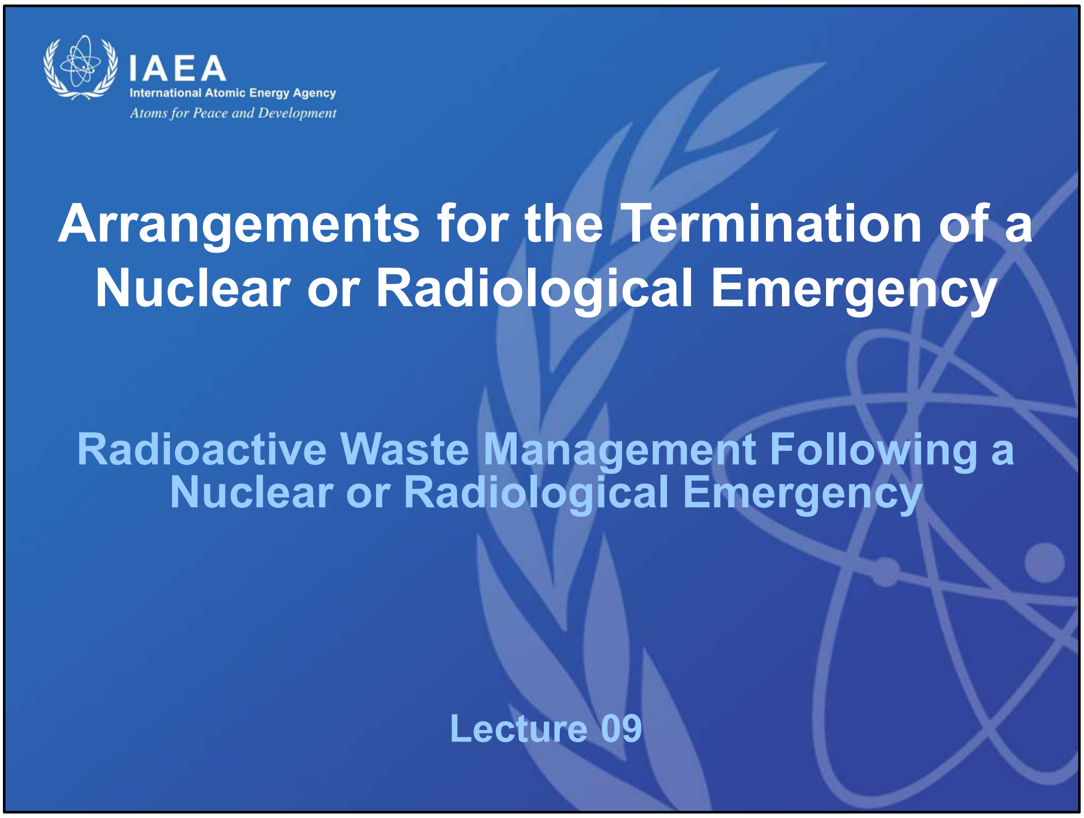
Arrangements for the Termination of a Nuclear or Radiological Emergency



Lecture: 09. Radioactive Waste Management Following a Nuclear or Radiological Emergency

Purpose of the Presentation:

- Present and discuss arrangements for ensuring safe and effective management of waste during the transition phase

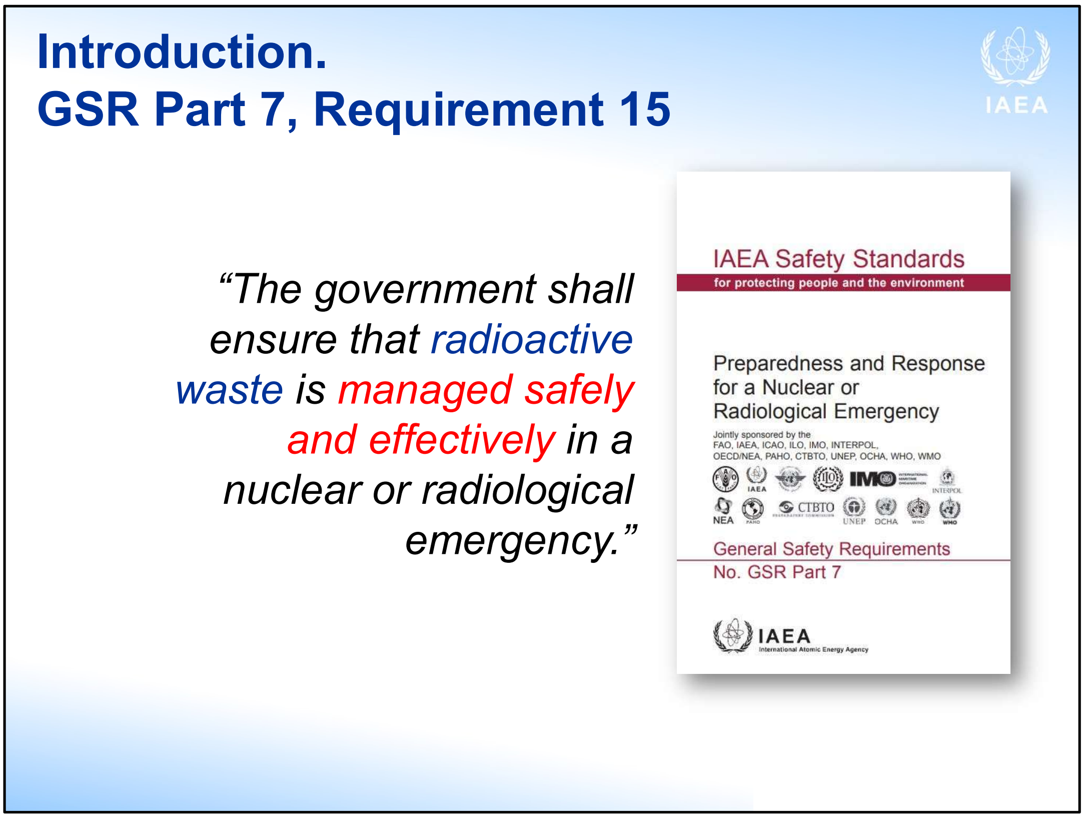
Learning Objectives:

- Recognize the challenges in managing radioactive waste generated during a nuclear or radiological emergency
- Recognize relevant international requirements and guidance
- Identify arrangements that need to be made at the preparedness stage to facilitate the safe and effective management of radioactive waste during the transition phase

Duration: 60 minutes

References:

1. International Atomic Energy Agency, Preparedness and Response for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GSR Part 7, IAEA, Vienna (2015).
2. International Atomic Energy Agency, Arrangements for the Termination of a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GSG-11, IAEA, Vienna (2018).
3. International Atomic Energy Agency, Management of Large Volumes of Waste Arising in a Nuclear or radiological Emergency, IAEA-TECDOC-1826, IAEA, Vienna (2017).
4. International Atomic Energy Agency, The Radiological Accident in Goiânia, IAEA, Vienna (1988).
5. International Atomic Energy Agency, Dosimetric and Medical Aspects of the Radiological Accident in Goiânia, IAEA-TECDOC-1009, IAEA, Vienna (1998)
6. International Atomic Energy Agency, Lessons Learned from the Response to Radiation Emergencies (1945-2010), EPR-Lessons Learned 2012, IAEA, Vienna (2012).



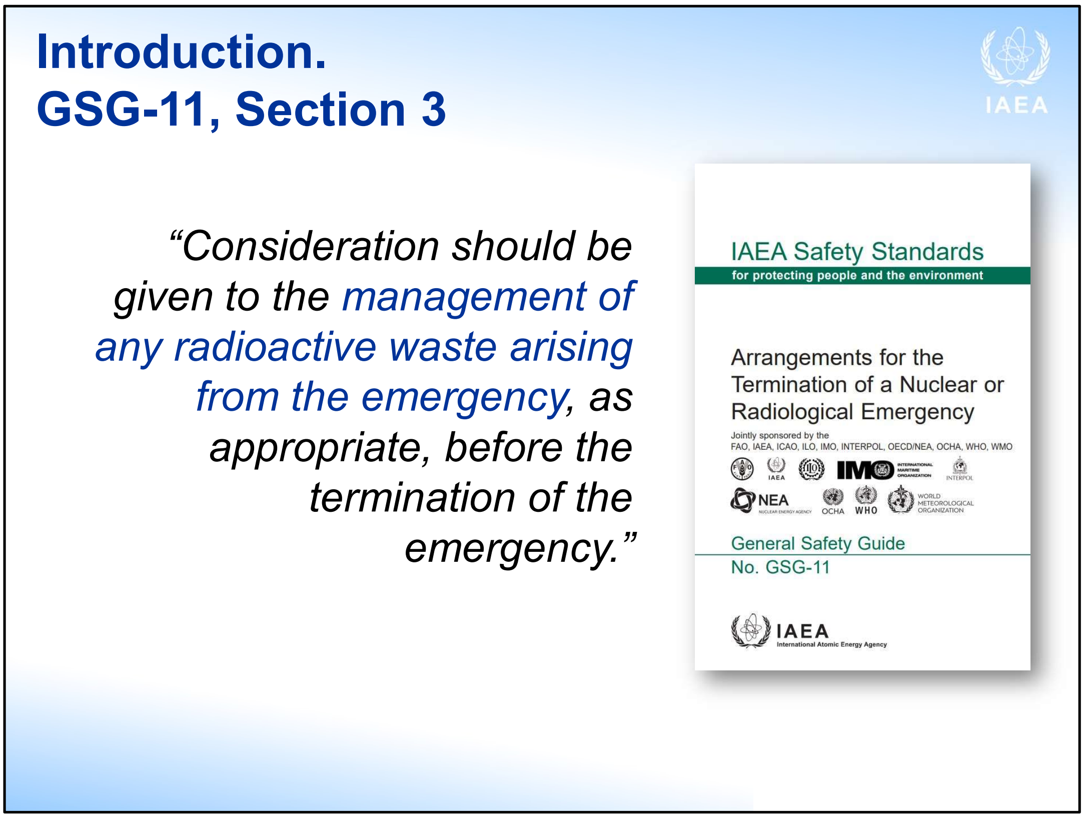
Lecture notes:

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 (e.g. the Chernobyl accident, the Goiânia radiological accident, 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. In recognition of this, Requirement 15 of GSR Part 7 relates to safe and effective radioactive waste management.

In addition to the requirements stipulated in GSR Part 7, there are other international requirements and guidance on the radioactive waste management and the respective regulatory framework, such as IAEA Safety Standards Series Nos GSR Part 5 (Predisposal Management of Radioactive Waste) and SSR-5 (Disposal of Radioactive Waste) and the supporting safety guides. They all apply for any radioactive waste, irrespective of its origin.

References:

1. International Atomic Energy Agency, Preparedness and Response for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GSR Part 7, IAEA, Vienna (2015).



Lecture notes:

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 to achieve the long term recovery objectives. Thus, one of the general prerequisites in GSG-11 reiterates the need to consider the issues related to waste management with the aim to facilitate the resumption of a normal social and economic activity and to provide for public protection and reassurance.

Reference:

1. International Atomic Energy Agency, Arrangements for the Termination of a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GSG-11, IAEA, Vienna (2018).

