IAEA assistance to the Ministry of the Environment, Japan on 'volume reduction and recycling of removed soil arising from decontamination activities after the Accident of the Fukushima Daiichi Nuclear Power Station'

FINAL REPORT ON THE EXPERTS MISSION

IAEA
International Atomic Energy Agency

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Executive Summary

In October 2022, the Director General of the Environmental Regeneration and Material Cycles Bureau of the Ministry of the Environment, Japan (MOEJ) requested the IAEA to perform in 2023-24 three International Expert Meetings (IEMs) on volume reduction and recycling of removed soil arising from decontamination of land in Fukushima Prefecture after the accident of the Fukushima Daiichi Nuclear Power Station (FDNPS) in Japan.

There are about 13 million cubic meters of removed soil and about 300,000 cubic meters of ash from incineration of organic material stored at the Interim Storage Facility (ISF) within Fukushima Prefecture (straddling Okuma Town and Futaba Town).

The internationally agreed waste management hierarchy includes waste minimisation, reuse and recycling where possible, in order to reduce the volume of waste that ultimately needs to be disposed of. The removed soil may be an important resource and therefore the MOEJ is evaluating options for recycling it. If these options are proved to be safe and feasible then they could significantly reduce the volume of waste that will need to go for the final disposal.

With this in mind, the objectives of the three IEMs were to:

- discuss the current progress and challenges associated with planning and implementing volume reduction and recycling of removed soil, and, for soil that cannot be recycled, the final disposal outside Fukushima Prefecture
- provide advice and support to Japan for these activities, especially from:
    - technical viewpoint (e.g., safety and recycling criteria); and,
    - social viewpoint (e.g., communication and engagement of interested parties).

A team of experts comprising 5 IAEA staff and 6 selected international experts provided dedicated advice and support to the MOEJ over the course of three IEMs.

The first IEM was organised from 8 to 12 May 2023 in Japan and the first summary report was made publicly available on 1 September 2023 on the IAEA website. The first IEM comprised:

- Summary and discussion of the MOEJ activities associated with planning and implementing volume reduction and recycling of removed soil;
- Technical site visits to the ISF where removed soil is characterised, treated and stored;
- Technical site visits to demonstration projects, where pilot projects are ongoing to demonstrate the safety of using recycled soil in construction and agriculture; and
- Courtesy visits and discussions with local officials and residents who have been engaged for a long time in recycling of the removed soil.

The MOEJ's summary included an introduction to some of the key policies and laws that frame the management of removed soil, namely:

- Act on Special Measures concerning the Handling of Pollution by Radioactive Materials (Act on Special Measures)
- Basic Policy on the Act on Special Measures (Basic Policy)
- Law for the Japan Environmental Storage and Safety Corporation (JESCO Law)

- Technology Development Strategy for Volume Reduction and Recycling of Removed Soil and Waste under Interim Storage (Technology Development Strategy)
- Basic Concept for Safe Use of Removed Soil Processed into Recycled Materials (Basic Concept)

Technical site visits to the demonstration projects within Fukushima Prefecture (one in Nagadoro District using removed soil for agricultural embankments and one in the premise of the ISF using removed soil for road embankments) and the ISF (Soil Separation Facilities, Soil Storage Facilities, etc.) emphasised both the enormity of the challenge and the opportunity for contributing to the reconstruction of areas affected by the accident. Courtesy visits to the municipalities provided the team of experts with a valuable insight into the viewpoint of the local officials and residents, and the reasoning behind the difficult decision to accept the demonstration projects and the ISF.

The second IEM was held from 23 to 27 October 2023 in Vienna, Austria, and the summary report was officially published on 12 January 2024. The third IEM was held from 5 to 9 February 2024 in Tokyo, Japan. Both IEMs continued discussions about the technical and social aspects of the following main topics:

- Approaches, concepts and standards regarding the safety of the managed recycling (use of recycled removed soil in civil engineering structures such as road embankments) and final disposal of removed soil and waste;
- Approaches to communication with residents; and
- Information dissemination to the international community.

During the second IEM, experts presented examples of the managed recycling and the final disposal of removed soil and radioactive waste in various countries (e.g., United Kingdom, Belgium, Germany and USA).

The third IEM focussed on the progress made by the MOEJ since the second IEM, and the team of experts shared case studies of stakeholder engagement for the final disposal of Low Level Waste (LLW) or Very Low Level Waste (VLLW) in Member States. In addition, a session was organized to discuss the extent to which activities implemented and planned by the MOEJ are consistent with the IAEA Safety Standards.

Neither the findings of the 3 IEMs nor the IAEA assistance project as a whole will result in approval or rejection of the solution proposed but will provide observations related to safety and in particular will review whether the Japan's approach is consistent with the IAEA Safety Standards. Regulatory review, including approval and/or authorisation to proceed with activities to manage the removed soil is the sole responsibility of the Japanese authorities in the context of the national regulatory framework.

This final IEM report describes Japan's position on each of the topics listed below and then presents the observations and conclusions of the team of experts:

- Regulatory aspects
- Volume reduction and the managed recycling of removed soil
- Final disposal of removed soil and waste
- Public communication and stakeholder engagement

Japan's position comprises facts and explanations made by the Japanese government and experts. Observations are the views of the team of experts on Japan's position, and conclusions summarize opinions of the team of experts for each topic taking account of discussions in all three IEMs.

Regulatory aspects

Considerable progress has been made on the regulatory aspects, in line with the Technology Development Strategy. The MOEJ's activities demonstrate a comprehensive approach to address the challenges of managing the removed soil and waste encompassing technology development, development of regulatory frameworks and transparent public engagement.

The Technology Development Strategy outlines a comprehensive approach to addressing the challenges associated with the volume reduction and recycling of removed soil, as well as the final disposal of removed soil unsuitable for the managed recycling outside Fukushima Prefecture to be completed by March 2045. Achievements and findings to date from implementation of the Technology Development Strategy will be compiled by the end of FY2024. The MOEJ has made progress in considering regulatory aspects for both the managed recycling and the final disposal of removed soil and waste. The MOEJ is working on developing necessary standards and guidelines for the managed recycling of removed soil in civil engineering structures, as well as for the final disposal of removed soil as waste (according to definition of waste in the IAEA Safety Standards). As part of developing the regulatory framework, regulatory oversight will ensure that the managed recycling projects and the final disposal activities are conducted in accordance with established laws, and standards of safety in Japan.

Under the Act on Special Measures, the MOEJ is responsible for developing the ministerial ordinance and the technical guidelines for the managed recycling of removed soil and for constructing and operating the final disposal facility. These should reflect that protection against exposure to ionizing radiation must be optimized to provide the highest level of safety that can reasonably be achieved taking into account relevant economic, societal and environmental factors (Principle 5 of the IAEA Fundamental Safety Principles). Therefore, the team of experts emphasised that the options for protection and safety should be evaluated considering their overall impact, not just the dose, and taking account of the prevailing circumstances.

The Act on Special Measures specifies that the MOEJ has an operator role (i.e., planning and implementing projects for the managed recycling and the final disposal of removed soil and waste) as well as a regulatory role. During the IEMs, the team of experts underlined the importance of having a regulatory function that is independent from the operational function as stated in Requirement 4 of GSR Part 1. This was acknowledged by the MOEJ and the MOEJ is considering approaches that will enable the independence of the operator function and regulatory function to be maintained and demonstrated.

The team of experts notes that a clear regulatory process, including review and authorisation will be key to the successful implementation of the managed recycling of removed soil, and will provide reassurance to the public. The MOEJ will consider an authorization process for future projects.

Volume reduction and the managed recycling of removed soil

Volume reduction and the managed recycling of removed soil is a sustainable process for the reconstruction and revitalization of the affected areas. Overall progress has been made on the development, assessment and demonstration of technology for volume reduction and the managed recycling in accordance with the Technology Development Strategy.

The MOEJ's Basic Concept prescribes a dose criterion of an additional effective dose of 1 mSv per year as a basis to derive a screening level for the concentration of radioactivity in recycled soil. Using recycled soil with a concentration of radioactivity that is equal to or less than a level derived from a

dose criterion via generic safety assessments is an approach that is consistent with the IAEA Safety Standards (GSG-18). Generic safety assessments, which are conducted in a conservative way consistent with established international practices, indicate that the dose criterion can be met by using recycled soil with a level of radioactivity of 8,000 Bq/kg or less (the screening level) under proper management to be stipulated in the ministerial ordinance and the technical guidelines.

The dose criterion of the additional effective dose of 1 mSv per year is an appropriate criterion for the managed recycling of removed soil. Through optimisation of protection, doses to the public from the managed recycling could be further reduced (e.g., using cover soil for prevention of scattering and leakage).

The generic safety assessments for the managed recycling of removed soil have been conducted considering various factors such as exposure pathways and dose rates. Conservative parameter values are used in the generic safety assessment to estimate, with a safety margin, the dose received from a particular activity concentration. The team of experts noted that safety assessments using more realistic parameter values, taking into account data and findings gained through the demonstration projects, will be useful to support optimization of protection and safety as required by the IAEA Safety Standards (Principle 5 of the IAEA Fundamental Safety Principles).

There is no intention to retrieve the recycled soil from the civil engineering structures (e.g., road embankment). The team of experts emphasised the importance of demonstrating the long-term safety of the structures and notes that the MOEJ will consider the long-term, post-management safety of the recycling projects before implementation. This will enable the post-management safety to be evaluated in due course and could be reflected in the ministerial ordinance and technical guidelines accordingly.

The team of experts highlighted that materials that will be recycled should be measured with a specified accuracy to demonstrate that relevant screening levels are not exceeded. The MOEJ is considering a suitable measuring method, based on the approach already applied to the ISF.

The MOEJ has measured the concentration of radionuclides in the removed soil, including Cs-134, Cs-137 and other isotopes (Sr-90, Pu-238 etc.). The team of experts notes that the results of these measurements reconfirm the appropriateness of the focus on radioactive caesium in safety assessments.

The MOEJ has undertaken several demonstration projects for the managed recycling of removed soil with radioactivity concentration of 8,000 Bq/kg or less. These demonstration projects showcase the feasibility of implementing the managed recycling projects safely. The demonstration projects use the removed soil for various purposes, demonstrating the potential for safe and beneficial use in different applications.

At the demonstration projects the MOEJ conducts continuous monitoring of radiation levels in the surrounding environment to ensure that they are below the relevant criteria, and that there are no big changes in dose rates compared with the pre-project situation. Regular monitoring of radiation dose rates is in place to assess potential exposure risks to workers, residents and the environment. Results of monitoring performed to date at the demonstration project show that the dose criterion selected by the MOEJ (additional effective dose of 1 mSv per year) and the relevant dose limits set in GSR Part 3 for the protection of people and the environment are met. The team of experts recommends that the demonstration projects and associated monitoring be continued to provide information on long-term safety, which will contribute to public understanding.

The MOEJ aims to develop the ministerial ordinance and the technical guidelines for the managed recycling of removed soil based on the results of the generic safety assessments and the demonstration projects by the end of FY2024. The MOEJ is planning for future projects beyond the demonstration phase in accordance with the ministerial ordinance and the technical guidelines.

The civil engineering structures used for the managed recycling are not expected to be artificially altered over a long period of time, under appropriate management by bodies (in principle public bodies) that have responsibilities clearly defined in Japanese laws. The MOEJ will retain full responsibilities from a radiological perspective for the appropriate management of the recycled soil during the construction and maintenance period, while the relevant bodies will have their responsibilities in terms of the construction and maintenance of the structure itself. There will be an agreement between the MOEJ and the relevant body before implementation of the projects concerning future management of the structure, including defining acceptance criteria and safety management arrangements.

The team of experts highlighted that the technical guidelines and/or agreements need to describe which situations and eventualities require the relevant body to inform the MOEJ, and to seek advice, review and agreement from the MOEJ before proceeding with planned action (e.g., taking remedial actions). The agreements should include procedures for prior notification of any change to the form or use of land to ensure that the safety of structures for the managed recycling is maintained. The team of experts notes that the level of management control that is needed to ensure safety of the managed recycling can be reduced over time due to radioactive decay. Special attention is no longer required when public exposure to radiation is as low as reasonably achievable taking account of economic, societal and environmental factors, and further radiation protection measures would yield no additional benefit. The team of experts observed that the MOEJ needs to consider the point at which no further management in terms of radiological protection is required.

Final disposal of removed soil and waste

Important progress has been made for consideration of final disposal options, including initiation of sensitivity analyses to understand the key processes and parameter values that are important for safety, but there are a lot of challenges still to be addressed to realize the final disposal outside Fukushima Prefecture by March 2045. The team of experts suggests that the MOEJ defines a holistic strategy and timeline for the final disposal outside Fukushima Prefecture of removed soil unsuitable for the managed recycling.

The MOEJ's approach to the final disposal outside Fukushima Prefecture involves careful consideration of options for volume reduction and characterization of waste, disposal options, and development of a generic safety assessment of the final disposal of removed soil unsuitable for the managed recycling. Different volume reduction treatment options are under investigation, which will result in different volumes of waste requiring the final disposal. An options study is required to assess which option will be most effective overall, taking into account the resulting volume and characteristics of waste (including secondary waste) and other relevant factors. Three types of final disposal facilities are under discussion, depending on the volume and radioactivity concentration of the removed soil and waste for the final disposal.

Based on information shared by the MOEJ, the team of experts expects that the removed soil and waste to be sent for the final disposal could be assigned as Low Level Waste or Very Low Level Waste according to the IAEA´s classification scheme defined in the GSG-1, although this will have to be

confirmed by a specific safety case including safety assessment. In such case, the final disposal concept of a near surface disposal facility as illustrated by the MOEJ would be appropriate.

The design of the disposal facility has so far been developed considering the operational and maintenance period. Consequently, the proposed safety measures to be stipulated in the ministerial ordinance of landfill disposal for removed soil and waste covers essential elements to ensure safety during the construction and maintenance period. The team of experts stresses the importance of designing the final disposal facility based on post-closure safety together with operational safety. The team of experts notes that the generic safety case including generic safety assessment on post-closure safety has been initiated, which will contribute to the ongoing development of a design for the final disposal facility.

To meet the requirement for optimization of protection and safety, the MOEJ should consider different options for the location and design of the final disposal facility (or facilities), in due time before implementation. The MOEJ should understand the value of the different options for increasing protection and reducing exposure to radiation in terms of economic, societal and environmental factors in addition to safety. The MOEJ has implemented an initial assessment to identify radionuclides of importance for the safety of the final disposal, and come to a provisional conclusion, that the contribution of other radionuclides is much less than that of radioactive caesium. At an appropriate stage, the MOEJ should conduct additional site-specific sensitivity analyses for all the safety-critical parameters to reduce uncertainties in the design of the disposal facility.

