be specific, and detailed planning for all aspects of waste management might not be possible, arrangements should be made, as part of overall emergency preparedness, to address these expected issues and challenges in radioactive waste management following the emergency. As part of these arrangements, the following should be considered:

(a) Responsibilities for radioactive waste management during and after an emergency should be allocated clearly and consistently, to the extent possible, within the national policy and strategy for radioactive waste management.

(b) Responsibilities for the management of conventional waste and conditions under which conventional waste arising from the emergency and from emergency response actions will be managed should be agreed upon (see paras 4.186 − 4.189).

(c) A mechanism should be established to coordinate the development of various arrangements by responsible organizations at the preparedness stage as well as to coordinate, under the unified command and control system (see para. 5.7 of GSR Part 7 [2]), the management of radioactive waste and conventional waste during the emergency response.

(d) Characteristics and the volume of radioactive waste to be generated in postulated nuclear or radiological emergencies should be identified, to the extent possible, on the basis of the hazard assessment, with account taken of past experience.

(e) Guidance should be put in place on the characterization and classification of radioactive waste that takes into account the diversity of radiological, chemical, physical, mechanical and biological properties of the waste likely to be generated in a range of postulated emergencies in accordance with the applicable regulations and guidance on radioactive waste management. This guidance should be in accordance with the applicable regulations and guidance on radioactive waste management.

(f) Guidance should be put in place on the handling of conventional waste and radioactive waste during an emergency that describes the acceptance criteria of existing storage or disposal facilities to be applied for waste generated in the emergency. Guidance on measures for management of waste that deviates from the acceptance criteria of existing facilities should also be given. This guidance should be in accordance with the applicable regulations and guidance on management of conventional waste and on management of radioactive waste.

(g) Methodologies should be developed for initiating predisposal management activities for radioactive waste (e.g. segregation, packaging, transport, storage) in a timely and appropriate manner following the emergency. As part of these methodologies:

– Feasible options for minimization of radioactive waste (such as clearance, reuse and recycling) should be identified.

– Necessary tools, equipment, procedures, training, drills and exercises to support effective waste management should be identified and put in place.

– Consideration should be given to the interdependences among various steps in the predisposal management of radioactive waste as well as to the impact of decisions on waste management on the future disposal options [33].

(h) Limitations of available options and resources should be identified and well understood by all interested parties, and mechanisms for requesting and obtaining international assistance should be determined.

4.183. The guidance on the characterization and classification of radioactive waste in para. 4.182(e) should take into account the complexity of the characteristics, including the volume, of radioactive waste generated during the emergency, compared with radioactive waste arising from normal operations. Thus, it may be necessary to identify specific techniques and methodologies that may need to be available to characterize the waste to complement those used for waste arising from normal operations. The general requirements and guidance on waste characterisation and classification are provided in Refs [34–38].

Review of the national legal and regulatory framework

4.184. The establishment of the emergency arrangements described in para. 4.182 should be accompanied by a review of the national legal and regulatory framework for the management of radioactive waste established in accordance with GSR Part 5 [33]. The aim of this review is to identify whether there is a need to revise the national framework to accommodate radioactive waste generated in a nuclear or radiological emergency. Considerations should include, but are not limited to: a) the applicability of existing provisions for exemption and clearance and existing classification schemes for such waste, if available; b) the robustness of safety demonstrations and licensing processes; and c) the impact of the licensing processes on the management of radioactive waste in a timely manner following the emergency.

4.185. The national framework should be revised, as appropriate, to facilitate the safe management of radioactive waste following a nuclear or radiological emergency in a timely manner, with account taken of the fact that, for a small scale emergency, the management of radioactive waste may easily fit within the available waste management options and respective licensing framework established in accordance with GSR Part 5 [33] and SSR-5 [38].

Radioactive waste versus conventional waste generated during the emergency

4.186. As seen in past emergencies, authorities may be under public and political pressure to consider all waste resulting from the emergency as radioactive waste. The justification of such decisions should be carefully considered, as the management of waste and its impact on the economy and society can be further complicated by introducing low criteria for the clearance of material from regulatory control, compared with those derived from radiation protection considerations.

4.187. In the IAEA Safety Glossary, radioactive waste is defined as follows:

> "For legal and regulatory purposes, waste that contains, or is contaminated with, radionuclides at concentrations or activities greater than clearance levels as established by the regulatory body." [23]

This is a 'regulatory' definition that recognizes that material with activity concentrations equal to, or less than, the established clearance levels is radioactive from a 'scientific' point of view, but the associated radiological hazards are considered to be negligible.

4.188. The specification and classification of radioactive waste generated in an emergency should consider the exemption and clearance levels established in Schedule I of GSR Part 3 [3] or relevant national criteria established for the same purpose, in accordance with the national policy and strategy for radioactive waste management. For material that is below these levels, arrangements should be made to manage it within conventional waste management practices, where possible, and thus to minimize the amount of material declared unduly as radioactive waste. Where exemption and clearance levels and concepts or relevant national criteria established for the same purpose are applied, conventional measures taken by workers for their protection while dealing with such waste (e.g. gloves, masks) should be assessed as to whether they are adequate in providing for their radiation protection.

4.189. Considering para. 4.188, authorities and organizations with responsibilities for conventional waste management should also be engaged, at the preparedness stage, in the development of arrangements regarding radioactive waste management following an emergency.

Predisposal management

4.190. The radioactive waste should be properly segregated and characterized as early as possible in the transition phase, with account taken of both radiological and non-radiological aspects of waste (see Refs [34–38]). Emergency arrangements should also consider that, in order to support the emergency response actions, radioactive waste may need to be managed during the urgent response phase and early response phase, before its characteristics are fully understood (e.g. to allow for mitigatory actions to be taken while protecting emergency workers). In all circumstances, the mixing of waste from different origins and/or of different compositions should be carefully considered for compliance with national regulations and guidance for radioactive waste management.

4.191. The predisposal management of radioactive waste should take account of the characteristics of the radioactive waste generated in the nuclear or radiological emergency. The general requirements for the predisposal management of radioactive waste established in GSR Part 5 [33] apply.

4.192. Arrangements made in advance for the predisposal management (e.g. pretreatment, treatment, conditioning, transport and storage) of radioactive waste arising from a nuclear or radiological emergency should include consideration of:

(a) National experience in radioactive waste management;
(b) Acceptable waste collection points and their characteristics;
(c) The characteristics of acceptable storage sites (such as geographical, physical and demographic aspects, as well as the proximity to the affected site or area and the availability of necessary public infrastructure);
(d) The need for transport of radioactive waste, adherence to transport regulations [39] and any deviation from established practices, as necessary.

Disposal

4.193. Considerations for disposal options that depend on both the nature of the emergency and the national policy and strategy on radioactive waste management may be less urgent compared with other aspects of predisposal management. Thus, the identification of disposal options should not delay the timely decision for terminating a nuclear or radiological emergency and the subsequent transition to either a planned exposure situation or an existing exposure situation.

Managing human remains and animal remains

4.194. Paragraph 5.88 of GSR Part 7 [2] states that consideration is required to be given to the management of human remains and animal remains with contamination as a result of a nuclear or radiological emergency, with due account taken of religious practices and cultural practices.

4.195. Arrangements to prepare for the management of human remains and animal remains with contamination as a result of a nuclear or radiological emergency should include:

(a) Identification of common religious practices and cultural practices within the State;
(b) Identification of possible management options applicable to the identified practices and the type of contamination (internal or on the surface of the remains);
(c) Consultation on what management options may be acceptable with the relevant interested parties, including representatives of different religious groups;
(d) Training of workers assigned to handle the remains in accordance with basic radiation protection principles, including ways of preventing the spread of radionuclides and their inadvertent ingestion.

4.196. Conventional measures taken by workers for their general protection while handling remains (e.g. gloves, masks) should be considered as to whether they are adequate in providing for their radiation protection.

CONSULTATION WITH THE PUBLIC AND OTHER INTERESTED PARTIES

General

4.197. A successful transition from an emergency exposure situation to an existing exposure situation will also facilitate the recovery of individuals and communities in a manner that sustains their physical, emotional, social and economic well-being. Therefore, emergency management should enable the active participation and involvement of the affected local communities and other relevant interested parties in the transition phase (see prerequisite in para. 3.17). The active involvement of interested parties will not only increase public trust in, the credibility of and public acceptance of the arrangements planned at the preparedness stage, including the prerequisites to be met for terminating the emergency, but will also enhance community resilience to nuclear or radiological emergencies.

4.198. In recognition of para. 4.197, GSR Part 7 [2] states that:

– "The termination of a nuclear or radiological emergency … shall include prior consultation with interested parties, as appropriate" (para. 5.97 of GSR Part 7 [2]).
– "The government shall ensure that, as part of its emergency preparedness, arrangements are in place for the termination of a nuclear or radiological emergency… The planning process shall include … arrangements for consultation of interested parties" (para. 5.100 of GSR Part 7 [2]).
– "Adjustment of protective actions and other response actions and of other arrangements that are aimed at enabling the termination of an emergency shall be made by a formal process that includes consultation of interested parties" (para. 5.95 of GSR Part 7 [2]).

4.199. The involvement of, and consultation with, relevant interested parties should start as early as possible in the preparedness stage and should develop with an aim to continue, as appropriate, throughout the transition phase and after the termination of the emergency.

4.200. As shown in Fig. 4, the consultation process should vary in form and extent throughout the various phases of an emergency, allowing for an effective response during the emergency response phase with limited consultation or no consultation at all. In the transition phase, as the situation stabilizes and more information becomes available, consultation with relevant interested parties should start and gradually increase to enable the progressive engagement of interested parties and to make use of their contributions to implementing an effective protection strategy.

4.201. During the emergency response, particularly in the period when decisions about the termination are to be made, public opinion and media response are required to be closely monitored in order to ensure any concerns or rumours are addressed promptly [2].

4.202. Consultation with relevant interested parties should be based on effective communication mechanisms that are founded on transparency, inclusiveness, shared accountability and measures of effectiveness, and should allow for feedback to be accommodated in a timely fashion.

4.203. The responsibility for ensuring that the public and other relevant interested parties have been consulted should lie with the relevant organizations, at all levels, in line with the predetermined consultation mechanism and responsibilities.

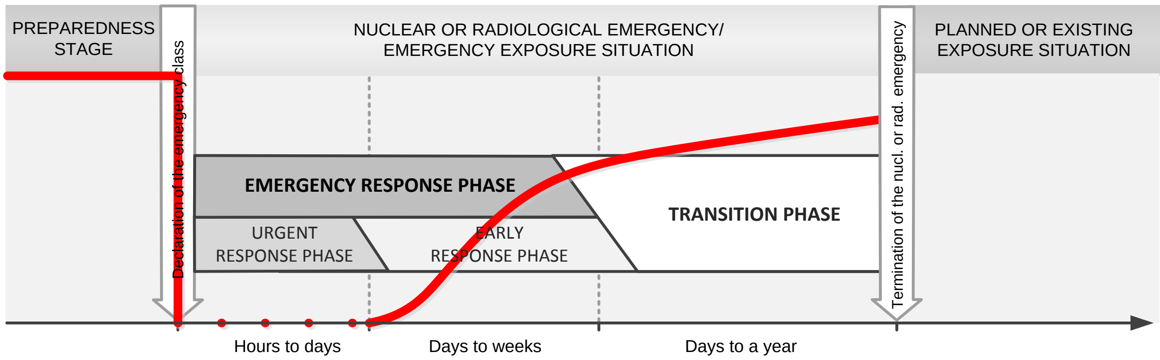

Fig. 4. Involvement of, and consultation with, interested parties in the different phases of a nuclear or radiological emergency.

Preparedness stage

4.204. Interested parties who are to be involved in and consulted on nuclear or radiological emergency preparedness and response should be identified at the preparedness stage. Special attention should be given to achieving a diverse and balanced representation among the recognized interested parties, including individuals with special needs and different backgrounds.

4.205. Mechanisms for involving and consulting with relevant interested parties should be developed to enhance the understanding of the complexity of the community, the recognition of the community's capabilities and needs, the fostering of a relationship with community leaders, the building and maintaining of partnerships and the empowering of the local community. The actual involvement of particular interested parties will depend on the actual situation (the type of emergency, the source involved and the actual consequences), the scale of the emergency and the phase of the emergency.

4.206. As part of the consultation mechanisms, the following should be determined:

(a) The objectives of the consultation;

(b) The targeted interested parties;

(c) Applicable legal and regulatory requirements;

(d) Timeframes for effective consultation;

(e) Relevant documents to be published or otherwise made publicly available;

(f) Ways in which interested parties may comment, directly or through representative consultative bodies, on relevant documents;

(g) Possibilities for communicating with interested parties through public meetings, formal hearings and other appropriate means of consultation;

(h) Arrangements for reviewing and assessing the result of the consultation;

(i) Provisions to consider the result of the consultation in the decision making processes.

4.207. Interested parties should be made aware, at the preparedness stage, of the rationale for the options selected for the protection strategy, as well as of the consequences and limitations associated with the implementation of different protective actions and strategies. Interested parties should be made aware that, while many aspects can be considered in advance, emergencies can be dynamic, and the specific conditions that exist at the time of an emergency may require the protection strategy or management options to be adapted to cope with the actual situation.

COMPENSATION OF VICTIMS FOR DAMAGE

4.208. Many past nuclear or radiological emergencies resulted in the loss of life, health consequences and loss of or damage to property and the environment. This loss and damage may have an adverse impact on the economy, industry, trade, tourism, agriculture and the quality of life of those affected. Ensuring an efficient return to normal social and economic activities following the emergency is likely to necessitate payment of compensation for the damage caused either by the emergency or by the emergency response actions taken.

4.209. Paragraph 4.6 of GSR Part 7 [2] states that "The government shall ensure that arrangements are in place for effectively governing the provision of prompt and adequate compensation of victims for damage due to a nuclear or radiological emergency". The following paragraphs address the compensation based on the legal regime of civil liability. Other possible forms of compensation that are not based on the civil liability regime are not covered.

4.210. Compensation for damage caused by radiological (i.e. non-nuclear) emergencies is exclusively governed by the national laws of each State, and no international treaty has been adopted to harmonize the various national laws. Compensation is usually based on national rules relating to 'civil liability', in particular those relating to 'third-party' (i.e. non-contractual) liability, which are also known in some legal systems as 'tort law' rules. Under the general rules relating to third-party liability, a person causing someone else a loss or harm has to pay compensation for the damage caused. In most legal systems, specific rules have also been adopted to govern third-party liability for damage caused by dangerous activities, such as those involving a potential for radiation exposure.

4.211. In the case of nuclear emergencies, a number of treaties (see Refs [41–48]) have been adopted by States in order to harmonize national laws relating to third-party liability for nuclear damage caused by emergencies at nuclear installations, as defined, and in the course of transport of nuclear material to and from such installations. Thus, compensation for nuclear damage in States is based either on these treaties or on national rules implementing them.

4.212. All of these treaties are based on the same basic principles of civil liability for nuclear damage. These principles are: a) exclusive liability of the operator of a nuclear installation; b) strict (no fault) liability[41] of the operator; c) minimum liability amount; d) the operator's obligation to cover liability

[41] Referred to in Refs [42, 45] as 'absolute liability'.

through insurance or other financial security; e) limitation of liability in time; f) equal treatment (i.e. non-discrimination) of victims; and g) exclusive jurisdictional competence of the courts of one Contracting Party. In addition, some of these treaties provide for supplementary compensation based on public funds in cases where the financial amount available under the civil liability regime is insufficient to compensate for nuclear damage.

INFRASTRUCTURE

Plans and procedures

4.213. Requirement 23 of GSR Part 7 [2] requires that emergency plans, procedures and other arrangements be established, at the preparedness stage, for an effective response to a nuclear or radiological emergency. In order to ensure a timely and effective response from the onset of the emergency until the time the emergency is terminated, these arrangements should cover the transition phase in accordance with the guidance provided in this Safety Guide.

4.214. The emergency plans, procedures and other arrangements for the transition phase should be developed by all relevant organizations in a manner that will allow for the effective implementation of the protection strategy, which includes considerations for meeting the prerequisites in Section 3 and with account taken of the results from the hazard assessment.

4.215. As more organizations and parties become involved in the response during the transition phase, the national emergency plan developed in line with para. 6.17 of GSR Part 7 [2] should clearly describe the roles and responsibilities of all relevant actors during the transition phase and beyond. The national emergency plan should take into account any changes in the authority and discharge of responsibilities between different phases, the triggering mechanism for this change, the coordination arrangements, the decision making processes and criteria, the necessary human resources, the type of data and information that needs to be transferred or made accessible by relevant parties and the arrangements and mechanism for carrying out.

Training, drills and exercises

4.216. GSR Part 7 [2] states that:

– “The operating organization and response organizations shall identify the knowledge, skills and abilities necessary to perform the functions [for emergency response]” (para. 6.28 of GSR Part 7 [2]).
– “The government shall ensure that personnel relevant for emergency response shall take part in regular training, drills and exercises to ensure that they are able to perform their assigned response functions effectively in a nuclear or radiological emergency” (Requirement 25 of GSR Part 7 [2]).

– “Exercise programmes shall be developed and implemented to ensure that all specified functions … for emergency response [and] all organizational interfaces … are tested at suitable intervals” (para. 6.30 of GSR Part 7 [2]).
– “The operating organization and response organizations shall make arrangements to review and evaluate responses in actual events and in exercises, in order to record the areas in which improvements are necessary and to ensure that the necessary improvements are made” (para. 6.38 of GSR Part 7 [2]).

4.217. The knowledge, skills and abilities necessary to carry out activities in the transition phase may differ from and may extend beyond those necessary for the emergency response phase. Therefore, the selection of the requisite knowledge, skills and abilities for personnel who will be involved in the transition phase should consider the different aspects of the transition phase, and should also be directed at those personnel who will actually be engaged.

4.218. The training programmes developed in the area of emergency preparedness and response at different levels for the transition phase should consider the personnel who will participate in the training and re-training. These programmes should also consider the level of the training (e.g. its duration, frequency, type and format, and arrangements for performance review) warranted for the different personnel carrying out the different activities in the transition phase.

4.219. The exercise programmes developed and implemented to systematically test the overall adequacy and effectiveness of the emergency arrangements should include the objective of testing existing arrangements set up to facilitate the timely resumption of normal social and economic activity within an agreed timeframe (e.g. within three to five years), including the participation of the relevant organizations. Small scale exercises (e.g. table top exercises) should also be designed and used frequently to test various aspects of the transition phase within an organization (e.g. coordination, information exchange, transfer of information and data, and changes in authority and in discharge of responsibilities decision making processes) at the facility, local, regional or national levels.

4.220. As part of the management system, training, drill and exercise programmes should be evaluated, and areas of improvements should be identified. The feedback from this evaluation should be used for review and, as necessary, revision of the emergency arrangements for the transition phase.

Logistical support and facilities

4.221. Requirement 24 of GSR Part 7 [2] states that “The government shall ensure that adequate logistical support and facilities are provided to enable emergency response functions to be performed effectively in a nuclear or radiological emergency”. To enable the termination of the emergency, adequate logistical support and facilities should be made available, when and where necessary, in the transition phase.

4.222. The logistical support and facilities required should be identified and selected in consideration of the activities that need to be carried out in the transition phase in order to meet the prerequisites in

Section 3. Arrangements for the acquisition, deployment and mobilization of logistical support should be established and communicated to the relevant parties at the preparedness stage.

Quality management system

4.223. Requirement 26 of GSR Part 7 [2] states that "The government shall ensure that a programme is established within an integrated management system to ensure the availability and reliability of all supplies, equipment, communication systems and facilities, plans, procedures and other arrangements necessary for an effective response in a nuclear or radiological emergency". This includes periodic and independent appraisals, and arrangements for incorporating lessons from research, operating experience and exercises and for record keeping. The programme should cover all the arrangements for the transition phase.

APPENDIX

CONSIDERATIONS FOR ADAPTING OR LIFTING PROTECTIVE ACTIONS AND OTHER RESPONSE ACTIONS

A.1. This Appendix provides the generic criteria and operational intervention levels (OILs) that should be considered for initiating the adaptation or lifting of protective actions and other response actions implemented in a nuclear or radiological emergency, with account taken of generic criteria and OILs established in GSR Part 7 [2] and GSG-2 [5]. It also provides guidance on further considerations for the adaptation or lifting of specific protective actions and other response actions.

A.2. National generic criteria and OILs should be established at the preparedness stage to support the adaptation or lifting of specific protective actions and other response actions, with account taken of the generic criteria and OILs contained in Table A.1. These pre-established OILs for the transition phase should be used to initiate considerations for adapting or lifting specific protective actions (including what protective actions may need to be lifted, when this might happen and to whom the decision may apply) in accordance with para. 4.66.

A.3. Following the preliminary screening based on the pre-established OILs, the decision on adapting or lifting of protective actions should be taken on the basis of an assessment of the residual dose from all exposure pathways against the pre-set reference level (see paras 4.57 and 4.74).

A.4. The pre-established OILs for adapting or lifting protective actions and other response actions should consider the following:[42]

(a) The generic criteria established in GSR Part 7 [2] for enabling the transition to an existing exposure situation (see para. 4.64);
(b) A ‘ground’ exposure scenario in which it is assumed that, in the affected area, all members of the public, including those most vulnerable to radiation exposure such as pregnant women and children, will be living normally[43] and that the lifting of restrictions on food, milk or drinking water will be implemented through the use of OIL6 [5][44] (see Table A.1);
(c) All individuals being exposed;
(d) The contribution from all relevant radionuclides and their progenies;
(e) The contribution from all relevant exposure pathways;
(f) Any behaviour of the radioactive material that will have a significant impact on the OIL value;
(g) The relevant effective dose (annual) and, as appropriate, calculations of the organ dose (annual or for the full period of in utero development);

[42] Further details on the methodology for deriving OILs can be found in Ref. [48].

[43] That is, carrying out normal activities, such as children playing on the ground and people working outside.

[44] The simultaneous use of OIL_T and OIL6 will ensure that all relevant exposure pathways are considered, covering: the ingestion of affected food, milk or drinking water (with OIL6), external exposure from radioactive material deposited on the ground (i.e. ground shine), external exposure from resuspended radioactive material (i.e. air shine), inhalation of resuspended radioactive material and inadvertent ingestion of soil (e.g. from dirt on the hands) (with OIL_T).

(h) The response of monitoring instruments;

(i) Relevant operational requirements (e.g. usability of OILs under field conditions);

(j) The overall protection strategy.

A.5. A methodology that can be used for deriving default OILs for enabling the transition to an existing exposure situation, i.e. default OIL_T[45] value, for a specific radionuclide mix is given below. The relative activity of the radionuclides comprising the radionuclide mix will vary over time owing to processes such as radioactive decay, resulting in a time dependent OIL_T(t,mix), given by:

$$OIL_T(t,mix) = \left(\sum_i (RA_i(t,mix) \times IR_{grd,i})\right) \times Min\left\{ \left(\frac{GC(Transition, E, 1a)}{\sum_i (E_{grd-scenario,i}(1a) \times RA_i(t,mix))} \right), \left(\frac{GC(Transition, H_{fetus}, 9mo)}{\sum_i (H_{fetus,grd-scenario,i}(1a) \times RA_i(t,mix))} \right) \right\} \times WF$$

where:

- RA_i(t,mix) [unitless] is the relative activity of radionuclide i at time t for a specific radionuclide mix. It is determined by $RA_i(t,mix) = A_i(t,mix) / \Sigma_i[A_i(t,mix)]$, where A_i(t,mix) [Bq] is the activity of radionuclide i at time t, for a specific radionuclide mix;
- $IR_{grd,i}$ [(Sv/s)/(Bq/m^2)] or [cps/(Bq/m^2)] is the instrument response per unit ground surface activity of radionuclide i;
- GC(Transition,E,1a) = 0.02 Sv is the generic criterion used for transition to an existing exposure situation based on the total effective dose to the representative person over 1 year [2];
- GC(Transition,H_{fetus},9mo) = 0.02 Sv is the generic criterion used for transition to an existing exposure situation based on the total equivalent dose to the fetus for the full period of in utero development [2];
- $E_{grd\text{-}scenario,i}$ (1a) [Sv/(Bq/m^2)] is the total effective dose to the representative person over 1 year for the 'ground' exposure scenario, per unit ground surface activity of radionuclide i [48];
- $H_{fetus,grd\text{-}scenario,i}$ (9mo) [Sv/(Bq/m^2)] is the total equivalent dose to the fetus for the full period of in utero development for the 'ground' exposure scenario, per unit ground surface activity of radionuclide i [48];
- WF [unitless] is a weighting factor used to allow for the quantification of other considerations. For the example values given below, it was set to 1 for simplicity.