Purpose

- Present and discuss arrangements for ensuring safe and effective management of waste during the transition phase.

Lecture notes:

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. 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. This lecture looks at the aspects to consider in the development of the necessary arrangements.

Learning Objectives

- Recognize the challenges in managing radioactive waste generated during a nuclear or radiological emergency.
- Recognize relevant international requirements and guidance.
- Identify arrangements that need to be made at the preparedness stage to facilitate the safe and effective management of radioactive waste during the transition phase.

Contents

- Introduction to:
  - Origins of radioactive waste in an emergency
  - Issues and challenges in managing radioactive waste following an emergency
- Relevant international standards
- Planning basis
- Arrangements at the preparedness stage
- Some predisposal and disposal considerations
- Managing human remains and animal remains

Discussion

What are the sources of radioactive waste following a nuclear or radiological emergency?

Lecture notes:

Allow for about 3 mins. of discussion.

Waste Origin

- Waste may originate from:
  - Decontamination activities;
  - Remediation and clean up activities;
  - Decommissioning;
  - Ending the operational life of a source.

Image reproduced from 'The Radiological Accident in Goiânia', IAEA , Vienna (1988)

Image reproduced from' The Fukushima Daiichi Accident', IAEA, Vienna (2015)

Lecture notes:

Waste may origin from:

- Decontamination activities:
  - Including decontamination of contaminated buildings, equipment and land.
- Remediation and clean up activities:
  - The lower the decontamination, remediation and clean up criteria, the higher the volume of waste produced and costs associated with its management;
  - Examples of such wastes include food, runoff water from firefighting activities or decontamination of buildings or vehicles.
- Decommissioning:
  - Damaged nuclear fuel and fuel debris are important and particularly challenging waste streams.
- Ending the operational life of a source:
  - Particularly where the source is damaged, this may be a challenging waste item unless there are arrangements in place with radioactive waste facilities in advance.

Lecture notes:

FIG.1: Contaminated rubble from the demolition the house where the source assembly was dismantled and the source capsule broken open, International Atomic Energy Agency, The Radiological Accident in Goiânia, IAEA , Vienna (1988)

FIG.2: Remediation of forests around residential areas, International Atomic Energy Agency, The Fukushima Daiichi Accident, Technical Volume 5/5, Post-accident Recovery, IAEA, Vienna (2015)

Waste Origin Example.
Goiânia, Brazil (1987)

- Goiânia, Brazil (1987): Radiological accident involving a radioactive source (Cs - 137, 50 TBq):
  - **3500 m³** of radioactive waste;
  - A total of **3800 drums**, **1400 boxes**, **10 containers** and **6 concrete wells** used;
  - Cleanup cost of **$20 million.**

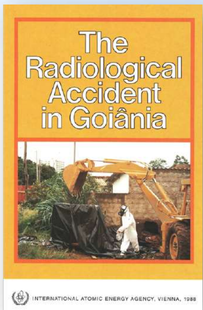


Image reproduced from 'The Radiological Accident in Goiânia', IAEA , Vienna (1988)

Lecture notes:

We will look at a few examples from past experience – these can be useful for planning purposes and to engage waste operators/regulators in considering the types and volumes of waste we may need to plan for (based on the national hazard assessment). The photographs show the report published in by the IAEA 1988 on the radiological accident in Goiânia and the contaminated rubble from the demolition of contaminated homes.

Remediation activities included:

- Demolishing and removal of houses;
- Removal of soil;
- Collection of contaminated clothes, personal items and homegrown produce;
- Pruning trees and discarding fruits.

These activities resulted in the following numbers:

- 3500 m³ of radioactive waste produced.
- A total of 3800 drums, 1400 boxes,10 containers and 6 concrete wells used.

Lecture notes:

Cleanup cost was estimated at $20 million.

FIG.: Clearing the site at Junkyard II on 6th Street., International Atomic Energy Agency, The Radiological Accident in Goiânia, IAEA, Vienna (1988)

Waste Origin Example.
Goiânia, Brazil (1987) (cont'd)

IAEA

Major challenges faced:

- **Delayed decontamination** due to temporary storage site (TSS) selection because of public opposition:
  - Selection and building of TSS completed in 1987.
- **Lack of proper packaging** for waste disposal.
- **Large amounts of waste and disposal costs** arising from the use of very low radiological criteria.

Lecture notes:

From the response to the accident (end of September 1987), the technical staff recognized immediately the need to designate a suitable site in Goiânia or in the vicinity to which the waste, properly packaged, could be readily transported to facilitate decontamination work. In October 1987, a temporary storage site (TSS) was selected. There was no inherent technical difficulty in constructing a waste storage site. However, the choice of a site was delayed by political considerations. In the interim, substantial public opposition was expressed about leaving the waste in Goiânia, and so a site outside Goiânia had to be identified.

The political decision was made that a site would be found to store the waste for up to two years, and that the selection of a permanent repository would be deferred until a later date. The building of the final repository was accomplished in 1997, almost ten years after the accident. The waste was repackaged.

While the repository was being built, industries located in Goiânia manufactured metal boxes specially designed for storage of the radioactive waste.

Lecture notes:

During the Goiânia accident, it was very difficult to set OILs for relocation during the emergency because of time constraints, political pressure and the lack of international guidance. The result was the use of very cautious assumptions in developing OILs (based on the dose limits for normal operation), which in turn resulted in the generation of additional amounts of radioactive waste and additional decontamination and disposal costs. This illustrates the inter-connectedness of the protection strategy: the choice of OILs for relocation and for resuming normal social and economic activity led to huge volumes of waste that needed to be dealt with. Personal items and utensils that presented even low levels of contamination were treated as waste, because the population did not want any decontaminated objects. One of the permanent repository stores about 40% of the waste volume that has low level specific activity. Under the current legislation in Brazil, such waste could now be disposed of at an urban waste repository.

References:

1. International Atomic Energy Agency, The Radiological Accident in Goiânia, IAEA, Vienna (1988).
2. International Atomic Energy Agency, Dosimetric and Medical Aspects of the Radiological Accident in Goiânia, IAEA-TECDOC-1009, IAEA, Vienna (1998).
3. International Atomic Energy Agency, Lessons Learned from the Response to Radiation Emergencies (1945-2010), EPR-Lessons Learned 2012, IAEA, Vienna (2012).

Waste Origin Example.
Fukushima Daiichi Accident (2011)

Fukushima Daiichi Accident, Japan (2011):

- **Off-site waste**: Remediation activities;
- **On-site waste**: Cooling of the reactors, dismantling, decontamination and demolition.

Images reproduced from 'The Fukushima Daiichi Accident', IAEA, Vienna (2015)

Lecture notes:

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

FIG.: Landscapes before and after remediation in Tamura City (Photographs courtesy of the Ministry of the Environment, Japan), International Atomic Energy Agency, The Fukushima Daiichi Accident, Report by the Director General, IAEA, Vienna (2015)

Waste Origin Example.
Fukushima Daiichi Accident (2011) (cont'd)

Off-site waste:

- **2.3 Mt of contaminated debris** from the earthquake and tsunami collected during 2011;
- **16-22 million m^3 soil and waste were estimated (after volume reduction).**

Images reproduced from 'The Fukushima Daiichi Accident', IAEA, Vienna (2015)

Lecture notes:

The volume of waste within the Fukushima Prefecture is approximately 800 000 t (as of 26 December 2013), and that of designated waste is approximately 130 000 t (as of the end of December 2014). The amount of soil and waste generated from decontamination is estimated to be 16–22 million m^3 after volume reduction (incineration) (as of October 2013).

Outside Fukushima Prefecture, the amount of designated waste is approximately 28 000 t (as of the end of December 2014) and the amount of soil. The waste generated from decontamination is estimated to be 1.4–13 million m^3 (as of October, 2011).

FIG.: Examples of TSS designs (Photograph on the left courtesy of the Ministry of the Environment, Japan), International Atomic Energy Agency, The Fukushima Daiichi Accident, Technical Volume 5/5, Post-accident Recovery, IAEA, Vienna (2015)

Waste Origin Example. Fukushima Daiichi Accident (2011) (cont'd)

On-site waste:

- **131 900 m^3** of debris and **79 700 m^3** of trees were collected (2014);
- Generation of contaminated water: **400 m^3/day;**
- Estimated contaminated material: **560 000 m^3 after fuel debris removal (2027).**

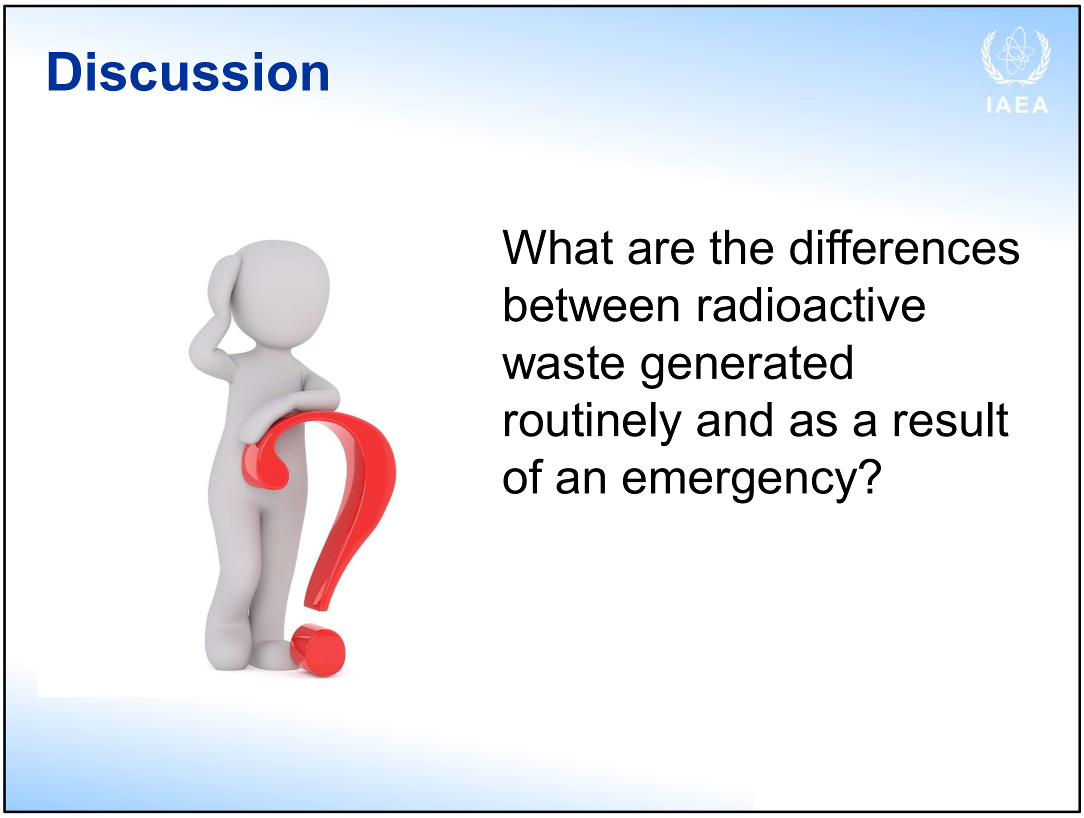
21 February 2012 22 July 2013

Images reproduced from 'The Fukushima Daiichi Accident', IAEA, Vienna (2015)

Lecture notes:

Estimated waste: 560 000m^3 of contaminated material will be generated by the end of the fuel debris removal, which is planned for 2027.