Safety measures will be stipulated in the ministerial ordinance for the final disposal. Associated documents need to be developed in due time, to make it clear, which situations and eventualities require the operator function of the MOEJ (for the final disposal facility) to inform the regulatory function of the MOEJ and to seek their advice, review and agreement before proceeding to the next stage in the development and operation of the final disposal facility.

Public communication and stakeholder engagement

The MOEJ has made significant progress in the area of public and stakeholder engagement since the first IEM and should continue to develop and refine its approach as the project progresses.

The MOEJ emphasizes the importance of transparent communication and engagement with the public to foster understanding and acceptance of recycling initiatives. This includes providing clear information on safety assessments, radionuclide impact assessments, and measurement results to address public concerns.

From FY2025, in line with plans to accelerate work on siting and design of the final disposal facility to meet the challenging timelines prescribed in law, the MOEJ is expected to continue development of its master plan for public communication and stakeholder engagement regarding options for the final disposal. The team of experts advised that for both the managed recycling and the final disposal of removed soil and waste, the MOEJ needs to be clear with the public and key stakeholders about the consequences and trade-offs between different options (e.g., in relation to lower activity / higher volume disposal as opposed to higher activity / lower volume options). Communicating the potential associated benefits of options should include not just financial considerations but other factors such as supporting reconstruction, long-term sustainability of the community and so on. Efforts have been undertaken by the MOEJ to actively disseminate information about Japan's initiatives for the managed recycling and the final disposal of removed soil and waste and information will continue to be disseminated domestically and internationally.

Overall evaluation

Based on comprehensive discussions with the MOEJ through 3 IEMs, the team of experts concluded that the approach and activities implemented by the MOEJ to date for the managed recycling and the final disposal of removed soil and waste are consistent with the IAEA Safety Standards. This includes activities at the ISF and the demonstration projects.

Looking ahead to implementation of the managed recycling and the final disposal of removed soil and waste beyond the demonstration phase, the team of experts is confident that with the MOEJ's continuous exploration of solutions to meet fully the advice provided by the team of experts (e.g., performing post management safety assessments of the managed recycling and the final disposal, and demonstrating the independence of the regulatory function of the MOEJ), the MOEJ's evolving approach to the managed recycling and the final disposal of removed soil and waste will be consistent with the IAEA Safety Standards. This can be confirmed by future follow-up assessments of the MOEJ's approach.

During the three IEMs, the team of experts recognised the many technical and social challenges facing the MOEJ. It raised numerous issues to be addressed in order to implement the managed recycling of removed soil and secure final disposal outside Fukushima Prefecture by March 2045. The team of experts encouraged the MOEJ to continue to make its best efforts to realize this challenging goal.

The team of experts noted that efforts to recycle removed soil generated from decontamination activities contribute to reconstruction and revitalization in Fukushima Prefecture. The findings of the advanced efforts for the managed recycling of removed soil can be used as a useful case study for reference by other countries. Dissemination to international society, through international forums, publications and media, including cooperation with the IAEA, is encouraged.

The IAEA will continue to support Japan in its further efforts for the managed recycling and the final disposal of removed soil and waste now and towards the future.

In conclusion, the MOEJ's proactive approach to managing removed soil and waste arising from decontamination activities reflects a commitment to ensuring safety, protecting public health and promoting environmental sustainability in Fukushima Prefecture and beyond. The team of experts encourages and praises the MOEJ's continued efforts in refining safety assessments, optimizing protection measures, establishing clear regulatory processes, developing technologies and recycling initiatives to minimise the volume of radioactive waste requiring disposal, and engaging stakeholders. Through ongoing collaboration, transparency, and adherence to the IAEA Safety Standards, Japan continues to make significant strides towards the long-term management of removed soil and waste.

I – Introduction

I.1 – Background to the IAEA's assistance

In October 2022, the Director General of the Environmental Regeneration and Material Cycles Bureau of the Ministry of the Environment, Japan (MOEJ) requested the International Atomic Energy Agency (IAEA) to organize and perform in 2023-24 three International Experts Meetings (IEMs) on volume reduction and recycling of removed soil arising from decontamination activities after the accident of the Fukushima Daiichi Nuclear Power Station (FDNPS) in Japan.

Since the accident at the FDNPS occurred in March 2011, a large number of activities involving Japanese authorities and the IAEA have been taking place. Especially, under the IAEA Action Plan on Nuclear Safety established in September 2011, a wide variety of programmes of learning and acting upon lessons following the accident have been implemented in order to strengthen nuclear safety, emergency preparedness and radiation protection of people and the environment worldwide. Lessons learned from the accident were shared and disseminated through a series of international experts meetings, international peer review missions, and different types of technical documents. The IAEA Report on the Fukushima Daiichi Accident (IAEA Fukushima Report), which was presented at the 59th IAEA General Conference in September 2015, assessed the causes and consequences of the accident and explored a lot of lessons learned from it.

In particular, the Technical Volume 5 of the IAEA Fukushima Report extensively addressed the challenges related to the post-accident recovery including off-site remediation, on-site stabilization, and radioactive waste management. The report produced significant commentary on the strategy development and implementation of the environmental remediation in the off-site areas affected by the accident.

The post-accident recovery including the environmental remediation work is continuing. Progress, challenges and solutions may all benefit from consideration by the IAEA, as well as sharing with the international community. Hence, it was proposed that a continuous process of consultation composed of bilateral meetings between the IAEA and the MOEJ, the Government of Japan (including other relevant authorities, as appropriate) could be established, so that progress on the environmental remediation activities would be updated and discussed in a more detailed way. This consultation mechanism will give a chance for both sides to have a more effective and constructive exchange of information; for the IAEA and international experts selected by IAEA to obtain better understanding of the recent progress; and consequently, for the MOEJ to receive more useful advice from the international community through the IAEA. The findings (additional experiences and lessons learned) to be collected through this consultation will be disseminated to the international community.

I.2 – Background to volume reduction and recycling of removed soil

The environmental remediation has resulted in a very large volume of removed soil and waste and most of what was generated in Fukushima Prefecture is currently stored at the Interim Storage Facility (ISF) within Fukushima Prefecture (straddling Okuma Town and Futaba Town). The remaining removed

soil and waste are stored at Temporary Storage Sites (TSSs) throughout Fukushima Prefecture. According to the Technology Development Strategy for Volume Reduction and Recycling of Removed Soil from Interim Storage, an estimate as of 2019 indicates there are about 13 million cubic meters of removed soil and about 300,000 cubic meters of ash from incineration of organic material stored at the ISF. The removed soil brought in from TSSs is sorted at the Soil Separation Facilities. The facility plays a crucial role in the initial treatment and sorting of the soil before it is stored in the Soil Storage Facilities. The combustible materials (e.g., container bags, plants, roots) obtained from the separation treatment are sent to the Temporary Incineration Facilities. The fly ash obtained from the Temporary Ash Treatment Facilities is mainly stored in the Waste Storage Facilities, but small part of the fly ash is currently treated in the Test Facility for Fly Ash Cleaning Technology as a demonstration project to seek the feasibility for further volume reduction of the waste.

The current approach to volume reduction and the managed recycling of removed soil comprises a variety of activities, such as technology development (see Section IV.3), two demonstration projects using removed soil in the managed recycling (see Section IV.5 and IV.6), and building public understanding (see Chapter VI). Japanese law requires that any removed soil unsuitable for the managed recycling is sent for the final disposal outside Fukushima Prefecture by March 2045 (see Chapter V).

The internationally agreed waste management hierarchy supports volume reduction, reuse and recycling where possible, in order to reduce the volume of waste that needs to be disposed of. The removed soil may be an important resource and therefore options for the managed recycling of the removed soil are being evaluated. If these options are proved to be safe and feasible, they will significantly reduce the volume of removed soil and waste that will need to go for the final disposal.

I.3 – Objective

The IAEA assistance project marks an important step in supporting Japan towards reducing the volume of radioactive waste from the accident of the FDNPS and promoting the managed recycling of removed soil arising from decontamination activities after the accident. This time, the IAEA assistance comprised three IEMs and addressed both the technical perspective (e.g., technical and safety aspects of the managed recycling and the final disposal), as well as the social perspective (e.g., public and stakeholder engagement).

The objectives of the IEMs are:

- To discuss the current progress and challenges of the activities associated with planning and implementation of volume reduction and recycling of removed soil, which is mainly stored in the ISF.
- To provide advice and support to Japan for the above works, especially from the technical viewpoint (e.g., recycling and safety criteria), as well as the social viewpoint (e.g., engagement of interested parties).

The IAEA Safety Standards were the basis of advice provided during the IEMs. As such, for those topics raised by the MOEJ for discussion, the IEMs included an assessment of whether the approach taken by Japan to date is consistent with the IAEA Safety Standards. Any such assessment will not result in

approval or rejection of the solution provided. Regulatory review, including approval and/or authorisation to proceed with activities to manage the removed soil and waste is the sole responsibility of the Japanese authorities.

I.4 – Scope

The scope of the IAEA assistance project covers the following items:

- Discussion about the current status of the volume reduction and recycling of removed soil.
- Discussion about the current status of the implementation of the Strategy and Roadmap for volume reduction and recycling.
- Assessment, support and advice regarding the progress and plans, especially in terms of recycling of removed soil and the final disposal outside Fukushima Prefecture, in specific areas listed in the Strategy and Roadmap such as:
    - From the technical viewpoints for recycling (e.g., safety, methodology, criterion of recycling, quality control, maintenance of structures, monitoring),
    - From the social viewpoint (e.g., communication with the public and promotion of public awareness).
- Visiting sites relevant to the volume reduction and recycling of removed soil (e.g., the ISF, demonstration project sites for the managed recycling of removed soil).
- Dialogue with associated mayors and representatives.

The Waste and Environment Safety Section of the Radiation, Transport and Waste Safety Division, Department of Nuclear Safety and Security of the IAEA implemented the project with the support of a team of 6 international experts. All selected experts have considerable experience in the areas under the scope of the IAEA assistance project and have previously worked with the IAEA on radioactive waste management, volume reduction, recycling or stakeholder engagement. The IAEA staff members and the international experts selected by the IAEA are hereafter referred to as “the team of experts”.

I.5 – Key relevant laws and documents

Since shortly after the accident of the FDNPS, significant efforts have been made on off-site remediation activities, including the volume reduction and recycling of removed soil, based on relevant Japanese laws and documents. This section summarises the key laws and documents that underlie policy on the managed recycling and the final disposal, and explain the development history and the relationship between them.

Act on Special Measures concerning the Handling of Pollution by Radioactive Materials (Act on Special Measures)

The Act on Special Measures concerning the Handling of Pollution by Radioactive Materials (Act on Special Measures) was promulgated in August 2011 and fully taken into effect in January 2012. This act clarifies the responsibilities of relevant stakeholders (e.g., national and local governments, nuclear business operators) which deal with the environmental pollution from radioactive materials released by the accident, to promptly reduce the impacts on human health and the living environment. In this Act, soil arising from decontamination activities is defined as 'removed soil', and it is differentiated from combustible waste arising from decontamination activities (e.g., twigs, leaves) and other kinds of waste (e.g., ash). The ministerial ordinance defines standards for treatment of the Specified Waste.

Basic Policy on the Act on Special Measures (Basic Policy)

After the promulgation of the Act on Special Measures, the Basic Policy on the Act on Special Measures (Basic Policy) was published in November 2011. This Basic Policy represents basic necessary items to be included in the approach for off-site environmental remediation activities, including monitoring, decontamination, transportation, storage, disposal and other important issues to be addressed.

Law for the Japan Environmental Storage and Safety Corporation (JESCO Law)

The Law for the Japan Environmental Storage and Safety Corporation (JESCO Law) was originally promulgated in 2003. Based on the amendment in November 2014, Japan Environmental Storage & Safety Corporation (JESCO) has conducted projects relevant to reliable and appropriate implementation of interim storage, to contribute to prompt reduction of impact on human health and the living environment caused by the accident.

In the law, it is stipulated that the government is responsible for taking necessary measures to complete final disposal of removed soil and waste generated from decontamination activities outside Fukushima Prefecture within 30 years after the start of interim storage (March 2045).

Technology Development Strategy for Volume Reduction and Recycling of Removed Soil and Waste under Interim Storage (Technology Development Strategy)

The Technology Development Strategy for Volume Reduction and Recycling of Removed Soil and Waste under Interim Storage (Technology Development Strategy) was established in April 2016, with a subsequent review in March 2019. The Technology Development Strategy represents an overall future mid-term and long-term basic policy on volume reduction and the managed recycling of removed soil and waste toward realization of the final disposal. This includes technology development, the basic approach for consideration of final disposal as well as building nationwide understanding, also taking account of discussions in the experts group.

Basic Concept for Safe Use of Removed Soil Processed into Recycled Materials (Basic Concept)

Based on the Technology Development Strategy, the Basic Concept for Safe Use of Removed Soil Processed into Recycled Materials (Basic Concept) was developed in June 2016, with subsequent reviews in 2017 and 2018, to show the basic approach to realize recycling of removed soil under safe management, on the premise of safety of workers and the public.

This Basic Concept includes concepts for radiation protection of workers and residents relevant to the managed recycling project, radioactivity concentration in the recycled material and conditions for planning and designs of structure.

In addition to the above laws and documents, amendment of the ministerial ordinance of the Act on Special Measures and development of the technical guidelines are under consideration by the MOEJ to give a basis for full-scale projects for the managed recycling to be implemented in FY2025 onward, and their concepts and approaches were intensively discussed during the three IEMs.

II – Contents of the three International Experts Meetings

II.1 - Preparatory Work

The IAEA and the MOEJ agreed on the terms of reference of the IAEA assistance project on 11 November 2022. A project implementation plan describing the activities to be implemented during the three planned IEMs was developed.

By 14 December 2022, the IAEA recruited the 6 experts dedicated to the IEM. As agreed in the project implementation plan, the MOEJ provided the team of experts with reference information to give them an overview of the activities undertaken by Japan under the scope of the IEM as well as their legal basis. The team of experts prepared presentations based on the IAEA Safety Standards and examples based on the experience and feedback of activities implemented in their countries.

The first IEM was organised from 8 to 12 May 2023 in Japan and the report of the meeting was officially published on 1 September 2023.