A.6. For a single radionuclide, the equation in para. A.5 will result in a single time independent OIL_T value. For a single radionuclide mix, it will result in a time dependent OIL_T(t) curve based on which a single time independent value should be chosen. For an emergency involving a variety of radionuclide mixes (e.g. an accident at a nuclear power plant), this will result in a set of time dependent OIL_T(t,mix) curves based on which a single time independent value should be chosen.

[45] See para. A.6. of this Appendix.

A.7. Examples of default OIL_T values[46] calculated using the methodology in para. A.5 for a light water reactor emergency and for an emergency involving a specific radionuclide, e.g. Cs-137, are given below:

- $OIL_{T,LWR}$[47] = 4.8 μSv/h ambient dose equivalent rate above gamma background at 1m above ground level.
- $OIL_{T,Cs\text{-}137}$ = 4.8 μSv/h ambient dose equivalent rate above gamma background at 1m above ground level.

A.8. A methodology for deriving a default OIL_C value for a specific radionuclide mix is given below. The relative activity of the radionuclides comprising the radionuclide mix will vary over time due to processes such as radioactive decay, resulting in a time dependent OIL_C(t,mix), given by:

$$OIL_C(t,mix) = \left(\sum_i (RA_i(t,mix) \times IR_{comm,i})\right) \times Min\left\{ \begin{array}{l} \left(\dfrac{GC(Commodities,E,1a)}{\sum_i (E_{comm-scenario,i}(1a) \times RA_i(t,mix))}\right), \\ \left(\dfrac{GC(Commodities,H_{fetus},9mo)}{\sum_i (H_{fetus,comm-scenario,i}(1a) \times RA_i(t,mix))}\right) \end{array} \right\} \times WF$$

where:

- RA_i(t,mix) [unitless] is the relative activity of radionuclide i at time t for a specific radionuclide mix. It is determined by $RA_i(t,mix) = A_i(t,mix) / \Sigma_i[A_i(t,mix)]$, where A_i(t,mix) [Bq] is the activity of radionuclide i at time t, for a specific radionuclide mix;
- $IR_{comm,i}$ [(Sv/s)/(Bq/m^2)] or [cps/(Bq/m^2)] is the instrument response per unit activity of radionuclide i on the non-food commodity's surface;
- GC(Commodities,E,1a) = 0.01 Sv is the generic criterion for non-food commodities based on the total effective dose to the representative person over 1 year [2];
- GC(Commodities,H_{fetus},9mo) = 0.01 Sv is the generic criterion for non-food commodities based on the total equivalent dose to the fetus over the period of in utero development [2];
- $E_{comm\text{-}scenario,i}$ (1a) [Sv/(Bq/m^2)] is the total effective dose to the representative person over 1 year for a 'non-food commodities' exposure scenario, per unit activity of radionuclide i on the non-food commodity's surface;
- $H_{fetus,comm\text{-}scenario,i}$ (9mo) [Sv/(Bq/m^2)] is the total equivalent dose to the fetus over the period of in-utero development for the non-food commodities' exposure scenario, per unit activity of radionuclide i on the non-food commodity's surface.

[46] For a nuclear or radiological emergency involving a large scale release of radioactive material to the environment. The default value was calculated in accordance with the assumptions outlined in Ref. [48]. The contribution from the progenies that are in equilibrium with the respective radionuclides were also considered.

[47] OIL_T for a release of radioactive material resulting from a severe emergency at a light water reactor or its spent fuel, in accordance with the assumptions outlined in Ref. [48].

A.9. For a single radionuclide the equation in para. A.8 will result in a single time independent OIL_C value. For a single radionuclide mix it will result in a time dependent $OIL_C(t)$ curve based on which a single time independent value should be chosen. For an emergency involving a variety of radionuclide mixes (e.g. an accident at a nuclear power plant), it will result in a set of time dependent $OIL_{T,C}(t,mix)$ curves based on which a single time independent value should be chosen.

A.10. The ambient dose equivalent rate should be the preferred quantity for ground monitoring and for monitoring commodities during a nuclear or radiological emergency. If the radionuclide or the radionuclide mix is such that the ambient dose equivalent rate is not usable (e.g. measured values are within the gamma background levels), the beta or alpha count rates should be monitored and used instead.

TABLE A.1. GENERIC CRITERIA FOR THE PROJECTED DOSES AND OILs FOR INITIATING CONSIDERATIONS TO ADAPT OR LIFT SPECIFIC PROTECTIVE ACTIONS AND OTHER RESPONSE ACTIONS

Protective action	**Generic criteria for taking the action [2]**		**Generic criteria for considering to adapt/lift the action**		**OILs for considering to adapt/lift the action**	**Consideration**
	E [a]	$\boldsymbol{H_{fetus}}$ [b]	***E*** [a]	$\boldsymbol{H_{fetus}}$ [b] for the full period of in utero development		
Evacuation	≥ 100 mSv in the first 7 days	≥ 100 mSv in the first 7 days	≥ 100 mSv in the first year	≥ 100 mSv	≥ OIL2 [5]	Substituting evacuation with relocation.
			< 100 mSv in the first year	< 100 mSv	< OIL2 [5]	Lifting the evacuation only if limited restrictions are still necessary for people living normally in the area, with account taken of: (1) the actual residual doses in comparison to the pre-set reference level, and (2) the preconditions referred to in para. 4.101.
			≤ 20 mSv per year	≤ 20 mSv	< OIL_T (see paras A.5 and A.6)	Lifting the evacuation along with the decision to terminate the emergency if the prerequisites specified in Section 3 and the preconditions referred to in para. 4.101 are fulfilled.
Relocation	≥ 100 mSv in the first year	≥ 100 mSv for the full period of in utero development	< 100 mSv in the first year	< 100 mSv	< OIL2 [5]	Lifting the relocation only if limited restrictions are still necessary for people living normally in the area, with account taken of: (1) the actual residual doses in comparison to the pre-set reference level, and (2) the preconditions referred to in para. 4.101.

			≤ 20 mSv per year	≤ 20 mSv	< OIL_T (derived based on the methodology outlined in para. A.5.)	Lifting the relocation along with the decision to transition to the emergency exposure situation if the prerequisites specified in Section 3 and the preconditions referred in para. 4.101 are fulfilled.
Food, milk and drinking water restrictions in affected areas	≥ 10 mSv in the first year	≥ 10 mSv for the full period of in utero development	< 10 mSv in the first year	< 10 mSv	< OIL6 [5]	Lifting the restriction only after estimation of the actual doses from the ingestion pathway and their contribution to the residual dose from all exposure pathways.
Food, milk and drinking water restrictions for international trade	≥ 1 mSv per year	≥ 1 mSv for the full period of in utero development	< 1 mSv per year	< 1 mSv	< Guideline Levels in Ref. [30]	Lifting restrictions on international trade for infant and non-infant food in line with Ref. [30].
Non-food commodities restrictions in affected areas	≥ 10 mSv in the first year	≥ 10 mSv for the full period of in utero development	< 10 mSv in the first year	< 10 mSv	< $OIL_{T,C}$ (derived based on the methodology outlined in para. A.8)	Lifting the restriction only after estimation of the actual doses from the use of non-food commodities and their contribution to the residual dose from all exposure pathways.
Non-food commodities restrictions in affected areas for international trade	≥ 1 mSv per year	≥ 1 mSv for the full period of in utero development	< 1 mSv per year	< 1 mSv	< $OIL_{T,C}$ (derived based on the methodology outlined in para. A.8)	Lifting restrictions on trading non-food commodities internationally.

[a] Effective dose.

[b] Equivalent dose to the fetus.

REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Convention on Early Notification of a Nuclear Accident and Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, Legal Series No. 14, IAEA, Vienna (1987).

[2] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL CIVIL AVIATION ORGANIZATION, INTERNATIONAL LABOUR ORGANIZATION, INTERNATIONAL MARITIME ORGANIZATION, INTERPOL, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, PREPARATORY COMMISSION FOR THE COMPREHENSIVE NUCLEAR-TEST-BAN TREATY ORGANIZATION, UNITED NATIONS ENVIRONMENT PROGRAMME, UNITED NATIONS OFFICE FOR THE COORDINATION OF HUMANITARIAN AFFAIRS, WORLD HEALTH ORGANIZATION, WORLD METEOROLOGICAL ORGANIZATION, Preparedness and Response for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GSR Part 7, IAEA, Vienna (2015).

[3] EUROPEAN COMMISSION, FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANIZATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, UNITED NATIONS ENVIRONMENT PROGRAMME, WORLD HEALTH ORGANIZATION, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, IAEA Safety Standards Series No. GSR Part 3, IAEA, Vienna (2014).

[4] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR OFFICE, PAN AMERICAN HEALTH ORGANIZATION, UNITED NATIONS OFFICE FOR THE CO-ORDINATION OF HUMANITARIAN AFFAIRS, WORLD HEALTH ORGANIZATION, Arrangements for Preparedness for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GS-G-2.1, IAEA, Vienna (2007).

[5] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR OFFICE, PAN AMERICAN HEALTH ORGANIZATION, WORLD HEALTH ORGANIZATION, Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GSG-2, IAEA, Vienna (2011).

[6] INTERNATIONAL ATOMIC ENERGY AGENCY, The Fukushima Daiichi Accident, Report by the Director General, IAEA, Vienna (2015).

[7] INTERNATIONAL ATOMIC ENERGY AGENCY, The Fukushima Daiichi Accident, Technical Volume 3/5 Emergency Preparedness and Response, IAEA, Vienna (2015).

[8] INTERNATIONAL ATOMIC ENERGY AGENCY, The Radiological Accident in Nueva Aldea, IAEA, Vienna (2009).

[9] INTERNATIONAL ATOMIC ENERGY AGENCY, OECD-IAEA Paks Fuel Project, IAEA, Vienna (2010).

[10] INTERNATIONAL ATOMIC ENERGY AGENCY, The Radiological Accident in Lia, Georgia, IAEA, Vienna (2014).

[11] INTERNATIONAL ATOMIC ENERGY AGENCY, Investigation of an Accidental Exposure of Radiotherapy Patients in Panama, IAEA, Vienna (2001).

[12] INTERNATIONAL ATOMIC ENERGY AGENCY, The Radiological Accident in Goiânia, IAEA, Vienna (1988).

[13] INTERNATIONAL ATOMIC ENERGY AGENCY, The International Chernobyl Project: Technical Report, Assessment of Radiological Consequences and Evaluation of Protective Measures, Report by an International Advisory Committee, IAEA, Vienna (1991).

[14] WORLD HEALTH ORGANIZATION, Health Effects of the Chernobyl Accident and Special Health Care Programmes, Report of the UN Chernobyl Forum Expert Group 'Health', Bennett, B., Repacholi, M., Carr, Z. (Eds), WHO, Geneva (2006).

[15] US NUCLEAR REGULATORY COMMISSION, Investigation into the March 28, 1979 Three Mile Island Accident by Office of Inspection and Enforcement, NUREG-600, USNRC, Washington, DC (1979).

[16] INTERNATIONAL ATOMIC ENERGY AGENCY, Remediation Process for Areas Affected by Past Activities and Accidents, IAEA Safety Standards Series No. WS-G-3.1, IAEA, Vienna (2007).(A revision of this publication is in preparation.)

[17] INTERNATIONAL ATOMIC ENERGY AGENCY, Radiation Protection of the Public and the Environment, IAEA Safety Standards Series No. GSG-8, IAEA, Vienna (in preparation).

[18] INTERNATIONAL ATOMIC ENERGY AGENCY, Decommissioning of Medical, Industrial and Research Facilities, IAEA Safety Standards Series No. SSG-XX, IAEA, Vienna (in preparation).

[19] INTERNATIONAL ATOMIC ENERGY AGENCY, Decommissioning of Nuclear Power Plants, Research Reactors and other Nuclear Fuel Cycle Facilities, IAEA Safety Standards Series No. SSG-47, IAEA, Vienna (in preparation).

[20] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225/Revision 5), IAEA Nuclear Security Series No. 13, IAEA, Vienna (2011).

[21] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Security Recommendations on Radioactive Material and Associated Facilities, IAEA Nuclear Security Series No. 14, IAEA, Vienna (2011).

[22] EUROPEAN POLICE OFFICE, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL CIVIL AVIATION ORGANIZATION, INTERNATIONAL CRIMINAL POLICE ORGANIZATION–INTERPOL, UNITED NATIONS INTERREGIONAL CRIME AND JUSTICE RESEARCH INSTITUTE, UNITED NATIONS OFFICE ON DRUGS AND CRIME, WORLD CUSTOMS ORGANIZATION, Nuclear Security Recommendations on Nuclear and Other Radioactive Material out of Regulatory Control, IAEA Nuclear Security Series No. 15, IAEA, Vienna (2011).

[23] INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA Safety Glossary: Terminology Used in Nuclear Safety and Radiation Protection, 2016 Revision, IAEA, Vienna (in preparation).

[24] INTERNATIONAL ATOMIC ENERGY AGENCY, Governmental, Legal and Regulatory Framework for Safety, IAEA Safety Standards Series No. GSR Part 1 (Rev. 1), IAEA, Vienna (2016).

[25] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, The 2007 Recommendations of the International Commission on Radiological Protection, ICRP Publication 103, Ann, ICRP 37 (2–4).

[26] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Application of the Commission's Recommendations for the Protection of People in Emergency Exposure Situations, ICRP Publication 109, Ann, ICRP 39 (1).

[27] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Application of the Commission's Recommendations to the Protection of People Living in Long-term Contaminated Areas After a Nuclear Accident or a Radiation Emergency, ICRP Publication 111, Ann, ICRP 39 (3).

[28] INTERNATIONAL ATOMIC ENERGY AGENCY, Actions to Protect the Public in an Emergency due to Severe Conditions at a Light Water Reactor, EPR–NPP Public Protective Actions 2013, IAEA, Vienna (2013).
[29] WORLD HEALTH ORGANIZATION, Guidelines for Drinking-water Quality, Fourth Edition, WHO, Geneva (2011).
[30] CODEX ALIMENTARIUS COMMISSION, FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, WORLD HEALTH ORGANIZATION, General Standard for Contaminants and Toxins in Food and Feed, Schedule 1 — Radionuclides, CODEX STAN 193-1995, Codex Alimentarius Commission, Rome (2006).
[31] INTERNATIONAL ATOMIC ENERGY AGENCY, Occupational Radiation Protection, IAEA Safety Standards Series No. GSG-7, IAEA, Vienna (in preparation).
[32] INTERNATIONAL ATOMIC ENERGY AGENCY, Environmental and Source Monitoring for Purposes of Radiation Protection, IAEA Safety Standards Series No. RS-G-1.8, IAEA, Vienna (2005).
[33] INTERNATIONAL ATOMIC ENERGY AGENCY, Predisposal Management of Radioactive Waste, IAEA Safety Standards Series No. GSR Part 5, IAEA, Vienna (2009).
[34] INTERNATIONAL ATOMIC ENERGY AGENCY, Predisposal Management of Radioactive Waste from Nuclear Fuel Cycle Facilities, IAEA Safety Standards Series No. SSG-41, IAEA, Vienna (2016).
[35] INTERNATIONAL ATOMIC ENERGY AGENCY, Predisposal Management of Radioactive Waste from Nuclear Power Plants and Research Reactors, IAEA Safety Standards Series No. SSG-40, IAEA, Vienna (2016).
[36] INTERNATIONAL ATOMIC ENERGY AGENCY, Predisposal Management of Radioactive Waste from the Use of Radioactive Materials in Medicine, Industry, Agriculture, Research and Education, IAEA Safety Standards Series No. GSG-45, IAEA, Vienna (in preparation).
[37] INTERNATIONAL ATOMIC ENERGY AGENCY, Classification of Radioactive Waste, IAEA Safety Standards Series No. GSG-1, IAEA, Vienna (2009).
[38] INTERNATIONAL ATOMIC ENERGY AGENCY, Disposal of Radioactive Waste, IAEA Safety Standards Series No. SSR-5, IAEA, Vienna (2011).
[39] INTERNATIONAL ATOMIC ENERGY AGENCY, Regulations for the Safe Transport of Radioactive Material, 2012 Edition, IAEA Safety Standards Series No. SSR-6, IAEA, Vienna (2012).
[40] Convention on Third Party Liability in the Field of Nuclear Energy of 29th July 1960, as amended by the Additional Protocol of 28th January 1964 and by the Protocol of 16th November 1982 (Paris Convention), Organisation for Economic Co-operation and Development, Paris (1982).~~http://www.oecd-nea.org/law/nlparis_conv.html.~~
[41] Convention of 31st January 1963 Supplementary to the Paris Convention of 29th July 1960, as amended by the additional Protocol of 28th January 1964 and by the Protocol of 16th November 1982 (Brussels Supplementary Convention), Organisation for Economic Co-operation and Development, Paris (1982). ~~https://www.oecd-nea.org/law/brussels-supplementary-convention.html.~~
[42] Vienna Convention on Civil Liability for Nuclear Damage, INFCIRC/500, IAEA, Vienna (1996). ~~https://www.iaea.org/sites/default/files/infcirc500.pdf~~.
[43] Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention, INFCIRC/402, IAEA, Vienna (1992). ~~https://www.oecd-nea.org/law/nljoint_prot.html.~~
[44] Protocol to Amend the Vienna Convention on Civil Liability for Nuclear Damage, INFCIRC/566, IAEA, Vienna (1998). ~~https://www.iaea.org/sites/default/files/infcirc566.pdf.~~
[45] Convention on Supplementary Compensation for Nuclear Damage, INFCIRC/567, IAEA, Vienna (1998). ~~https://www.iaea.org/sites/default/files/infcirc567.pdf.~~

[46] Protocol to Amend the Paris Convention on Nuclear Third Party Liability (2004 Protocol to the Paris Convention) (not yet in force), https://www.oecd-nea.org/law/brussels_supplementary_convention.pdf.

[47] Protocol to Amend the Brussels Supplementary Convention on Third Party Liability in the Field of Nuclear Energy (2004 Protocol to the Brussels Supplementary Convention) (not yet in force), https://www.oecd-nea.org/law/brussels_supplementary_convention.pdf.

[48] INTERNATIONAL ATOMIC ENERGY AGENCY, Operational Intervention Levels for Reactor Emergencies, and Methodology for Their Derivation, EPR-NPP-OILs 2017, IAEA, Vienna (2017).

ANNEX I
CASE STUDIES

I–1. This annex provides case studies that consider the guidance and recommendations provided in this Safety Guide in the context of the emergency response to: the Fukushima Daiichi accident in Japan (2011), the radiological accident in Goiânia, Brazil (1987), the Paks fuel damage incident in Hungary (2003) and the incident involving a stolen radioactive source in Hueypoxtla, Mexico (2013). The case studies briefly include descriptions of the management of the incidents and accidents and their consequences, from the declaration of the emergency to the preparation for dealing with the recovery aspects and with the long term consequences under a different exposure situation.

I–2. The four case studies have been selected to present representative examples for transition to either a planned exposure situation (the Paks fuel damage incident and the stolen radioactive source in Hueypoxtla) or an existing exposure situation (the Fukushima Daiichi accident and the radiological accident in Goiânia). The examples are also chosen to cover emergencies associated with the nuclear industry as well as with the use of radioactive source in other applications, for a range of the initiating circumstances.

I–3. The case studies provided in this annex are neither intended to give an extended description of the incidents or accidents and the respective emergency response nor to evaluate the manner in which these events were managed. Each case study is used to draw conclusions from a comparison with the prerequisites elaborated in Section 3 of this Safety Guide, with the aim of facilitating understanding of this guidance.

I–4. The terminology used in these case studies generally follows that used in the associated references and employed by the Member States in which the incidents or accidents occurred; thus, it does not necessarily correspond to the terminology used in the IAEA Safety Standards Series.

I–5. The description of ach case study includes a figure that presents a retrospective sequencing of events and milestones associated with the emergency under consideration. These figures do not represent the official dates on which termination of the emergency was declared but rather the results of a retrospective analysis of the case study to determine when the prerequisites contained in Section 3 had been fulfilled. This process served to demonstrate from experience when the prerequisites can be met in case of a large scale or a small scale emergency and to test the appropriateness of the guidance given in this Safety Guide (e.g. the guidance in Section 3 on the timeframes in which an emergency can be terminated).

THE FUKUSHIMA DAIICHI ACCIDENT, JAPAN

I–6. The Great East Japan Earthquake, with a moment magnitude of 9.0, occurred at 14:46 (Japanese Standard Time) on 11 March 2011. The seismic motions and the tsunami caused by the earthquake led to severe damage to the Fukushima Daiichi nuclear power plant operated by the Tokyo

Electric Power Company (TEPCO), and associated infrastructure. As a result, the plant, which had six boiling water reactors (BWRs), experienced a station blackout, i.e. the loss of all external power and practically its entire alternative power supply. At Units 1–3, which were operating at full power at the time of the accident, the reactor cores eventually melted, and radioactive material was released to the environment. The information presented in this section is taken from reference [I-1], except where otherwise stated.

Emergency declaration and urgent protective actions

I–7. At 19:03 on 11 March 2011, the national government established the Nuclear Emergency Response Headquarters (NERHQ); at the same time, the declaration of a 'nuclear emergency' was issued.

I–8. At 20:50 on 11 March 2011, the Fukushima prefectural government decided to evacuate residents within a radius of 2 km of the Fukushima Daiichi nuclear power plant. However, just over half an hour later, at 21:23, the national government issued an order for evacuation within a 3 km radius of the plant, and for sheltering within a radius of 3–10 km. At 05:44 on 12 March 2011, the national government extended evacuation to a radius of 3–10 km. At 18:25, following the hydrogen explosion in Unit 1 of the Fukushima Daiichi nuclear power plant, evacuation was further extended to the area within a radius of 20 km of the plant.

I–9. The order for residents living in a 20–30 km radius of the plant to shelter was given at 11:00 on 15 March 2011 and continued to be in force for 10 days. On 25 March 2011, the national government recommended that residents voluntarily evacuate the area because of the difficulties associated with prolonged sheltering.

I–10. Administration of stable iodine for iodine thyroid blocking was not implemented uniformly. Some local governments distributed stable iodine tablets but did not advise the public to take them, while others distributed the tablets along with advice for their ingestion or awaited instructions from the national government.

I–11. On 21 March 2011, the national Government began to issue restrictions on the distribution of specific foods. These restrictions evolved with the changing situation. They were formulated on the basis of the results of monitoring food samples, which identified the foods that exceeded the national criteria and determined the geographical location(s) affected.