FIG.: Example of debris removal from Unit 3 reactor building, International Atomic Energy Agency, The Fukushima Daiichi Accident, Technical Volume 5/5, Post-accident Recovery, IAEA, Vienna (2015)



Lecture notes:

Allow for about 3 mins. of discussion.

The key differences may include:

- The volumes of waste generated;
- The complexity of the waste: the mix of radionuclides it contains, physical/chemical/biological characteristics (including soil, buildings, food, etc.);
- Lack of information on the waste characteristics;
- Perception by public/politicians that it all constitutes ‘radioactive waste’;
- Could include human or animal remains.

Waste Origin Example.
Fukushima Daiichi Accident (2011) (cont'd)

IAEA

Major challenges faced:

- Allocation of relevant **responsibilities** for waste management;
- Developing **legislative and regulatory framework** for dealing with on-site and off-site waste:
  - Development of detailed strategies, guidelines and instructions for radioactive waste management;
- **Management of large volumes of waste** (incl. liquids):
  - Developing waste conditioning techniques and procedures;
  - Construction and operation of waste treatment and storage facilities.
- **Transportation** of the waste;
- **Controlling the amount of contaminated material** generated during remediation activities.

Lecture notes:

Immediately following the accident, the most important challenge for off-site waste management was the need to allocate relevant responsibilities. The Ministry of the Environment was appointed as the body responsible for implementing off-site remediation activities. The primary responsibility for on-site waste management rested with the nuclear facility operator, TEPCO. Legislative and regulatory instruments for dealing with on-site and off-site waste, including detailed strategies, guidelines, instructions etc., have been developed since the Fukushima Daiichi accident. Those existing prior to the accident did not apply to waste of such origin.

Waste Management.
Issues and Challenges

For routine radioactive waste management expect to have:

- A well defined and established governmental, legal and regulatory framework for waste management from normal operations, including:
  - National policies and strategies for radioactive waste management;
  - Criteria for classification of radioactive waste;
  - Storage and/or disposal options;
  - Well known waste streams.

Lecture notes:

GSR Part 5 provides the general basis for a national strategy and policy on radioactive waste (irrespective of its origin). However, often national arrangements do not account fully for waste that may be generated in an emergency (only waste generated routinely). 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.

Waste Management.
Issues and Challenges (cont'd)

IAEA

- An emergency will introduce a new (high volume) waste stream:
  - Waste may have diverse characteristics:
    - Radiological, chemical, physical, mechanical, biological.
- Management may necessitate development of:
  - New techniques, equipment and methodologies for waste characterization;
  - Options for radioactive waste minimization;
  - Planning for appropriate predisposal management activities;
  - New storage and/or disposal facilities.

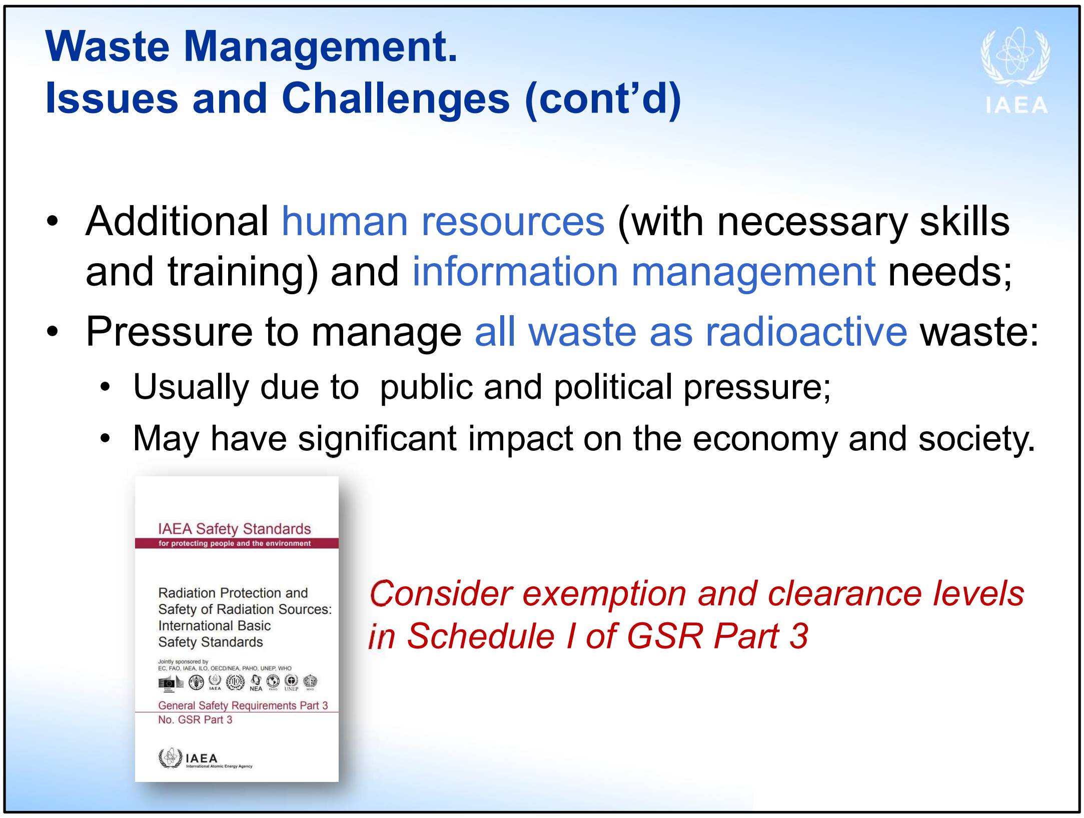
Lecture notes:

Nuclear or radiological emergencies resulting in significant contamination of the environment 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. The arrangements in place for routinely generated waste may not be sufficient to deal with the different properties and volumes of emergency waste – new techniques, facilities, etc. may be required, as seen in the past.

Lecture notes:

The additional challenges for characterizing waste following an emergency are:

- The large volume implies the need for considerable equipment to characterize and process the waste.
- The complex composition or diverse properties of the waste will make it very challenging to characterize. Lack of uniformity of the wastes may require additional time to acquire more measurements and samples.
- There may be a lack of adequate procedures and instrumentation in place to support characterization activities (at least initially).
- There may be a shortage of radiation protection equipment (and/or remote handling equipment) to enable the workforce to perform the characterization tasks safely (at least initially).
- Similar problems can be expected concerning the limited availability or capacity of equipment and facilities for processing, storage and disposal of waste.



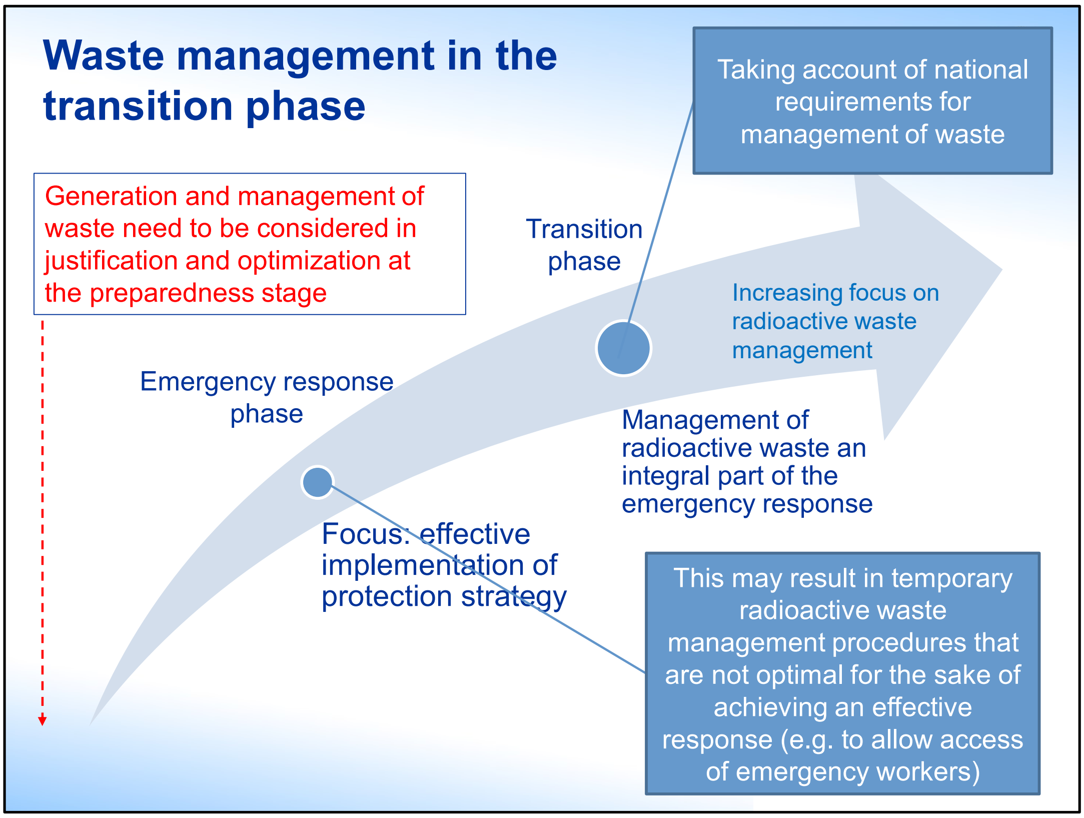
Lecture notes:

Following an emergency there will likely be pressure to treat all waste generated by the emergency and response actions as 'radioactive waste'. This should be carefully considered and avoided if possible. Management of waste and its impact on the economy and society can be further complicated by introducing low criteria, compared with those derived from radiological protection considerations. Establishing adequate exemption/clearance levels will help minimizing the amount of material declared unduly as radioactive waste and its management as a conventional waste. The identification and classification of radioactive waste generated in an emergency should consider the exemption/clearance levels given in Schedule I of GSR Part 3 or relevant national criteria set for that purpose at the preparedness stage. If such criteria are not adopted in preparedness, it will be difficult to avoid this pressure, as even waste that would normally be treated as conventional waste will be seen to be contaminated and may be assumed to be too hazardous for normal waste disposal routes, such as landfill.

Lecture notes:

When 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 in terms of their adequacy in providing for conventional safety and radiation protection (given that there may be different physical/chemical/biological characteristics than for routine waste).

Background: In GSR Part 3 (Basic Safety Standards) radioactive waste is defined as follows: "For legal and regulatory purposes, material for which no further use is foreseen that contains, or is contaminated with, radionuclides at activity concentrations greater than clearance levels as established by the regulatory body." 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.



Lecture notes:

Overcoming these challenges requires that adequate attention be given at the preparedness stage to the waste that will be generated and will thus need to be managed (particularly in the context of identifying how we can prepare for anticipated situations and how waste must be considered in the justification and optimization); it also needs to be taken into account in the emergency response, once time allows to do so without jeopardizing the effectiveness of the emergency response efforts.