The second IEM was held from 23 to 27 October 2023 in Vienna, Austria and the report of the meeting was officially published on 12 January 2024.

The third IEM took place from 5 to 9 February 2024 in Tokyo, Japan. The present report is the final report including the observations and conclusions of the three IEMs.

The IEMs were not open to the public (this is consistent with the IAEA's common approach for technical meetings), while summary reports and the final report were publicized to inform the public about the contents of discussions and observations of the team of experts.

II.2 – Contents of the first IEM

The agenda of the first IEM is provided in the Annex 1.

In May 2023, the team of experts conducted its first IEM with the MOEJ in accordance with the terms of reference for the IAEA's assistance to the MOEJ on volume reduction and the managed recycling of removed soil arising from decontamination activities after the Accident of the FDNPS.

In response to the request from the MOEJ, the objective and the scope of the review mission were tailored to provide advice and support to the MOEJ regarding the volume reduction and the managed recycling of removed soil, according to their strategy and the relevant Japanese laws. The objectives of the mission focused on discussing the current progress and challenges of the volume reduction and the managed recycling of the removed soil, and providing advice and support to the MOEJ for the works both from the technical viewpoint and the social viewpoint.

To meet the objectives, the IEM covers the scope mentioned in the Section I.4.

During the first IEM, in addition to the full cooperation of the MOEJ, the team of experts received full cooperation of local authorities and other interested parties in Fukushima. Over the course of the week, a wide range of topics were discussed in Tokyo, and the team of experts had very fruitful opportunities to have hands-on experience in Fukushima, including site visits to the ISF and sites of the demonstration projects, as well as courtesy visits and discussion with mayors and people who have been involved for a long time with the projects relevant to the volume reduction and the managed recycling of the removed soil.

The team of experts noted progress made to date by the MOEJ and identified the topics to be discussed in the forthcoming meetings.

The summary report of the first IEM was made publicly available on 1 September 2023 on the IAEA website[1].

II.3 – Contents of the second IEM

The agenda of the second IEM is provided in the Annex 2.

The second IEM was held from 23 to 27 October 2023 in the headquarters of the IAEA in Vienna on a face-to-face basis, with some participants joining online from Japan.

The second IEM provided an opportunity for the MOEJ to present the progress made after the first IEM in May 2023 including the current status of the institutional arrangement for the managed recycling and the final disposal of removed soil and waste, progress on the approach to communication and dissemination of information, and to share views of the MOEJ on the consistency of their approach with the IAEA Safety Standards.

The team of experts noted significant progress during the second IEM. In addition, measures for managing removed soil and waste implemented by the MOEJ and relevant measures taken by other countries were shared.

The team of experts presented examples of measures related to the managed recycling and the final disposal of removed soil and radioactive waste in various countries (e.g., United Kingdom, Belgium, Germany and USA). Furthermore, a site visit was conducted to the Nuclear Engineering Seibersdorf facility, where sorting and disposal of radioactive soil has been implemented in Austria.

This summary report was written and endorsed by the team of experts and was published by the IAEA on its website[2] on 12 January 2024.

II.4 – Contents of the third IEM

The agenda of the third IEM is provided in the Annex 3.

[1] The summary report of the first IEM is available on the website of the IAEA: https://www.iaea.org/sites/default/files/23/08/summary-report-140823.pdf

[2] The summary report of the second IEM is available on the website of the IAEA: https://www.iaea.org/sites/default/files/24/01/report_iem2_iaea_moe.pdf

The third IEM organised from 5 to 9 February 2024 concluded the series of three IEMs to provide assistance to the MOEJ on volume reduction and the managed recycling of removed soil arising from decontamination activities after the Accident of the FDNPS.

This meeting was held in Tokyo, Japan with the objective to discuss the progress made by the MOEJ after the second IEM.

The MOEJ provided an update on the progress made on initiatives for volume reduction and recycling of removed soil, with a particular focus on the implementation of the Technology Development Strategy and the Roadmap for volume reduction and the managed recycling and future plans.

Regarding the final disposal outside Fukushima Prefecture, the MOEJ is proceeding with the development of volume reduction and recycling technology in order to present several feasible options for the required area and structure of the final disposal facility (or facilities) in time to include within the Technology Development Strategy (target is the end of fiscal year (FY) 2024). Safety and technology related aspects were extensively discussed.

The team of experts provided technical presentations on the IAEA Safety Standards dealing with the safety of disposal facilities as well as the guidance on the application of the screening levels introduced in IAEA General Safety Guide GSG-18: Application of the Concept of Clearance.

The MOEJ also provided updates on its significant progress made since the second IEM and future planning for public and stakeholder engagement, distinguishing between nationwide communication efforts and activities within Fukushima Prefecture. Effective national and international dissemination of the overall project remains an important element for maintaining trust and confidence in both the MOEJ and in the long-term safety of the project.

The team of experts shared case studies of stakeholder engagement for final disposal of Low Level Waste (LLW) or Very Low Level Waste (VLLW) in Member States, which were discussed.

A specific session was organized to discuss all activities implemented and planned by the MOEJ (i.e., volume reduction, the managed recycling of removed soil, and the final disposal) with regard to the consistency with the IAEA Safety Standards. On this occasion, the different terminologies used by the MOEJ and the IAEA were discussed in order to ensure a shared understanding of the different terms used by the experts in the conclusion of the three IEMs.

The discussions and observations made during this and previous IEMs are presented in the chapters that follow:

III Regulatory aspects

IV Volume reduction and the managed recycling of removed soil

V Final disposal of removed soil and waste

VI Public communication and stakeholder engagement

III – Regulatory aspects

The regulatory aspects for the managed recycling and the final disposal of removed soil and waste were discussed at all three IEMs. The team of experts recognizes that considerable progress has been made by the MOEJ between the first IEM and third IEM. The discussions between the team of experts and the MOEJ, and the observations made by the team of experts, are described here under broad topic headings.

III.1 – Overall process

Japan position

The Technology Development Strategy (see Section I.5) was formulated in 2016 and reviewed in 2019.

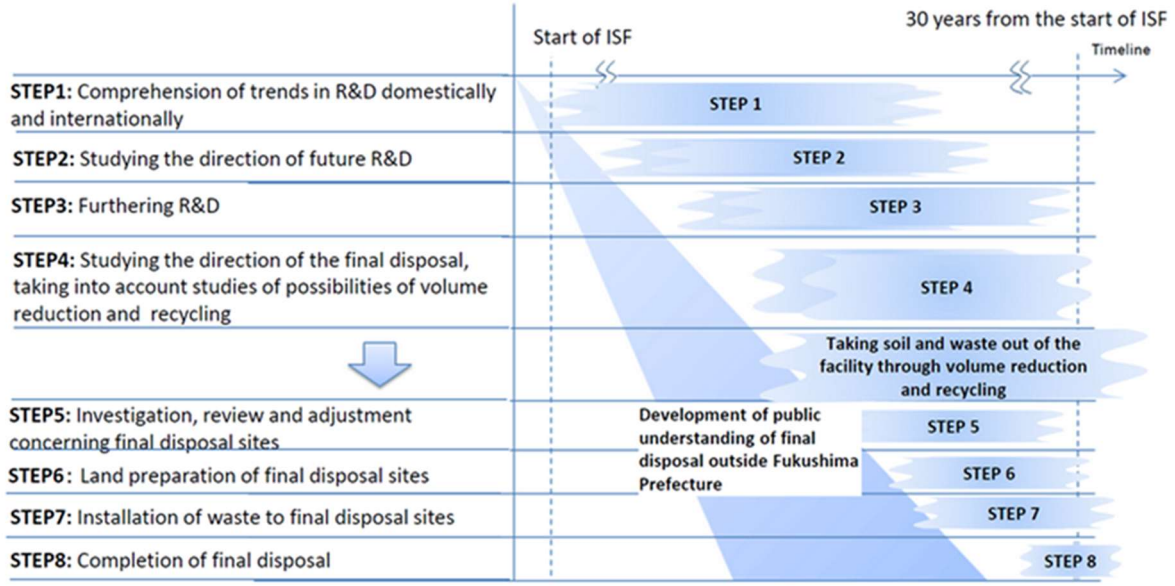


Figure I Eight steps toward completion of the final disposal by March 2045[3].

Figure I shows the eight steps toward the final disposal outside Fukushima Prefecture of removed soil unsuitable for the managed recycling, and Figure II shows an overview of the Roadmap for volume reduction and recycling.

[3] Measures on the Interim Storage Facility (July, 2014) (available in the following website): https://josen.env.go.jp/chukanchozou/action/acceptance_request/

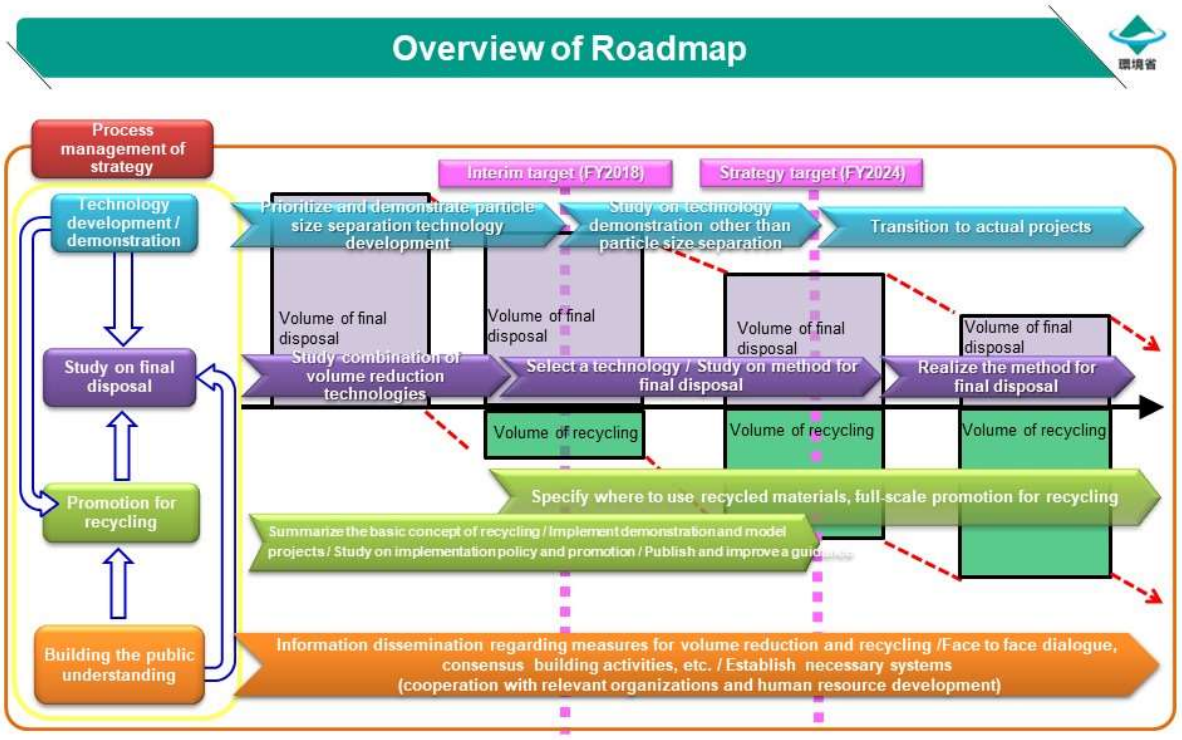


Figure II Overview of Roadmap toward the final disposal.

The end of FY2024 is the target for compiling achievements and findings to date from implementation of the Technology Development Strategy. Therefore the MOEJ is proceeding with the development of volume reduction and recycling technology in order to present several feasible options for the required area and structure of the final disposal site. From FY2025 onwards, the MOEJ will proceed with studies and adjustments related to the final disposal site.

Regarding regulatory aspects, the proposed system of regulation will be captured in ministerial ordinance and technical guidelines (the System) for the managed recycling and the final disposal of removed soil and waste (see Section III.4). It will cover:

1. Managed recycling of removed soil:
   - Handling of soil: Use of removed soil as a resource (civil engineering material).
   - Objective: The engineering properties of the removed soil are adjusted to ensure that it is suitable for use. It is used under appropriate management and on limited basis as materials such as fill in public works projects.
   - Upper part: The upper part is used as roads, agricultural land, etc.
   - Concentration: Removed soil with low radioactivity concentration will be used.
   - Location: Can be used inside and outside of Fukushima Prefecture.

2. Final disposal of removed soil:
   - Handling of soil: Disposal of removed soil as waste.
   - Objective: Final disposal at a final disposal site (no intention to retrieve). Regulation during operational period such as to put up a notice, install fence to restrict entry into the final disposal site.

- Upper part: Use of the upper part is not the objective.
- Concentration: No limitation on radioactivity concentration, but structure of final disposal sites depends on the radioactivity concentration.
- Location: In accordance with the law, removed soil will be transported outside Fukushima Prefecture.

With regard to the managed recycling, the MOEJ is implementing demonstration projects based on the Basic Concept as a guideline, as well as working to encourage understanding throughout the nation. Different treatment (volume reduction) options are being considered for the removed soil (see Chapter IV).

Expert committees have been set up by the MOEJ. The committees will review progress achieved and challenges to be addressed in order to have the required results by the end of FY2024. They will review the ministerial ordinance on standards for the managed recycling and the final disposal, and the technical guidelines. The standards will be established through the Radiation Council and public comments.

Taking removed soil out of the ISF through volume reduction and recycling could commence from FY2025, in the transition from the demonstration project phase to the full-scale project phase.

Observations

The team of experts recognized the progress made regarding the consideration of regulatory aspects for the overall process, in line with the eight steps defined in the Measures on the Interim Storage Facility. The team of experts noted the efforts to compile findings from demonstration projects and technology development by the end of FY2024.

The team of experts notes that several treatment (volume reduction) options for removed soil are currently being evaluated and that future policy will be influenced by the treatment (volume reduction) options that will be finally selected.