Early response actions

I–12. On 11 April 2011, the national government announced that an effective dose criterion of 20 mSv, projected to be received within one year of the accident, would be used to determine the areas beyond the 20 km evacuation zone from which people might also need to be relocated. On 22 April 2011, a 'deliberate evacuation area' was established beyond the 20 km evacuation zone, which included the areas where the projected dose criterion of 20 mSv in one year might be exceeded. The national government ordered that relocation of people from this area should be implemented within approximately one month. On the same day, the NERHQ issued an instruction for restricted access to the 20 km evacuation zone (called the ‘restricted area’).

I–13. In addition to the deliberate evacuation area, an ‘evacuation prepared area in case of emergency’ (hereafter referred to as the ‘evacuation prepared area’) was established on 22 April 2011. Residents of the evacuation prepared area were advised to shelter or evacuate by their own means in the event of possible renewed concerns regarding the Fukushima Daiichi nuclear power plant. The designation of the evacuation prepared area was lifted on 30 September 2011. As a result of the monitoring conducted beyond the restricted area (i.e. the 20 km evacuation zone) and the deliberate evacuation area, specific locations were identified where residents were projected to receive effective doses in excess of 20 mSv within one year of the accident. On 16 June 2011, the national government announced that such locations would be designated as ‘specific spots recommended for evacuation’. The designation of these locations commenced on 30 June 2011 and, by May 2012, numerous locations with almost 300 houses had been identified as specific spots. However, evacuation orders based on the Nuclear Emergency Act were not issued for residents of the ‘specific spots’. Instead, the national Government provided them with information that alerted them of the possibility of radiation exposure and supported them if they needed to be evacuated [I-2].

I–14. The areas and locations where protective actions were ordered or recommended until 30 September 2011 are shown in Fig. I-1.

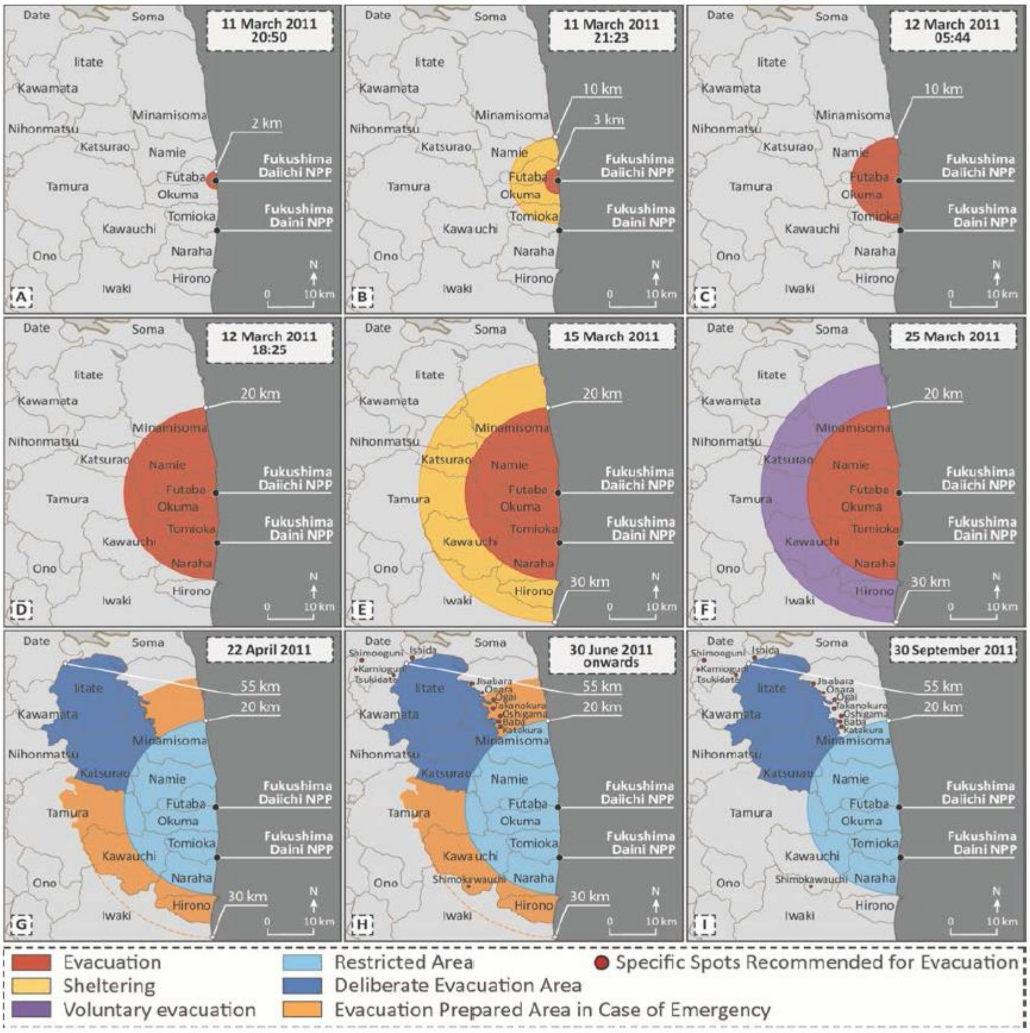

Fig. I-1. Areas and locations where protective actions were ordered in or recommended until 30 September 2011 [I-1].

Transition to long term recovery

I–15. In developing arrangements for the transition from the emergency response phase to the recovery phase after the accident, the Japanese authorities decided to apply the latest recommendations of the ICRP [I-3, I-4]. The Nuclear Emergency Act [I-5] included a chapter on general Measures for Restoration from Nuclear Emergency. However, the specific policies, guidelines and criteria, as well as the overall arrangements for the transition from the emergency response phase to the recovery phase, were developed after the accident [I-1, I-6].

I–16. The overall responsibility for managing the process for returning to normality rested with NERHQ. The Nuclear Emergency Act specified that the NERHQ would cease to exist when the termination of a nuclear emergency was declared. The Nuclear Safety Commission (NSC) had the responsibility to provide advice on the termination of the emergency [I-1].

I–17. On 17 April 2011, TEPCO issued a roadmap [I-7] that outlined the steps towards recovery on the site. In particular, the roadmap described the basic policy, targets and immediate actions in the areas of cooling, mitigation of consequences, monitoring and decontamination [I-1].

I–18. With regard to off-site recovery, the Policy for Immediate Actions for the Assistance of Nuclear Sufferers was issued and a roadmap was established by the NERHQ on 17 May 2011 defining the objectives and conditions to be met for returning to normality [I-7]. It listed nine groups of actions, divided into steps, that were scheduled to be implemented over the following target periods that were also related to TEPCO's roadmap for on-site recovery: by mid-July 2011, within 3–6 months and in the mid-term.

I–19. The nine groups of actions were:

(a) Actions for the restoration of the Fukushima Daiichi nuclear power plant from the effects of the accident;
(b) Actions related to the area evacuated based on plant conditions up to a 20 km radius of the nuclear power plant (restricted area);
(c) Actions related to the area from which people were relocated (deliberate evacuation area);
(d) Actions related to the area in which people were advised to shelter (evacuation prepared area);
(e) Actions to ensure the safety and reassurance of those affected;
(f) Actions to secure employment, and provide support for farms and industries;
(g) Actions to support the local municipalities in the affected areas;
(h) Actions related to compensation to sufferers and affected businesses, etc.; and
(i) Actions to assist those returning to areas that had been evacuated.

I–20. The roadmap was intended to facilitate communication and preparations for the transition to long term recovery operations and the resumption of normal social and economic activity. It allocated responsibilities and specified other organizational aspects of the transition process and specified the objectives and conditions for the termination of the emergency response phase [I-1].

I–21. The attainment of Step 1 of Action 1 (radiation dose is in steady decline) and the transition to Step 2 (Release of radioactive materials is under control and radiation dose is being significantly held down') was confirmed on 19 July 2011 by monitoring results indicating that the release of radioactive materials had steadily declined since the onset of the accident. Actions 2–4 outlined the steps to be taken in the areas where the population had been evacuated, relocated or advised to shelter.

I–22. During the emergency and transition phases, the NSC gave various kinds of technical advice about radiation protection of residents in the surrounding areas. On 19 July 2011, the NSC issued a policy that summarized its recommendations for the termination of protective actions and the restoration of normal life [I-1].

Reopening of schools

I–23. Fukushima Prefecture requested the national government to provide advice concerning the reopening of schools and other educational facilities in the prefecture. In response, on 19 April 2011, the Ministry of Education, Culture, Sports, Science and Technology (MEXT), stated that a dose criterion of 20 mSv per year would be used for that purpose, following consultation with the NSC. In accordance with this criterion, MEXT decided to restrict the outdoor activities of children and students only at school and kindergarten grounds where ambient dose rate measurements of more than 3.8 μSv/h had been measured. The reopening of schools was categorized as an action in an existing exposure situation, while the establishment of the deliberate evacuation area was handled as an emergency exposure situation. However, in both cases, the criterion of 20 mSv projected annual dose was used [I-1].

I–24. The criterion of 20 mSv per year was later reduced to 1 mSv per year, in response to concerns on the part of the public. On 27 May, a notification was issued by MEXT for reducing the dose to children, students and others at schools and other facilities in Fukushima Prefecture. The notification specified a target dose of 1 mSv per year, stipulated that dosimeters should be distributed to schools and stated that financial support for decontamination was to be offered to schools where ambient dose rate measurements higher than 1 μSv/h had been measured [I-1].

Environmental monitoring

I–25. On 13 June 2011, the Plan to Conduct Detailed Monitoring in Restricted Area and Planned Evacuation Area [I-8] was announced. This plan addressed monitoring of air, soil, forests, water and human-made materials (such as homes and roads) in the restricted area and the deliberate evacuation area. The results of this monitoring programme were intended to be used to develop model projects for decontamination. In July 2011, a coordination meeting was held at the national level among relevant ministries, officials from Fukushima Prefecture and TEPCO representatives in order to promote coordination in relation to monitoring. A comprehensive monitoring plan was then issued in August 2011, which also specified the roles of the various organizations. This plan was later revised. The plan stipulated that environmental restoration of the area surrounding the Fukushima Daiichi NPP and more detailed monitoring to meet the needs of children’s health and people’s safety and security would be implemented [I-9]. The plan was revised in March 2012 to enable a review of the areas where evacuation orders had been issued, and to address increasing concerns of the release of radioactive materials into the sea from the rivers over the medium to long term [I-1].

Health surveillance

I–26. Long term health surveillance was initiated at the end of June 2011, following the establishment of The Fukushima Health Management Survey Committee, on 27 May 2011 [I-2]. The terms of reference of the survey were “to assess residents’ radiation dose, and to monitor residents’ health conditions, which result in disease prevention, early detection and early medical treatment, thereby to maintain and promote their future health” [I-10]. The health management surveys included a basic survey which comprised self-administered questionnaires mailed out to people who met residential or location criteria connected with the accident [I-10]. In the basic survey, respondents were asked to record their movements in the weeks and months following the accident in order to allow the results to be used in estimating radiation exposure from assessments of the variations in ambient dose equivalent in time and location [I-10].

I–27. Four specialized surveys were undertaken that involved:

(a) a thyroid examination of children aged 18 and younger (target population: around 380 000);

(b) comprehensive medical check-ups of evacuees (210 000);

(c) a survey of mental health and lifestyle of the same evacuees; and

(d) a survey of pregnant women and nursing mothers (approximately 15 000 each year) [I-10].

I–28. The first round of the thyroid examinations, which consisted of thyroid ultrasonic examinations and detailed examinations, started in October 2011 and was completed in March 2014. The second round of thyroid ultrasound examinations began in April 2014 and was completed in March 2016 while the detailed examinations have been conducted. An ultrasound examination of children will continue to be carried out biennially until the participants reach the age of 20 years; thereafter, they will be examined every five years [I-11]. The comprehensive medical check-ups started in July 2011 and include tests for body mass index, glycated haemoglobin (HbA1c), liver function and blood pressure. The survey of pregnant women and nursing mothers involved a questionnaire that was sent out to all mothers who were given a Maternal and Child Health Handbook between 1 August 2010 and 31 July 2011; it was returned by about 15 000 respondents. When answers on the questionnaire indicated that consultation was needed, doctors provided telephone consultations in some cases. This survey is being updated every year to take account of new data, particularly on pregnancies and births. The mental health and lifestyle survey started from January 2012 and has been conducted every year with questionnaires covering physiological and mental conditions, lifestyle changes, experiences of the earthquake and tsunami, and radiation related issues, to provide adequate mental care and lifestyle support for evacuees [I-10].

Emergency workers and helpers from the public

I–29. The provisions for the protection of workers were gradually modified during the transition phase, depending on the work being undertaken. The increased dose criterion for emergency workers of 250 mSv[48] was withdrawn gradually. From 1 November 2011 this criterion ceased to apply to newly engaged emergency workers and, on 16 December 2011, (when the attainment of the cold shutdown state at the plant was announced) for most other emergency workers) [I-1]. On 30 April 2012, the higher criterion was withdrawn for a group of about 50 TEPCO employees with accumulated doses exceeding 100 mSv who had specialized knowledge and experience in operating the reactor cooling systems and in maintaining the facilities and equipment for suppressing the emission of radioactive materials [I-1].

[48] Applicable for the duration of the emergency work.

I–30. In parallel, the preparation for the planned decontamination and restoration work had started. The Basic Policy for Emergency Response on Decontamination work was issued on 26 August 2011. This policy and associated guidelines defined the responsibilities and requirements for radiation protection of emergency workers. The framework for occupational exposure in normal operation was applied for workers engaged in decontamination work, restoration and waste management [I-1].

I–31. In the aftermath of the accident, people from the affected areas, as well as from other parts of Japan and from a number of non-governmental organizations (helpers), volunteered to assist in such activities as the provision of food, water and necessities, and later in decontamination and monitoring activities. Relevant guidance was prepared to allow for their protection within the dose limit for members of the public under normal operations (1 mSv per year). [I-1]

Termination of urgent protective actions

I–32. On 19 July 2011, the NSC issued the Basic Policy on Radiation Protection for Termination of Evacuation and Reconstruction [I-12]. It outlined protection measures to be taken against radiation in accordance with the particular exposure situations, specifically the emergency exposure situations and existing exposure situations. It set forth the necessity of introducing systems for environmental monitoring and the dose estimation of individuals that would constitute the scientific basis for administrative decisions to implement protective measures, including decontamination and remediation, and to lift the evacuation measures. Over the long term, it recommended combining a full range of decontamination and improvement methods in setting forth radiation protection measures, and it stated the public should participate in the planning of activities and policies related to these measures.

I–33. On 4 August 2011, the NERHQ requested advice from the NSC on whether it was necessary to make any changes to the protective actions that were then being implemented (evacuation, relocation and sheltering). The NSC provided their response in the Standpoint of the Nuclear Safety Commission for the Termination of Urgent Protective Actions implemented for the Accident at Fukushima Daiichi Nuclear Power Plant [I-1]. The guidance included three bases for determining whether the termination of the protective measures in place in specific areas was appropriate:

(a) The projected annual dose to the public is lower than the criterion of 20 mSv;

(b) Preparation for the implementation of long term protective actions had been made;

(c) A framework for the participation of the relevant local governments and residents in the process of deciding on the long term protective actions had been developed.

I–34. The NSC statement also specified conditions for the termination of the designation for each type of area (evacuation prepared area, deliberate evacuation area and restricted area) where major protective measures were applied [I-8].

I–35. On 9 August 2011, based on this recommendation, the NERHQ prepared a review of evacuation areas. The following three requirements for termination of protective actions were outlined in the review [I-1]:

(i) The safety status of the nuclear power plant;

(ii) A decrease in the dose rate; and

(iii) Restoration of the public service functions and infrastructure.

I–36. Based on the Radiation Monitoring Action Plan for Homecoming regarding the Evacuation Prepared Area in Case of an Emergency, which was established on 25 July 2011, MEXT conducted various monitoring activities in municipalities of this area. As a result, ambient dose rates at all of the municipalities, including main spots near schools, were measured. Additionally, on 19 September 2011, all cities, towns and villages in the evacuation prepared areas began to prepare disaster recovery programs, for submission to the NERHQ. Based on these disaster recovery programs, the NERHQ decided that conditions (i) to (iii) for the termination of the evacuation prepared areas had been met [I-2].

I–37. The NERHQ consulted with the leaders of the cities, towns and villages concerned on the termination of the evacuation prepared areas and the disaster recovery programmes and, on 30 September 2011, the advice to shelter was withdrawn by the Japanese government as a result of an assessment of the safety status of the nuclear power plant and measurements of dose rate in the relevant areas. The announcement stated that monitoring would continue to be conducted and that local governments would implement their restoration plans. It was also noted that the date by which the public could return to the area would vary among local governments and would be undertaken with support provided by the national Government [I-1].

Waste management and decontamination works

I–38. Off-site waste that was generated following the accident was classified either as debris from the earthquake/tsunami (often referred to as disaster waste) or as a consequence of remediation activities [I-1]. The debris consisted of materials such as wood, concrete and metal, while remediation waste included sludge from water and sewage treatments, incinerated ash, trees, plants and soil resulting from decontamination activities.

I–39. Arrangements for the management of radioactive waste established in Japan prior to the accident covered waste generated within facilities, such as nuclear power plant s, but it did not include radioactive waste that had been generated in public areas. The Waste Management and Public Cleansing Act did not apply to waste that was contaminated with radioactive material, and there was no other law that regulated the disposal of disaster waste contaminated with radioactive material [I-13].

I–40. On 25 March, 12 April, 26 April and 6 May 2011, , instructions were issued on how to dispose of vegetables and raw milk in areas subject to food restriction(s) by the Ministry of Agriculture, Forestry and Fisheries (MAFF), based on technical advice from the NSC [I-14]. Instructions on what to do with foods that were not suitable for consumption were issued in the form of Question and Answers on the MAFF web site on 26 April 2011 [I-15].

I–41. The Near-Term Policy to Ensure the Safety for Treating and Disposing Contaminated Waste Around the Site of Fukushima Dai-ichi Nuclear Power Plants [I-16] was issued by the NSC on 3 June 2011. This document provided dosimetric criteria for: recycled materials; the protection of workers treating the materials; and the protection of members of the public in the vicinity of treatment facilities and disposal sites. The NSC proposed that materials affected by the accident — i.e. debris, sludge from the water and sewage treatments, incinerated ash, trees, plants and soil resulting from decontamination activities — would be disposed of under proper management, and that some materials may be considered for reuse. Products manufactured from these reused materials were checked for contamination and managed appropriately before being released onto the market. Appropriate protective measures were implemented to ensure that radiation exposures of workers and the public were kept as low as reasonably achievable. A final disposal strategy was derived based on the quantities of waste, types of radioactive material, radioactivity concentration and evaluations of the long term safety of disposal facilities [I-1].

I–42. Legislative and regulatory instruments were developed after the accident for dealing with on-site and off-site waste. Post-accident issues concerning off-site waste management were addressed in the Act on Special Measures Concerning the Handling of Environmental Pollution[49], which was enacted following governmental and ministerial ordinances issued by the Ministry of the Environment (MOE) [I-17]. This Act specifies the wastes that were the responsibility of the national government, and those that were dealt with by the prefectures and municipalities. The Act was enacted on 26 August 2011 (promulgated on 30 August 2011) and took full effect on 1 January 2012. In effect, the Act underpinned the remediation strategy for Japan, as it sets out the means for achieving the principles and requirements stated in the national policy. It outlined the management of the contaminated areas and included the assignment of responsibilities to the national and local governments, the operator and the public. It facilitated the transition from an emergency exposure situation to an existing exposure situation. It also formalized the long term management of environmental monitoring, decontamination measures and the designation, treatment, storage and disposal of soil and waste contaminated by radioactive material [I-1]. Based on this Act, the Ministry of Environment established guidelines on decontamination and on waste in December 2011.

I–43. In accordance with the basic principles of the Act, the goals for dose reduction were outlined as follows: "In the area where the additional dose is 20 mSv/y or higher, measures shall aim to

[49] Act on Special Measures Concerning the Handling of Environmental Pollution by Radioactive Materials Discharged by the Nuclear Power Station Accident Associated with the Tohoku District — Off the Pacific Ocean Earthquake that Occurred on March 11, 2011, Act No. 110, 2011.

decrease the size of the area. The following shall be aimed at areas where the additional radiation dose is less than 20 mSv per year:

- To reduce the additional radiation dose to 1 mSv per year or lower over the long term;
- To reduce the additional annual radiation dose the public is exposed to by around 50% (including the physical attenuation of radioactive materials) by the end of August 2013 from the level at the end of August 2011; and
- To reduce the additional annual radiation dose affecting children by around 60% (including the physical attenuation of radioactive materials) by the end of August 2013 from the level at the end of August 2011 by decontaminating the living environment of children, such as schools, playgrounds, etc., on a priority basis, since it is crucial to recover the environment under which children can live safely and securely.

"These targets shall be reviewed from time to time based on the effects of measures for the decontamination of the soil, etc. and so forth." [I-13]

I–44. As decontamination was an urgent issue, the NERHQ established the Basic Policy for Emergency Response on Decontamination Work [I-18] on 26 August 2011 prior to the Act took coming fully into force. The policy permitted the commencement of decontamination in advance of the formal implementation of the Act. The Basic Concept for Pushing Ahead with Decontamination Works and Basic Policy for Emergency Response on Decontamination Work [I-9, I-18]. Act No. 110 of 2011 [I-17] outlined the management of the contaminated areas and included the assignment of responsibilities to the national and local governments, the operator and the public. It was enacted on 30 August 2011 and came into force in January 2012. The act facilitated the transition from an emergency exposure situation to an existing exposure situation; it formalized the long term management of environmental monitoring, decontamination measures, and the designation, treatment, storage and disposal of radioactive waste [I-1].

Stabilization of the plant conditions and delineation of areas

I–45. On 16 December 2011, a 'cold shutdown' state was achieved at the nuclear power plant, which was used to indicate that the control of the situation had been regained [21]. This meant that Step 2 of Action 1 of the roadmap issued in May had been completed..

I–46. A review of the areas where protective actions were being implemented was required for completion of Step 2 of Action 1. The review of areas (Restricted Area and Deliberate Evacuation Area) was issued on 26 December 2011 by the Japanese Government in a document called Basic Concept and Issues to be Challenged for Rearranging the Restricted Areas and Areas to which Evacuation Orders have been Issued where Step 2 has been Completed [21]. The review of the areas was undertaken in consideration of the dose criterion of 20 mSv per year in terms of projected dose. Its criteria and area designations are presented in Table I–1.

TABLE I–1. CRITERIA, DESIGNATION AND COLOUR OF AREA SHOWN IN FIG. I–2 [21]

Criteria	Designation	Colour shown in Fig. I-2
Annual cumulative dose would be less or equal to 20 mSv	Areas in which evacuation orders are ready to be lifted	Green (Area 1)
Annual cumulative dose may exceed 20 mSv but is less than 50 mSv	Areas in which residents are not permitted to live	Orange (Area 2)
Annual cumulative dose exceeds 50 mSv	Areas in which residents will not be able to return for a long time	Red (Area 3)

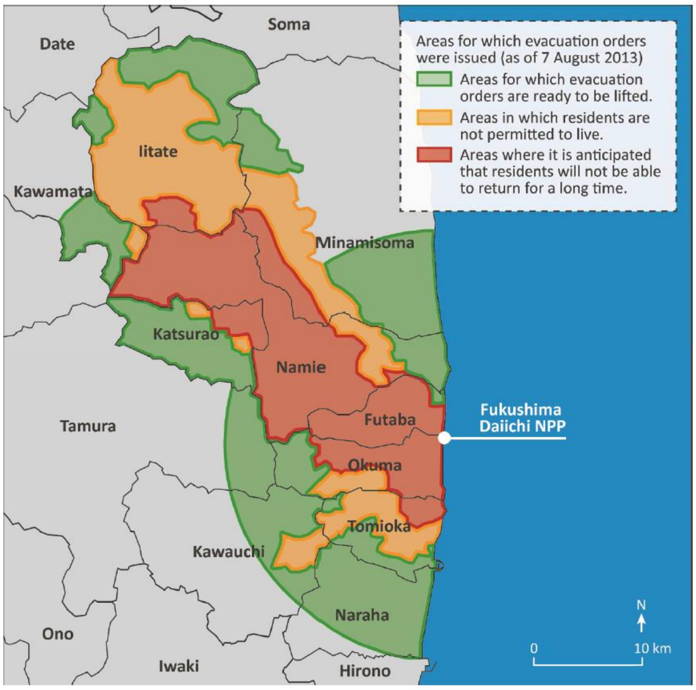

Fig. I-2. Completion of the arrangement for areas where evacuation orders were issued (7 August 2013) [I-1].