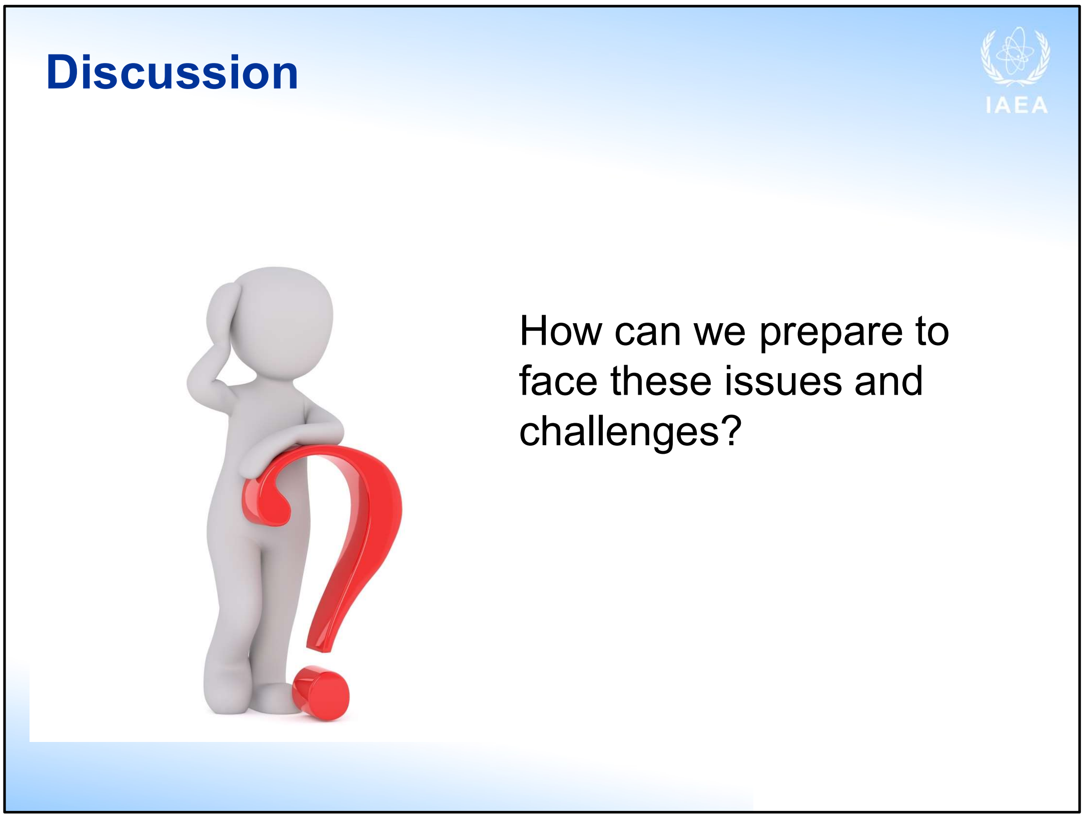
The management of radioactive waste will not be of primary importance early in the response (especially during the urgent response phase), when the focus will be on the effective implementation of the protection strategy and on bringing the situation under control. However, the generation of radioactive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

Lecture notes:

For example, where there are two options providing a comparable level of protection for people but one generates significantly more waste than the other, the one generating less waste should be chosen (other factors being equal). Similarly, the doses to those eventually managing the waste should be factored into the optimization of the protection strategy.

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, taking into account the national requirements for radioactive waste management.

Emergency arrangements should also consider that, 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 mitigatory actions to be taken while protecting emergency workers).

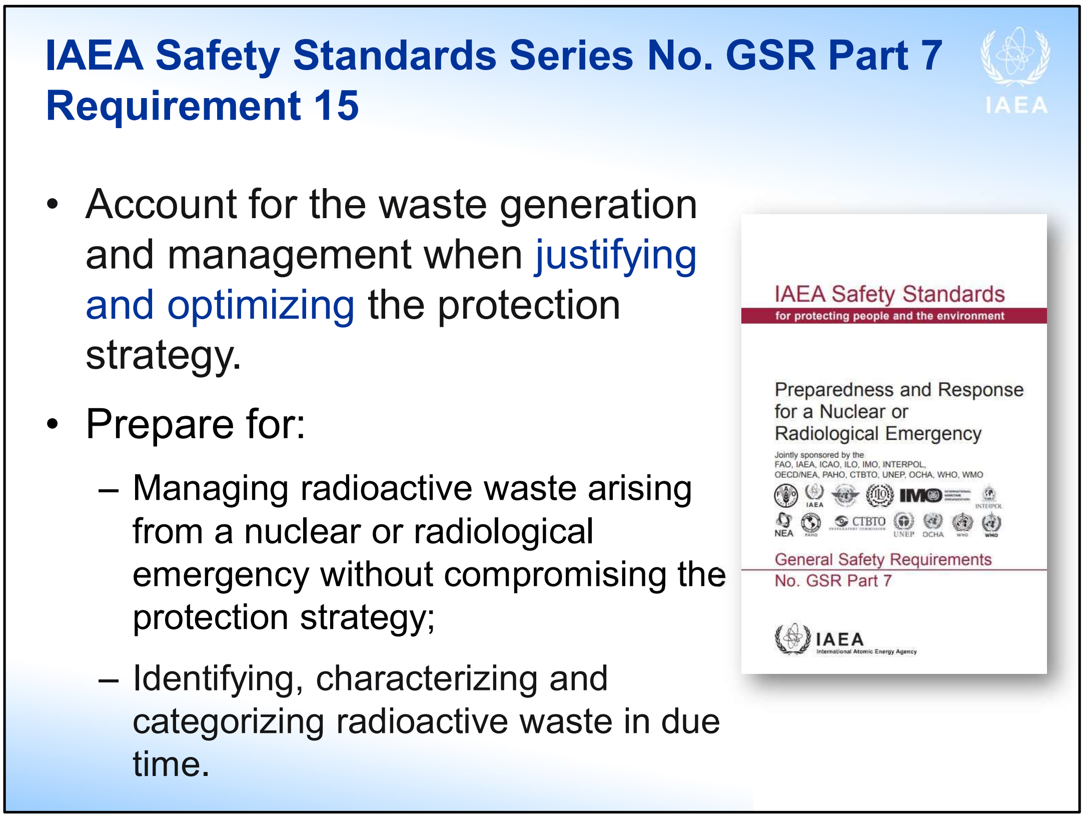


Lecture notes:

Allow for about 3 mins. of discussion.

Some questions to prompt discussion, if needed:

- Are there any aspects of the existing national waste framework and infrastructure that need to be revised to account for waste arising from emergencies?
- What arrangements can be developed in preparedness?
- What criteria should be agreed on with relevant stakeholders before an emergency?



Lecture notes:

With regard to the issues and challenges addressed on earlier slides, GSR Part 7 explicitly addresses the requirements for safe and effective radioactive waste after a nuclear or radiological emergency.

GSR Part 7, Req. 15 [paragraphs 5.81 – 5.85]:

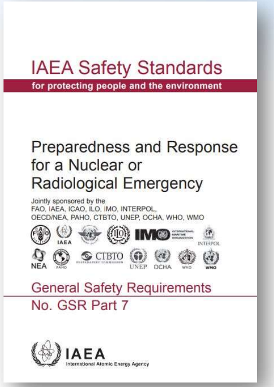
“5.81. The national policy and strategy for radioactive waste management shall apply for radioactive waste generated in a nuclear or radiological emergency taking into account these requirements.

5.82. The protection strategy shall take into account radioactive waste that might arise from protective actions and other response actions that are to be taken.

5.83. Radioactive waste arising in a nuclear or radiological emergency, including radioactive waste arising from associated protective actions and other response actions taken, shall be identified, characterized and categorized in due time and shall be managed in a manner that does not compromise the protection strategy taking into account prevailing conditions at these evolve.“

IAEA Safety Standards Series No. GSR Part 7 Requirement 15 (cont'd)

- Criteria for waste categorization;
- Avoiding the mixing of wastes;
- Waste minimization;
- Method for determining options for predisposal management;
- Method for identifying storage options and sites;
- Consideration of non-radiological aspects;
- Consideration of management of human remains and animal remains.



Lecture notes:

GSR Part 7, [paragraphs 5.84-5.85]:

"5.84. Arrangements shall be made for radioactive waste to be managed safely and effectively. These arrangements shall include:

(a) a plan to characterize waste, including in situ measurements and analysis of samples;

(b) criteria for categorization of waste;

(c) avoiding, to the extent possible, the mixing of waste of different categories;

(d) minimizing the amount of material declared unduly as radioactive waste;

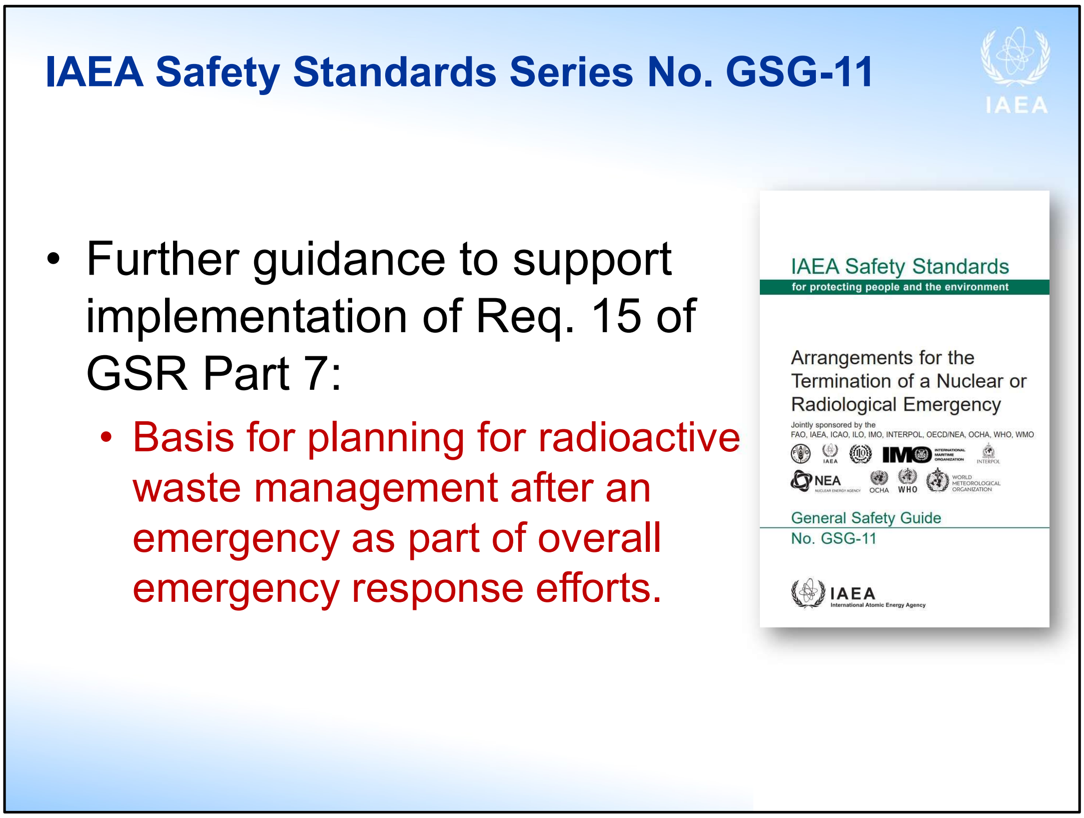
(e) a method of determining appropriate predisposal management options (including processing, storage and transport), with account taken of the interdependences between all steps as well as impacts on the anticipated end points (clearance, authorized discharge, reuse, recycling, disposal);

(f) a method of identifying appropriate storage options and sites;

(g) consideration of non-radiological aspects of waste (e.g. chemical properties such as toxicity, biological properties).