Conclusions of the team of experts for the section

- *Considerable progress in the consideration of the regulatory aspects has been made, in line with the eight steps (Figure I) and the Technology Development Strategy for the managed recycling and the final disposal of removed soil and waste.*
- *The team of experts notes with appreciation that the MOEJ will review and consolidate by the end of FY2024 the findings of the demonstration projects and consideration of volume reduction treatment options to develop the ministerial ordinance and the technical guidelines for the managed recycling and the ministerial ordinance for the final disposal, taking into account the expected quantities and activity concentrations of the removed soil and waste.*
- *The MOEJ should complete the treatment (volume reduction) options study in good time to input into future policy.*

III.2 – Justification of the managed recycling and the final disposal

Japan position

The justification for the managed recycling of removed soil and the final disposal is as follows:

- The Japanese Government has positioned the reconstruction of Fukushima as a top-priority issue.
- Decontamination has contributed to reduction of radiation risk, lifting of evacuation orders and reconstruction of the affected areas.
- Soil removed and waste arising in Fukushima Prefecture have been transported to and stored in the ISF.
- The policy of the final disposal of removed soil and waste outside Fukushima Prefecture within 30 years is stipulated in the law (the JESCO Law), taking into consideration the fact that the residents of Fukushima have already borne an excessive burden to environmental pollution caused by the accident.
- In order to reduce the volume for the final disposal, the Japanese Government has promoted volume reduction technologies and the managed recycling of removed soil and waste with public understanding.
- These initiatives will reduce radiation risk, make effective use of removed soil, which is originally a valuable resource, and contribute to the reconstruction of Fukushima.

The MOEJ explained that both the recycling and disposal will be managed in accordance with the relevant laws, appropriate dose standards will be set in accordance with the IAEA Safety Standards, and the MOEJ will have regulatory oversight of the projects of the managed recycling and the final disposal. The managed recycling projects can take place within or outside Fukushima Prefecture. The final disposal will be outside Fukushima Prefecture.

Observations

Justification is one of the fundamental radiation protection principles (IAEA Safety Standards (SF-1, Principle 4)): the action must do more good than harm. In this case the 'action' is the removal of soil and waste in the affected areas, and the management of the removed soil and waste generated. Management of the removed soil and waste does not need to be justified as a separate action. Identifying removed soil that is suitable for the managed recycling is consistent with the IAEA Safety Standards (SF-1, Principle 7) to minimise the generation of radioactive waste to be disposed of[4].

Conclusions of the team of experts for the section

- *The justification of the managed recycling and the final disposal of removed soil and waste described by the MOEJ is consistent with IAEA Safety Standards (SF-1, Principle 4).*

[4] SF-1, principle 7 stipulates: "The generation of radioactive waste must be kept to the minimum practicable level by means of appropriate design measures and procedures, such as the recycling and reuse of material."

- *Identifying removed soil that is suitable for the managed recycling is consistent with the IAEA Safety Standards (SF-1, Principle 7) to minimise the generation of radioactive waste to be disposed of.*

TERMINOLOGY CHECK / Radioactive waste vs removed soil without further use

The IAEA Nuclear Safety and Security Glossary, 2022 (Interim) Edition (IAEA Glossary), defines radioactive waste as "material for which no further use is foreseen that contains, or is contaminated with, radioactivity at activity concentrations greater than clearance levels".

GSR Part 5 Requirement 10 stipulates on Processing of radioactive waste: "Radioactive material for which no further use is foreseen, and with characteristics that make it unsuitable for authorized discharge, authorized use or clearance from regulatory control, shall be processed as radioactive waste".

In the context of the accident of the FDNPS, removed soil is defined as soil that has been generated as a result of decontamination activities after the accident of the FDNPS. Other wastes such as grass, trees and building materials etc also arise as a result of the decontamination activities. This removed soil can be sorted, based on the radiological content of the removed soil, and, if suitable, it can be sent for the managed recycling. Removed soil that is unsuitable for the managed recycling for which there is no further use is sent for the final disposal. Waste generated as a result of the volume reduction activities, for which no further use is foreseen, will be sent for final disposal. Removed soil that is unsuitable for the managed recycling and waste generated from volume reduction activities, for which no further use is foreseen, therefore need to be processed in a manner analogous to radioactive waste defined in the IAEA Safety Standards.

III.3 – Application of optimization of radiation protection

Japan position

The Basic Concept used the additional effective dose of 1 mSv per year to limit the activity concentration of recycled materials and then the screening level (8,000 Bq/kg or less) was derived from the sufficiently conservative generic safety assessment for the managed recycling (discussed further in Chapter IV). The MOEJ also applies optimisation measures to reduce the doses to the public from the managed recycling of removed soil.

In considering optimization, 10 microSv per year was studied and it was indicated by the MOEJ that further reduction to 10 microSv per year was possible by installing sufficient shielding (e.g., cover soil). Based on advice of the team of experts in the first IEM, the MOEJ is considering clarifying in the System that the dose level to be aimed at will be determined in consultation with stakeholders such as local residents and municipalities. After the formulation of the ministerial ordinance and the technical guidelines, the managed recycling will be implemented in accordance with them.

Observations

During the third IEM, the concept and importance of optimisation of protection and safety was addressed. Optimisation of protection and safety is the process of determining what level of protection and safety is appropriate. This involves exploring options for reducing the dose below the selected dose criterion (in this case 1 mSv per year) for each project of the managed recycling of removed soil (e.g., thickness of soil cover) and for the final disposal (e.g., location and design of the final disposal facility (or facilities)).

The team of experts confirmed that the dose criterion of an additional effective dose of 1 mSv per year and optimisation to further reduce the dose below the dose criterion is appropriate. Optimisation is not the same as dose minimisation and therefore does not mean that the dose level to be aimed for must be 10 microSv per year. A dose of the order of 10 microSv per year is regarded as the level at which radiation protection measures are no longer required (a trivial level of dose).

The IAEA Glossary defines optimisation as follows:

> 'Optimization is 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 (ALARA).'

ALARA does not mean that the dose level is 'of the order of 10 microSv per year'. The dose should be below the dose criterion that has been chosen (e.g., 1 mSv per year), and an options assessment is used to find the option that gives rise to the overall optimized impact, taking into account the prevailing circumstances (e.g., environmental, technical, safety and social impacts, and monetary cost).

The MOEJ should make it clear in their documents that, as stated in the IAEA Glossary, optimisation considers other possible impacts not just the level of dose and, therefore, the process of optimisation does not mean that the dose to members of the public from the project has to be of the order of 10 microSv per year or less.

If a dose of the order of 10 microSv per year is used in designing the structure for the managed recycling, then after the recycled material is used in the structure, it will be practically impossible and not required to measure 10 microSv per year on the ground. Also, it is not required to meet 10 microSv per year during abnormal situations (e.g., disasters) according to the IAEA Safety Standards. It is important to explain the differences of meaning between 1 mSv per year and 10 microSv per year clearly, including the concept of 10 microSv per year.

ALARA does not mean just minimising dose: other impacts (e.g., cost, environmental, social) need to be taken into account and therefore the overall optimal option, in the prevailing circumstances, may not be the one with the lowest dose. For example, reducing the dose may result in greater volumes of removed soil for the final disposal leading to increased transport miles and increased associated conventional risks to people, increased environmental impacts, and increased costs. Hence, the optimal option may be the option where these other impacts are reduced; the associated dose is ALARA. A comparison could be useful where factors, which can be taken into consideration, are assessed, and the impacts are compared across the options.

The optimisation process therefore compares two or more alternatives by considering several factors (e.g., dose, conventional safety, environmental effects, cost, practicability), for each alternative in

turn. An example of a framework for optimisation is the UK Nuclear Decommissioning Authority (NDA) Value Framework. The factors considered in the NDA Value Framework are:

- Health and Safety
- Security
- Environment
- Risk/Hazard Reduction
- Socio-economic impacts
- Lifetime cost
- Enabling the Mission

Optimisation could be done with the dose assessments for each alternative based on realistic parameter values rather than on conservative assumptions. Conservative assumptions may distort the difference between the doses associated with the different alternatives.

Conclusions of the team of experts for the section

- *The team of experts emphasises that optimisation of radiation protection is 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. This is about considering the overall impact, not just the dose. Therefore, it takes into account the prevailing circumstances (e.g., environmental, technical, safety, social, monetary cost etc) to determine the option that lowers overall impacts as much as possible.*
- *The dose criterion of the additional effective dose of 1 mSv per year is an appropriate criterion for the managed recycling of removed soil and it is appropriate to use the recycled soil under proper management to meet the 1 mSv per year.*
- *The MOEJ's approach to optimisation, i.e. exploring options for reducing the dose below the dose criterion of 1 mSv per year (e.g., using cover soil) is consistent with the IAEA Safety Standards. The team of experts recognizes that the level of dose to be aimed at through the optimization approach will be determined in consultation with stakeholders such as local residents and municipalities.*
- *The MOEJ should make it clear in their documents that, as stated in the IAEA Glossary, optimisation considers other possible impacts not just the level of dose and, in line with that, the MOEJ should indicate that optimisation does not mean that the dose to members of the public from the project has to be of the order of 10 microSv per year or less. Taking into account more realistic (site-specific) parameter values when designing a structure for the managed recycling, could support optimization.*

TERMINOLOGY CHECK / Optimization vs ALARA

The IAEA Nuclear Safety and Security Glossary, 2022 (Interim) Edition, defines optimization (of protection and safety) 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 (ALARA).” Adding that “The acronym ALARA should not be used to mean optimization of protection and safety.” Optimisation is the process, ALARA is the result of the process.

III.4 - Development of the ministerial ordinance and the technical guidelines for the managed recycling

Japan position

The structure of the proposed system for the managed recycling (the ‘System’) is shown in Figure III.

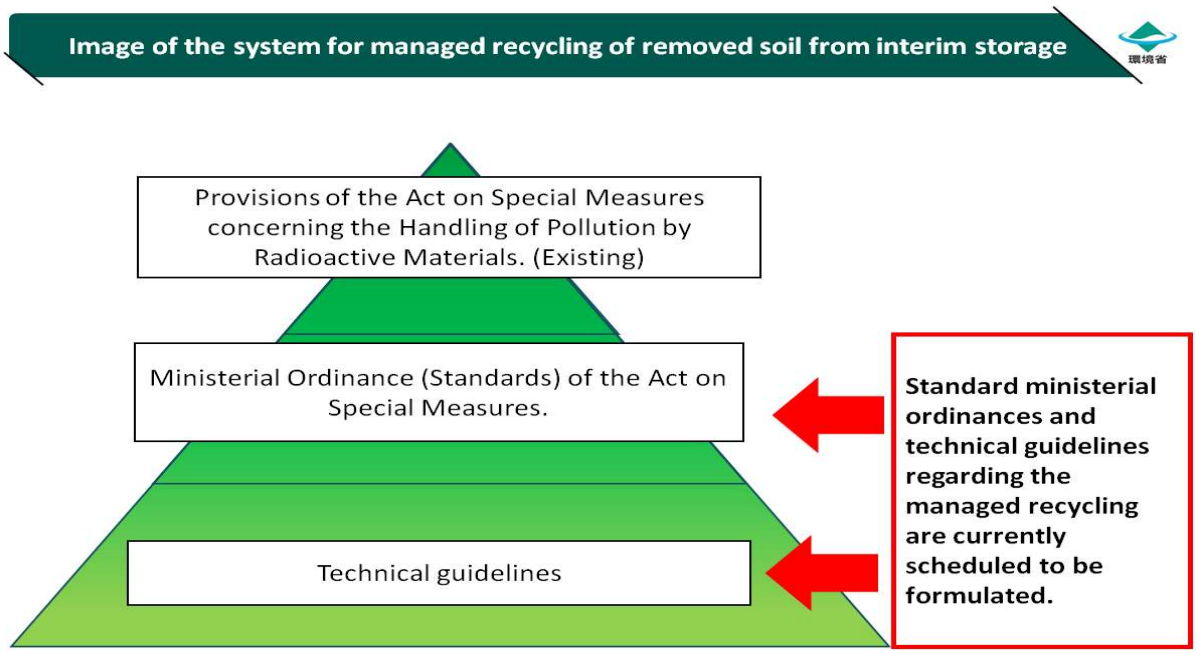


Figure III System for regulating the managed recycling of removed soil.

The MOEJ is currently developing the ministerial ordinance and the technical guidelines for the managed recycling of removed soil. The ministerial ordinance and the technical guidelines will contain criteria and technical measures necessary for the implementation of the managed recycling (e.g., activity concentration of recycled soil, measures to prevent scattering and leakage of the removed soil, monitoring of air dose rate, recording and storage of information on project sites) based on the knowledge gained during the demonstration projects and the ISF project.

The recycled soil will be used in projects that are managed by public bodies and other bodies whose management and responsibilities are clearly defined in Japanese laws (“public bodies, etc.”). The

MOEJ will retain full responsibility from a radiological perspective for the appropriate management of the recycled soil during the construction and maintenance period, while the relevant public bodies, etc. will have their responsibilities in terms of the construction and maintenance of the structure itself. There will be an agreement between the operator function of the MOEJ and the operator of the structure containing the recycled soil (e.g., national/local government) concerning the future management of the structure (see Section III.5 for details of the MOEJ's operator and regulatory functions).

Basic matters concerning construction and maintenance for the managed recycling will be defined in consultation with the operator of the structure, facility manager and landowner, etc. for each project, at the start of the project. This will include procedures for notifying the MOEJ of a change of landform and for periodic review of safety performance and operational status by the MOEJ in consultation with the operator of the structure and facility manager. Information to be recorded and kept will be defined, including quantity of soil, location, activity concentration, acceptance criteria/summary of the project. Points to be considered for potential disaster events (e.g., flood) will be clarified to ensure safety. Those types of information will be reflected into the technical guidelines, which will be used from the stage of planning, through design, construction and maintenance. The draft ministerial ordinance and the technical guidelines will be available in FY2024, drawing on advice from the team of experts. They will contain technical and management/administrative requirements.

The draft ministerial ordinance and the technical guidelines will be reviewed by members of the expert committees.

The generic safety assessment for the managed recycling does not include human intrusion as it was argued that intrusion would not happen because the site is expected to be managed for a long time.

The MOEJ has implemented the demonstration projects to gain findings on the safety of the managed recycling to develop the regulatory framework (i.e., the ministerial ordinance) in accordance with the Act on Special Measures.

The managed recycling deals with removed soil with radioactivity concentration of 8,000 Bq/kg or less, which is less than the criterion stipulated in relevant laws for radiation protection of workers (10,000 Bq/kg). Hence, even during construction and recovery process in case of disaster, necessary responses can be carried out as conducted in ordinary structure operations.

Observations

The team of experts notes that a clear regulatory process, including review and authorisation is key to the successful implementation of the managed recycling of removed soil. This regulatory process should be developed at an early stage and communicated to the public when proposing the managed recycling projects.