Conclusions

I–47. Prior to the accident, the national framework for radiation protection and safety in Japan had not taken into account situations requiring long term recovery operations over wide areas. The specific policies, guidelines and criteria, as well as overall arrangements for the transition from the emergency response phase to the recovery phase, were developed after the accident taking into account the latest recommendations of the ICRP.

I–48. The emergency response phase began on 11 March 2011, when the loss of off-site and almost all on-site electric power was experienced as a consequence of the earthquake and tsunami. After the declaration of a nuclear emergency, urgent protective actions, such as evacuation and sheltering of people in the vicinity of the site and restrictions on the distribution and consumption of food and the consumption of drinking water, were implemented during the following days. Early protective actions, such as the relocation of people outside the evacuation areas and relocation of people from locations at which hot spots of activity had been identified, were taken on the basis of detailed monitoring. These actions took place within the first few months following the accident and were completed by November 2011. The emergency response phase, during which the radiation dose was in steady decline (the target of Step 1), was generally completed by around 19 July 2011. However, some hot spots were detected up to November 2011 from which people were evacuated (or relocated).

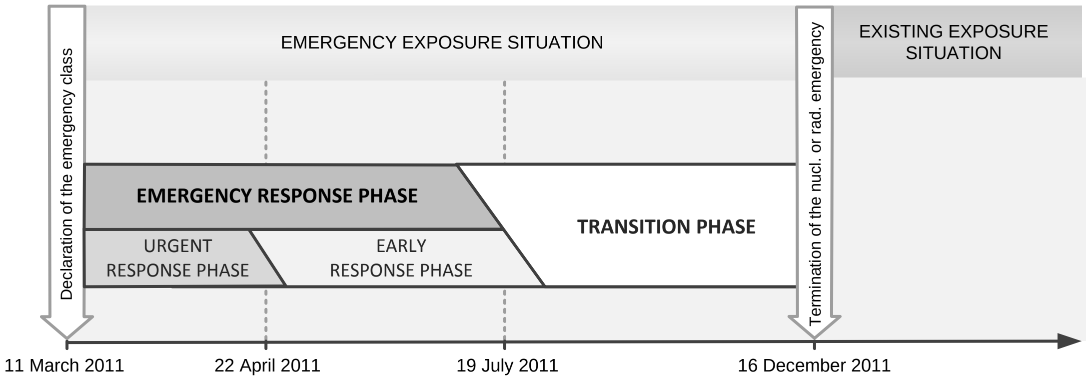

Fig. I-3. Retrospective sequencing and milestones of the Fukushima Daiichi accident.

I–49. The following months, from around July to December 2011, might be considered to be a transition period in which the policies and arrangements for the recovery phase were established. This included the following activities:

- Detailed monitoring to characterize the exposure situation and exposure pathways;
- Arrangements for the implementation of long term health surveillance;
- Determination of the criteria for termination of protective measures;
- Formalization of the long term management of radioactive waste;
- Adjusting arrangements for the protection of emergency workers, other workers and helpers, both on and off the site;
- Re-evaluation and rearrangement of areas in which protective actions were in place ;
- Establishment of long term plans for decontamination;
- Announcement that control of the situation had been regained at the plant.

I–50. On 16 December 2011, a cold shutdown state was reached at the nuclear power plant, but no termination of the emergency was officially declared at that time. The basic concept underlying the arrangement of the areas where evacuation orders had been issued was issued on 26 December 2011. The Act on Special Measures Concerning the Handling of Environmental Pollution came into force on 1 January 2012. Among other things, the Act created the necessary institutional arrangements for the implementation of a coordinated work programme involving different organizations at the national level. Issues addressed by the Act also include the prioritization of sites to be remediated and the allocation of funds to carry out the remediation works. The Act recognized the need to involve different stakeholders in the overall remediation process. Further information on the implementation of remediation activities are provided in References [I-6, I-13].

I–51. The results of an analysis of the case study with regard to the fulfilment of the prerequisites for the termination of a nuclear or radiological emergency, contained in Section 3 of this Safety Guide, are presented in Tables I-2 and I-3. These tables reflect the situation that existed on 16 December 2011 (see Fig.I-3), which is the date at which the retrospective analysis indicates that the conditions for termination existed.

TABLE I-2. STATUS WITH RESPECT TO THE GENERAL PREREQUISITES FOR TERMINATION OF AN EMERGENCY FOR THE FUKUSHIMA DAIICHI CASE STUDY

General prerequisite	Status with respect to the prerequisite
Had the necessary urgent and early protective actions been implemented?	The majority of the public protective actions had been identified and implemented by July 2011. This included the implementation of food monitoring and restrictions, and access controls to the areas from which people had been evacuated. However, some additional locations were found at which hot spots of activity were identified and from which it was necessary for people to be relocated, in November 2011.
Was the exposure situation stable and well understood?	No further significant release of radioactive materials to the environment was expected; extensive monitoring had been carried out, which had given the authorities a clear understanding of the exposure situation.
Was the radiological situation well characterized, and were the exposure pathways identified and doses assessed for all the affected people?	Intensive monitoring had been carried out, most of the affected people and areas had been identified, and doses had been assessed and regularly reassessed as the amount of information concerning the situation increased.
Was the source of exposure brought under control and were no further significant accidental releases or exposure expected due to the event?	Completion of the objective of Step 2 (Release of radioactive materials is under control and radiation doses are being significantly held down) was declared on 16 December 2011.
Was the current situation assessed, and were the existing emergency arrangements reviewed and new arrangements established?	Many analyses were carried out following the accident to investigate the circumstances that led to the accident and to identify improvements that needed to be implemented in the regulatory control and emergency arrangements in Japan. Lessons identified from these analyses were incorporated in the respective arrangements of different organizations and at different levels by 2012. Upon declaration of the achievement of Step 2 on 16 December 2011, a new organization, the Government–TEPCO Mid-to-Long Term Response Council was created at TEPCO Headquarters. On 21 December 2011, the Council issued the Mid-and-Long-Term Roadmap towards the Decommissioning of Fukushima Daiichi Nuclear Power Station Units 1–4.

General prerequisite	Status with respect to the prerequisite
	The NSC established a working group to review the regulatory guide on emergency preparedness for nuclear facilities in July 2011 and submitted its interim report on its revision in March 2012. This document was then used as a basis for developing the new regulatory guidelines issued in October 2012, by the newly established Nuclear Regulatory Authority (NRA).. On 7 November 2012, the NRA designated the Fukushima Daiichi nuclear power plant as a ‘specified reactor facility’, which is a facility where a nuclear accident has occurred and special regulations commensurate with the condition of the equipment are stipulated [I-13].
Were the requirements for occupational exposure as for a planned exposure situation confirmed for all workers engaged in recovery activities?	All the recovery work off-site (e.g. decontamination works) had been carried out to ensure that workers did not exceed the national dose limits for planned exposure situations. However, it was necessary to continue to apply higher dose limits (specified for emergency work) to complete some on-site work. The increased dose criterion for emergency workers of 250 mSv was withdrawn gradually starting on 1 November 2011. From that date, this limit was not applied for newly engaged emergency workers and, from 16 December 2011, it no longer applied to most of the remaining emergency workers. However, there was a continued need to apply the higher criterion for a group of about 50 TEPCO employees, who had received accumulated doses exceeding 100 mSv, but who had necessary specialized knowledge and experience to complete some on-site activities. On 30 April 2012, it was announced that the increased dose criterion of 250 mSv had also been withdrawn for this group of on-site emergency workers.
Was the radiological situation assessed against reference levels, generic criteria and operational criteria, as appropriate?	This was done on a continuous basis to account for any new information that had become available. A criterion of 20 mSv annual projected effective dose was generally used for this purpose. However, from the end of May 2011, dose rates associated with the selected long term criterion of an additional annual effective dose of 1 mSv were applied to assess the need for decontamination of schools and their surrounding areas.
Were non-radiological	Arrangements implemented during the transition phase and

General prerequisite	Status with respect to the prerequisite
consequences (psychosocial, economic) and other factors (technology, land use options, availability of resources, community resilience) identified and considered?	strategies/policies developed considered the need for restoration of normal social and economic activities, mitigation of economic impacts, and restoration of public services. Remediation work and dialogues had been carried out with local communities, and different support centres had been established to help those returning in the affected areas. Long term screening for psychological and psychosocial consequences among affected population had also been planned and implemented.
Was a registry of those individuals requiring further medical follow-up established prior to the termination of the emergency?	Activities to identify these individuals and respective surveys were initiated in May 2011.
Was a strategy for the management of radioactive waste arising from the emergency developed when appropriate?	The first policy in this regard was issued in June 2011. The Act on Special Measures Concerning the Handling of Environmental Pollution was adopted in August 2011 and entered into force on 1 January 2012. The Act defined responsibilities for monitoring, decontamination and waste management, as well as for the provision of financial resources. An interim policy was in force (from August 2011 – 1 January 2012), which allowed remediation work to commence and was used to guide the waste management operations.
Were the interested parties consulted?	The Roadmap for Immediate Actions for the Assistance of Nuclear Sufferers was issued by METI on 17 May 2011. It was intended to facilitate communication and preparations for the transition to long term recovery operations and the resumption of normal social and economic activity. It allocated responsibilities and specified other organizational aspects of the transition process and the objectives of, and conditions for, the termination of the emergency response phase. The roadmap was revised in July 2011. Status updates on the progress in implementing the policy were issued each month until December 2011. For example, consultations were held between the local governments and national government on the evacuation prepared areas before . the designation of this area was withdrawn on 30

General prerequisite	Status with respect to the prerequisite
	September 2011.

TABLE I-3. STATUS WITH RESPECT TO THE SPECICIC PREREQUISITES FOR TRANSITION TO AN EXISTING EXPOSURE SITUATION FOR THE FUKUSHIMA DAIICHI CASE STUDY

Specific prerequisite	Status with respect to the prerequisite
Were justified and optimized actions taken to reach the generic dose criteria which would enable transition to an existing exposure situation and to ensure that the assessed residual doses would approach the lower bound of the reference level for an emergency exposure situation?	Remedial actions were being implemented with the aim of reaching the projected effective dose criterion of 20 mSv per year within the affected areas. The relevant policies had also specified a long-term target for additional exposure of 1 mSv per year.
Were areas delineated which were not open for unrestricted use by the public prior to the termination of the emergency?	Initial delineation of areas was carried out in March and April 2011, when urgent and early protective actions were implemented. On 22 April 2011, the status of these restrictions were clarified and announced and, in the period up to November 2011, such further areas were specified where hot spots of activity had been found and from which people were advised to relocate. By 26 December 2011, clear policies and directions for each restricted area had been formulated.
Were administrative and other provisions put in place for these delineated areas to monitor compliance with the restrictions?	On 28 March, a decision was taken to prohibit access to the evacuated areas, and evacuees were informed about this decision on 30 March 2011 [I-1]. The 20 km zone was announced as a restricted area on 22 April 2011. Conditions for temporary access to the area within a 20 km radius of the nuclear power plant were defined. On 9 May 2011, the NSC provided advice on the implementation of temporary access. Access was sequentially permitted after coordination of relevant local governments, Fukushima Prefecture and others. The arrangements included specific instructions and monitoring for contamination.
Was a strategy developed for the	Arrangements implemented during the transition phase and

Specific prerequisite	Status with respect to the prerequisite
restoration of infrastructure, workplaces and public services necessary to support normal living in the affected areas (e.g. public transportation, shops and markets, schools, kindergartens, health care facilities, police and firefighting service, etc.)?	strategies/policies developed considered restoration of normal social and economic activities and mitigation of economic impacts and restoration of public services. Remediation work and dialogues had been carried out with local communities, and different support centres had been established to help those returning in the affected areas.
Were mechanisms and means in place for continued communication and consultation with all interested parties, including local communities?	Different radiation protection measures were implemented in different areas and it was necessary to provide affected people with more detailed information on radiation safety and matters affecting their daily lives following the accident. One of the challenges in achieving this was the unavailability of television and the Internet in many areas. The Local NERHQs published a newsletter and distributed it to each evacuation site; as of April 2011, this information was also periodically broadcasted by local radio stations. Instructions from the Director General of the NERHQ, press releases on monitoring data from the MEXT, and materials on support measures for local business corporations; were provided to local municipalities depending on their need. Such information was also released to the local media by means of press conferences.
Was any change or transfer of authority and responsibilities from the emergency response organization to organizations responsible for the long term recovery operations completed?	The adopted policies for the management of different areas identified the conditions under which the situation would be managed by local authorities. For example, according to the Act on Special Measures Concerning the Handling of Environmental Pollution, the contaminated areas were arranged into two categories, based on the additional annual effective dose estimated in the autumn of 2011: Special Decontamination Area and Intensive Contamination Survey Area. Within the Special Decontamination Area, which overlaps the former restricted areas, the national government has the responsibility for formulating and effecting remediation plans. The Intensive Contamination Survey Area includes those municipalities where the additional radiation doses in the first year were estimated to be between 1 mSv and 20 mSv. Municipalities conduct

Specific prerequisite	Status with respect to the prerequisite
	monitoring surveys to identify areas requiring decontamination implementation plans and implement remediation activities in these areas, with the national government providing financial and technical support to facilitate the remediation.
Were the information and data gathered during the emergency with regards to the long term planning shared among relevant organizations and authorities?	MEXT opened a portal site on radiation monitoring in August 2011 that included information on the monitoring being conducted by related ministries and agencies in line with their own administrative objectives. In order to collate monitoring data and to facilitate its use, the Japan Atomic Energy Agency created a database that linked the data to geographical information. The response to the accident provided a number of examples that show the benefits of involving affected populations in activities for recovery, from consultation and dialogue to involvement in remediation actions (so-called self-help actions). An information hub, called the Decontamination Information Plaza, was opened in Fukushima City in January 2012 as a joint project of Fukushima Prefecture and the MOE.
Was a long term monitoring strategy developed in relation to residual contamination?	The plan for detailed monitoring was announced on 13 June 2011. Further activities to formulate a comprehensive monitoring plan continued in August 2011. The plan was subsequently revised in April 2012.
Was a long term medical follow-up programme for the registered individuals developed?	The first stage of a screening and monitoring programme was initiated in June 2011. It included programmes for the early detection of radiation induced cancers and effects on mental health and lifestyle.
Was a strategy for mental health and psychosocial support of the affected population and for consultation in relation to psychosocial health consequences developed?	Comprehensive medical check-ups for evacuees were conducted and the mental health and lifestyle survey, conducted as part of the Fukushima Health Management Survey, included questionnaires covering physiological conditions, lifestyle changes, experiences of the earthquake and tsunami and radiation related issues. With regard to the general public, the Ministry of Health Labour and Welfare has been engaged in efforts to dispatch mental health care teams. These efforts include providing access to telephone counselling for persons who were found by the Fukushima Health

Specific prerequisite	Status with respect to the prerequisite
	Management Survey to have high risk, or those who indicated a wish to talk about their concerns. Public health officials (district nurses, midwives, etc.) have set up a number of initiatives on a local basis, including focus group discussions and counselling for pregnant women and young mothers [I-13]. With regard to mental health care resources, new major facilities were established in Fukushima after the accident. For example, a mental health support team from Fukushima Medical University has been providing counselling by telephone to approximately 4000 evacuees at risk of psychiatric disorders such as posttraumatic responses or depression every year since the accident [I-20]. Another facility, the Fukushima Kokoro No Care Center, with around 50 staff consisting of psychiatrists, social workers, clinical psychologists, nurses, and occupational therapists, also began to provide mental health intervention programs in 2012 [I-20].
Was a strategy under consideration to compensate victims of damage resulting from the emergency?	The Dispute Reconciliation Committee for Nuclear Damage Compensation (Reconciliation Committee), which was established in April 2011, to provide guidelines defining the scope and amount of compensation falling under the responsibility of the operator (TEPCO). Its first interim guidelines were published on 5 August 2011, These guidelines clarify the compensation and damage associated with: evacuation; the establishment of marine exclusion zones and no-fly zones; restrictions on shipping agricultural products other government orders; 'rumour-related' damage; radiation exposure, decontamination and other indirect damage [I-13]. The enactment on 5 August 2011 of the Act on Emergency Measures Related to Damage Caused by the 2011 Nuclear Accident (Act No. 91 of 2011) [I-21], inter alia, enabled the Government of Japan to start making provisional compensation payments in place of TEPCO as an emergency measure. The government also implemented other means to allow the operator to cope with its obligations towards the victims of the accident. In September 2011, the government pursuant to the Nuclear Damage Compensation Facilitation Corporation Act (Act No. 94, 10 August 2011) [I-22] set-up the Nuclear Damage Compensation Facilitation Corporation (currently the Nuclear Damage

Specific prerequisite	Status with respect to the prerequisite
	Compensation and Decommissioning Facilitation Corporation (NDF)). The Act envisages a procedure whereby the liable operator may request financial support from NDF in cases where the actual amount of damage to be compensated is expected to exceed the financial security amount envisaged in the Compensation Act. Additionally, in July 2012, NDF paid Yen 1 trillion for preferred shares and became the controlling shareholder of TEPCO with a little over 50% voting rights [I-23].
Were administrative arrangements, legislative and regulatory provisions in place, or were the corresponding amendments underway, for the management of the existing exposure situation, including provisions for the necessary financial, technical and human resources?	The national system in place prior to the emergency did not cover the management of an existing exposure situation of this size. All the necessary policies, guidelines and acts were therefore prepared after the accident, beginning in June 2011. Resource needs (expertise, manpower, equipment and material) were mobilized from all over Japan, and the logistic support (transport, housing, etc.) was organized accordingly
Was individual monitoring of members of the general public still required for radiation protection purposes?	No, only for the affected population.

THE RADIOLOGICAL ACCIDENT IN GOIÂNIA, BRAZIL

I–52. In 1985, a radiotherapy institute, the Instituto Goiano de Radioterapia (IGR) in Goiânia (Brazil), moved to new premises. During this process a ^{137}Cs teletherapy unit was left in place, without notifying the licensing authority, the Brazilian National Nuclear Energy Commission (CNEN), as required under the terms of the institute's licence. The former premises of the IGR were subsequently partly demolished. As a result, the radioactive source remained in an insecure condition, which subsequently led to the radiological accident (elaborated in details in Ref. [I-24]).

I–53. On 13 September 1987, two people (W.P. and R.A.) entered the premises looking for valuable material and scrap that they could sell. They found and dismantled the abandoned teletherapy unit with common tools and removed the rotating radiation head that contained the source assembly. They transported these items in a wheelbarrow to their homes, half a kilometre from the site of the institute. In the evening both people began to vomit.

I–54. On 14 September 1987, W.P. suffered from diarrhoea, dizziness and oedema on one hand. He consulted a medical doctor on 15 September 1987 and his symptoms were diagnosed as an allergic reaction to food. In the meantime, R.A. proceeded to dismantle the radiation head in his backyard. He finally extracted the ^{137}Cs capsule from the source wheel, punctured the 1 mm thick window of the source capsule with a screwdriver and scooped out some of the radioactive material.

I–55. On 18 September 1987, the remnants of the source assembly were sold for scrap to a junkyard. The junkyard owner (D.F.) noticed that the source material glowed blue in the dark and took the capsule into his house. In the following days, several persons — neighbours, relatives and acquaintances — were invited to see this phenomenon. Fragments of the source, of the size of grains of rice, were distributed among several families. This continued for several days, by which time a number of people suffered from vomiting and diarrhoea including D.F.'s wife.

I–56. On 25 September 1987, D.F. sold the lead shielding that had been removed from the unit and the remnants of the source assembly to another junkyard. By 28 September 1987, D.F.'s wife suspected that the glowing powder was the cause of the symptoms of ill health. She reclaimed the materials from the second junkyard and transported them by bus in a bag to the Vigilância Sanitária, a public health department in Goiânia. In the morning of 29 September 1987, a medical physicist, visiting the Vigilância Sanitária, identified the presence of radioactivity using a scintillation counter.

Emergency declaration and urgent protective actions

I–57. On 29 September 1987, the Director of the Department of Nuclear Installations at CNEN was notified by telephone. He suggested that more information should be gathered about the radioactive source, the nature of the accident and the extent of the contamination. He also called the IGR. In Goiânia, the authorities alerted the police, the fire brigade, ambulance services and hospitals. The local authorities transferred management responsibilities to CNEN, when the first CNEN teams arrived on 30 September 1987. They were supported by the state military police and fire brigades, and later by the Brazilian army.

I–58. Existing emergency arrangements at the time of the accident were designed to respond to possible nuclear accidents at the Central Nuclear Almirante Álvaro Alberto (CNAAA) nuclear power plant, or small scale radiological emergencies in the non-nuclear power sector, such as transport accidents or accidents with radiography sources. The Goiânia accident did not fall into either category; it was therefore necessary to establish specific arrangements based on an appropriate combination of elements from the existing plans.

I–59. Priority in the emergency response was given to the medical aspects; the isolation of the radioactive source and the contaminated areas that had been identified; the assessment of the environmental contamination and the reinforcement of human and technical resources.

Isolation of the source

I–60. The remnants of the source located in the courtyard of the Vigilância Sanitária were shielded in place on 30 September 1987. Using a crane, a section of sewer pipe was placed over the remnants and filled with concrete pumped over the wall of the courtyard. This operation was completed by the early afternoon of the second day. As a result, the dose rates in the surrounding area were significantly reduced, and since contamination was not a major problem in this area, most of the area that had been cordoned off around the site could be reopened.

Monitoring and medical response

I–61. Upon identification of the accident, the Goiás State Secretary for Health made plans for receiving and isolating identified patients and screening people who might have been exposed at the Olympic stadium in the city. The areas surrounding the known contaminated sites, where the dose rate exceeded 2.5 µSv/h[50], were evacuated and the residents directed to the stadium for contamination control. Access to these areas was further restricted.

I–62. As the environmental monitoring proceeded, several other sites of significant contamination were identified. Residents at these sites were evacuated and sent to the local soccer stadium for medical examination and contamination checks. Blood, urine and faeces samples were obtained from each of the patients for bioassays.

I–63. At the stadium, individuals identified with symptoms of over exposure to radiation were sent to the Tropical Diseases Hospital for medical care. Contaminated persons were requested to place their clothes in bags and to take showers. Those people showing signs of internal contamination were referred for further medical care.

I–64. As a consequence of spreading rumours, many people went to the stadium for reassurance, which strained the limited monitoring resources then available.

I–65. On 1 October 1987, six patients, and, two days later, four more patients, were transported to Naval Hospital in Rio de Janeiro for intensive medical care.

I–66. Monitoring teams mapped the main contaminated sites and identified all hot spots, ensuring that no one else was at risk of serious exposure. This, however, did not preclude the possibility of later discovering other, less severely contaminated, areas that might also require action and control.