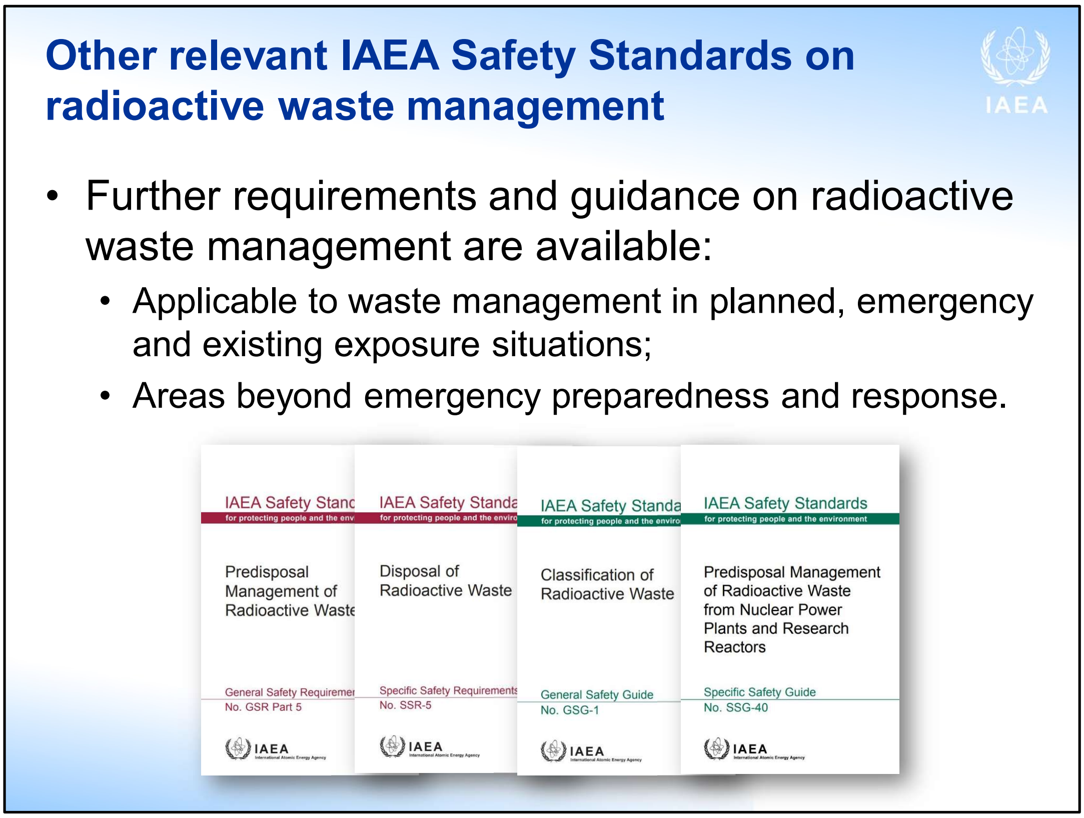
Lecture notes:

5.85. Consideration shall 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.”



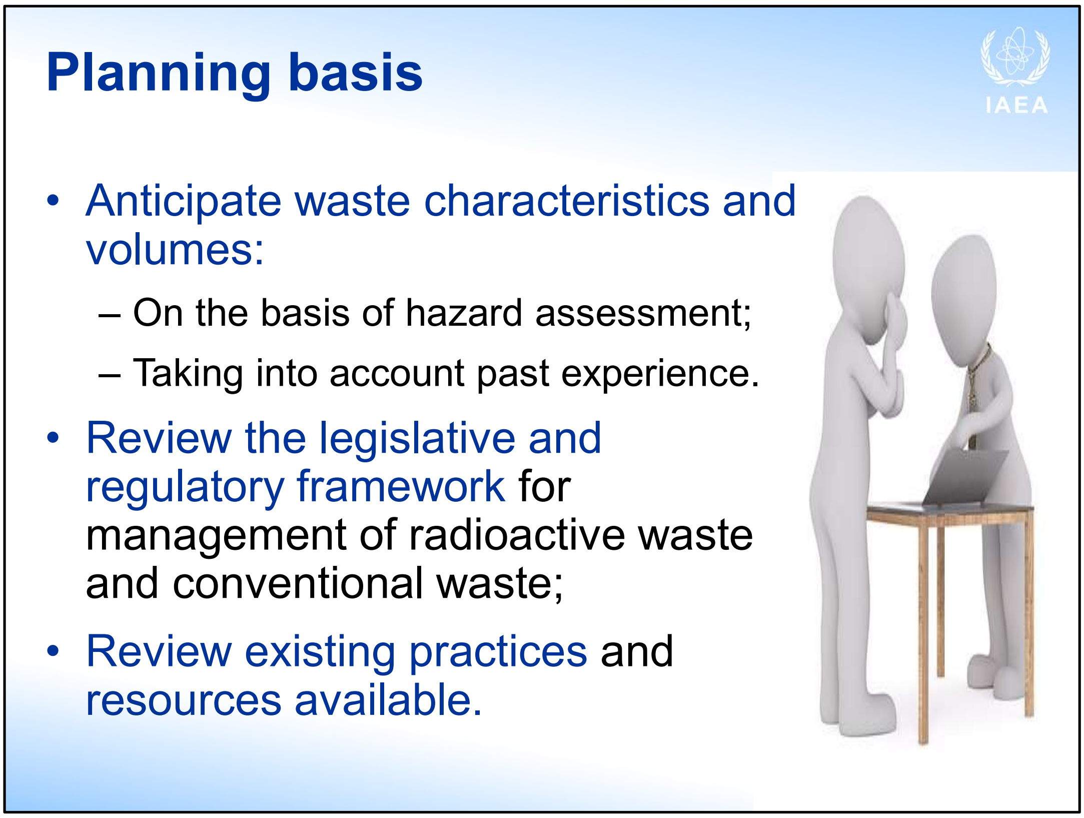
Lecture notes:

Further, GSG-11 provides useful guidance to support GSR Part 7 by providing the basis for planning for radioactive waste management after an emergency as part of the overall emergency response efforts. As noted, the issue of radioactive waste will become more important as we move from the emergency response phase to the transition phase – and it will have to be considered before we can terminate the emergency. The focus of this presentation is actually on the guidance provided in this safety guide that helps considering this aspect not in isolation but within the overall emergency preparedness.



Lecture notes:

Other Safety Standards - examples of which are shown on this slide - provide further requirements and guidance on radioactive waste management. These standards are applicable for any radioactive waste, irrespective of its origin. These standards go beyond what is considered as the EPR area.



Lecture notes:

What we can do in preparedness to ensure that we have an adequate basis to plan for waste management following an emergency:

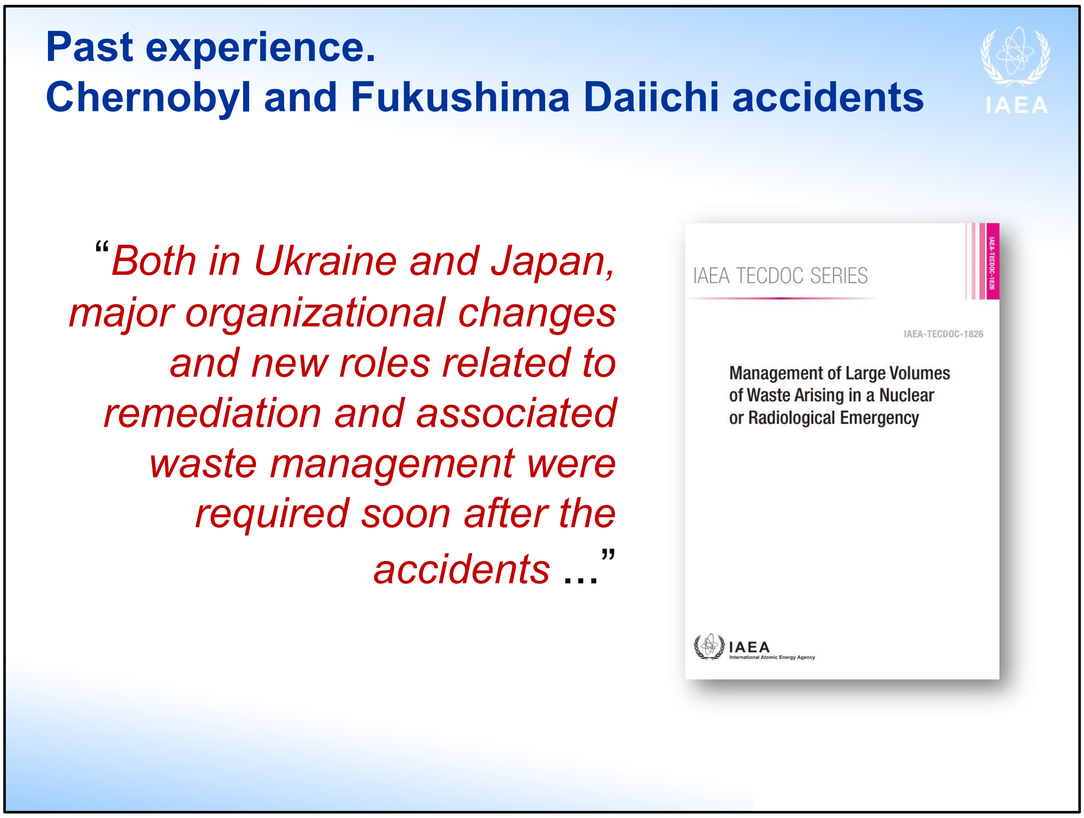
- The characteristics and volume of the radioactive waste to be generated in postulated nuclear or radiological emergencies should be identified, to the extent possible, on the basis of the hazard assessment, with account taken of past experience. This can help to identify the necessary characterization, treatment, storage etc. options and means to prepare for.
- Review the legislative and regulatory framework for radioactive waste safety and for management of conventional waste. Any gaps should be identified at the preparedness stage to ensure effective and safe waste management after an emergency. For example, in some States where conventional waste is managed by private organizations, the legal basis may need to be reviewed, including any contracts to ensure that these organizations can accept as conventional waste the waste that may be insignificantly contaminated after an emergency. If this is not possible at the moment, additional arrangements on dealing with such waste may need to be considered.

Lecture notes:

- Review existing practices and resources available, so any limitations are well understood, contingencies are planned for and resource mobilization is considered.