The team of experts notes that the System for the managed recycling of removed soil (i.e., the ministerial ordinance and the technical guidelines, as shown in Figure III), which includes setting activity concentration of recycled soil, measures to prevent scattering and leakage of the removed soil, monitoring of air dose rate and recording and storage of information on project sites, etc., will cover the essential elements to ensure safety during the management period (including construction and maintenance).

The team of experts notes that the MOEJ approach for determining the radioactivity concentrations for the managed recycling is consistent with the approach for the screening levels described in the IAEA GSG-18 (discussed further in Chapter IV). It also notes that the proposed concept of the managed recycling described in the Basic Concept is appropriate.

It is reasonable that since the leaching characteristics of radioactive caesium from removed soil are extremely low, special measures (e.g., impervious sheets) to prevent groundwater contamination by radioactive caesium are not required, based on the scientific evidence presented during the IEMs.

The team of experts notes that as the radioactivity in the removed soil decays with time, the level of management control that is needed to ensure safety can be reduced as time goes by. 'Special attention' is no longer required when the dose to members of the public is optimised (ALARA) below the dose criterion and further radiation protection measures would yield no additional benefit.

Some form of authorisation process is needed, also taking into account the graded approach specified in the IAEA Safety Standards, for the managed recycling of removed soil. The process may differ for each application of removed soil, but should be clearly specified in the technical guidelines/agreement. The authorisation process for the managed recycling could be notification, and the regulator may require a notification of any intent to use recycled soil and then confirm if the notified design is in line with the ministerial ordinance and the technical guidelines, according to the situation.

The technical guidelines, therefore, need to make it clear which situations and eventualities require an operator to inform the MOEJ and to seek further input from the MOEJ before proceeding with planned actions (e.g., to take remedial actions). Examples of situations requiring further regulatory response on safety and a decision could be a repair of damage due to earthquake etc. There should be a clear point at which an operator needs to get an approval from the MOEJ, if the response to the situation is not described in the technical guidelines.

The team of experts notes that the removed soil will be used only for structural foundations such as embankments (e.g., road embankment, farmland), that are not expected to be artificially altered over a long period of time, and are under appropriate management by public bodies, etc. Hence, the technical guidelines should contain the statement that the removed soil in the structure is to remain in the structure for a long period. In addition, any proposed changes or developments should be notified to the MOEJ, so that subsequent safety of the projects can be ensured.

The generic safety assessment for the managed recycling (see Section IV.4) will be useful in identifying the situations that are already covered by the conditions that are specified in the technical guidelines (i.e., the response has been shown to give rise to doses below the dose criteria used). The team of experts understood that the agreements will include review points and allowed actions, which are applicable on a site-specific basis as much as possible.

The safety assessment for the managed recycling described in the Basic Concept is conservative and can therefore be used for all potential projects. Hence, they could be used to derive a generic set of guidelines, that are common to all projects.

Development of the ministerial ordinance and the technical guidelines requires cooperation with related ministries and other relevant organizations. This is particularly the case when developing the agreements which is applicable to more specific projects.

Specific role sharing between the MOEJ and the public bodies, etc., for implementation of the managed recycling projects is important to ensure safety. Therefore, the agreements between the MOEJ and the public bodies, etc., should be developed. The team of experts recommended that the points to be included in a generic form of the agreements be considered and be presented in the technical guidelines so that the responsibilities of each party are clearly defined.

Regarding efforts to build public confidence, after construction of the structure, monitoring will be required to confirm the expected low dose rate and to reassure the safety of the public.

The public will also be reassured by existence of a formal authorisation process for future projects of the managed recycling, and knowing that this activity is scrutinised by the MOEJ. The team of experts suggests that the Nagadoro demonstration project be continued (in line with the ministerial ordinance and the technical guidelines after their development) and that findings be used for building public understanding.

While the demonstration projects have demonstrated safety and feasibility, it would be useful to continue radiological monitoring to show long-term data to build public understanding on the managed recycling of removed soil.

Similarly, it would be beneficial if the technical guidelines will include importance of public consultation and stakeholder engagement throughout the projects. This is not uncommon internationally where governments recognise the fundamental importance of obtaining public acceptability for radioactive waste management proposals. Therefore, the importance of opportunities to listen carefully to the opinion of the public regarding the managed recycling can be emphasized iteratively.

Conclusions of the team of experts for the section

- *The generic safety assessment for the managed recycling is sufficiently conservative, and the approach for derivation of the screening level, which is consistent with established international approaches, is appropriate, therefore the dose criterion can be sufficiently achieved by using the recycled soil of 8,000 Bq/kg or less.*
- *The components proposed by the MOEJ for inclusion in the System for the managed recycling of removed soil (i.e., the ministerial ordinance and the technical guidelines), which includes setting activity concentration of recycled soil, measures to prevent scattering and leakage of the removed soil, monitoring of air dose rate and recording and storage of information on project sites etc., cover the essential elements to ensure safety during the construction and maintenance period.*
- *The team of experts notes that the MOEJ has already started to consider long term, post-management safety of the recycling projects before implementation, as it is important to perform a long term, post-management radiological impact assessments of the recycling projects, to understand the dose of the potential future scenarios. This will enable the post-management safety to be evaluated, in due course*.
- *The technical guidelines and/or agreements need to be clear which situations and eventualities require the operator of the structures (i.e., public body in principle) to inform the MOEJ and to seek advice, review and agreement from the MOEJ before proceeding with planned action (e.g., to take remedial actions). The agreements should include procedures for prior notification of any change of landforms or use at the project sites to ensure the safety of structures for the managed recycling.*

- *The MOEJ needs to consider the point at which no further management in terms of radiological protection is required. The MOEJ needs to proceed with the consideration process for the end of special attention carefully, in a step-by-step manner, taking the acceptability of operators/people into account.*
- *Site-specific agreements should be developed, in conjunction with other stakeholders (e.g., operator of the structure, facility manager, landowner) when the site is identified, and before implementation of the project. These agreements should include the soil acceptance criteria for the project (e.g., allowed activity concentration).*
- *The ministerial ordinance and/or the technical guidelines should contain technical requirements, and they should also describe management arrangements required to ensure safety, administrative requirements (including records to be kept and displayed) and the importance of communication with local government and local communities (e.g., provision of necessary information about communication in each stage of the project).*
- *The importance of public and stakeholder consultation about the managed recycling projects should be enshrined in the technical guidelines, also taking recommendations of the Working Group for measures to secure regional social acceptance for the managed recycling and the final disposal (see Section VI.3) into consideration.*
- *The technical guidelines should clearly define the procedures for the decision-making, when undesirable events happen.*

III.5 – Independence of regulatory functions

Japan position

Under the Act on Special Measures, the MOEJ has an operator role (i.e., planning and conducting projects for the managed recycling and the final disposal of removed soil and waste, which is currently stored in the ISF) as well as a regulatory role (i.e., regulation through instructions and recommendations to review compliance with the relevant legislative system for each project). The MOEJ will review in the future, how the implementation and supervision of those projects will be performed to demonstrate that the regulatory function is separated from the operator function. The approach will be different for the managed recycling and for the final disposal.

For the managed recycling, the MOEJ as a regulator will develop the requirements of the managed recycling for each structure in the ministerial ordinance and the technical guidelines. The MOEJ as an operator of the managed recycling will be responsible for planning and conducting the managed recycling projects, in accordance with the ministerial ordinance and the technical guidelines, in cooperation with the operator of the structure (public bodies, etc. responsible for construction and maintenance of the structure itself). The MOEJ as a regulator will then scrutinise whether the proposed projects follow the specifications and whether the managed recycling projects meet the requirements. The MOEJ will also scrutinise the implementation of the project by the operator.

For the final disposal, the MOEJ is the regulator and also the operator of the disposal facility according to the Act on Special Measures.

The MOEJ has established expert committees consisting of scientists, university professors, and social representatives to review the safety of the managed recycling of removed soil. In addition, in each

municipality in the Special Decontamination Areas (SDA), an independent verification committee consisting of scientists and university professors has been established, to review whether the radiation dose is low enough in light of the condition for lift of evacuation orders.

The MOEJ recognises that it is important to demonstrate that the planning (operator) section of the MOEJ is functionally independent of the reviewing (regulator) section of the MOEJ. The MOEJ is considering potential options for the separation of the operational functions and the regulatory functions. The MOEJ will continue to have responsibility for ensuring safety from radiological perspective within the mandate of the Act on Special Measures (this responsibility cannot be transferred to another organisation).

Observation

During the IEMs, the team of experts noted that it is important that the regulator is independent from the operator. This is specified in the IAEA GSR Part 1 requirement 4, which states:

> 'Requirement 4: Independence of the regulatory body. The government shall ensure that the regulatory body is effectively independent in its safety related decision making and that it has functional separation from entities having responsibilities or interests that could unduly influence its decision making.'

The team of experts also noted that in line with relevant Japanese laws, the status has been appropriate for the MOEJ to be both operator and regulator after the accident. The decontamination activities by the MOEJ have been confirmed by the independent verification committee in each municipality in the SDA. It is important to demonstrate independence of regulatory function, in line with relevant Japanese laws. A clear separation of the operator and regulatory functions will help to provide an explanation for the public confidence in the future.

The MOEJ is considering an approach to demonstrate the independence of the regulatory function from the operator function. The team of experts recommends that the MOEJ investigate how the potential options would provide the required process for decision making regarding the safety of the project and choose an option that will enable them to demonstrate the independence of the regulatory function from the operator function.

The independence of the regulator is important to ensure safety (they need to be able to say 'no' if the proposed project does not meet the specified requirements). Demonstrating the independence of the regulating function from the operating function is an important requirement in the IAEA General Safety Requirements (GSR) Part 3 (the "BSS"). It is also essential for the building of trust in the process and will support stakeholder engagement (including with the public and with international organisations).

The team of experts also notes that the public may be interested in how safety will be kept, because these projects will last for a long time, probably a decade or more in the future. A clear separation of the operator and regulatory functions will help to provide an explanation in the future. A possible option could be making a planning (operator) section of the MOEJ and a reviewing (regulator) section of the MOEJ independent of each other. The MOEJ operator function section will develop the project and explain how it meets the requirements defined in the ministerial ordinance, and a different section of the MOEJ as a regulator will review and double-check that the project meets the

requirements. This is an example of the independence of regulatory function from operational function, but other options also need to be also considered and scrutinized by the MOEJ.

Conclusions of the team of experts for the section

- *The team of experts noted that, following the accident, the status of the MOEJ as both regulator and operator has been appropriate.*
- *Going forward, and in accordance with IAEA SF (Safety Fundamentals)-1, the regulatory function should be independent from the operator function. This could be helpful for enhancement of the long-term safety of the sites, as well as the public and stakeholder confidence. Hence, the MOEJ should demonstrate the independence of their operator and regulatory functions before implementing both the managed recycling and the final disposal in accordance with the ministerial ordinance under the Act on Special Measures.*
- *Development of a decision-making procedure will enable the MOEJ to identify the key point at which the independence of the regulatory function is to be demonstrated. Development of management structure within the MOEJ could be one of the options to demonstrate the independence of the regulatory function from the operator function. The MOEJ is considering potential options and they should be further discussed.*

IV – Volume reduction and the managed recycling of removed soil

Decontamination, construction of infrastructure and other recovery efforts have been carried out intensively by the MOEJ to create a favourable and stimulating environment for facilitating people to return to Fukushima Prefecture. During each of the three IEMs, the MOEJ explained its technologies of volume reduction and recycling of removed soil and the progress made on their demonstration projects. The demonstration projects for embankments for roads and agriculture were visited by the team of experts during the first IEM in May 2023. Most of the removed soil is currently stored at the ISF.

The following sections in this Chapter describe the discussions between the team of experts and the MOEJ, the observations and conclusions made by the team of experts, on the different technologies for volume reduction and the managed recycling of removed soil and the individual demonstration project.

IV.1 - Overall approach to volume reduction and the managed recycling of removed soil

Japan position

The national government is making efforts to reduce the volume for the final disposal by using volume reduction treatment processes and by recycling suitable removed soil (the managed recycling).

The MOEJ uses the term ‘removed soil’ based on the definition of the Act on Special Measures, and it is originally a valuable resource. Therefore, it is differentiated from combustible waste (e.g., twigs, leaves) and other secondary waste (e.g., fly ash) after heat treatment.

The managed recycling can be done inside and outside Fukushima Prefecture, whereas the final disposal of material unsuitable for recycling must be only done outside Fukushima Prefecture, as specified in the JESCO Law.

The term ’clearance’ is not considered as applicable to the managed recycling of removed soil, since it refers to releasing radioactive materials from any regulatory control for radiological protection in a planned exposure situation, and applies the concept of ’trivial (additional) dose’ of the order of 10 microSv per year, as introduced in GSR Part3 and GSG-18. The approach for the managed recycling of removed soil in Japan is described as an example of using the screening levels in the IAEA Safety Standards (Appendix of GSG-18). The derivation of these screening levels is based on radiological impact studies in line with the ones used for clearance levels.

The Basic Concept used a dose criterion of the additional effective dose of 1 mSv per year to derive the activity concentration of recycled materials (screening levels of 8,000 Bq/kg or less) using a sufficiently conservative generic safety case. The MOEJ also applies optimisation measures to reduce

the doses to the public from the managed recycling of removed soil. In considering optimization, achieving a trivial dose of 10 microSv per year was studied and it was confirmed that further reduction to 10 microSv per year was possible by installing sufficient shielding (e.g., cover soil). Based on advice of the team of experts in the first IEM, the optimized dose level will be determined in consultation with stakeholders such as local residents and municipalities (see Section III.3).The managed recycling of removed soil will be implemented as public works or other works projects for which the management entity and responsibilities are clearly defined in Japanese law, such as foundations for embankments and other structural infrastructures that are not expected to be artificially altered over the long term. Examples are:

- embankments for roads, railways and seawalls in Japan;
- embankments to cover soil, earthen dikes, and other structures at waste treatment sites;
- embankments for coastal protection (creation of greenery zones by the coast);
- embankments for agricultural land (horticultural crops, resource crops);
- embankments and fill materials for land reclamation and land development.

Other applications will be considered as necessary, and those deemed appropriate will be added accordingly.

The managed recycling will use removed soil that meets the screening levels (8,000 Bq/kg or less) and then other aspects of the soil quality (e.g., engineering properties) will be adjusted as needed, so that it is suitable for the proposed recycling option (e.g., embankments for roads or agriculture). Once it is confirmed that the removed soil meets the relevant quality criteria then it can be considered to be a resource material.