Transition phase

I–67. By 3 October 1987, the situation had been brought under control; there was no further risk of high exposures, and the most contaminated sites had been identified and evacuated. The main

---

[50] This first approximation was roughly based on the occupational dose limit of 5 rem (50 mSv) per year (about 240 workdays at 8 h/day) recommended at the time and considering that the dose limit for the public was 10 times lower. This value was confirmed later because the underestimation of residential occupancy compared to occupational occupancy was counteracted by the fact that the clean-up lasted about 3 months.

concerns were the continuing treatment of the injured, improvement of the conditions at the sites of contamination, clean-up operations and waste management.

I–68. The following week was devoted to the preparation of plans and strategies for the recovery. Resource needs (expertise, manpower, equipment and material) were assessed and mobilized. Taking into account the expected increase of resources, the logistic support (transport, housing etc.) was organized accordingly.

I–69. Patients in hospital and inhabitants of contaminated residences were interviewed concerning their own movements and those of any visitors in order to identify potential additional routes by which contamination may have spread. Further surveys were conducted to confirm and localize less contaminated spots. Prior to environmental decontamination, plans were made for carrying out a comprehensive survey by car- and airborne gamma spectrometry and organizing an environmental survey programme. Various procedures were developed and written for: access control to contaminated areas; action criteria; equipment quality assurance and control; and medical follow-up (selection for cytogenetic and other blood tests). Plans for dealing with the large amount of waste expected to be generated by clean-up activities were also established (including procuring the necessary professional, technical and support staff, equipment, chemicals and machinery; identifying a suitable temporary disposal site; and defining the specifications for waste containers).

I–70. The dose rate criterion of 2.5 μSv/h for evacuation, established at the beginning of the emergency, was reconsidered taking into account the annual exposure limit for members of the public (5 mSv per year) and more realistic, but still conservative, estimates for occupancy and the spatial distribution of activity to relate the mean dose rate to the maximum dose rate. A time factor was also applied to reflect the decrease in radioactivity due to, for example, cleaning or weathering. A revised criterion of 10 μSv/h for evacuation (and return) was adopted.

Medical follow-up

I–71. Measures were taken to protect medical staff from contamination and exposure during the patients’ treatment in hospital. The doses received by the medical staff were below 5 mSv over the three month duration of the patients' hospital care.

I–72. Follow-up studies, including a continuing bioassay and whole body monitoring programme, were performed on the contaminated persons. Prussian Blue was used to speed up the biological excretion processes for ^{137}Cs.

Comprehensive environmental monitoring

I–73. The subsequent monitoring efforts encountered various difficulties in surveying the urban area and the river basin. Due to the heavy rain that had fallen between 21 and 28 September 1987, the caesium contamination had been dispersed from the ruptured capsule into the environment. Instead of being washed out as expected, radioactive materials were deposited on roofs, and became the major contributor to dose rates in houses.

I–74. Samples of soil, vegetation (leaves, branches and fruits), water (from the nearby river, wells and public water supply), rainwater and air were collected and measured.

Post-accident recovery operations

I–75. Some 550 workers were engaged in the decontamination operations.

I–76. Significant contamination was found in 85 houses. Movable items (e.g. clothes, furniture) were removed to a nearby uncontaminated area for monitoring. Items free of contamination were wrapped in plastic, while contaminated items were decontaminated, where possible, or disposed of as waste. When the contents of a house had been removed, the inside and roofs were cleaned. Seven highly contaminated houses were demolished because decontamination was not feasible.

I–77. Forty-five public places, including pavements, squares, shops and bars were decontaminated. Contamination was also found on about 50 vehicles.

I–78. In gardens, fruits were pruned from trees and disposed of. Much of the soil from enclosed gardens and yards was also removed, following soil profile measurements. The site of the highest contamination was the house where the source capsule had been dismantled. Exposure rates were very high, necessitating rotation among workers to keep their daily exposure below a criterion of 1.5 mSv.

I–79. After removal of rubble and soil, the decontaminated area was covered by concrete or clean soil.

Waste management and disposal

I–80. By 3 October 1987, it was evident that large volumes of radioactive waste would be generated. Plans were developed for dealing with the decontamination operations and waste management.

I–81. The preparation of decontamination operations included:

— Choice of a suitable disposal site;
— Design and construction of waste containers;
— Collection of the heavy machinery, such as excavators and back- and front-loaders;
— Updating written operational procedures;
— Testing various decontamination techniques;
— Preparation of a work timetable.

I–82. It was necessary to find suitable location for the disposal site and to identify and address the constraints associated with the disposal and transport conditions. As a consequence of public concern, it was not possible to locate the disposal site in Goiânia. The decision on the location of the waste storage site, its planning and construction took more time than had been expected. A site, 20 km outside the city, was chosen as a temporary disposal site on 16 October 1987 and major decontamination work started in mid-November. The decontamination operations continued until the end of December 1987. The total volume of waste stored was approximately 3500 m³ [I-24].

Conclusions

I–83. The different stages of the management of the accident, and a number of key milestones can be recognized by retrospective analysis and roughly associated with the different phases of an emergency described in Section 2 of this Safety Guide (see Fig. I-4). However, the complexity of the accident, together with the absence of specific emergency plans to address such a situation, resulted in the demarcations between the specific activities and phases being less clear at the time.

I–84. The emergency response phase began on 29 September 1987, when the broken ^{137}Cs source was identified as the cause of the symptoms affecting those who had been in contact with it, and when the CNEN was notified. Urgent and early protective actions, such as the identification and care of severely exposed people; identification and isolation of the source; evacuation and cordoning off the most heavily contaminated areas; and contamination controls and decontamination of evacuees were carried out during the following days. The emergency response phase, during which all potential sources of contamination were brought under control, was completed by around 3 October 1987.

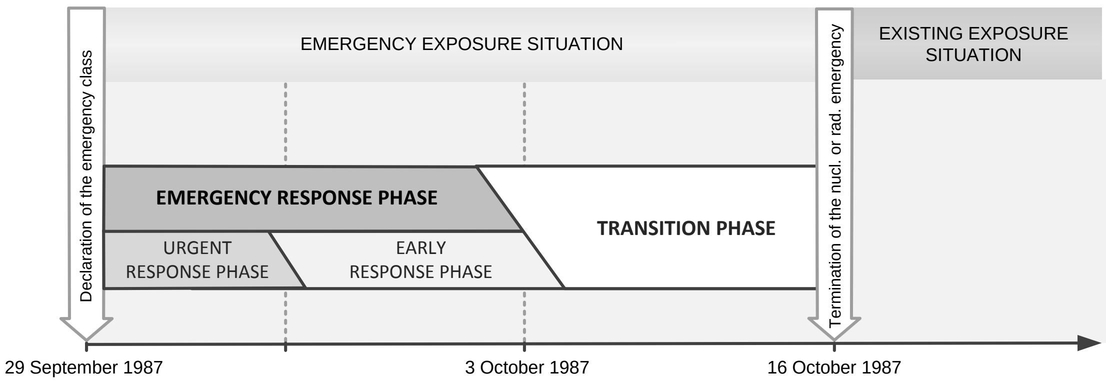

Fig. I-4. Retrospective sequencing and milestones of the Goiânia accident management.

I–85. The following two weeks, from 3 to 16 October 1987, can be considered as to be the transition period, during which the main focus of response was to set up a general strategy for the overall recovery. This included:

— Organizing the management structure for the recovery operations;
— Re-evaluating or setting dosimetric criteria and operational criteria for implementing relevant works;
— Assessing and gathering the resources needed;
— Mapping the geographical distribution of the contamination;
— Developing and writing procedures for access control, equipment QA/QC and the selection of health screening methods (cytogenetic and other blood tests);
— Choosing a suitable location for the disposal of waste;
— Defining specifications for waste containers;

— Setting up an environmental monitoring network;
— Developing a public communication strategy.

I–86. Although there was no clear termination of the emergency, 16 October 1987 might be considered as the beginning of the existing exposure situation, with the decision regarding the waste site. Decontamination operations started in the middle of November following the necessary preparations. The decontamination of the main foci and remaining areas was carried out from mid-November until the end of December 1987. The rehabilitation phase, with the aim of restoring normal living conditions, continued until March 1988.

I–87. The results of an analysis of the case study with regard to the fulfilment of the prerequisites for the termination of a nuclear or radiological emergency, contained in Section 3 of this Safety Guide, are presented in Tables I-4 and I-5. These tables reflect the situation that existed on 16 October 1987 (see Fig.I-4), which is the date at which the retrospective analysis indicates that the conditions for termination existed.

TABLE I-4. STATUS WITH RESPECT TO THE GENERAL PREREQUISITES FOR TERMINATION OF AN EMERGENCY FOR THE GOIANIA CASE STUDY

General prerequisite	Status with respect to the prerequisite
Had the necessary urgent and early protective actions been implemented?	The affected people had been identified and were taken care of; the contaminated areas had been delimited; residents had been evacuated and access controls were in place; and the radioactive source had been located and isolated.
Was the exposure situation stable and well understood?	The radioactive source had been isolated; no further significant dispersion of the contamination was expected; the history, affected individuals and responsible parties associated with the accident were known.
Was the radiological situation well characterized, and were the exposure pathways identified and doses assessed for all the affected people?	Monitoring had been carried out, the affected people and the contaminated areas had been identified and doses had been assessed; initial intervention criteria had been revised, taking into account more realistic and site specific parameters associated with the habits of the affected people.
Was the source of exposure brought under control, and were no further significant accidental releases or exposures expected due to the event?	The radioactive source had been located and brought under control; residents had been evacuated from contaminated areas and access controls were in place, preventing further significant exposure.
Was the current situation assessed, and were the existing emergency arrangements reviewed and new arrangements established?	The IAEA report on the accident recommended that "preparedness to respond to radiological emergencies should extend not only to nuclear accidents but to the entire range of possible radiological accidents" [I-24]. Prior to the accident, Brazil had not considered the potential for radiological emergencies in its emergency arrangements. Any changes in the national arrangements that followed the accident occurred on a timeframe beyond that of the references consulted.
Were the requirements for occupational exposure during a planned exposure situation confirmed for all workers engaged in the recovery activities?	A daily effective dose criterion for workers was set at 1.5 mSv; other criteria were used for longer periods of work (5 mSv per week; 15 mSv per month and 30 mSv per quarter). These limits were compatible with the annual effective dose limit of 50 mSv in force at the time.
Was the radiological situation	A maximum effective dose level of 5 mSv was set and used

General prerequisite	Status with respect to the prerequisite
assessed against reference levels, generic criteria and operational criteria, as appropriate?	as the reference for public exposure; operational criteria for evacuation and remedial actions were defined accordingly.
Were non radiological consequences (psychosocial, economic) and other factors (technology, land use options, availability of resources, community resilience) identified and considered?	It is not clear whether, and to what extent, these aspects had been thoroughly considered and to what extent this would have been necessary, given the type of the emergency. However, it was noted that some of the inhabitants of Goiânia were subjected to discrimination, even by their own relatives. Sales of the main economic products of Goiás State (cattle, cereals and other agricultural products, as well as cloth and cotton products) fell by one quarter in the period after the accident.
Was a registry of those individuals requiring further medical follow-up established prior to the termination of the emergency?	The affected people had been identified and were receiving the necessary medical attention.
Was a strategy for the management of radioactive waste arising from the emergency, when appropriate, developed?	In the period up to 16 October 1987, various activities associated with choosing a suitable location for the disposal of waste and for defining the specifications for waste containers were carried out.
Were the interested parties consulted?	It is not clear whether or to what extent consultation with interested parties occurred before 16 October 1987. A communication strategy was, however, under consideration at that time.

TABLE I-5. STATUS WITH RESPECT TO THE SPECIFIC PREREQUISITES FOR TRANSITION TO AN EXISTING EXPOSURE SITUATION FOR THE GOIANIA CASE STUDY

Specific prerequisite	Status with respect to the prerequisite
Were justified and optimized actions taken to reach the generic dose criteria enabling transition to an existing exposure situation and to ensure that the assessed residual doses approach the lower bound of	The dosimetric and operational criteria were developed during the accident on the basis of dose limits for planned operations. Thus, they were more conservative than might be considered appropriate for short-term exposures. These values were the main drivers for the response actions and remedial actions taken and the limited monitoring and

Specific prerequisite	Status with respect to the prerequisite
the reference level for an emergency exposure situation?	medical response resources were placed under additional pressure as a consequence. The decision on the criteria was influenced by the pressure of public opinion.
Were areas delineated for which it was feasible to allow unrestricted use by the public prior to the termination of the emergency?	By 16 October 1987, the evacuated areas to which access was restricted were known.
Were administrative and other provisions put in place for these delineated areas to monitor compliance with the restrictions?	Access to these restricted areas was controlled.
Was a strategy developed for the restoration of infrastructure, workplaces and public services necessary to support normal living in the affected areas (e.g. public transportation, shops and markets, schools, kindergartens, health care facilities, police and firefighting service, etc.)?	No relevant information was found or expected, in view of the limited area and number of people affected by the accident.
Were mechanism and means for continued communication and consultation with all interested parties, including local communities, in place?	In order to restore public trust and improve credibility, decontamination workers were encouraged to explain to people what they were doing and why, and to accept offers of drinking water and food from people's houses. They also made frequent appearances on television, using simple language and analogies with common applications of radiation, such as medical X-rays. Several dialogues were held with different sections of the population, community groups and journalists. Around 250 000 copies of a pamphlet explaining radioactivity and radiation were distributed. A telephone service was operated 24 hours a day to answer enquiries or receive information about other possibly contaminated people or sites.
Was any change or transfer of authority and responsibilities from	The authority remained with CNEN and, thus, there was no need for any transfer of responsibilities.

Specific prerequisite	Status with respect to the prerequisite
the emergency response organization to organizations responsible for the long term recovery operations completed?	
Were information and data gathered during the emergency that was relevant to the long term planning shared between relevant organizations and authorities?	Not applicable, as CNEN remained in charge.
Was a long term monitoring strategy developed in relation to residual contamination?	Consideration had been given to the development of a monitoring strategy for residual contamination by 16 October 1987. The general environmental monitoring programme continued in 1988. The monitoring of decontaminated sites was maintained on a continuous basis until 1996.
Was a long term medical follow-up programme for the registered individuals developed?	Follow-up studies, including a continuing bioassay and whole body monitoring programme were performed on the contaminated persons. These studies continued until the beginning of 1988.
Was a strategy for mental health and psychosocial support of the affected population and for consultation in relation to psychosocial health consequences developed?	Some consideration was given to supportive psychological therapy for the exposed people, but it was recognized that further development of the system of social and psychological support was needed.
Was a strategy under consideration to compensate victims of damage resulting from the emergency?	No information was found.
Were administrative arrangements, legislative and regulatory provisions in place, or were the corresponding amendments underway for the management of the existing exposure situation, including provisions for the necessary financial, technical and	Resource needs such as expertise, manpower, equipment and material, were assessed and mobilized. The necessary logistic support, for example transport and housing, was organised accordingly.

Specific prerequisite	Status with respect to the prerequisite
human resources?	
Was individual monitoring of members of the general public still required for radiation protection purposes?	There was no need for continuing individual monitoring of members of the general public, with the exception of the registered affected people.

THE NUCLEAR INCIDENT AT THE PAKS NUCLEAR POWER PLANT, HUNGARY

I–88. The Paks nuclear power plant in Hungary comprises four WWER 440 MWe reactors that supply about forty percent of the electricity to the country. Units 1−4 went into commercial operation between 1983 and 1987.

I–89. On 10 April 2003, an incident occurred in the course of operations to clean fuel assemblies, during a scheduled maintenance shutdown for Unit 2. Thirty fuel assemblies had been removed from the Unit 2 reactor and placed in a fuel cleaning tank approximately ten meters under water in a shaft adjacent to the fuel pool. The external surfaces of the fuel assemblies were being cleaned to remove depositions of magnetite from their cladding, using a specially designed chemical cleaning process [I-25 – I-27].

I–90. At 21:53[51] on 10 April 2003, workers detected an increase in the activity of ^{85}Kr, from a measurement system installed in the cleaning circuit. At about the same time, the instruments measuring the activity concentrations of noble gases in the reactor hall indicated that the ‘emergency level’ had been reached. The timeline of the different events during the incident is shown in Fig. I-5 [I-27].

Taking response actions and activating the site emergency response organization

I–91. Once the noble gas instruments in the reactor hall indicated that the emergency level had been reached, the plant shift supervisor ordered the evacuation of workers from the area. Initially, it was suspected that a fuel assembly was leaking as a result of the cleaning operation. However, several days later, a video inspection indicated that most of the fuel had suffered heavy damage. About 16−17% of the fuel material was located at the bottom of the cleaning vessel in the form of debris. Figure I-6 illustrates the extent of the damage and the location of fuel debris.

[51] All times are given in local time (due to the summer time system, this is UTC +02:00 hours).

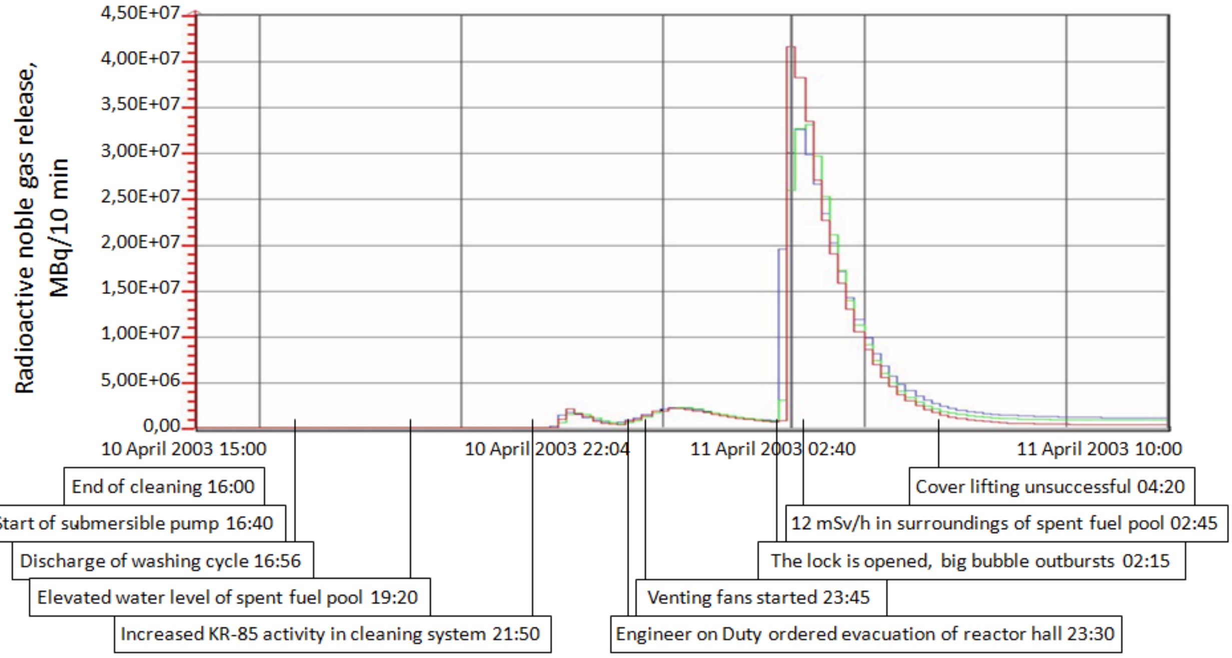

Fig. I-5. Timeline of events during the incident (courtesy of the Hungarian Atomic Energy Authority (HAEA) and the Paks nuclear power plant).

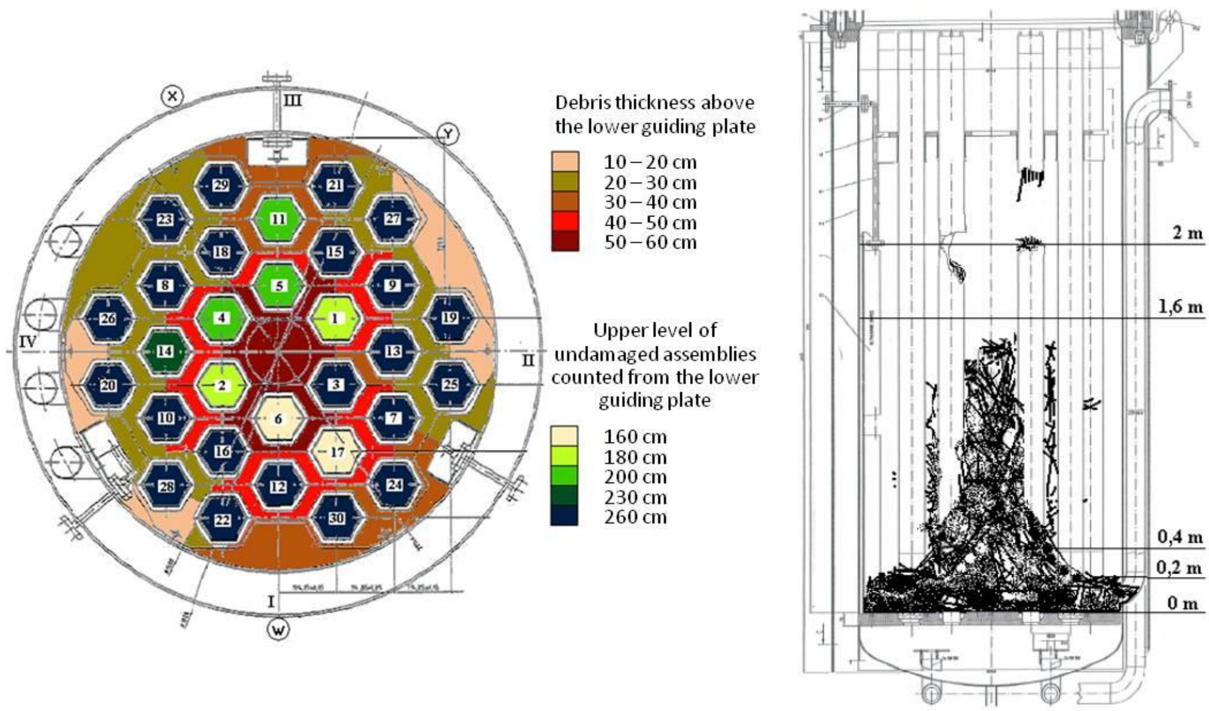

Fig. I-6. Extent of damage and location of fuel debris (courtesy of the HAEA and the Paks nuclear power plant).

I–92. The incident was of low significance in terms of its health impact. There was some increase in the release of radioactive noble gases to the environment compared to the normal operational situation. However, the rate of release initially exhibited a decreasing trend and did not approach the discharge limits. The shift supervisor (the primary head of the Site Emergency Response Organization —

SERO) evaluated the event on the basis of the site emergency response plan and decided that there was no need for immediate emergency response action or to alert of the SERO.

I–93. At 02:15 on 11 April 2003, the situation deteriorated. However, the version of the site emergency response plan valid at the time did not allow the event to be recognized as an accident on the basis of the conditions and information available at that time. .

I–94. The rate of the release of noble gases did not reach the level specified in the SERP as a threshold for classifying the event as accident. The readings from the monitors designed to detect radioiodine were distorted and increased by the release of noble gases, making the results difficult to interpret.. The assessment of samples and laboratory analysis would have provided more accurate information on the release of iodine. This form of measurement was carried out at around 07:45 on 11 April 2003. With full knowledge of the more accurate data on the magnitude and the form of release, the situation was revaluated in line with SERP. This confirmed the finding that the event did not constitute an accident. Nevertheless, at 12:40 on 11 April 2003, the shift supervisor decided to partially set up the SERO in order to provide a continuous control and evaluation of the situation. This SERO comprised a control team, communication organization and a radiation situation evaluation group. It functioned according to the relevant procedures until 16:00 on 13 April 2003, when its operation was terminated.