Lecture notes:

It will be necessary to work with the waste management experts, radiation protection experts and regulators in addition to EPR experts to ensure that the current legislation, regulations and arrangements will allow for waste generated in an emergency to be safely and effectively managed. 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 the respective licensing framework established in accordance with GSR Part 5 and SSR-5.

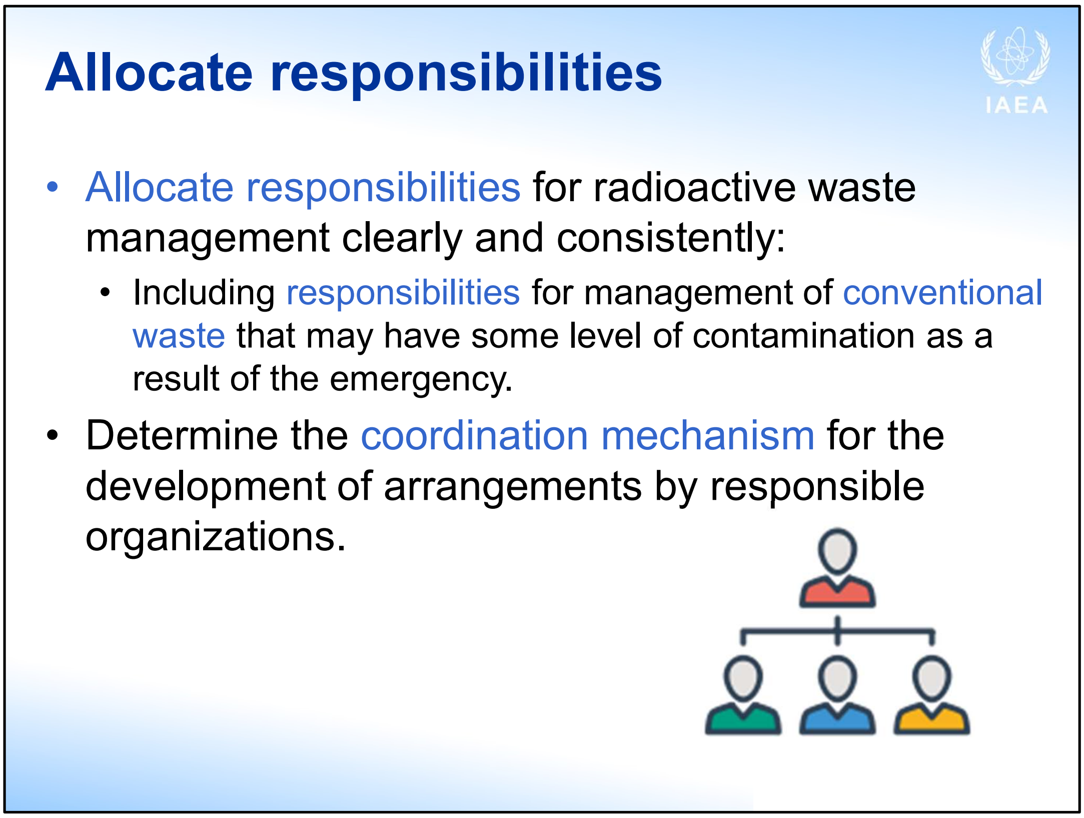


Lecture notes:

This is an example experience that underlines the importance of the review mentioned on the previous slides. Even large legal and regulatory frameworks addressing normal situations may pose difficulties in an emergency. Enacting new laws and preparing the new organizational changes in the aftermath of an emergency under huge public and political pressure would be very challenging and may result in unnecessary delays. Adequate work being done at the preparedness stage can overcome this challenge and enable effective emergency response and recovery.

Reference:

1. International Atomic Energy Agency, Management of Large Volumes of Waste Arising in a Nuclear or radiological Emergency, IAEA-TECDOC-1826, IAEA, Vienna (2017).



Lecture notes:

While it should be recognized that each emergency will be specific and detailed planning for all aspects of waste management may not be possible, arrangements should be made, as part of the overall emergency preparedness, for radioactive waste management following the emergency. These arrangements should be developed taking into account the planning basis developed as a starting point. As part of these arrangements:

- Responsibilities for radioactive waste management after an emergency should be allocated clearly and consistently, to the extent possible, with the national policy and strategy for radioactive waste management;
- Responsibilities should be agreed for conventional waste management and conditions under which conventional waste arising from the emergency and emergency response actions is to be managed;
- Mechanisms response should be established to coordinate the development of arrangements at the preparedness stage by responsible organizations and to coordinate, under the unified command and control system, the waste management during the emergency.

Prepare necessary guidance

- Guidance for:
  - Characterization and classification of radioactive waste:
    - Taking account of its diverse properties.
  - Handling **radioactive** waste and **conventional** waste.
- In the guidance:
  - Consider the **acceptance criteria** of existing storage/disposal facilities;
  - Elaborate **measures to take in case of deviation** from these criteria.

Lecture notes:

- Guidance should be developed for:
  - Characterization and categorization of radioactive waste, which takes into account the diversity of radiological, chemical, physical, mechanical and biological properties of the waste to be generated in a range of postulated emergencies;
  - Handling of waste and radioactive waste during an emergency, which describes what types of radioactive waste can be accepted in existing storage or disposal facilities.
- Guidance on measures for handling of waste which deviates from the acceptance criteria of the existing facilities should be also given;

Lecture notes:

The guidance on the characterization and categorization of radioactive waste should take into account the complexity in characteristics of radioactive waste generated during the emergency compared to the radioactive waste arising from normal operations. Thus, it may necessitate to identify new techniques and methodologies to characterize the waste to complement those used for waste arising from normal operations. The general requirements and guidance on waste characterization can be found in the references given previously (such as GSR Part 5 and IAEA-TECDOC-1826).

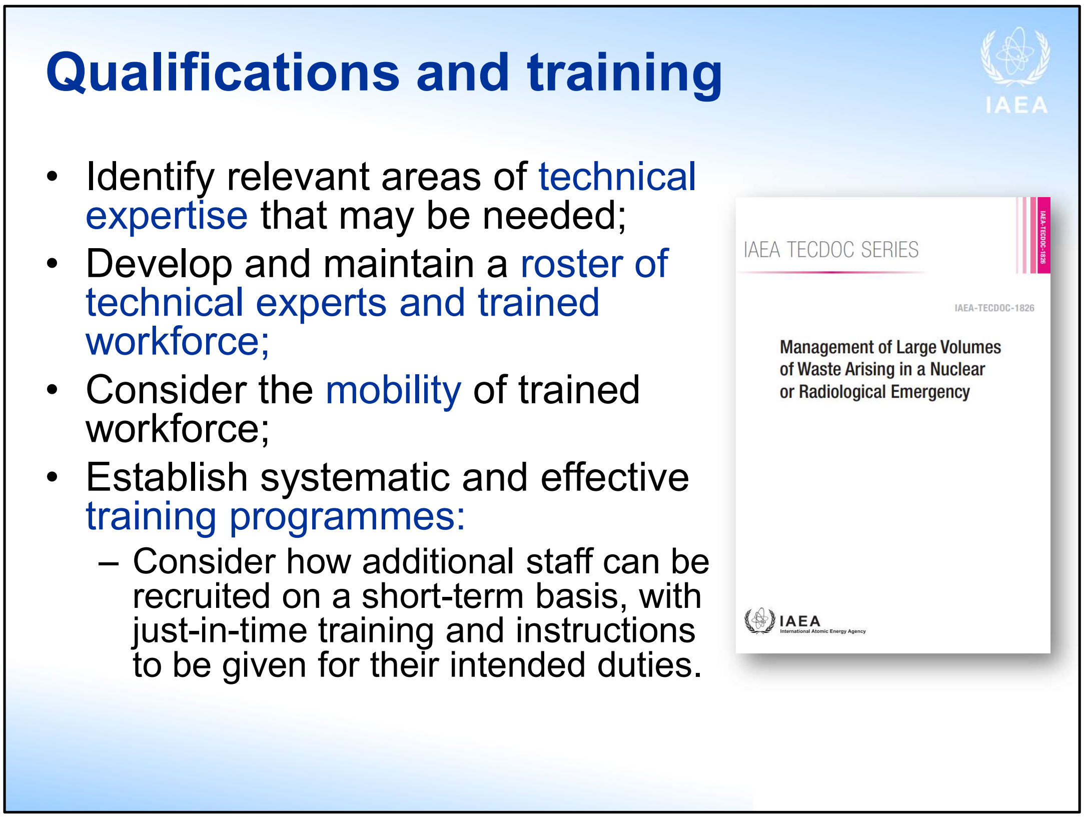
Develop methodologies

- Develop methodologies for initiating predisposal management of radioactive waste:
  - Segregation, packaging, transport, storage;
  - Options for minimization.
- Identify needs for and ensure:
  - Tools, equipment, procedures, training and drills necessary for predisposal management.
- Consider interdependencies among steps in the predisposal management;
- Identify limitations of available options and resources.

Lecture notes:

Methodologies should be developed for initiating radioactive waste management activities (e.g. segregation, packaging, temporary storage) in a timely and appropriate manner. Options for radioactive waste minimization that are feasible should be identified.

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



Lecture notes:

In identifying the needs for human resources and any associated limitations as part of the methodologies mentioned before, the bullet points on this slide may be considered.

Waste minimization options

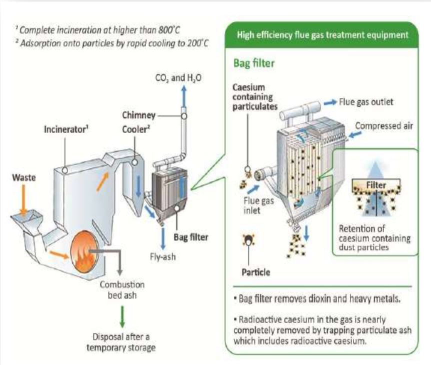


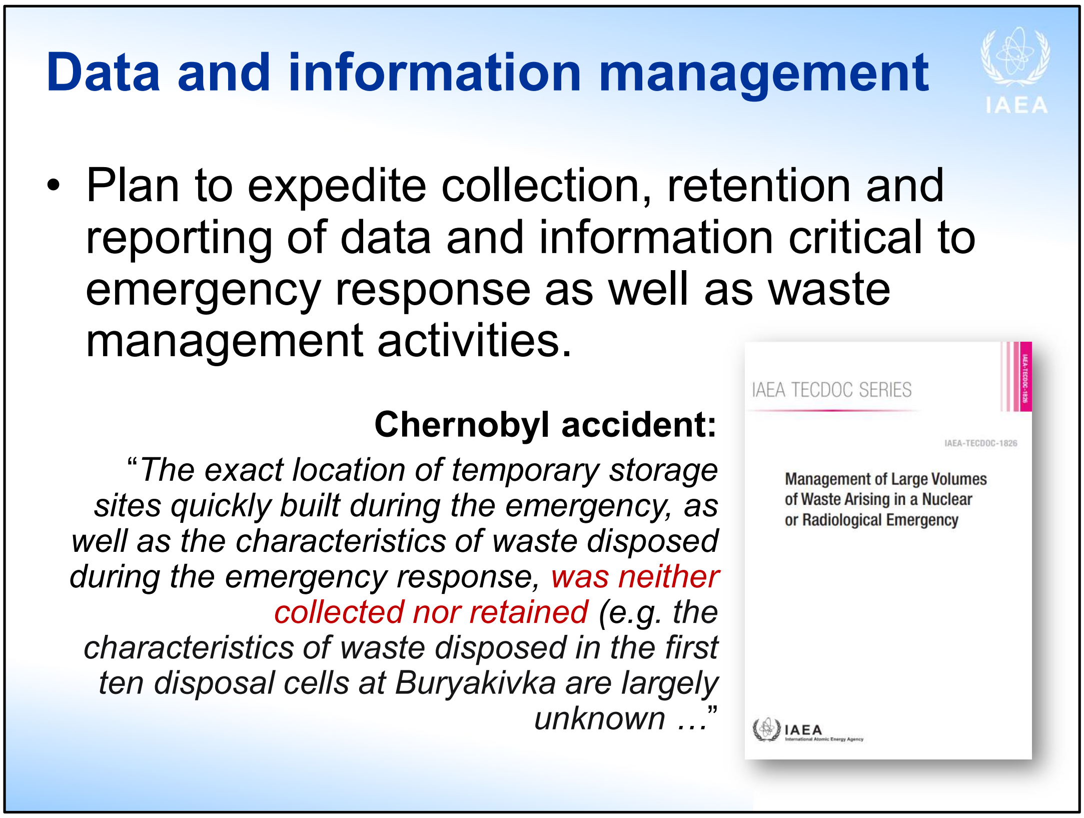
Image reproduced from' The Fukushima Daiichi Accident', IAEA, Vienna (2015)