The options under consideration for the removed soil that is currently more than 8,000 Bq/kg, include sorting and treatment processes and these processes may remove some soil with relatively high radioactivity, so that the removed soil at the end of the process contains 8,000Bq/kg or less. Therefore, this processed removed soil may potentially be recycled through necessary engineering properties adjustments according to the objectives for its use.

Measurements of the radioactivity concentration in the removed and recycled material are required to verify compliance with the screening levels prior to it leaving the ISF for use in the managed recycling. The large volume of removed soil means that the MOEJ will, for example, use a conveyor belt and detector system to continuously measure the soil and to sort it, which is a system similar to that used at the ISF Soil Separation Facilities (described in Section IV.2).

The MOEJ has implemented demonstration projects on the managed recycling based on the Basic Concept, as well as worked to foster understanding throughout the nation.

The MOEJ is using learning from the demonstration projects to develop the ministerial ordinance and the technical guidelines for the managed recycling projects of removed soil in the future.

The MOEJ also reassessed the contributions of other radionuclides and confirmed that their impact on the dose rate from the removed soil is very low relative to Cs-134 and Cs-137. The activity concentrations of these other radionuclides are, even now, the same as background levels in soil before the accident.

As introduced in Section III, the MOEJ will retain whole responsibility for the appropriate management of the recycled soil, from radiological perspective, during the construction and maintenance period. The management is expected to continue for a long period of time. Conditions for deciding the end of

this special attention will be considered in due course, also taking the ongoing international discussion about the end of special attention of radioactive materials into consideration. Approaches for defining the end of special attention are discussed further in Section IV.4.

Observations

The national government is making efforts to reduce the volume of removed soil to be sent for final disposal by using treatment processes and by recycling suitable removed soil under the proper management by public bodies, etc. (the managed recycling). The team of experts acknowledge that the managed recycling will reduce the volume to be disposed of in the final disposal facility (or facilities), which is in accordance with the waste hierarchy and relevant IAEA Safety Standards.

The team of experts notes the progress that has been achieved in the demonstration projects for volume reduction and the managed recycling. The team of experts notes that the proposed concept of the managed recycling described in the Basic Concept is appropriate. Demonstration projects have confirmed that the concept of the managed recycling is safe (additional effective dose of 1 mSv per year or less) , and the necessary scientific findings have been obtained to provide the basis for the ministerial ordinance and the technical guidelines. The work has been steadily progressing in accordance with the Technology Development Strategy and Roadmap.

The team of experts stressed the importance of recycling demonstration projects. They enable progress to be made in developing the technology for the managed recycling and in public communication to increase acceptance of the managed recycling. Experience with successful recycling projects within Fukushima Prefecture will help the practical implementation of the managed recycling outside Fukushima Prefecture.

The team of experts also advises that transition from a demonstration project to a model managed recycling project is an important next step, once the ministerial ordinance and the technical guidelines for the managed recycling are developed. Implementation of a model project outside Fukushima Prefecture, in line with the developed ministerial ordinance and the technical guidelines, has the potential to increase public awareness and acceptance of the managed recycling.

The sorting strategy for the managed recycling of removed soil will be based on the screening levels (i.e., 8,000 Bq/kg or less) and then other aspects of the soil quality (e.g., engineering properties) will be adjusted so that it is suitable for the proposed managed recycling option (e.g., road embankments, agricultural land).

This criterion (screening level) is in good accordance with other national criteria (for example criteria in EU countries) and the approach could be a useful reference for other countries.

The team of experts notes that measurement of the radioactivity concentration of the large amount of removed soil with a continuous measuring system using a conveyor belt and NaI (Sodium Iodide) scintillators or other similar detectors is a proven and well-developed method. This would be appropriate for measurement of the removed soil to be sent for the managed recycling. Quality assurance of the measurement is important to ensure that the relevant screening levels for the managed recycling of removed soil are not exceeded. Records of the measurements should be kept.

The team of experts welcomes the progress of the radionuclide survey of radionuclides other than radioactive caesium in the removed soil. The team of experts notes that the results presented during

the IEM on the analysis of the contribution of the relevant radionuclides other than radioactive caesium, including the potential future leaching of the relevant radionuclides from the removed soil over the long term, reconfirm the appropriateness of the focus on radioactive caesium. It is important to continue to make efforts to explain this scientific-based knowledge to the public.

The team of experts considers that recycling such large volume of removed soil is a new topic and the issues are not straightforward to be addressed. A clear description of the difference between the managed recycling and the final disposal with their different end points was made during the IEMs and is explained in Chapter III.

Conclusions of the team of experts for the section

- *Volume reduction and the managed recycling of removed soil is a sustainable process for the reconstruction and revitalization of the affected areas. The overall progress has been made in accordance with the Technology Development Strategy and Roadmap.*
- *The approach to using the recycled soil of a certain activity level or less derived from the dose criterion based on generic safety assessments is consistent with the IAEA Safety Standards (GSG-18).*
- *Materials which will be recycled should have a proof by measurement with a specified accuracy demonstrating that the relevant screening levels are not exceeded. The MOEJ should document the results and the conditions of measurements.*
- *The results of the analysis of the contribution of the relevant radionuclides other than radioactive caesium reconfirm the appropriateness of the focus on radioactive caesium. It is important to continue to make efforts to explain this scientific-based knowledge to the public.*

IV.2 - Interim storage of removed soil and waste

Japan position

The management of the ISF (see Figure IV) falls under the responsibility of the MOEJ. It provides a safe, centralized place to manage and store removed soil, waste (e.g., ash) until they will be recycled or permanently disposed of.

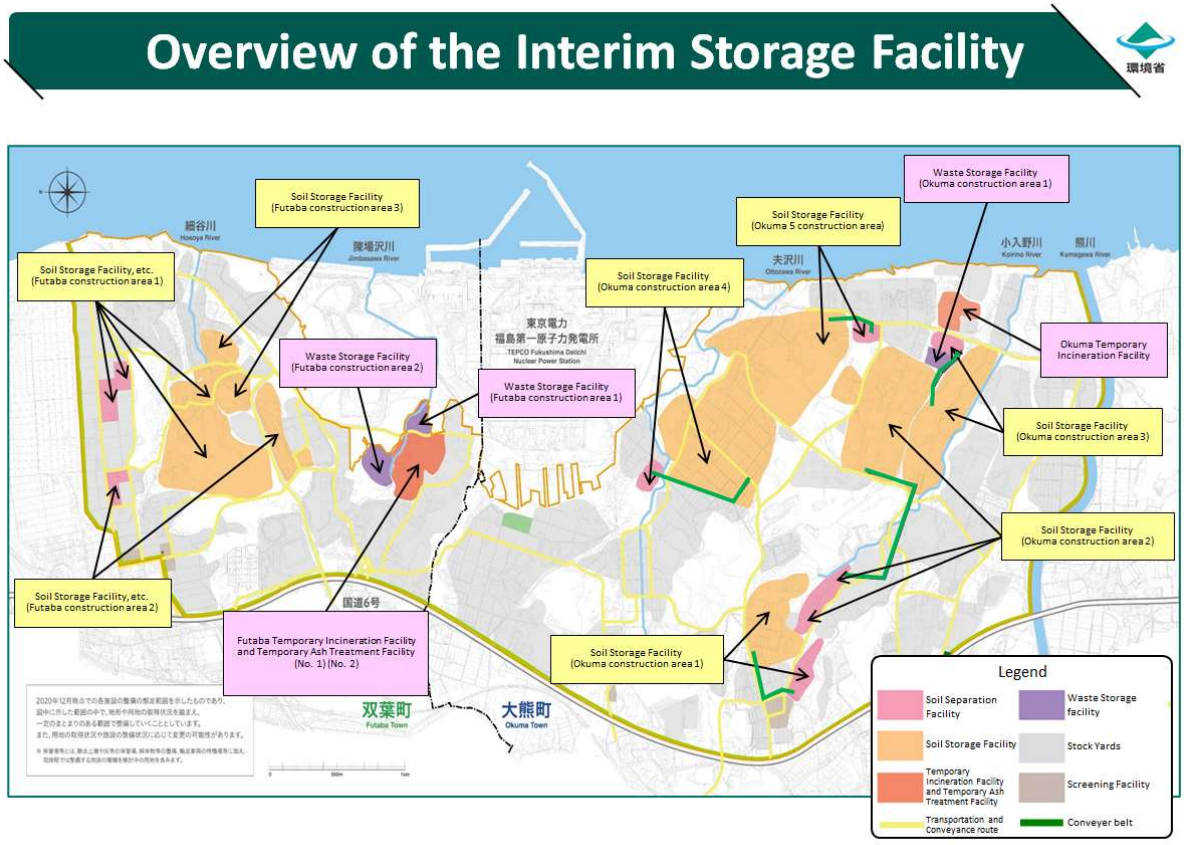


Figure IV Facilities at the Interim Storage Facility (ISF).

The removed soil is sorted at the Soil Separation Facilities (see Section IV.3) before it is stored in the Soil Storage Facilities. The Soil Storage Facilities are landfill facilities with double impermeable sheets and a drainage water collection system at the bottom and along the enclosing dikes. The arriving soil is levelled and compacted by bulldozer equipment. The drainage water is collected and directed to the leachate treatment facilities. Upon completion, the landfill is covered by impermeable sheets, soil and vegetation.

The volume of removed soil and waste transported to the ISF is about 13,790,000 cubic meters as of the end of April 2024. About 75% of this removed soil contains low concentrations of activity (under 8,000 Bq/kg) and is planned to be recycled. Thus, a volume of more than 10 million m^3 is assumed to be recycled within embankments, roads, agricultural lands and other structural infrastructure components in Japan.

The leaching behaviour of radioactive caesium in the removed soil has been studied through leaching tests performed on the removed soil, measurements taken at the demonstration projects, and the maintenance and management of the ISF. Leaching tests on two samples of removed soil gave elution rates of approximately 0.12% and 0.08%, respectively, whereas all other samples were below the level of detection. The radioactive concentration in the leachate at the Soil Storage Facilities is well below the effluent standard (Cs-134(Bq/L)/60 + Cs-137(Bq/L)/90 $\leq$1). Measurements of the embankment seepage water in the removed soil used in the recycling demonstration project (Eastern Temporary Storage Site, Minamisoma City) showed that the radioactive caesium concentration was well below

the effluent standard. Similarly, measurements of water discharged from embankment seepage and sedimentation ponds in the removed soil recycling demonstration project (Nagadoro District, Iitate Village) showed that the concentration of radioactive caesium is well below the effluent standard.

Observation

The team of experts visited the ISF during the first IEM and noted that the removed soil in the ISF is properly stored in the Soil Storage Facilities (considering, for example, the consistency of the concept for the storage, the use of impermeable sheets, and the use of cover soil). The measurements confirm that the elution of radioactive caesium in soil into water is well below the effluent standards. The dose to workers is appropriately managed by monitoring air dose rate around the facilities and by personal dosimeters, and they meet the dose limit for workers. The courtesy visit to officials of Okuma Town and Futaba Town, prior to visiting the ISF, gave the team of experts the opportunity to better understand the point of view of the local population regarding the ISF and the recycling projects being carried out on site.

Conclusions of the team of experts for the section

- *It is reasonable for the removed soil and waste arising from decontamination activities in Fukushima Prefecture to be transported to the ISF, and the removed soil in the ISF is properly stored in the Soil Storage Facilities after its treatment. The measurements confirm that the elution of radioactive caesium in the removed soil into water is well below the effluent standards.*

IV.3 – Technologies for volume reduction

Japan position

The Soil Separation Facilities at the ISF segregate the removed soil of different classes based on its characteristics and radioactivity concentration levels, as stipulated in the existing Japanese guidelines. These classes determine the subsequent storage and management procedures for the soil as well as the potential use in future recycling projects, as shown in Figure V.

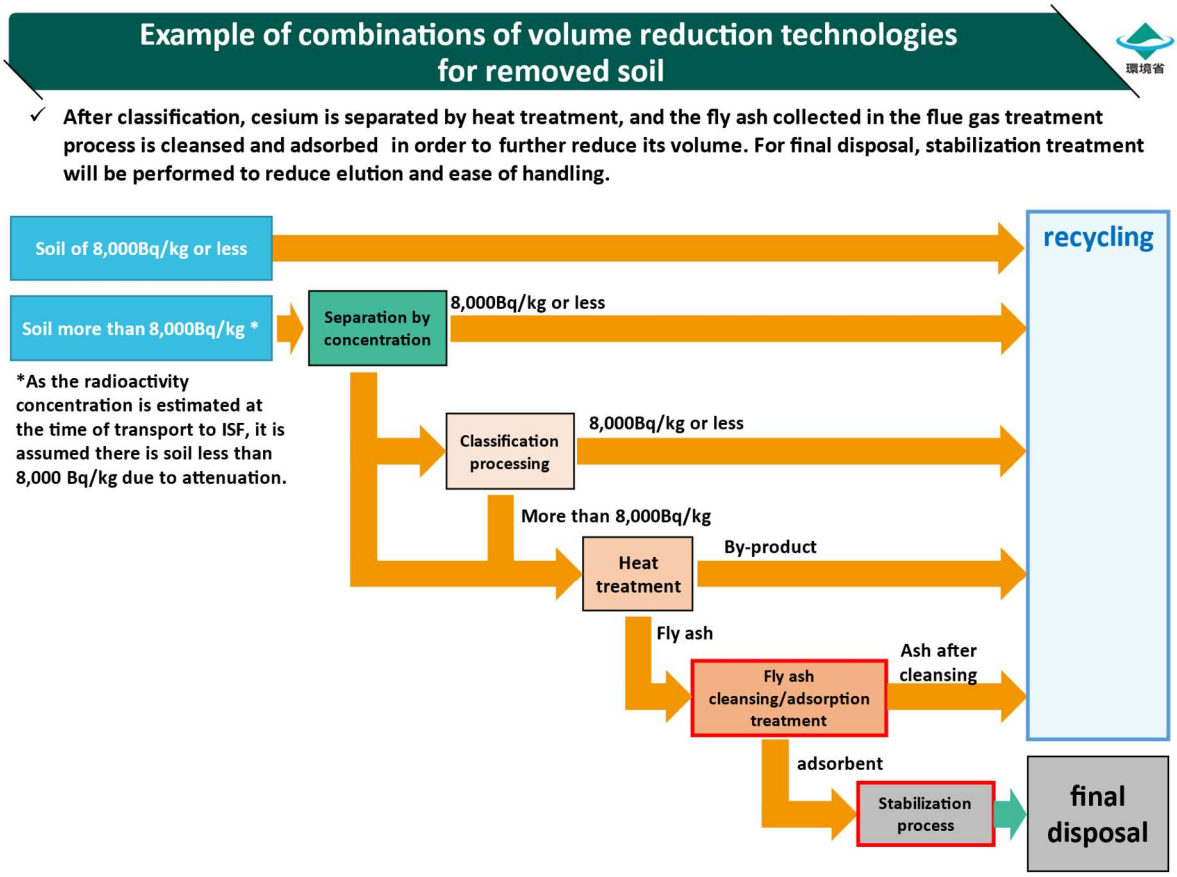


Figure V Example of combination of volume reduction technologies of removed soil.