I–95. After removal of the tank cover and completion of the visual inspection of the fuel assemblies within the tank, the SERO was fully reactivated at 22:30 on 16 April 2003 and remained in operation until 09:00 on 20 April 2003. In general, the assessment of the situation and the operation of the SERO were performed in compliance with the requirement for providing information to, and supporting decision making of, local off-site organizations. The SERO operated in partial response mode (comprising the management group, radiological assessment group, staff support group and technical support group) at the emergency response centre and continuously evaluated the situation, kept in contact with authorities and exercised readiness for full activation if the situation deteriorated.

I–96. The operator had on-line access to a network of nine continuously operating environmental gamma dose rate monitors located around the Paks nuclear power plant. Results from these monitors were also available to off-site authorities. The monitors had an alert level (500 mSv/h) based on the average dose rate over a ten minute period. The ten minute average level was not exceeded during the incident, but the dose rate at one monitor rose significantly during the peak in the initial release. The operating personnel at the site did not notice this change at the time, when it could have provided additional information about the nature of the release. Operating staff at the Paks nuclear power plant noted that they were faced with significant amounts of other information, which was a contributing factor to the inability to fully understand the situation at the time [I-25]. In addition, there were no specific plans in place for dealing with such releases.

Recovery operations

I–97. The continuous cooling of the cleaning tank was ensured by the use of an auxiliary cooling system, which was installed on 17 April 2003. In addition, continuous monitoring of the cleaning tank and its immediate surroundings was performed. Three days later, a plastic foil 'greenhouse' was built above the pond accommodating the cleaning tank. The air space within the greenhouse was subject to continuous analysis and purification. From 12 April to 20 April 2003, between 40 and 80 workers per day performed work in the reactor hall., Workers wore personal protective equipment consisting primarily of protective clothes, compressed air breathing apparatus and gas masks with iodine filters, depending on their workplace within the hall. Working hours were limited to ensure that dose limits for normal operation were not exceeded.

I–98. Professional teams involving specialists in, for example, reactor physics, hydrodynamics and technical logistics, were established to determine the safest options for recovery. Their work was supported by competent specialists from Hungarian universities and research institutes and by engineers from Germany. In addition, representatives of the Russian fuel manufacturer arrived at Paks in May 2003. The final solution for recovery, which involved the removal of the damaged fuel assemblies, the provision for long term cooling and storage, was the outcome of a major refurbishment effort. An autonomous cooling system and an emergency boron system for the service pool were established during the first half of 2004. For the recovery from the incident, the Paks nuclear power plant established a working group (called the Recovery Project), which was charged with the design of, preparation for and conduct of the removal of the damaged fuel. This group had previously been charged with the normalization of the state of the system, and the preparation for and licensing of the recovery operations [I-27]. The licensing documentation was submitted to the Hungarian Atomic Energy Authority (HAEA) in November 2004. The HAEA issued a license for recovery operations in the service pool based on the licensing documentation in July 2005. Manufacturing licences for cases and containers for the storage of the damaged fuel assemblies and solid radioactive waste were issued in March 2006. Authorization for the removal of damaged fuel was granted in September 2006.

I–99. During the normalization of the system's status, the following main steps were taken [I-27]:

— Separation of the refuelling pit with the damaged cleaning tank and the spent fuel pool from the reactor;
— Increase of the boric acid concentration in the refuelling pit to 20 g/kg;
— Development of the safety borating system for the cleaning tank;
— Construction of an independent cooling system for the cleaning tank;
— Separation of the refuelling pit from the spent fuel pool;
— Installation of redundant temperature, coolant level and neutron measurement instrumentation in order to provide the refuelling pit with an independently operated instrumentation and control (I&C) system;

— Detailed visual exploration of the state and geometry of the damaged fuel assemblies and the cleaning tank.

I–100. Several criteria were used to ensure that workers' exposures, surface contamination and activity concentrations in air during recovery operations were consistent with those for normal operation. The plant radiation protection code listed these criteria as well as the situations in which the use of personal protective equipment (such as protective clothes, breathing apparatus and gas masks) was necessary; it also provided information on how to use the equipment.

I–101. In planning for radiation protection measures, it was necessary to determine the radiological situation inside the reactor hall. The activity of radionuclides accumulated in the fuel assemblies was calculated on the basis of the time the assemblies had spent in the reactor and some other parameters influencing the burnup of fuels. To validate the model calculations, gamma dose rate measurements were performed at several locations inside the cleaning tank with a gas ionization detector.

Monitoring and assessment

I–102. Following the incident, several activities were undertaken to monitor and assess the situation in detail and to confirm its stability. This also included assessments of the characteristics of the release to the environment.

I–103. National arrangements included a national radiation monitoring and warning system (NMWS) comprising organizations participating in the emergency response system and other professional organizations. The system was intended to be activated in the event of a radiation emergency and to operate to support the availability of the information necessary for decision making.

I–104. In order to improve understanding and assessment of the radiological situation, a coordinated environmental monitoring survey was initiated with the involvement of the NMWS. The objectives of the monitoring activities were to collect and evaluate detailed information on the radiological situation in the areas surrounding the Paks nuclear power plant in order to assess whether there was a need for any off-site protective actions and to provide authentic, trustworthy and timely information to the public. In addition, the Hungarian Meteorological Service provided trajectories of the likely dispersion and distribution of radioactive material over the territory of Hungary. Mobile laboratories of different organizations were involved in measuring the ambient gamma dose rates, and the system of fixed laboratories provided grass, soil and water samples and in-situ measurement results from various locations in Hungary. The increased measurement campaign continued for the entire period of the incident, from 11 to 26 April 2003. The following figures show, respectively, the results of the extensive radiological measurement and assessment activities: Fig. I-7 presents estimates of the noble gas release, Fig.I-8 presented estimates of the ^{131}I equivalent release and Fig. I-9 the estimated airborne releases; Fig. I-10 presents the ^{131}I equivalent activity in different plants in central Hungary; and Fig. I-11 shows the results of the same measurement types for the region surrounding Paks (all figures courtesy of the HAEA and the Paks nuclear power plant).

I–105. Based on the measurement results and the assessment of the situation following the incident, it was concluded that no significant release of radioactive material to the environment had occurred and no actions were needed for the protection of the public in the region surrounding the Paks nuclear power plant.

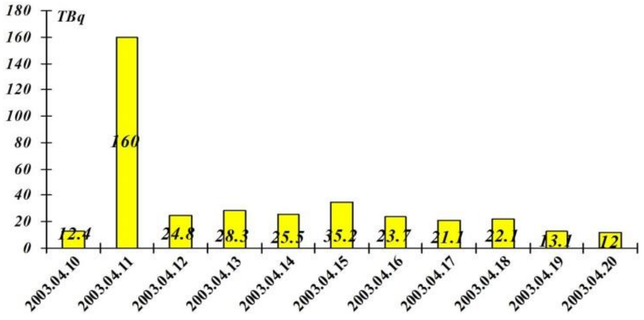

Fig. I-7. Noble gas release.

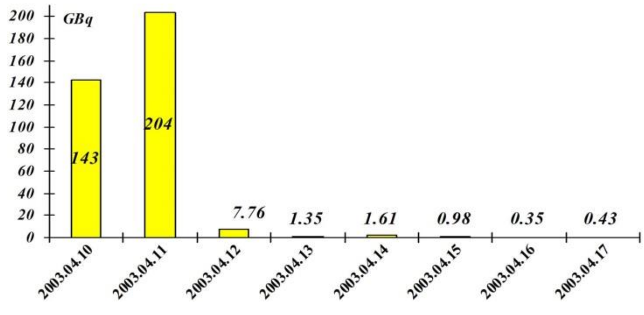

Fig. I-8. ^{131}I equivalent release.

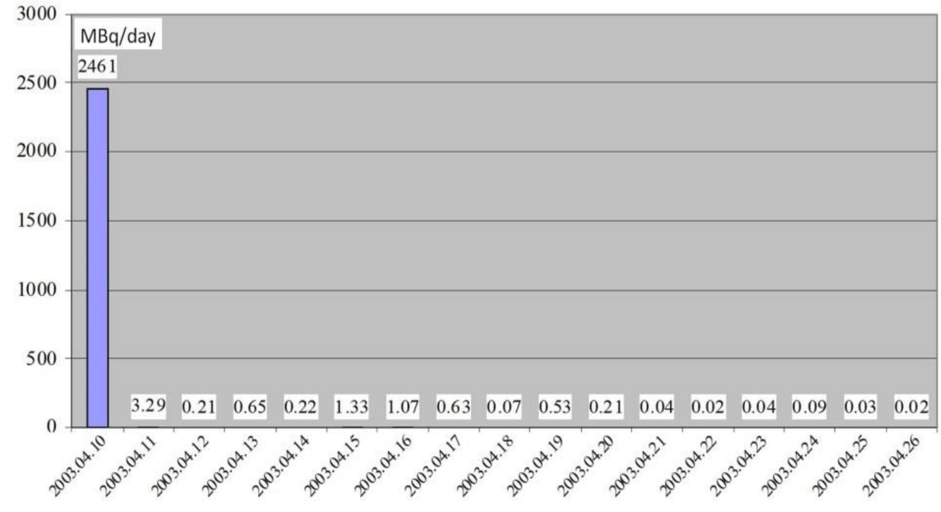

Fig. I-9. Airborne release.

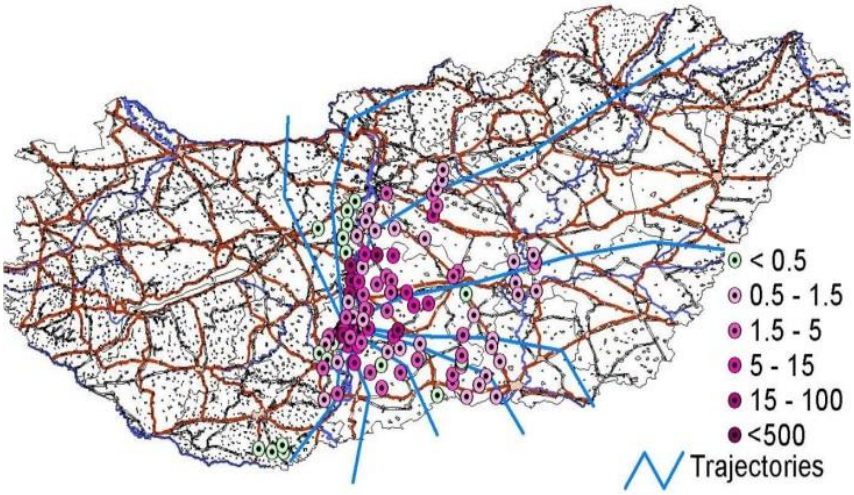

Fig. I-10. ^{131}I equivalent activity in different plants in central Hungary [Bq/kg fresh weight].

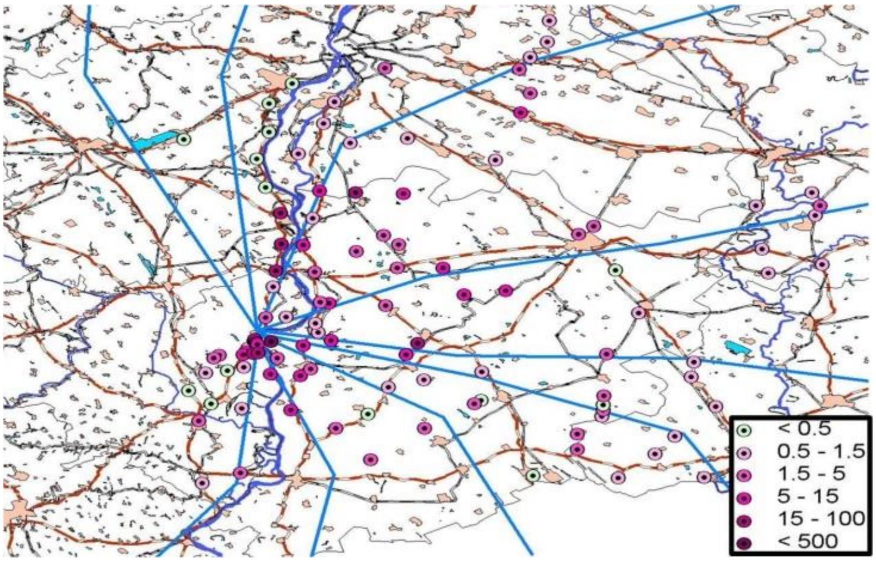

Fig. I-11. ^{131}I equivalent activity in different plants in the region surrounding Paks [Bq/kg fresh weight].

I–106. From 16 April 2003, the HAEA conducted model calculations to assess the doses to members of the public due to the release of radioactive material to the atmosphere. The source term was provided by the operator of the Paks nuclear power plant. Initially, it was assumed that only a few fuel pins had been damaged. However, further calculations concerning the total amount of noble gases, iodine and fission products released indicated that this was not the case. This subsequent information, and evidence from a video recording of the interior of the cleaning tank, led the HAEA and the operator of the Paks nuclear power plant to conclude that most, if not all, of the fuel rods had been damaged in the incident.

I–107. The operator estimated the type and quantity of the release. Essentially, it consisted of:

— A few hundred TBq of noble gases, mostly ^{133}Xe (half-life of 5.2 days) — see Fig. I-7.

— A few tens of TBq of radioiodine, mostly ^{131}I (half-life of 8 days) — see Fig. I-8.

— Less than 1/100th TBq of other radionuclides, principally ^{134}Cs (half-life 2 years) and ^{137}Cs (half-life of 30 years) — see Fig. I-9.

I–108. The assessment of doses indicated that the radiological consequences of the incident were low. Doses to workers were maintained well within the limits set out for normal operation. Doses to members of the public were a very small fraction of the relevant dose limit and less than the dose from exposure due to natural background radiation for one day.

I–109. Data provided by the Paks nuclear power plant staff were collected and evaluated independently by the regulatory body. No obvious discrepancies between expectations, data and model calculations were found. The data collected by the various bodies and agencies appeared to be consistent. For these reasons, no further detailed checks were performed on the dose assessment provided by the Paks nuclear power plant.

Protection of emergency workers and recovery workers

I–110. Appropriate procedures were followed to minimize the individual and collective doses to workers involved in the management of the incident. Dosimetry control, personal protective equipment, work order management, training and education on relevant activities were employed for that purpose. The need for dose estimation and for medical consultation was also considered.

I–111. Attempts to lift the lid of the cleaning tank, which started at 00:21 on 11 April 2003, required the presence of two framatome advanced nuclear power operators — a crane operator, a fuel handling machine operator — as well as a member of the dosimetry control staff from among the Paks nuclear power plant personnel.

I–112. All personnel present were equipped with respirators connected to an external oxygen supply. The crane operator had a full beard underneath his respirator. He had not received formal training in the use of a respirator prior to the incident but was instructed at the time.

I–113. As part of the routine checks for contamination at the exit point from the reactor area, external contamination above the prescribed maximum level for normal operation was detected on the crane operator. He was decontaminated by repeated showering, followed by shaving off his beard and cutting his hair. These activities reduced his external contamination levels to below the prescribed levels.

I–114. The operator implemented a programme for monitoring intakes of radionuclides by personnel present at the site during the incident, prioritizing on the basis of the potential for intake. The first measurements were performed in the morning of 11 April 2003. Over 600 personnel were measured using the whole body counter located at the Paks nuclear power plant. Only seven personnel had received intakes that indicated assessed doses of close to or above 0.1 mSv. Whole body monitoring of relevant personnel was also performed at the National Frederic Joliot Curie Radiobiology and Radio-diagnostic Research Institute (OSSKI). The two sets of results were consistent. Committed effective doses from inhalation of radionuclides ranged up to approximately 1 mSv. The crane operator received the highest committed effective dose from intakes [I-26]. From the records reviewed, the highest doses from external gamma radiation, received by staff and contractors at the Paks nuclear power plant during and after the incident, were in the range of 7 mSv.

Communication and consultation with authorities and the public

I–115. With respect to emergency preparedness, the respective responsibilities of the HAEA and the operator appear to have been well defined and there was no evidence to suggest that a lack of understanding of these responsibilities contributed to the impact of this incident.

I–116. The public was informed of the incident in the early hours of 11 April 2003. Thereafter, there was an emphasis on providing communications to the population of Paks and the regions in the vicinity of the plant. All locally available channels were used for this purpose. As new details became available, countrywide bulletins were issued. In addition, a number of press conferences were given. These channels generally provided objective and correct communications.. The Paks nuclear power plant answered all enquiries and accepted all requests for interview received from the press.

I–117. Two media releases were issued by the plant operator on 11 April 2003. The second one classified the incident as level 2 on the IAEA’s International Nuclear and Radiological Event Scale (INES). The IAEA was informed on 17 April 2003, once the actual state of the fuel assemblies had been discovered, even though there was no obligation to do so under the Convention on Early Notification of a Nuclear Emergency. However, the use of the INES levels, which is intended to help to explain the severity of an emergency situation to the public, actually undermined the credibility of the authorities in this case. On 11 April 2003, the operator proposed, and the HAEA approved, the INES level 2 classification of the incident. On 17 April 2003, after the lid had been opened and a visual inspection of the fuel had revealed the full extent of the damage, the INES level was revised to level 3. Although this revision was correct, it created a public perception that either the incident was getting worse or the authorities had not communicated fully in the first instance [I-26].

I–118. According to national requirements included in the national emergency plan and the facility emergency plan there was no need to warn the public of possible protective actions, given the nature of the hazard. However, the incident was immediately communicated to the mayors of the communities within a 30 km radius of the plant via a special SMS system provided for this purpose, in order to allow them to answer any questions that may arise.

I–119. A press conference was held in the reactor hall of Unit 2 on 22 April 2003, and the Chairman of the Environmental Committee of the parliament was received at the plant on 27 April 2003 by the Chief Executive of the Paks nuclear power plant. On the following day, a number of parliamentary representatives accepted the invitation for an information meeting. On the same day, the Chief Executive met the mayors of the 13 neighbouring communities and the representatives of civilian organizations, who also visited the reactor hall.

I–120. The managers of the company also attended public hearings and meetings of local councils and regional associations during the several months following the stabilization of the situation.

Investigation of the incident

I–121. The designers of the nuclear power plant had not expected that the fuel cleaning process could lead to an accidental release of radioactivity, and certainly not on the scale observed during the incident. A series of independent national and international investigations were conducted in order to understand the circumstances that led to the incident in order to draw conclusions for improving operational and emergency arrangements and to avoid a repetition such an event [I-25 –I-27].

I–122. According to regulatory requirements, the operator of the Paks nuclear power plant was required to conduct an investigation of the incident and to submit the investigation report to the HAEA. In parallel with this investigation, the HAEA also conducted an independent investigation, in line with its internal procedures. The HAEA investigation report was available and approved by the Director General of the organization on 29 May 2003 [I-25].

I–123. Considering the seriousness of the incident, the Hungarian parliament also appointed a parliamentary committee to investigate the causes of and responsibilities for the incident. This committee submitted its report to the Hungarian parliament by the end of 2003.

I–124. The Hungarian government also invited an expert mission of the IAEA to assess the results of the HAEA investigation of the incident. The expert mission took place from 16 to 25 June 2003 and made several suggestions and recommendations for the improvement of the operation of the Paks nuclear power plant and the functioning of the regulatory system [I-26].

I–125. The Paks nuclear power plant invited an Operational Safety Review Team (OSART) follow-up mission from 21 February to 1 March 2005 [I-26]. The mission focused primarily on the implementation of suggestions and recommendations formulated during the previous OSART mission, which took place from 8 to 25 October 2001 and the expert mission of the IAEA referred to above [I-26].

Revision of emergency arrangements following the incident

I–126. Following the IAEA expert mission, the Paks nuclear power plant prepared an action plan to address deficiencies identified in the following areas: management system; regulatory oversight; design; fuel cleaning operation; radiation protection; and emergency planning and preparedness. The action plan specified tasks and deadlines and was approved by the HAEA. Actions aimed at improving the arrangements that related to emergency preparedness and response were implemented by the Paks nuclear power plant by 2006 and included the following [I-26]:

— The emergency classification scheme was revised to ensure that it covered all potential alert events and emergencies at the Paks nuclear power plant. The classification scheme included Emergency Action Levels (EALs) and Readiness Action Levels (RALs)[52] based on measured parameters. A comprehensive review of the plant hazard assessment was conducted to ensure that all potential accident sequences had been identified.
— The site emergency response plan was revised to include a procedure that took account of the revised emergency classification scheme and postulated emergency scenarios.
— The internal regulation on technological modifications at the Paks nuclear power plant was revised to ensure that it covered interactions between the site emergency response plan and the impact of planned modifications. With this revision, it was necessary to conduct an analysis of

[52] RALs represent initiating levels for a new operational mode introduced for the Hungarian Nuclear Emergency Response System (referred to as Readiness Operational Mode) when no public protective actions are warranted but when coordination may be needed in the operation of the NRMWS, in consequence assessment as well as when extensive public information may need to be provided.

the emergency related aspects of modifications before any decision on such modifications could be made.

- Verification and/or validation of the new Paks Release and Environmental Monitoring System related to critical parameters for emergency detection and classification was conducted. Actions were then taken to improve the system to better support emergency alert and notification activities.
- The emergency preparedness section was required to participate in preparatory training for operative personnel on new safety-relevant activities, together with all contractors.
- The competent organization of the Paks nuclear power plant, which was responsible for the general management of emergency preparedness, was also involved in the assessment of the contractors' emergency procedures.
- Involvement of dosimetry control staff in the conduct of unanticipated drills or exercises.
- In addition, the Paks nuclear power plant decided to ensure that:
  - Emergency kits (containing gas masks, iodine tablets, breathing equipment, fire-fighters' clothes and personal dosimeters) for operating personnel were to be available in each operational room.
  - Field training on the application of breathing apparatus (for respiratory protection) was to be adopted in relevant procedures for urgent protective actions.
  - Training and field first aid tasks were to be fulfilled by facility fire brigade personnel.

Authorization for continuing normal operation

I–127. As a consequence of the incident, the conditions for safe operation could not be met and the operator of the Paks nuclear power plant could not complete its planned refuelling in April 2003. The following major activities were planned to be completed in the 2003–2004 period to recover conditions for safe operation:

(a) Assure sub-criticality and cooling of the fuel debris structure;
(b) Decontaminate internal surfaces of the primary circuit;
(c) Re-establish conditions for conducting refuelling; and
(d) Assure safe conditions for the long term storage of fuel debris.

I–128. These activities were implemented under the supervision of the HAEA. For each major step, a licence application was submitted by the operator of the Paks nuclear power plant to the HAEA, and a formal authorization process was conducted. Finally, when all safety conditions and regulatory requirements had been met, a new operational licence was issued for Unit 2 to restart operation in September 2004.

I–129. Other series of activities were aimed at: the removal of the fuel debris from the chemical cleaning vessel; the establishment of the safe conditions for storing the removed fuel debris; the removal of the chemical cleaning vessel from the service pool in order to re-establish safe operation in the service pool, which was an integral part of the pool system of Unit 2. In early 2004, at the beginning of these activities, the HAEA issued regulatory requirements for nuclear and radiation safety and security and for the management system of all recovery works and operations. . The unique nature of the incident required an overview of the wide range of existing requirements at national and international levels, and the derivation of further requirements in some cases. The removal and recovery process was designed, planned and implemented by several domestic and international expert organizations, providing support to the Paks nuclear power plant operational staff and also independently to the HAEA. The operator of the Paks nuclear power plant was required to regularly submit reports on the progress of the recovery operations. At the end of the authorization process, licences were issued to produce and use debris fuel containers, to utilize various kinds of technical equipment necessary for the removal activities, and to remove the fuel debris and the chemical vessel. All recovery operations were conducted by the end of 2007.