- A balanced selection of clean-up and remediation criteria;
- Selection of remediation techniques;
- Optimize possibilities for reuse, recycling, and/or disposal in non-radioactive waste management facilities:
  - Requires a clearance/exemption process.
- Use volume reduction technologies (incineration, compaction, evaporation, etc.).

Lecture notes:

In the aftermath of the Fukushima Daiichi accident, the strategy for the management of disaster waste and waste from decontamination aimed to use existing municipal incinerators, subject to the provision of adequate off-gas cleaning systems for the retention of caesium and additional measures to protect people and workers from radiation exposure.

FIG.: Schematic diagram of incinerator and off-gas cleaning systems, International Atomic Energy Agency, The Fukushima Daiichi Accident, Technical Volume 5/5, Post-accident Recovery, IAEA, Vienna (2015)



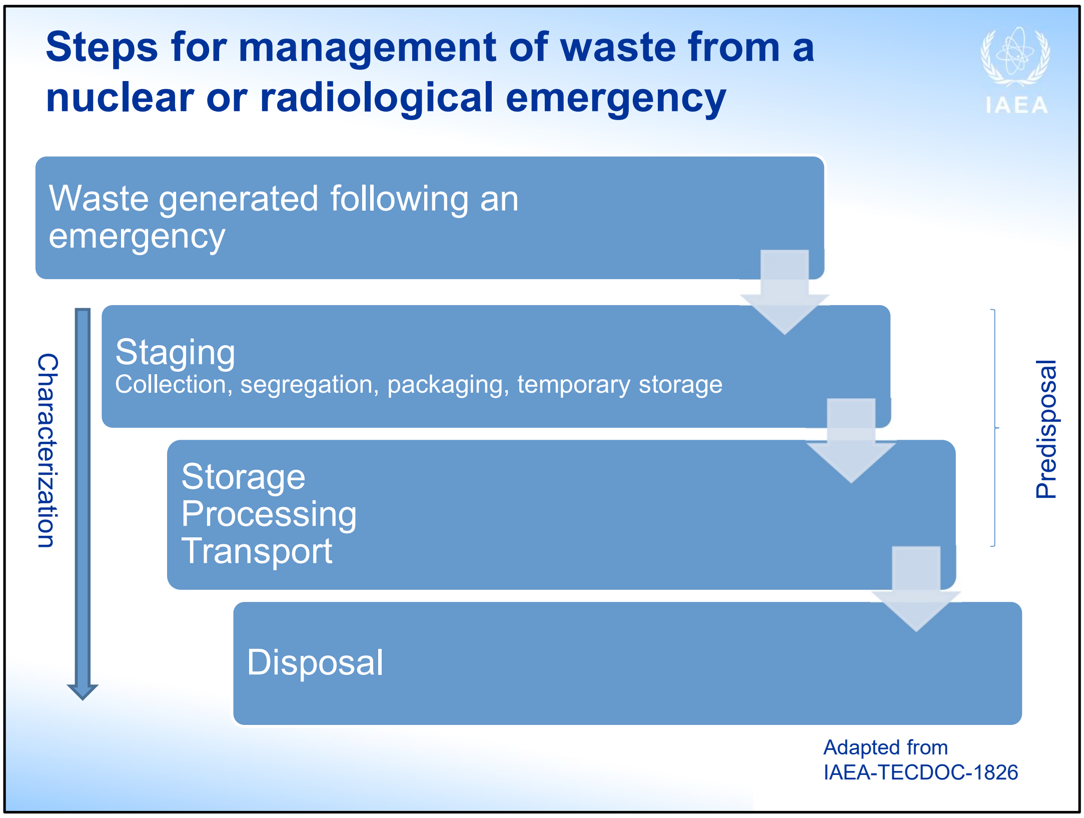
Lecture notes:

Based on IAEA-TECDOC-1826, in order to avoid the loss of important information and/or inefficient data management efforts after an emergency, the following preparatory actions can be taken:

- Definition of roles and responsibilities for establishment and maintenance of a data management system;
- Establishment of an integrated data management system to expedite collection, retention and reporting of data critical to emergency response and waste management activities, thereby enabling data management activities to begin promptly;
- Identification of applicable quality management requirements for data collection and data management systems;
- Development of a communications plan to effectively share data and interpretations on waste management planning, operations, waste characterization, technology, monitoring and progress toward endpoints;

Lecture notes:

- Establishment of an information management system to allow data for waste management activities for the recovery to be accessed by local government and other stakeholders. The system needs to be developed ahead of time and used in training exercises so that users are familiar with it and improvements can be made based on experience gained from exercises;
- Identification of all organizations that need to be involved at the preparedness stage;
- Periodical re-evaluation of the plans to ensure those resources are available when needed;
- Identification of data necessary to be collected during each step of waste management;
- Considering the needs for developing subsequent facilities such as storage and disposal.



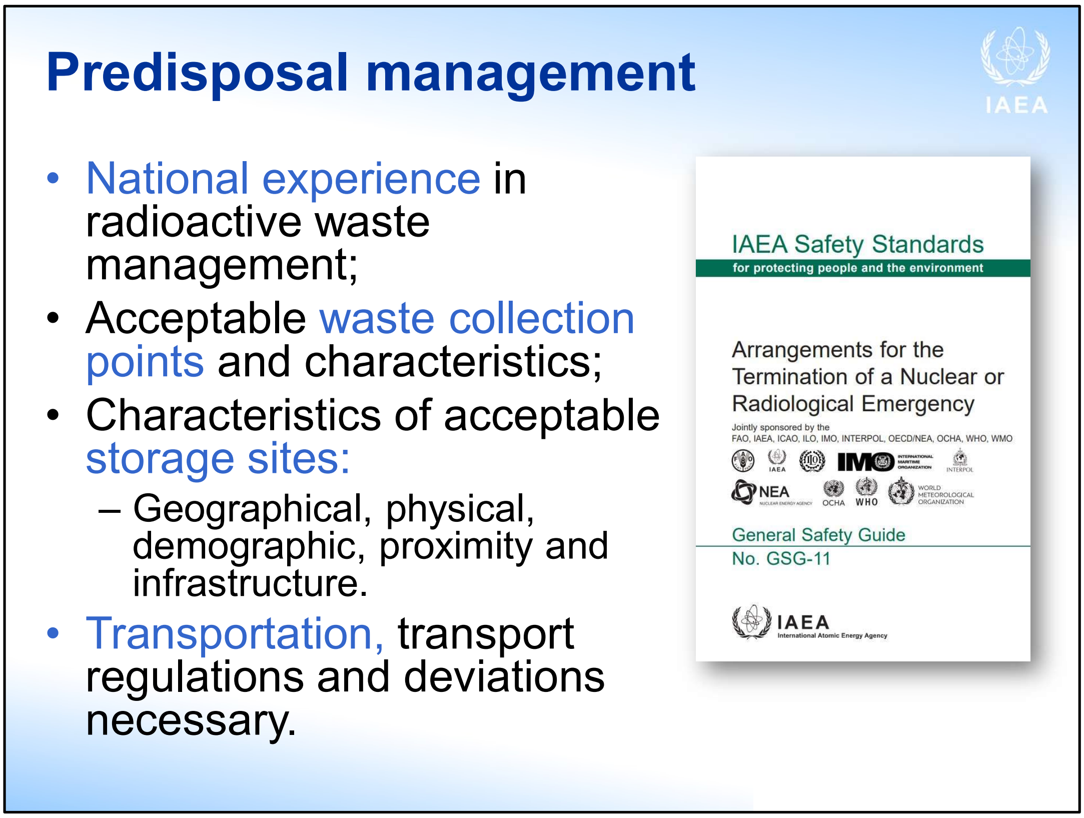
Lecture notes:

The figure represents simplified steps for the management of waste arising from a nuclear or radiological emergency. Note that in the actual situations, some steps such as storage and transport may be performed several times (e.g. storage after processing, transport before and after staging).

Management of waste covers all the steps from its generation up to disposal, including processing (pre-treatment, treatment and conditioning), storage, transport and disposal. Among the various steps of waste management, waste collection, segregation and packaging for temporary storage are the first waste management activities observed during emergency and recovery, which can be defined as staging in this document. Due to the sudden nature of waste generation after an emergency, the staging is considered as one of crucial step for early waste management activities, which has a role to initiate waste management activities in timely manner without affecting the other prioritized activities to deal with the emergency.

Lecture notes:

Following the initial step, waste will need to be further processed based on appropriate consideration of the characteristics of the waste and of the demands imposed by the different steps in its management. Throughout these different steps of waste management, characterization needs to be performed in stepwise manner to enhance the understanding of the characteristics of the waste.



Lecture notes:

Radioactive waste generated 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. 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 apply.