All removed soil, including treated removed soil, can still be considered for recycling if the level of radioactivity in the soil is below the screening levels (8,000 Bq/kg or less).

The combustible materials (e.g., bags, plants, roots) obtained from the first Soil Separation Facilities are sent to the Temporary Incineration Facilities in the Volume Reduction Facility. The fly ash obtained from the Temporary Incineration Facilities are treated in the Temporary Ash Treatment Facilities, followed by storage in the Waste Storage Facilities, but small part of the fly ash is transported to the Test Facility for Fly Ash Cleaning Technology and used for a demonstration project for volume reduction of the fly ash.

The development of basic technologies required for soil volume reduction and recycling will be completed by the end of FY2024. These technologies are summarised below.

Soil classification

Classification is a method of separating soil into fine particles (silt and clay), and gravel. This enables volume reduction of soil that contains more than 8,000 Bq/kg since radioactive caesium tends to adhere to fine particles of the soil. The demonstration project ran from FY2016 - FY2018. One example involved the classification of 23,330 Bq/kg of removed soil and confirmed a volume reduction of approximately 59 % (see Figure VI).

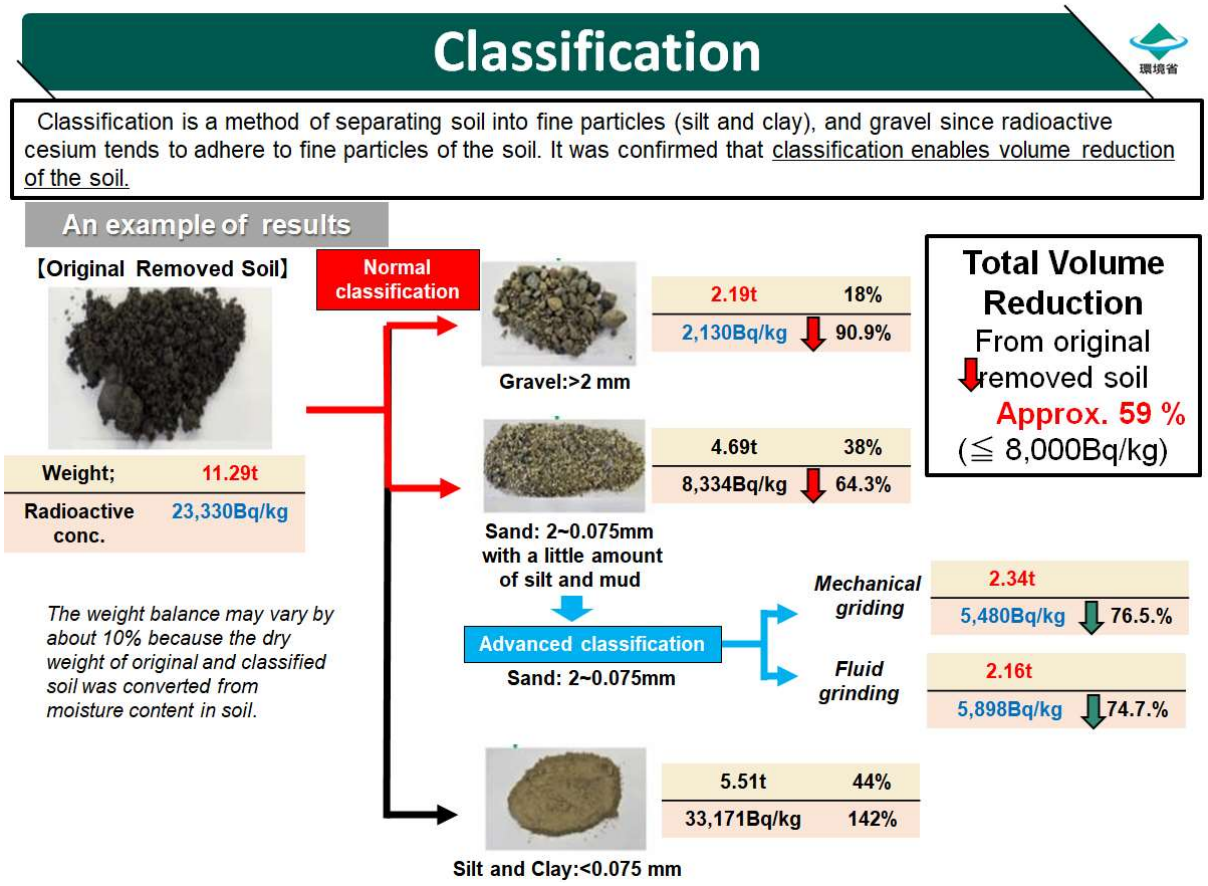


Figure VI Classification method for removed soil.

Heat treatment (burning)

Heat treatment is a method of collecting radioactive caesium by vaporization. Demonstration projects were performed in FY2018 - FY2019 for incineration ash and removed soil. It was confirmed that heat treatment can separate radioactive caesium and contribute to the volume reduction of soil and incineration ash. Two methods were considered: burning and melting (see Figure VII).

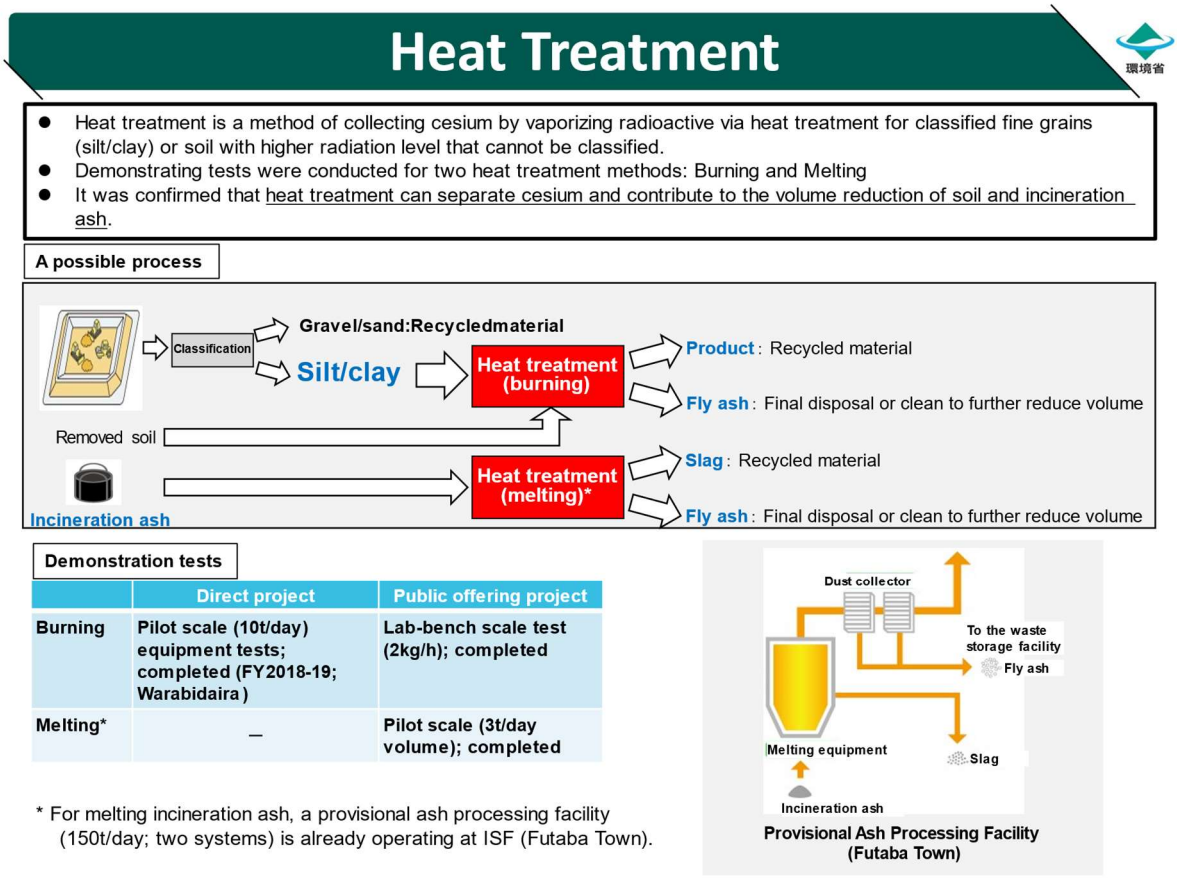


Figure VII Heat treatment methods for removed soil: burning and melting.

Further detail of the heat treatment (burning) of removed soil is given in Figure VIII.

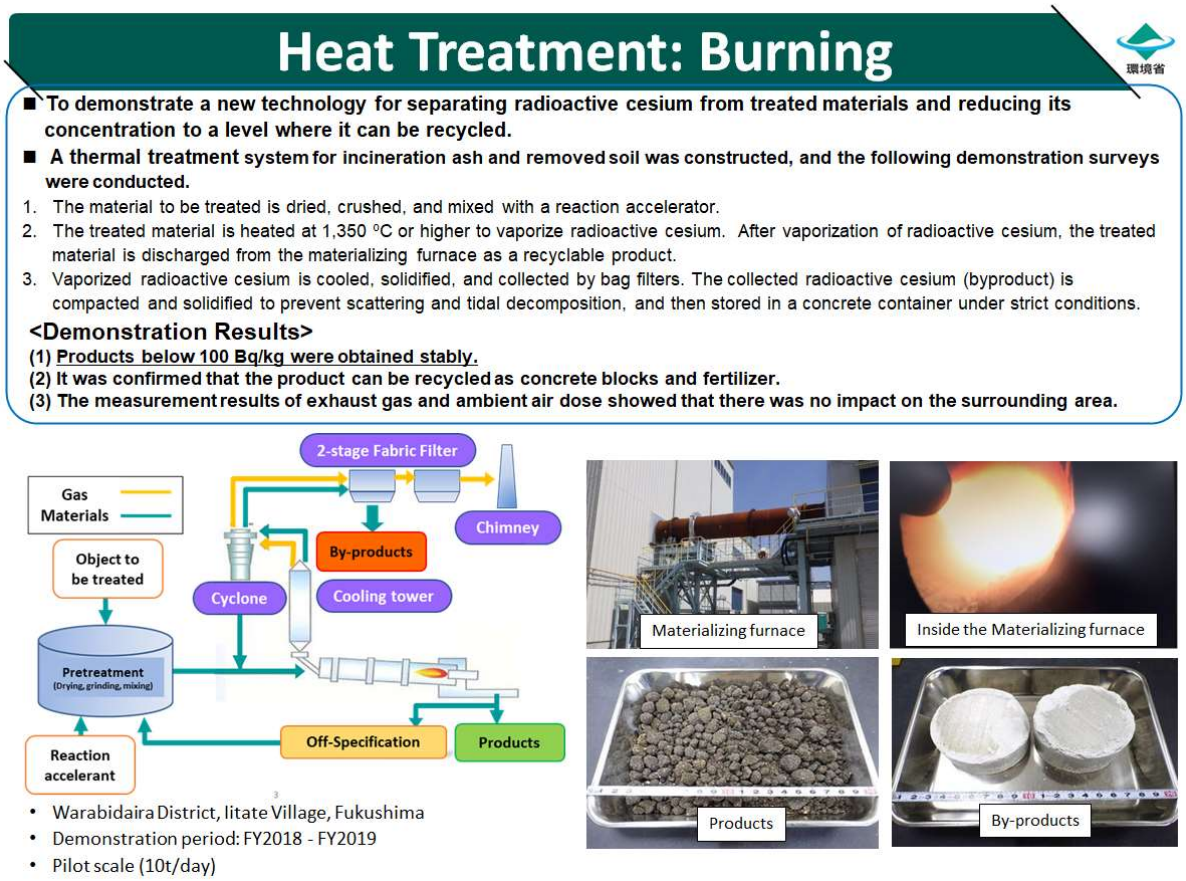


Figure VIII Heat treatment method for removed soil by burning.

The heat treatment produces a product and a by-product (fly ash). The product can be considered for recycling. The volume of the fly ash could be further reduced, when necessary and possible, followed by the final disposal in the future.

Ash cleaning and stabilization

Bench tests for cleaning and stabilizing the fly ash are ongoing since FY2022. Washing and dewatering tests show that: more than 99% of radioactive caesium has been transferred to the dewatered filtrate; and fly ash after dewatering has achieved a water content of less than 40% and a radioactivity concentration of less than 8,000 Bq/kg. More than 99.9% of the radioactive caesium in the dewatered filtrate has been adsorbed by the adsorbent, and the volume of the stabilized adsorbent has been reduced to several tenths to one hundredth of the volume of the original fly ash.

After cleaning, adsorbents with a high radioactivity concentration may need to be disposed of separately from the removed soil as they will need a specific treatment. Washed fly ashes with a radioactivity concentration of 8,000 Bq/kg or less are sent to a landfill type waste facility or may be available for later recycling. Future treatments of removed soil will help further demonstrate the disposal route for the resulting ash.

Observation

The effectiveness of the volume reduction technologies that have been developed so far (classification, heat treatment, and fly ash cleaning) has been determined. These volume reduction technologies differ in cost and in other aspects, and they result in different quantities of waste to be disposed of, and wastes with different characteristics. A volume reduction technology that is very expensive or results in waste that is difficult to dispose of, may not be the optimal approach. Therefore, an options comparison should be undertaken to determine the optimal approach. This will also enable the MOEJ to understand the quantity and type of wastes that will be sent for the final disposal.

The team of experts notes that separating the different stages (e.g., screening, quality adjustment, treatment) in their documents is key to explain the public the difference between the removed soil that is potentially a resource material and the removed soil that is not suitable for recycling and therefore has to go for the final disposal.

Conclusions of the team of experts for the section

- *The effectiveness of classification, heat treatment and fly ash cleaning technologies that have been developed so far as volume reduction technologies has been confirmed.*
- *An options study should be performed to identify the treatment technologies that will be most effective overall, taking into account volume reduction and other relevant factors, and to determine the quantity and characteristics of the waste to be sent for the final disposa*l.