Conclusions

I–130. The fuel cleaning incident occurred on 10 April 2003 during a scheduled maintenance shutdown. Thirty fuel assemblies had been removed from the Unit 2 reactor and placed in a fuel cleaning tank under water in a shaft adjacent to the fuel pool. The plan was to remove magnetite deposition on fuel cladding by means of a specially designed chemical cleaning process.

I–131. An increase of activity within the reactor hall was detected by the workers. Once the noble gas monitors in the reactor hall had indicated that the emergency level had been reached, the evacuation of workers from the reactor hall was ordered. Although the airborne release increased compared to the normal situation, it exhibited a decreasing tendency, and according to the data available, did not approach the national prescribed discharge limits. When all of the information and release data had been collated and reviewed, the situation was re-evaluated and it was confirmed that the event did not constitute an accident.

I–132. After the incident had been identified, the SERO was partially set up in order to provide continuous control and evaluation of the occurrences. The SERO operated according to the relevant procedures until 13 April 2003, when its operation was terminated. After the removal of the tank lid on 16 April 2003, the extent of the damage to the fuel assemblies within the tank was recognised and the SERO was re-activated. This status was maintained until 20 April 2003. During this period, the SERO operated in partial response mode at the emergency response centre and continuously evaluated the situation, kept contact with authorities and exercised readiness for full activation if the situation would get worse.

I–133. During the recovery operations, professional teams involving specialists from various fields of expertise were established to identify alternatives for recovery. An autonomous cooling system and the emergency boron system for the service pool were established during the first half of 2004.

I–134. A coordinated environmental monitoring survey was initiated in order to assess the radiological situation in the areas surrounding the Paks nuclear power plant, to determine whether any off-site protective actions were needed, and to provide authentic, trustworthy and timely information to the public. The survey covered the entire period of the incident from 11 to 26 April 2003. Based on the measurements results, and the assessment of the situation following the incident, it was concluded that no significant release had occurred and that no actions were needed for the protection of the public..

I–135. Appropriate procedures were followed to minimize the doses to workers involved in the management of the incident (e.g. collective and personal protective measures) and to keep the worker doses within the occupational dose limits for normal operation. Dose estimation and medical consultation for workers were also considered.

I–136. According to national requirements and the nature of the hazard, there was no need to warn the public of impending protective actions. However, the incident was immediately communicated to the mayors of communities within a 30 km range of the power plant. The public was informed of the incident in the early morning of 11 April 2003. Particular emphasis was placed on public communications and all locally available channels of communication were used for this purpose.

I–137. A series of independent national and international investigations was conducted following the incident to determine its causes and the circumstances that led to it, in order to draw conclusions for improving operational and emergency arrangements and for avoiding a repetition of such an event in the future.

I–138. As a consequence of the incident, the Paks nuclear power plant could not complete its planned refuelling in April 2003 and a series of activities was planned to reestablish the conditions for safe operation, to be completed in the 2003–2004 period. These activities were implemented under the supervision of the HAEA.

I–139. In a retrospective analysis of the event, the specific phases and their timing are represented in Fig. I-12, as they can be associated with different phases described in Section 2 of this Safety Guide. The emergency started on 10 April 2003, when limited urgent protective actions on the site to protect the personnel present were required. This state lasted from 11 April to 20 April 2003, when efforts focused on assessing the situation and its severity by undertaking various activities. During this period, all necessary measures were taken to ensure continuous cooling and monitoring of the damaged fuel and stabilization of the situation. Until 26 April 2003, the monitoring and assessment efforts continued to confirm the stability of the situation. The damaged fuel was brought under control, and the consequences on-site as well as off-site were in the process of being assessed. Following this period, beginning in May 2003, further planning for the recovery and investigation of the circumstances that led to the incident were carried out. As a result, in the second half of 2004, the Paks nuclear power plant was able to resume normal operation in compliance with national regulations. The public did not experience a new exposure situation resulting from this incident.

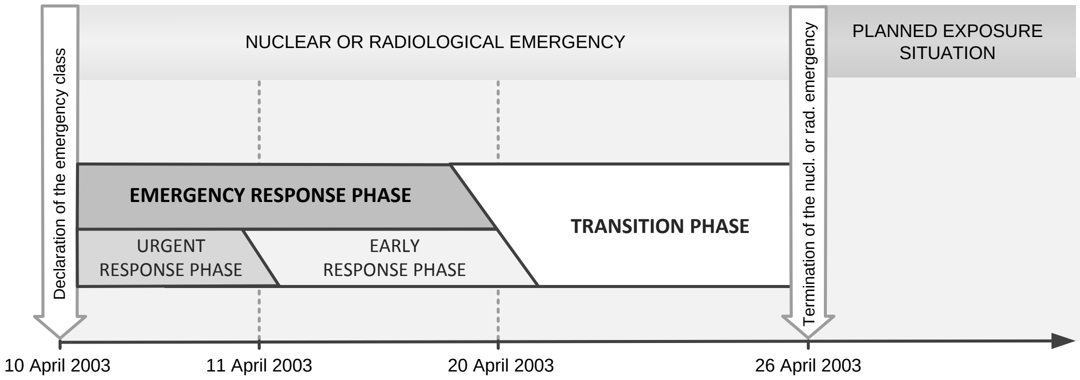

Fig. I-12. Retrospective sequencing and milestones of the Paks fuel damage incident.

I–140. The results of an analysis of the case study with regard to the fulfilment of the prerequisites for the termination of a nuclear or radiological emergency, contained in Section 3 of this Safety Guide, are presented in Tables I-6 and I-7. These tables reflect the situation that existed on 26 April 2003 (see Fig.I-12), which is the date at which the retrospective analysis indicates that the conditions for termination existed.

TABLE I-5. STATUS WITH RESPECT TO THE GENERAL PREREQUISITES FOR TERMINATION OF AN EMERGENCY FOR THE PAKS FUEL DAMAGE CASE STUDY

General prerequisite	Status with respect to the prerequisite
Had the necessary urgent and early protective actions been implemented?	Evacuation of workers from the reactor hall area was completed immediately following the detection of emergency levels of noble gases. Assessment results indicate that no other protective actions needed to be implemented for other site personnel or for members of the public.
Was the exposure situation stable and well understood?	In order to develop a more detailed understanding and assessment of the radiological situation, various activities were carried out in a coordinated manner. This resulted in an adequate estimation of the release source term. The airborne releases were continuously monitored and the reduction and stability of the levels were confirmed within the first week after the onset of the incident.
Was the radiological situation well characterized, and were the exposure pathways identified and doses assessed for all the affected people?	The radiological situation was well characterized, potential exposure pathways were identified and doses were assessed for potentially affected people. Assessment of doses showed the radiological consequences of the incident were of low significance.
Was the source of exposure brought under control, and were no further significant accidental releases or exposure expected due to the event?	After lifting of the cover of the cleaning tank, the possibility of further radioactive release was recognized and the SERO was partially re-activated. The SERO managed the situation and focused on preventing further releases. An important measure in this regard was the establishment of a plastic foil greenhouse above the pond accommodating the cleaning tank on 20 April 2003.

General prerequisite	Status with respect to the prerequisite
Was the current situation assessed, and were the existing emergency arrangements reviewed and new arrangements established?	The SERO continuously assessed the situation and the possible impacts on the plant safety measures and on emergency arrangements. Several independent assessments were also conducted in 2003. As a result, the operator of the Paks nuclear power plant reviewed on-site emergency plans and prepared an action plan to address necessary corrective measures and to revise the emergency arrangements. The necessary improvements were implemented by 2006.
Were the requirements for occupational exposure during a planned exposure situation confirmed for all workers engaged in recovery activities?	Due to the nature of the hazard, it was possible to conduct all response actions and the recovery operations were conducted within the dose limits for normal operations. Various measures were implemented to monitor the doses received by recovery workers. Personal external dosimeters were provided for anyone entering the main operational areas of the site. A film badge, distributed and evaluated by the radiation protection authority, provided the legal dose measurement. A thermoluminscent (TL) dosimeter was also provided for the recovery workers by the Paks nuclear power plant. People entering the reactor areas also received an electronic dosimeter. Reactor operation and maintenance personnel were equipped with TL neutron dosimeters. Contractors also wore their own dosimeters. Dosimetric data from external monitoring of the contractor and the Paks nuclear power plant staff on-site were collected and recorded. Results were provided from the dosimeters of the workers involved in the incident. Results were found to be consistent.
Was the radiological situation assessed against reference levels, generic criteria and operational criteria, as appropriate?	The radiological situation was assessed against the different response criteria, and it was concluded that none of them had been exceeded. The doses assessed remained within the dose limit for normal operation for both the public and the workers.
Were non-radiological consequences (psychosocial, economic) and other factors (technology, land use options,	The off-site radiological consequences of the incident were of low significance. No specific actions were taken to reduce the off-site non-radiological impact, except for the

General prerequisite	Status with respect to the prerequisite
availability of resources, community resilience) identified and considered?	provision of timely and consistent public information. On the other hand, increased pressure from the media was observed during the first few weeks after the incident. An ad-hoc public information policy was launched for the Paks nuclear power plant, the HAEA and the National Directorate General for Disaster Management in order to harmonize the ways of communicating with the public and the content of the information provided. The HAEA regularly uploaded public information articles about the results of assessments and measurements on to its website. A major contributor to the non-radiological consequences on the site was the economic loss sustained. One component of the economic loss was the damage to the fuel assemblies, which, if undamaged, could have been used for electricity production. Another component was the prolonged shutdown of the Unit 2, which lasted about 1.5 years, with no generation of electricity. The third component was the expense associated with the reestablishment of safe operating conditions of Unit 2, especially given that the service pool was unavailable. The fourth major component arose in relation to the costs of the removal of the fuel debris and the cleaning vessel and the establishment of safe storage conditions for the damaged fuel.
Was a registry of those individuals requiring further medical follow up established prior to the termination of the emergency?	Doses to members of the public and workers were within the dose limits for normal operation. Therefore, there were no individuals requiring any medical treatment or further medical follow up following the incident.
Was a strategy for the management of radioactive waste arising from the emergency, when appropriate, developed?	The Paks nuclear power plant had (and has) in place internal regulations and a general strategy for the management of radioactive waste arising from in normal operations and emergencies. During the incident, the plant was confronted with a new situation for which standard solutions were not available. After the initial measures, the operator of the Paks nuclear power plant introduced a recovery plan in 2004, which established dedicated strategies for the management

General prerequisite	Status with respect to the prerequisite
	of radioactive waste and the development of the storage areas as needed. The radioactive waste generated during the time of recovery works was managed by applying this strategy. The Paks nuclear power plant completed the corrective action plan by the end 2006.
Were the interested parties consulted?	In case of abnormal conditions, off-site authorities receive information within two hours after detecting the abnormal event, and this information is thereafter updated within 24 hours. During this incident, the authorities required information from the operator with greater frequency and detail. The public was also informed promptly. The IAEA was informed on 17 April 2003, after the actual status of the fuel assemblies had been discovered, even though there was no obligation under the Convention on Early Notification of a Nuclear Accident to do so. Due to the nature of the hazard, the incident did not warrant consultation with interested parties other than the off-site authorities, technical support organizations and scientific institutions. Consultation was initiated as early as possible following the incident to assess the situation as well as to plan the recovery operations.

TABLE I-6. STATUS WITH RESPECT TO THE SPECIFIC PREREQUISITES FOR TRANSITION TO A PLANNED EXPOSURE SITUATION FOR THE PAKS FUEL DAMAGE CASE STUDY

Specific prerequisite	Status with respect to the prerequisite
Were the circumstances that led to the emergency analysed and corrective actions identified?	The SERO of the Paks nuclear power plant investigated the circumstances that led to the incident to identify the causes and any necessary improvements in existing arrangements. Additional, independent investigations and missions (including from the IAEA) were carried out in 2003.
Was an action plan developed for implementation of corrective actions by the respective authorities?	Based on the outcomes of the specific investigations, corrective actions in various areas were identified. An action plan was developed to address the findings, to identify corrective actions to be implemented and to identify lessons

Specific prerequisite	Status with respect to the prerequisite
	for improving the existing arrangements. All the findings were addressed in the period 2004–2007. A set of corrective actions in relation to the management and operation of the Paks nuclear power plant was required in the HAEA regulatory resolution. The HAEA then followed the implementation of the corrective actions before issuing an operational licence in September 2004. The status of the implementation of these corrective actions was also reviewed during several international follow-up missions.
Were the conditions assessed to ensure compliance with the safe and secure handling of the sources in accordance with the national requirements set forth for the respective planned exposure situation?	Due to the unique nature of the damaged fuel debris, specific regulatory requirements for nuclear and radiation safety and security and for the management system of all recovery works and operations was established and issued by the HAEA. Compliance with these requirements was assessed throughout the recovery operations.
Was there a necessity for administrative procedures to limit or prevent any use or handling of the source until a better understanding of the circumstances that led to the emergency had been obtained?	The refuelling, planned for April 2003, was halted until it could be carried out safely, following the necessary recovery work. This work was conducted according to plans and specific instructions so that the work could be carried out safely and securely as a normal operation. Finally, following the compliance with all the regulatory requirements for the safe operation of Unit 2, a licence was granted to the operator to resume normal operation.
Was compliance with the requirements for dose limits for public exposure in planned exposure situations confirmed?	Doses to members of the public were continuously assessed. It was confirmed that the doses remained below the dose limits for members of the public in normal operation, throughout the incident.

THE RADIOLOGICAL INCIDENT IN HUEYPOXTLA, MEXICO STATE, MEXICO[53]

I–141. At 08:13 local time[54] on 2 December 2013, the Mexican nuclear regulatory body, the Comisión Nacional de Seguridad Nuclear y Salvaguardias (CNSNS), received a notification from a

[53] This summary has been drafted by the National Commission for Nuclear Safety and Safeguards of Mexico on the basis of internal records related to the incident and does not include nuclear security considerations in relation to the incident.

worker, from a company authorized to transport radioactive material, about the theft of a vehicle transporting the head of a teleteraphy unit containing a ^{60}Co source (see Fig. I-13). The approximate activity of the source was estimated to be 111 TBq[55]. The vehicle was stolen from a gas station near Tepojaco, in the municipality of Tizayuca, in Hidalgo State. The source belonged to the Mexical Social Security (a hospital) from the city of Tijuana, Baja California State, and was being transported to the radioactive waste storage facility located near the town of Santa María Maquixco, Temascalapa municipality, Mexico State.

I–142. Following the notification, CNSNS personnel contacted the transport company to validate the information and to investigate the circumstances under which the incident had occurred. At that point, CNSNS learned that, at approximately 02:00 on 2 December 2013, a group of armed individuals assaulted the driver of the vehicle, who had been resting at the gas station, before taking the vehicle together with the radioactive source.

Fig. I-13. Vehicle transporting the teletherapy unit with ^{60}Co (Credit: CNSNS).

Emergency declaration and urgent protective actions

I–143. The CNSNS personnel reviewed their databases to obtain more precise information about the stolen radioactive source, including its activity (95.24 TBq); the serial number of the source and the characteristics of its shielding They then drafted an information bulletin for distribution by the Civil Protection Agency, which described the incident, the potential risks of handling the radioactive source, the immediate actions to be taken by responders and the public, should they encounter the source, and the telephone numbers to contact if the source was found. This bulletin was transmitted on 2 December 2013 at 13:00 to the governments of the states of Hidalgo, Veracruz, Puebla, Tlaxcala, Mexico City, Mexico State, Querétaro and San Luis Potosí, as well as the Federal authorities. Later, the IAEA was also informed via the Unified System for Information Exchange in Incidents and Emergencies (USIE).

[54] All times in the case study are local time (UTC−6).

[55] Based on this activity, the ^{60}Co source falls in category 1 of radioactive sources in line with the Categorization of Radioactive Sources, IAEA Safety Standards Series No. RS-G-1.9, IAEA, Vienna, (2005).

I–144. Following the receipt of a communication from the army informing them that the vehicle had been found near the municipality of Hueypoxtla on 2 December 2013, the federal police sent officers to verify the information and to search the area for the radioactive source. A person from the community allowed the federal police officers to enter his house, where they found the empty shielding of the radioactive source in the backyard (see Fig. I-14); they reported their discovery to the CNSNS on 4 December 2013. On the same day, at approximately 08:00, CNSNS sent two teams equipped with vehicle-based radiation detectors to perform a search within a 10 km radius of the zone of the site, and the federal police searched locations in the municipalities of Tizayuca and Zumpango and the surrounding areas.

Fig. I-14. The empty shielding of the radioactive source (Credit: CNSNS).

I–145. The Federal Police officers detected unusual radiation levels in a corn field approximately 1 km from where the shielding had been found. The police then contacted the CNSNS to request that personnel be sent to search for the source and cordon off the area. The federal police and the army were asked to secure and guard the area in the meantime to ensure that only authorized personnel could enter it.

Isolation of the source

I–146. On 4 December 2013, CNSNS sent two teams from the CNSNS Radiological Contingencies Organization (OCR) to continue the search for the radioactive source. The federal police briefed the CNSNS staff about the possible discoveries in Hueypoxtla. The CNSNS staff analysed the photographs taken by the federal police officers and confirmed that the photographs appeared to be of an empty source container. The federal police guided the CNSNS staff to the areas where elevated radiation levels (ambient dose equivalent rates), exceeding 100 μSv/h, had been detected. They also assisted additional staff from CNSNS who were equipped with specialized equipment and arrived at Hueypoxtla by helicopter. With no lighting available, initial area monitoring was carried out quickly during the evening to identify the location of the radioactive source; the federal police was asked to control the access to this area in particular.

I–147. On 5 December 2013, the activities to delineate the areas exhibiting elevated radiation levels and to locate the source continued. Once the search perimeter of the source had been reduced sufficiently, CNSNS contacted CFE-Laguna Verde Nuclear Power Plant (CNLV) and the Ministry of the Navy (SM-AM) to assist in planning actions to recover the radioactive source.

I–148. On 6 December 2013, the CNSNS team at Hueypoxtla was reinforced by the arrival of staff from CNLV and SM-AM . CNLV staff entered the area previously identified by CNSNS and determined the approximate location of the source. The National Institute of Nuclear Research (ININ) was requested to provide a suitable container to contain the radioactive source for further transfer. Although such a container was not readily accessible, some adjustments to an available container were made to allow it to be used for the intended purpose.

I–149. On 7 December 2013, staff of CNSNS, CNLV, SM-AM and the federal police started planning to remove crops from the area by using a robot, belonging to the federal police, in order to be able to locate the source more exactly. On the same day, CNSNS received information that the person who had found the radioactive source was willing to indicate where it had been hidden. With the help of this person, the exact location of the source (which had previously been unshielded) was determined. CNLV and CNSNS staff asked the person about the amount of time he had spent near the source. They offered to give him a medical examination, but the person declined.

I–150. On 8 December 2013, staff of CNSNS, CNLV, SM-AM and the federal police returned to the area to continue the crop removal process remotely, so that the radioactive source could be more visible, rather than being hidden by crops. These tasks continued until the robot had a mechanical failure. The headquarters of CNSNS arranged for the transportation of the radioactive source after its recovery. In parallel, additional resources, such as concrete containers and lead blankets, were brought from CNLV facilities in Veracruz to help improve protection during transportation.

I–151. On 9 December 2013, CNLV personnel entered the area and finished the crop removal process, allowing the radioactive source to be seen (see Fig. I-15). The integrity of the source was confirmed. However, as repair work on the robot continued, alternative plans for the recovery of the source were necessary.

I–152. On 10 December 2013, the modified container arrived from ININ and the repaired robot also became available. The arrangements for the recovery of the radioactive source began on that day and included logistical support from the federal police and the Mexican Navy. The images taken by the robot camera confirmed that the source was intact and, after two attempts, the robot was able to hold the source, deposit it inside the container, which was then closed (see Fig. I-16). Following this, the CNSNS staff measured the radiation levels at the surface of the container and found very low levels. This was followed by a survey of radiation levels in the area in which the source had been found, and only background radiation levels were detected. An additional survey of the area was conducted on 13 December 2013, which confirmed these results.

Fig. I-15. Exposed radioactive source
(Credit: Federal Commission for Electricity of Mexico).

I–153. CNSNS, ININ, the federal police and the transport service provider agreed on the time, route and escort for the transportation of the radioactive source to the facilities of ININ at Ocoyoacac, Mexico State, where it was to be conditioned and stored, prior to its disposal at the ININ radioactive waste disposal facility in Temascalapa.

I–154. A dose limit of 50 mSv effective dose was set for the workers involved in the recovery process. The average dose received was less than 3 mSv, with the highest value at around 20 mSv.

Fig. I-16. Placing the source in the container using the robot (Credit: CNSNS).

Communicating with the public

I–155. On 4 December 2013, the public was informed by the Incident Command Group (ICG), consisting of representatives from CNSNS and the Ministry of Health, of the dangers of handling and being close to the source, although it was known to be located far away from any settlements. The ICG called on all those who may have been in contact with or in the immediate vicinity of the source to attend the hospital in Pachuca in order to have their doses estimated and to identify whether medical follow-up would be needed. Many enquires were received from villagers in Hueypoxtla regarding the status of the situation, the measures being taken and the progress of the operation. These queries were answered by a member of CNSNS staff at the scene.. However, as the situation showed signs of becoming unstable, the federal police discontinued this interaction by removing the representative of CNSNS from among the crowd.

Medical response and assessment of doses

I–156. On 8 December 2013, CNSNS contacted personnel from the Ministry of Health of the State of Veracruz (SSAEV), who acted as members of the external radiological emergency plan of CNLV, for support in examining individuals who may have been in contact with the radioactive source. The SSAEV contacted staff of the Ministry of Health (SSA) to ask for support in case it became necessary. The SSA confirmed the activation of its staff along with that of the SSAEV on 9 December 2013.

I–157. On 9 December 2013, representatives of SSA and SSAEV were accompanied by CNSNS personnel to the Hospital de Pachuca to begin examination of individuals who may have been exposed to the source. They then moved to Hueypoxtla to examine the individual who had assisted in locating the source and another individual who was believed to have had contact with the source in its shielded state. The second individual was found to have no symptoms of radiation exposure. The first individual was found with symptoms of radiation exposure on the left shoulder and right leg and was taken to the Hospital de Nutrición in Mexico City for treatment and follow up. No dose assessment for this individual was performed at that time.

I–158. On 10 December 2013, the SSA implemented a field investigation, questioning the people who were present at the site on the day the source had been found, reconstructing events and assessing the acute radiation exposure risk among these people. A total of 59 people who were presumed to have been exposed were identified. Within this group, 31 of the people were found not to have been present at the relevant dates and times. For 22 persons, a reconstruction of events was carried out in order to evaluate their possible exposure and to estimate the received doses, as a basis for assessing the acute radiation exposure risk.

I–159. On 13 December 2013, SSA and CNSNS requested ININ to perform biological dosimetry studies on 10 people, four of whom presented symptoms that could be associated with acute radiation syndromes.

I–160. On 15 December 2013, ININ performed the biological dosimetry studies of the 10 people, identified by the SSA, who were presumed to have been exposed. The findings indicated that only one person exceeded the limit, specified in the Mexican regulation to prevent non-stochastic effects among occupationally exposed personnel (500 mSv annual whole body effective dose).[56] This suggested that the person who had helped the Mexican authorities to locate the source was the only person who had handled the source after it had been removed from its shielding.