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

- National experience in radioactive waste management;
- Acceptable waste collection points and their characteristics;

Lecture notes:

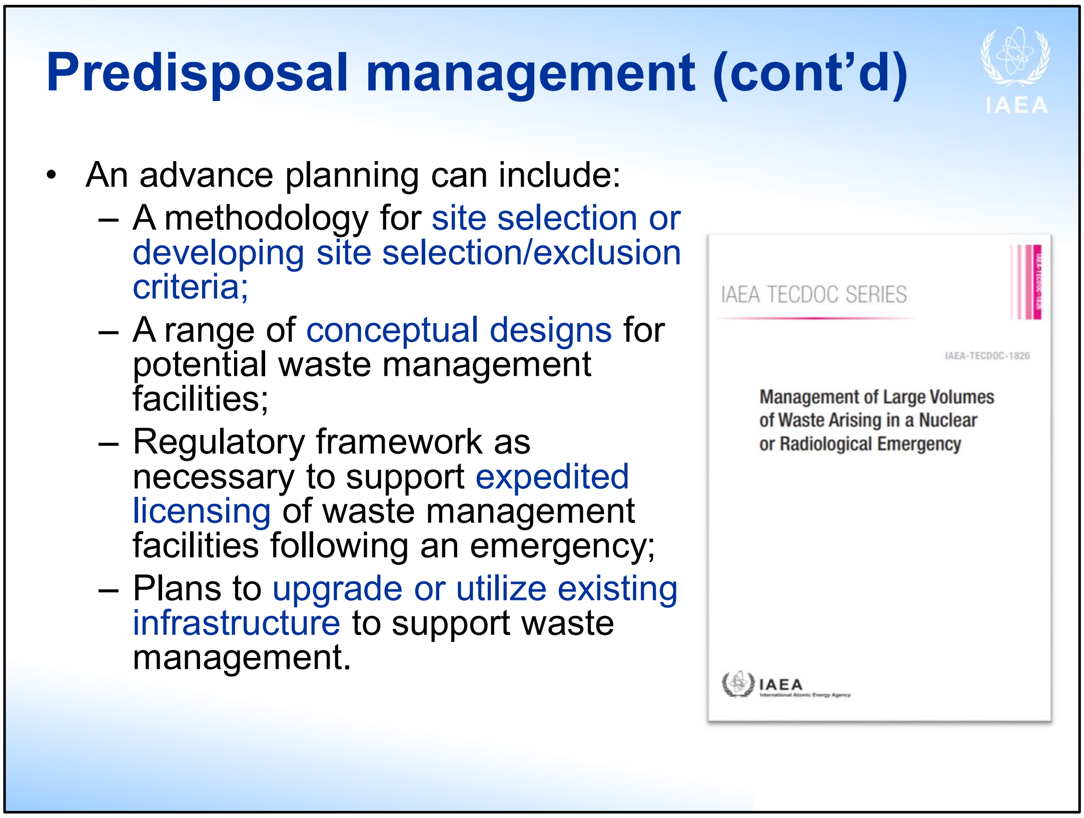
- The characteristics of acceptable storage sites, such as geographical, physical and demographic aspects, as well as the proximity to the affected site or area and the availability of the necessary public infrastructure;
- The need for the transport of radioactive waste, adherence to transport regulations and any deviation from established practices, as necessary.

Discussion

How can we prepare for identifying acceptable waste collection points and storage sites after an emergency?

Lecture notes:

Allow for about 3 mins. of discussion.



Lecture notes:

An advance planning to support predisposal management of waste following an emergency without causing unnecessary delays may include:

- Developing a methodology for site selection or developing site selection/exclusion criteria;
- Developing a range of conceptual designs for potential waste management facilities (e.g. containers and general design for staging, modular type storage facility, mobile treatment facilities);
- Developing a regulatory framework as necessary to support expedited licensing of waste management facilities following an emergency;
- Considering how to upgrade or utilize existing infrastructure to support waste management.

Disposal management

IAEA

- Disposal of radioactive waste is a long term issue:
  - Beyond emergency preparedness and response consideration;
  - Dependent on national policy and strategy for radioactive waste management.
- Identification of disposal options need not delay decision to terminate the emergency.

Lecture notes:

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 than other aspects of predisposal management. Disposal activities will take place over a longer time frame, allowing a return to normal waste management practices. By the time most materials are shipped for disposal, much of the uncertainty regarding the nature and extent of the recovery and the waste streams involved will have been resolved based on data obtained by waste characterization.

Thus, the identification of disposal options should not delay the timely decision to terminate a nuclear or radiological emergency and the subsequent transition to either a planned exposure situation or an existing exposure situation.

Disposal management (cont'd)

Goiânia accident (1987):

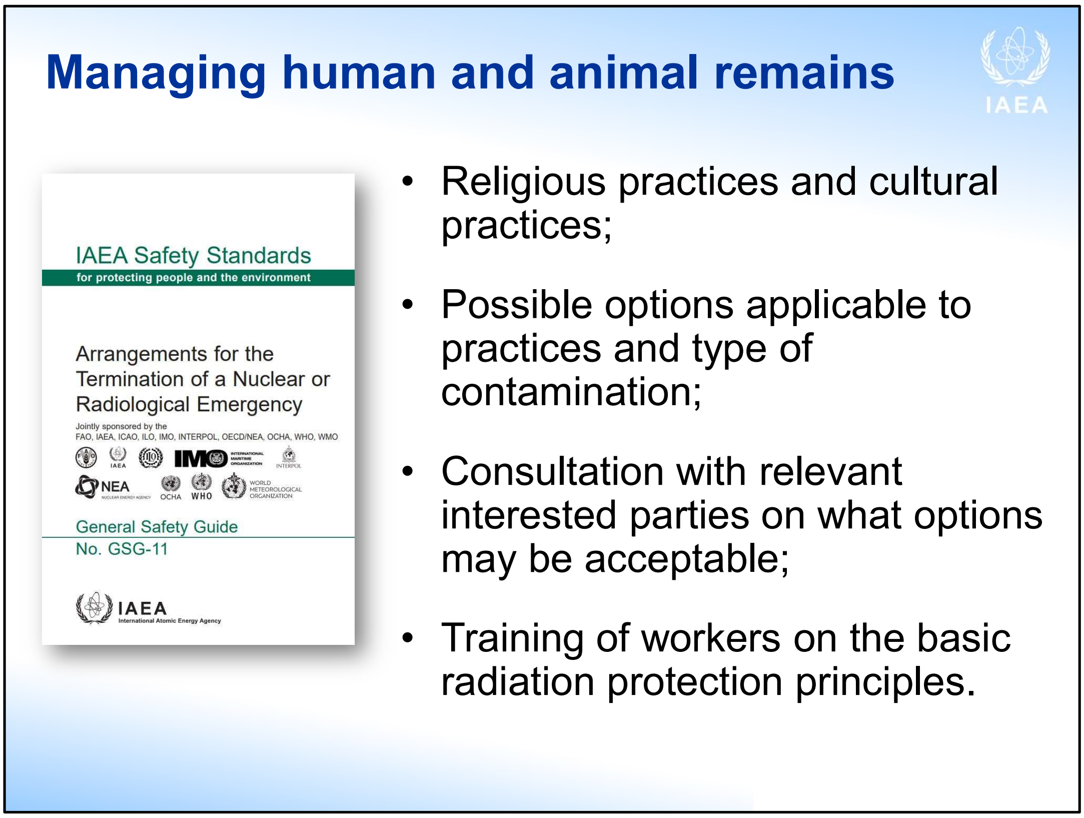
- Temporary storage site (1987)
- Final disposal facility (1997)

Image reproduced from 'The Radiological Accident in Goiânia', IAEA , Vienna (1988)

Lecture notes:

In the case of the Goiânia accident, it took about 10 years for the final disposal facility to be put in place.

FIG.: The temporary storage site, International Atomic Energy Agency, The Radiological Accident in Goiânia, IAEA, Vienna (1988)



Lecture notes:

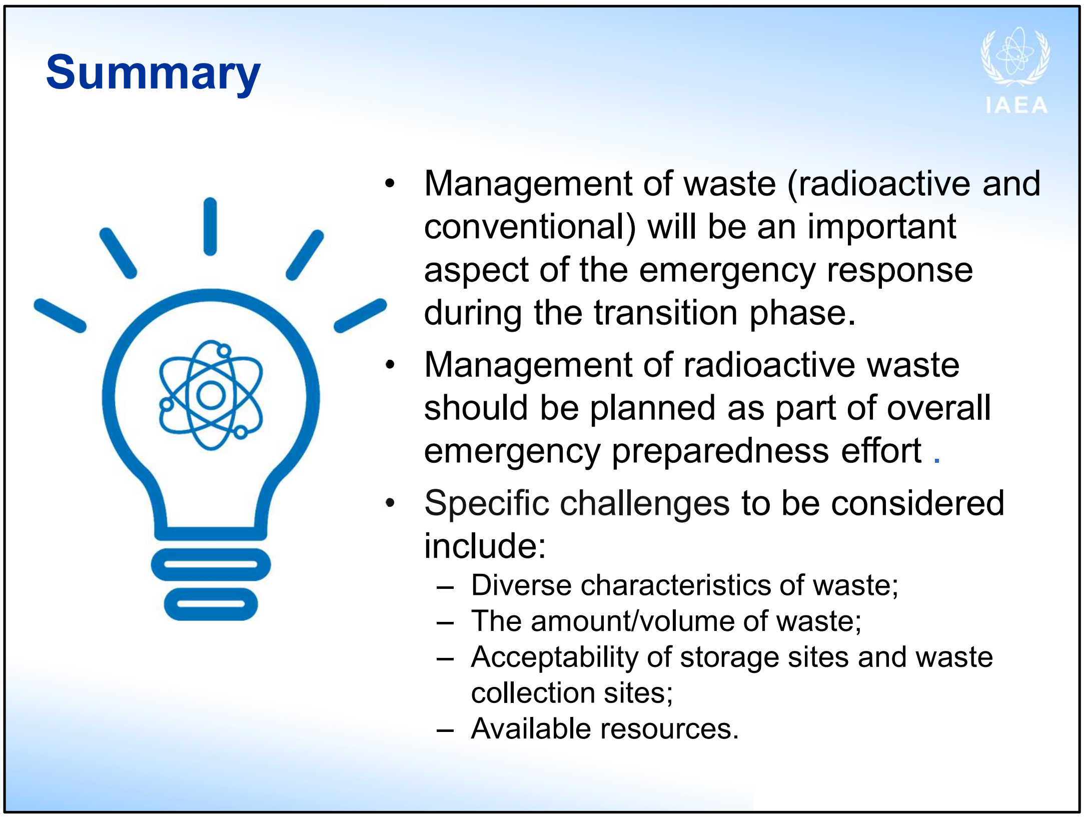
Management of human remains and animal remains that may be directly contaminated as a result of a nuclear or radiological emergency has been a challenge in the past, both at the Goiânia accident as well as the Fukushima Daiichi accident. Preparing to address this challenge will need to consider the following aspects:

- Identification of religious practices and cultural practices within the State (for example, there may be cultural/religious requirements on burial versus cremation, how quickly the deceased remains are buried or cremated, or normal practices on handling the body by family members) that will need to be factored into the advice and protection arrangements;
- Identification of possible options applicable to the identified practices and the type of exposure (internal or external);
- Consultation with relevant interested parties, which include representatives of different religious groups, on what options may be acceptable;

Lecture notes:

- Training of workers assigned to handle the remains on the basic radiation protection principles, including ways to prevent spread of contamination and inadvertent ingestion. Conventional measures taken by workers for their protection while handling the remains (e.g. gloves, masks etc.) should be considered adequate to provide for their protection.

The arrangements for the management of human remains and animal remains that may be directly contaminated as a result of a nuclear or radiological emergency should be part of overall national EPR framework.



Lecture notes:

Summarize the key points of the presentation.

Lecture notes:

Thank you!