[56] Since, in the Mexican regulation, there are no exposure limits to the public in case of a radiological emergency, it was agreed to use the limit of non-stochastic effects for the occupationally exposed personnel.

Transition phase

I–161. On 4 December 2013, the area where the radioactive source had been found had been cordoned off, and a security perimeter had been established. The risk of members of the public being exposed by entering this area and handling the source had thus been minimized. The radioactive source was found to be intact in a cornfield at some distance from any settlements. The next six days were used for planning and preparation for the recovery of the source.

I–162. A dose criterion of 500 mSv was established for medical examinations and follow-up of members of the public who may have been exposed. A limit 50 mSv was also established for the personnel involved in the actual source recovery.

I–163. The person who had been in contact with the radioactive source, and had received a dose in excess of 500 mSv as a consequence, was transferred to the Hospital de Nutrición in Mexico City on 7 December 2013, for treatment and follow-up.

Conclusions

I–164. The Hueypoxtla accident served to demonstrate that a radiological emergency could occur outside of the licensed installations in Mexico. It also showed that such an emergency may arise as a consequence of security events that might not be directly related to radioactive material itself. The incident highlighted the need to care for all the members of the public who may be involved in such events, and to provide for their reassurance. As a consequence of this incident, the Mexican authorities concluded that such emergencies cannot be dealt with by a single agency and that it is necessary to develop a multi-agency plan for response to radiological emergencies, in which the responsibilities and resources of every agency are described and clearly defined.

I–165. In a retrospective analysis of the event, the specific phases and their timing are represented in Fig. I-17, as they can be associated with different phases described in Section 2 of this Safety Guide. The emergency started on 2 December 2013, when the vehicle transporting a dangerous radioactive source was stolen. The urgent response phase lasted until 4 December 2013, with a focus on the efforts to locate the source and to issue warnings and information to the public and the media. On 4 December 2013, the source was located in an area of Hueypoxtla. The source location was cordoned off to secure the source and to prevent any individual from being unnecessarily exposed, while allowing the authorities to further identify the exact location and status of the source. This phase lasted until 9 December 2013, when the crops surrounding the source had been removed. It was then visible and its integrity could be confirmed. Meanwhile, the plan for storing the source had been developed and organized, resulting in rapid recovery of the source and its transport for conditioning prior to final disposal on 10 December 2013. By this date, the monitoring activities to confirm the absence of contamination had been completed, and all individuals who may have been in contact with the source had been identified for dose assessment and medical follow-up. Thus, this milestone is considered to represent the termination of the emergency and the move to a planned exposure situation, related to the further management of the source as radioactive waste. No new exposure situation for members of the public arose as a result of this incident.

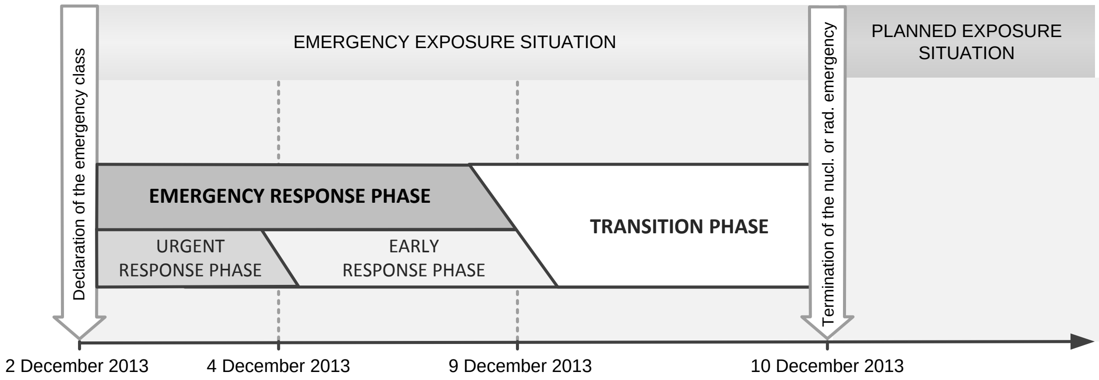

Fig. I-17. Retrospective sequencing and milestones of the radiological incident in Hueypoxtla.

I–166. The results of an analysis of the case study with regard to the fulfilment of the prerequisites for the termination of a nuclear or radiological emergency, contained in Section 3 of this Safety Guide, are presented in Tables I-8 and I-9. These tables reflect the situation that existed on 10 December 2013 (see Fig.I-17), which is the date at which the retrospective analysis indicates that the conditions for termination existed.

TABLE I-8. STATUS WITH RESPECT TO THE GENERAL PREREQUISITES FOR TERMINATION OF AN EMERGENCY FOR THE RADIOLOGICAL INCIDENT IN HUEYPOXTLA CASE STUDY

General prerequisite	Status with respect to the prerequisite
Had the necessary urgent and early protective actions been implemented?	Members of the public and first responders had been informed of the risks associated with the stolen radioactive source and the precautions that needed to be taken, in the event that the source was found. The location of the radioactive source had been identified, the area cordoned off and access controls had been established. The person who had handled the unshielded radioactive source had been identified.
Was the exposure situation stable and well understood?	The radioactive source had been isolated and it had been confirmed that the source was intact and that radioactive material had not been dispersed. Thus, further unexpected evolution of the situation was not expected.
Was the radiological situation well characterized, and were the exposure pathways identified and doses assessed for all the affected people?	Monitoring had been carried out, the affected people had been identified by 10 December 2013 and doses had been either assessed or arrangements had been made to do so.
Was the source of exposure brought under control, and were no further significant accidental releases or exposures expected due to the event?	The radioactive source had been located, the area cordoned off and access controls were in place, preventing further significant exposure due to the unshielded source.
Was the current situation assessed, and were the existing emergency arrangements reviewed and new arrangements established?	Mexico had developed plans and arrangements for a nuclear emergency at the CNLV, but there were no plans in place for responding to a radiological emergency at the national level. Inter-institutional plans had also not been developed. As a lesson learned from this incident, CNSNS was working in cooperation with the Civil Protection Agency to develop such a plan, at the time of the drafting this case study.
Were the requirements for occupational exposure as for a planned exposure situation confirmed for all workers engaged in recovery activities?	The response to this incident, including locating the radioactive source and its recovery, were carried out within the dose limits for normal operation of 50 mSv annual effective dose prescribed in the Mexican regulations. The average dose received by the workers was less than 3 mSv,

General prerequisite	Status with respect to the prerequisite
	with the highest value was around 20 mSv.
Was the radiological situation assessed against reference levels, generic criteria and operational criteria, as appropriate?	A criterion of 500 mSv was set to determine the possibility of non-stochastic effects among members of the public who were presumed to have been exposed. An occupational dose limit was established at 50 mSv effective dose for workers engaged in recovery of the source, which were used in assessing the situation.
Were non-radiological consequences (psychosocial, economic) and other factors (technology, land use options, availability of resources, community resilience) identified and considered?	The SSA and CNSNS endeavoured to provide public information to reassure the public living in the area where source was found and to directly respond to questions regarding the situation. The public was repeatedly assured that there was no danger in continuing daily activities as normal.
Was a registry of those individuals requiring further medical follow-up established prior to the termination of the emergency?	The affected people had been identified by 10 December through a reconstruction of the event. This was followed by dose assessments for each identified individual, which provided a basis for medical treatment provided by health professionals.
Was a strategy for management of radioactive waste arising from the emergency, when appropriate, developed?	Planning for the management of the source as radioactive waste took place during the period in which the source was being located and isolated. On 10 December 2013, the radioactive source was transported to the ININ facilities at Ocoyoacac, in order to be conditioned prior to its transfer to the radioactive waste disposal facility.
Were the interested parties consulted?	Limited consultation was necessary due to the type of event. However, CNSNS created a bulletin for distribution by the Civil Protection Agency among the involved agencies, providing information of the event, the associated risks and the precautions that needed to be taken. National authorities gave information to the national and international media regarding the incident and risks and precautions that needed to be taken. CNSNS informed members of the public present at the site of the incident of the development of the recovery tasks, and assured them that there was no risk of contamination or exposure in the area after the source had

General prerequisite	Status with respect to the prerequisite
	been recovered.

TABLE I-9. STATUS WITH RESPECT TO THE SPECIFIC PREREQUISITES FOR TRANSITION TO A PLANNED EXPOSURE SITUATION FOR THE RADIOLOGICAL INCIDENT IN HUEYPOXTLA CASE STUDY

Specific prerequisite	Status with respect to the prerequisite
Were the circumstances that led to the emergency analysed and corrective actions identified?	During the incident, it became evident that licensees needed to take measures to strengthen security arrangements during the transport of category 1 radioactive sources, in cooperation with the federal police and CNSNS. In addition, the necessity of developing and maintaining a national response plan for radiological emergencies was identified, including the need to identify all the involved agencies and their responsibilities.
Was an action plan developed for implementation of corrective actions by respective authorities?	Shortly following the incident, CNSNS established requirements for the measures to be undertaken by licensees during the transport of category 1 radioactive sources . At the time of the drafting of this case study, CNSNS and the Civil Protection Agency were working on the development of the national response plan for radiological emergencies, including identifying the agencies involved and their respective responsibilities.
Were the conditions assessed to ensure compliance with safe and secure handling of the sources in accordance with the national requirements set forth for the planned exposure situation?	It is considered that this was achieved by complementing the additional measures for secure transport as explained above.
Was there a necessity for administrative procedures to limit or prevent any use or handling of the source until better understanding on circumstances that led to the emergency was gathered?	The operational life of the radioactive source involved in the incident was ended following the recovery, and the radioactive source was dealt with as radioactive waste. Thus, there was not a need to set any such administrative measures, except those implemented during the recovery process.

Specific prerequisite	Status with respect to the prerequisite
Was compliance confirmed with the requirements for dose limits for public exposure in planned exposure situations?	All the recovery operations were carried out within the dose limits for normal operation. The management of the radioactive source as a radioactive waste followed the national regulations for normal operation.

REFERENCES TO THE ANNEX

[I-1] INTERNATIONAL ATOMIC ENERGY AGENCY, The Fukushima Daiichi Accident, Technical Volume 3/5, Emergency Preparedness and Response, IAEA, Vienna (2015).

[I-2] INVESTIGATION COMMITTEE OF THE ACCIDENT AT THE FUKUSHIMA NUCLEAR POWER STATIONS OF TOKYO ELECTRIC POWER COMPANY, Interim Report, Cabinet Secretariat of the Government of Japan (2011).

[I-3] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, The 2007 Recommendations of the International Commission on Radiological Protection, ICRP Publication 103, Ann, ICRP 37 (2–4).

[I-4] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Application of the Commission's Recommendations for the Protection of People in Emergency Exposure Situations, ICRP Publication 109, Ann, ICRP 39 (1).

[I-5] Act on Special Measures Concerning Nuclear Emergency Preparedness, as last amended by Act No. 156, Japan, 17 December 1999,

http://www.cas.go.jp/jp/seisaku/hourei/data/ASMCNEP.pdf.

[I-6] INTERNATIONAL ATOMIC ENERGY AGENCY, The Fukushima Daiichi Accident, Report by the IAEA Director General, IAEA, Vienna (2015).

[I-7] TOKYO ELECTRIC POWER COMPANY, Roadmap towards Restoration from the Accident at Fukushima Daiichi Nuclear Power Station (2011),
http://www.meti.go.jp/english/speeches/pdf/20110417_a.pdf.

[I-8] MINISTRY OF EDUCATION, CULTURE, SPORTS, SCIENCE AND TECHNOLOGY, Plan to Conduct Detailed Monitoring in Restricted Area and Planned Evacuation Zone (2011),
http://www.mext.go.jp/component/english/__icsFiles/afieldfile/2011/06/29/1304084_0613.pdf

[I-9] GOVERNMENT OF JAPAN, NUCLEAR EMERGENCY RESPONSE HEADQUARTERS, Additional Report of the Japanese Government to the IAEA — The Accident at TEPCO's Fukushima Nuclear Power Stations — Second Report, Tokyo (2011).

[I-10] INTERNATIONAL ATOMIC ENERGY AGENCY, The Fukushima Daiichi Accident, Technical Volume 4/5, Radiological Consequences, IAEA, Vienna (2015).

[I-11] FUKUSHIMA MEDICAL HEALTH UNIVERSITY, Report of the Fukushima Health Management Survey, revised version (25 April 2016)
http://fmu-global.jp/fukushima-health-management-survey/#report.

[I-12] NUCLEAR SAFETY COMMISSION OF JAPAN, Basic Policy of the Nuclear Safety Commission of Japan on Radiation Protection for Termination of Evacuation and Reconstruction (2011).

[I-13] INTERNATIONAL ATOMIC ENERGY AGENCY, The Fukushima Daiichi Accident, Technical Volume 5/5, Post-accident recovery, IAEA, Vienna (2015).

[I-14] NUCLEAR EMERGENCY RESPONSE HEADQUARTERS, Report of the Japanese Government to the IAEA Ministerial Conference on Nuclear Safety: The Accident at TEPCO's Fukushima Nuclear Power Stations, Government of Japan (2011).

[I-15] MINISTRY OF AGRICULTURE, FORESTRY AND FISHERIES, Actions such as Shipment Restraint Due to the Accident (as of April 26) (2011), http://www.maff.go.jp/e/quake/press_110426-3.html.

[I-16] NUCLEAR SAFETY COMMISSION, Near-term Policy to Ensure the Safety in Treating and Disposing Contaminated Waste around the Site of Fukushima Dai-ichi Nuclear Power Plants, NSC, Tokyo (2011).

[I-17] Act on Special Measures concerning the Handling of Environment Pollution by Radioactive Materials Discharged by the Nuclear Power Station Accident Associated with the Tohoku District — Off the Pacific Ocean Earthquake that Occurred on March 11, 2011, Act No. 110 as of 2011 (Japan), http://josen.env.go.jp/en/framework/pdf/special_act.pdf?20130118.

[I-18] NUCLEAR EMERGENCY RESPONSE HEADQUARTERS, Basic Policy for Emergency Response on Decontamination Work (2011), http://www.kantei.go.jp/jp/singi/genshiryoku/dai19/19_03_gensai.pdf.

[I-19] GOVERNMENT OF JAPAN, Map and numerical data, official communication (2015).

[I-20] MAEDA, M., OE, M., Mental Health Consequences and Social Issues after the Fukushima Disaster, Asia Pacific Journal of Public Health, 29 (2S), 36S – 46S (2017).

[I-21] Act on Emergency Measures on Damage Caused by Nuclear Accident in 2011, Act No. 91 of 2011(Japan).

[I-22] Nuclear Damage Compensation Facilitation Corporation Act, Act No. 94 of 10 August 2011 (Japan).

[I-23] OECD NUCLEAR ENERGY AGENCY, Japan's Compensation System for Nuclear Damage (2012), http://www.oecd-nea.org/law/fukushima/7089-fukushima-compensation-system-pp.pdf

[I-24] INTERNATIONAL ATOMIC ENERGY AGENCY, The Radiological Accident in Goiânia, IAEA, Vienna (1988).

[I-25] HUNGARIAN ATOMIC ENERGY AUTHORITY, Report to the Chairman of the Hungarian Atomic Energy Commission on the Authority's Investigation of the Incident at Paks Nuclear Power Plant on 10 April 2003, (Event Id. No. 1120), 23 May 2003, http://www.oah.hu/web/v3/HAEAPortal.nsf/7860FD50CC2E8C5FC1257C5C00381618/$FILE/haecreport041003_corrected.pdf.

[I-26] INTERNATIONAL ATOMIC ENERGY AGENCY, Report of the Expert Mission 'To Assess the Results of the Hungarian Atomic Energy Authorities Investigation of the 10 April 2003 Fuel Cleaning Incident at Paks NPP', 16–25 June 2003; and Operational Safety Review Team (OSART) Mission, 8–25 October 2001 to the Hungarian Atomic Energy Authority and Paks Nuclear Power Plant, Hungary; and Follow-Up Visit, 21 February–1 March 2005 (TC Project HUN/9/022, IAEA-TCR 02581, IAEA NSNI 112F), IAEA, Vienna (2005), http://www.oah.hu/web/v3/HAEAPortal.nsf/38B3D1CA0878305CC1257C5C00380641/$FILE/iaeaexpertmission2003.pdf.

[I-27] INTERNATIONAL ATOMIC ENERGY AGENCY, OECD-IAEA Paks Fuel Project, Final Report, IAEA, Vienna (2009).

ANNEX II

FACTORS FOR CONSIDERATION IN THE JUSTIFICATION AND OPTIMIZATION OF THE PROTECTION STRATEGY

II–1. Many factors, both radiological and non-radiological, influence the choice of protective actions and other response actions within a protection strategy for a nuclear or radiological emergency. For each of these factors, it may be necessary for different organizations and bodies to contribute to the decision-making processes. The table below lists a number of these factors to help emergency planners and decision-makers to identify the organizations and relevant interested parties that need to be prepared to contribute to, and should be involved in, the development and implementation of justified and optimized protection strategies, as appropriate, as described in Section 4.

II–2. Table II-1 builds upon the guidance provided in the Nordic Guidelines and Recommendations[57] on the factors affecting the choice of protective measures especially in the intermediate phase[58]. It is not intended to be an exhaustive list of such factors, but can be used as a starting point for the development of a national list of factors to be considered in the justification and optimization of the protection strategy at the preparedness stage. It could also be used in the transition phase of a nuclear or radiological emergency.

[57] Protective Measures in Early and Intermediate Phases of a Nuclear or Radiological Emergency, Nordic Guidelines and Recommendations (2014).

[58] The concept of an intermediate phase as used in the Nordic Guidelines and Recommendations (see previous footnote) roughly equates to the transition phase, as the term is used in this Safety Guide.

TABLE II-1: COMPILATION OF FACTORS FOR CONSIDERATION IN THE JUSTIFICATION AND OPTIMIZATION OF THE PROTECTION STRATEGY

Factors	
General goals	Goals of emergency response Primary objective for the termination of an emergency Primary prerequisites for the termination of the emergency Specific prerequisites for the termination of the emergency
Legislation and regulations	Criteria for implementing protective actions and other response actions • Generic criteria • Operational criteria (OILs, EALs, observables) Reference level for emergency exposure situation Measures for protecting emergency workers, including guidance values for restricting their exposures in emergency response Other respective requirements and guidance for: • Planned, emergency and existing exposure situations Commitments under relevant international instruments, bi-lateral and multilateral agreements in relation to transnational and/or transboundary emergencies
Nature of the emergency exposure situation	Radionuclides involved, activities and associated hazards Expected evolution of the situation Location and size of the affected area Number of exposed people Emergency response actions implemented during the urgent and early response phases
Radiation protection	Radiological situation: • Exposure scenario and dominant exposure pathways • Contamination of the living environment (dose rates, surface activity concentrations, activity concentrations in samples) • Contamination of food, milk and drinking water • Contamination of non-food commodities Dose to the public (projected doses, received doses, residual doses) Dose to the emergency workers and helpers Radiation induced health effects Need for medical follow-up
Timing	Urgency associated with implementation of effective protective actions Time needed for the implementation of protective actions Duration of protective actions Timescale over which doses will be and/or are received
Efficiency	Feasibility of actions (season of the year, weather conditions, etc.) Reducing exposure and contamination in consideration of pre-set reference level Limitations (technical, social, environmental, economical) Acceptability of protective actions Interaction between different actions
Resources	Availability of human resources Knowledge, skill and training needs Availability of material (trucks, buses, machinery etc.) Availability of financial resources Availability of iodine thyroid blocking agents Availability of chemicals and other means/resources for decontamination and decorporation Availability of infrastructure (e.g. for the relocation of people, for waste treatment, storage and disposal, for land use reconversion and change in industrial processes, for psychosocial support of people) Availability of logistical support
Environmental aspects	Type of affected area: urban, recreational, industrial, agricultural, forest, etc.

	Type of surfaces: buildings, roads, agricultural or forest soil Geographical location of area (coast, mountain etc.) and geology Indirect effect (e.g. use of land for other purposes)
Economic aspects	Direct costs associated with the implementation of emergency response actions Indirect costs associated with impacts from consequences of the emergency (e.g. costs of management of waste generated in the nuclear or radiological emergency) Compensation issues Interruptions in international trade Expected market response and evolution in the future
Social and ethical aspects	Disrupted living conditions Reduction in life expectancy due to stress (e.g. associated with resettlement) Impact on mental health and well-being Psychosocial effects Possibility of public self-help Feedback from interested parties on their concerns Socioeconomic aspects, including issues associated with public trust and credibility of authorities Need for routine public services (transport, shops, medical care, education etc.)
Waste	Production of radioactive waste and its relation to emergency response actions Type of waste and options for its characterization Options for pre-disposal management and for minimizing amount of waste Available waste management facilities and practices

CONTRIBUTORS TO DRAFTING AND REVIEW

Aaltonen, H.	Radiation and Nuclear Safety Authority, Finland
Asfaw, K.E.	International Atomic Energy Agency
Baciu, A.	International Atomic Energy Agency
Bana, J.	MVM Paks Nuclear Power Plant Ltd., Hungary
Blackburn, C.M.	Food and Agriculture Organization of the United Nations
Boemeke, M.	International Atomic Energy Agency
Buglova, E.	International Atomic Energy Agency
Carr, Z.	World Health Organization
Chen, S.-Y.	Illinois Institute of Technology, National Council on Radiation Protection and Measurements, United States of America
Ching Chi, L.	Hong Kong Observatory, China
Dodeman, J.-F.	Autorité de Sûreté Nucléaire, France
Gaunt, M.	International Labour Organization, International Organization of Employers
Gibbs, E.	Department of Radiation Health, Ministry of Health, Panama
Gioia, A.	International Atomic Energy Agency
González, A.J.	Nuclear Regulatory Authority, Argentina
Grant, J.D.	Nuclear Regulatory Commission, United States of America
Grzechnik, M.	Australian Radiation Protection and Nuclear Safety Agency, Australia
Hall, C.	EDF Energy, United Kingdom
Herrera Reyes, E.D.	International Atomic Energy Agency
Homma, T.	Japan Atomic Energy Agency, Japan
Hussain, M.	Pakistan Atomic Energy Commission, Pakistan
Johansson, J.	Swedish Radiation Safety Authority, Sweden
Kalinowski, M.	Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization
Krishnamurthy, P.R.	Atomic Energy Regulatory Board, Department of Atomic Energy, India
Krottmayer, M.	International Federation of Red Cross and Red Crescent Societies
Kumano, Y.	International Atomic Energy Agency

Macsuga, G.	Hungarian Atomic Energy Agency, Hungary
Martincic, R.	International Atomic Energy Agency
McMahon, C.	Environmental Protection Agency, Ireland
Metzger, I.	MVM Paks Nuclear Power Plant Ltd., Hungary
Nestoroska Madjunarova, S.	International Atomic Energy Agency
Nikalayenka, A.	Republican Scientific Practical Centre of Hygiene, Belarus
Niu, S.	International Labour Organization
Perrin, M.L.	Autorité de Sûreté Nucléaire, France
Rauber, D.	Federal Office for Civil Protection, Switzerland
Romero Arriola, E.C.	National Commission for Nuclear Safety and Safeguards, Mexico
Robinson, C.	International Atomic Energy Agency
Schultheisz, D.	Environmental Protection Agency, United States of America
Shimba Yamada, M.	International Atomic Energy Agency
Sigouin, L.	Canadian Nuclear Safety Commission, Canada
Vandecasteele, C.	Federal Agency for Nuclear Control, Belgium
Vilar Welter, P.	International Atomic Energy Agency
Wagner, E.	National Security Technologies, USA
Weiss, W.	Federal Office for Radiation Protection, Germany
Zodiates, A.M.	International Labour Organization, International Trade Union Confederation