IV.4 - Safety assessment for the managed recycling

Japan position

The dose to the public and workers caused by procedures (e.g., volume reduction, transportation, storage) should not exceed 1 mSv per year, in accordance with the Basic Policy. This concept is also applied to the managed recycling. The MOEJ has performed a generic safety assessment of the managed recycling to establish criteria for the radioactivity concentration in the removed soil that could be recycled (screening levels) to meet the dose criterion (1 mSv per year).

The generic safety assessment uses conservative parameter values to overestimate the dose received from a particular activity concentration. This leads to a lower 'allowed' activity concentration and therefore provides a safety margin. In addition, a criterion of 8,000 Bq/kg or less is applied to the managed recycling of removed soil, taking into consideration the uniformity in the regulatory system of the Act on Special Measures (a criterion for the designation of the Designated Waste). Ensuring that the radioactivity in the soil meets the criterion of 8,000 Bq/kg or less means that it is exempt from the application of the relevant rules concerning radiological protection for workers. This enables workers to respond in the same way as for usual civil engineering works, both for construction of the managed recycling and for recovery in the case of disasters, without special measures for radiological protection. Uncertainties are covered by the conservative parameter values.

The assessment approach is generic, so that it can be applicable to any potential site.

The safety assessment for the managed recycling includes consideration of a step to cover the removed soil with clean soil or other materials used for ordinary construction. This provides a

shielding effect that reduces the dose rate to the public for the completed structure. The safety assessment calculates the dose to the public for different thicknesses of the cover soil. This step provides further confidence that the dose criterion of 1 mSv per year is met and represents an option to be considered as part of optimizing protection and safety (see Section III.3).

The assessment focuses on Cs-134 and Cs-137, based on scientific findings gained from radionuclides surveys and dose assessments. Many of the parameter values were the same as those used to derive the 8,000 Bq/kg activity concentration level used as a criterion for the designation of the Designated Waste.

The MOEJ also reassessed the contributions of other radionuclides in the removed soil (e.g., Sr-90 and Pu isotopes) and confirmed that their impact on the dose rate from the removed soil is very low relative to Cs-134 and Cs-137. The activity concentrations of these other radionuclides in the removed soil are, even now, the same as background levels in soil before the accident.

Observations

The team of experts notes that the assessments underpinning the Basic Concept are conservative and that this is an appropriate approach to demonstrate the safety of the concept of the managed recycling of removed soil. The assessments show that construction workers for a facility using recycled soil will be most exposed to radiation, receiving a dose of 1 mSv per year or less. The dose to the neighbours and users of the facility will be much lower than the dose to the workers (1 mSv per year) in the management period and the process of optimisation will reduce them further. These results will be useful to help the public understand that there is no need to worry about radiological impact of the managed recycling of removed soil on their health.

The team of experts also notes that assessments using more realistic parameter values will also be useful, taking into account actual situation of applications and findings gained through demonstration projects, to support optimization as required by the IAEA Safety Fundamentals.

The team of experts also notes that site-specific safety assessments may also be effective to address specific concerns expressed by stakeholders such as local residents and municipalities. These assessments may not result in the highest doses but will provide reassurance that the specific concern has been addressed.

In general, the generic safety assessment is to consider all necessary safety aspects relevant to radiological protection. The generic safety assessment for the managed recycling has been conducted in a very conservative way including the potential future leaching of the radioactive caesium from the removed soil over the long term. The team of experts notes that consideration of additional relevant radionuclides in a generic safety assessment is important, but it has been confirmed that radioactive concentrations of radionuclides other than radioactive caesium are less than natural background levels, and therefore, they are not required to be assessed. The team of experts considers that it is important to reconfirm the focus on radioactive caesium by assessing the radiological impact of any other radionuclides measured in the removed soil, for public reassurance even though there are existing scientific findings. Re-confirmation measurements should be continued. The results will be useful in aiding public trust and confidence in the managed recycling.

There is no intention to retrieve the recycled removed soil from the specific application (e.g., road embankment). Therefore, analogous with the approach for deriving specific clearance levels described

in GSG-18, the safety assessment should be performed for the assumable potential scenarios after the use of the structure, during the management and post-management periods taking account of the graded approach. The safety during the management period of the managed recycling projects will be ensured in accordance with the ministerial ordinance and the technical guidelines, which incorporate requirements that are based on the generic safety assessment for the management period.

As outlined in previous sections, the managed recycling of removed soil is implemented based on the concept of screening levels. The screening levels and specific clearance levels have different values because they are based on different dose criteria: screening levels are based on the reference level chosen, whereas specific clearance levels are based on the clearance dose criterion of 'of the order of 10 microSv in a year'.

The dose criteria used to derive the screening levels are less than or equal to the reference level chosen for remediation of the affected area and may be the same or differ for workers implementing the project and for members of the public. Hence, for example, a dose of 1 mSv per year can be applied to both workers implementing the project (e.g., building road embankments) and to members of the public to derive the screening levels. The case where the screening levels are based on a dose of 1 mSv per year both to workers and to the public is an example of applying the screening levels. In all cases, the doses are optimised below the dose criterion used.

While management of the structure itself will continue for a long time, management of the removed soil will not be needed forever due to radioactive decay and therefore, as introduced in Section III.4, there will be a decision point at which the decision to end the period of special attention is made. The residual dose resulting from the structure could be one consideration in the decision, in consultation with key stakeholders such as the operator of the structure, facility manager, landowner, local residents and municipalities.

The end of special attention is when the controls in terms of radiation protection to reduce or prevent the doses from any situations and eventualities are no longer needed because they provide no net benefit. This may be because i) the radioactivity decays, and even if the structure is used for other purposes the dose criteria can be met; or ii) the situation becomes stable and predictable, and further control is not reasonable. In the case of specific clearance, the end of special attention occurs once the material has reached its destination. In the case of the managed recycling based on the screening levels, the end of special attention could also occur when the material has reached its destination, followed by construction (e.g., the embankment has been built according to the technical guidelines), and it comes to the end of management period.

The end of special attention of the managed recycling comes only when any future use of the soil also meets the dose criterion specified. If a particular use does not meet the dose criterion, then controls are still required, and the controls can be ceased when this use meets the dose criterion.

Of the order of 10 microSv per year is generally considered to be a trivial dose given in the IAEA Safety Standards, and further reduction is unlikely to be the overall optimal approach, hence this dose criterion is easier to explain to the public. However, of course other dose criteria can be also used: the message is that the dose needs to be as low as reasonably possible given the prevailing circumstances.

The range of dose criteria for the release of a site, specified in WS-G-5.1, may be relevant to the end of special attention: this specifies a dose criterion in the range from 10 microSv per year to 300 microSv per year for the dose to the public[5].

Discussions on the transition from the existing exposure situations to the planned exposure situations are ongoing by the ICRP.

Conclusions of the team of experts for the section

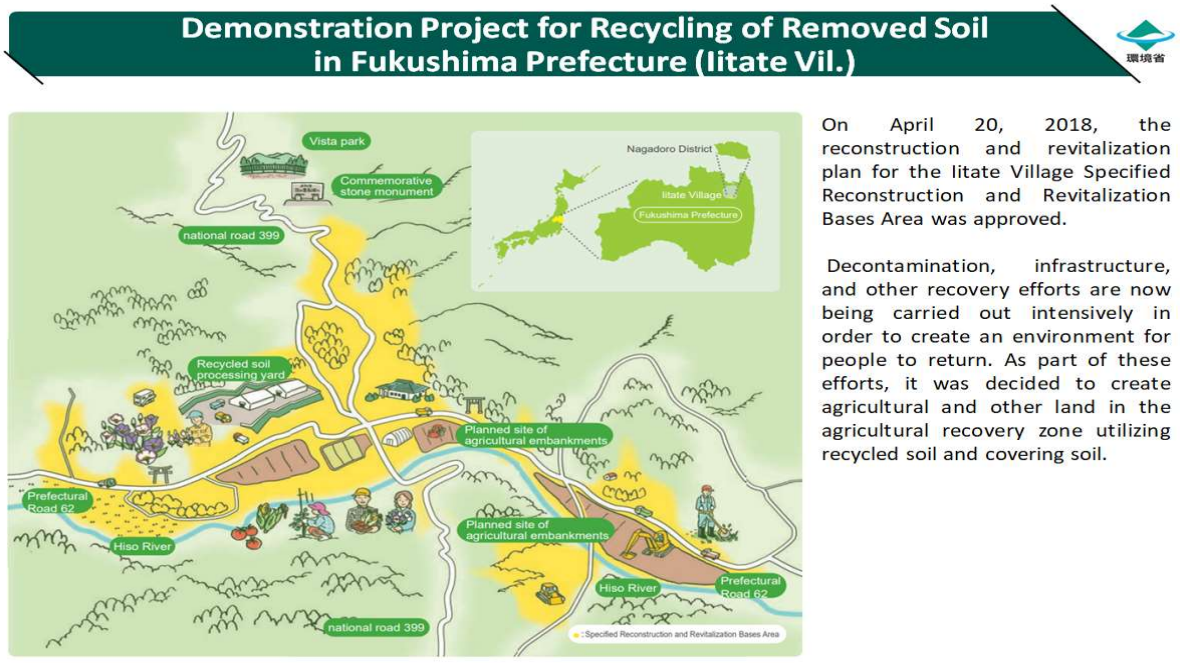
- *The dose criterion of the additional effective dose of 1 mSv per year is an appropriate criterion for the managed recycling of removed soil and it is appropriate to use the recycled soil under proper management to meet the 1 mSv per year.*
- *Generic safety assessment for the managed recycling is conducted in a very conservative way, and thereby the dose criterion can be sufficiently achieved by using the recycled soil of 8,000 Bq/kg or less under proper management including preventing scattering and leakage of removed soil.*
- *Site-specific safety assessments will support optimisation of protection and may also be effective to address specific concerns expressed by stakeholders such as local residents and municipalities.*
- *The assessment of radiological influence by elements other than radioactive caesium, such as Sr-90, Pu-238, etc, will be useful from the viewpoint of reassurance of people.*
- *The MOEJ has already started to consider safety of the post-management period of the managed recycling projects. It is important to perform a safety assessment for the post-management period of the managed recycling projects in order to demonstrate the long-term safety of the projects.*
- *The MOEJ should define in due course the decisions that are needed to end the period of special attention. The concept of the decision point should be documented and then the exact details and criteria can be developed in the future, in consultation with key stakeholders such as relevant ministries.*

IV.5 – Demonstration projects of agricultural embankments

Japan position

A demonstration project using removed soil for agricultural embankments has been implemented in Nagadoro District, Iitate Village (see Figure IX).

[5] IAEA, WS-G-5.1: Release of Sites from Regulatory Control on Termination of Practices, para 2.11 precises that "It is reasonable and appropriate to have different dose constraints for the release of sites than for the clearance of material from regulatory control. […] The dose criteria for the release of land from regulatory control should be optimized and can be higher than those for the clearance of material, because land remains in place and hence the degree of certainty about the potential uses of the land is higher than the degree of certainty associated with the uses of material after its release from regulatory control. Thus, it is reasonable to allow a larger fraction of the individual dose limit for the release of sites (i.e., the dose constraint (less than 300 microSv in a year)) than for the clearance of material (of the order of 10 microSv or less in a year)."



Mistry of the Environment, Gov. of Japan, "What Does "Recycling of Removed Soil"Mean?", http://josen.env.go.jp/chukanchozou/material/pdf/removed-soil_recycling-en_2205.pdf. Accessed 11 Oct. 2023.

Figure IX Overview of the demonstration project in Nagadoro District, Iitate Village.

Soil removed from Iitate Village with a radioactivity concentration of 5,000 Bq/kg or less is converted into soil suitable for recycling by removing all debris and foreign materials. The removed soil for recycling is used for the foundation of embankments, covered with other soil to prevent scattering and runoff of the removed soil, and the surface is improved for agricultural use, as shown in Figure X.

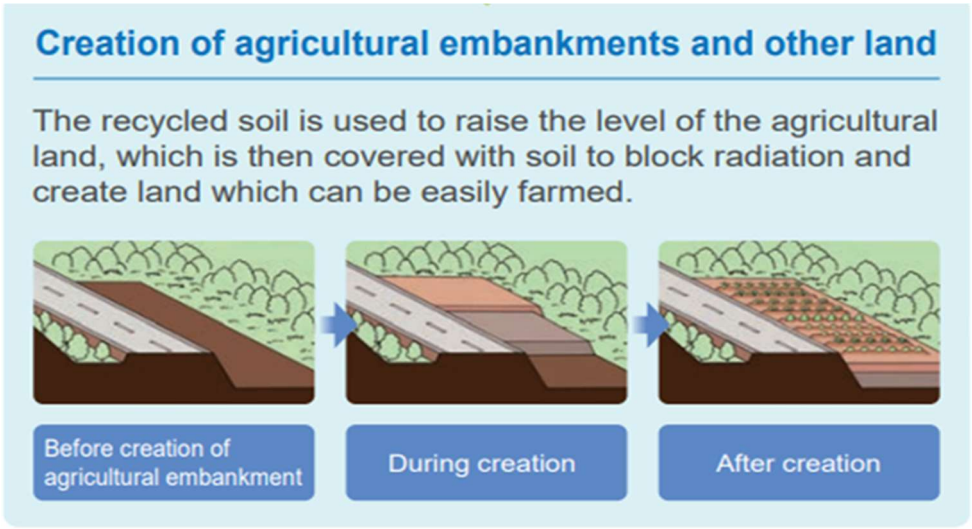


Figure X Overview of the creation of agricultural embankments using removed soil.

The projects have been carried out by the MOEJ with the close involvement of local residents and the first project has been ongoing since 2017. Test cultivation of flowers, vegetables and resource crops was performed on small fields in 2019 to confirm safety and soil productivity. Although the removed soil was predominantly on the top 5 cm of soil that was originally farmland, and is therefore good quality topsoil, 50 cm of sandy soil is placed on top of the removed soil for the prevention of runoff

the removed soil. This sandy soil is not very nutritious, and better plant growth has been obtained by fertilization of the sandy soil.

The monitoring programme includes the doses to workers constructing the embankments, the doses to workers cultivating the soil, the air dose rate, and the radioactivity concentration in discharged water, air, groundwater and rivers. Measurement results for the radioactive caesium level in harvested food crops in FY2020 and FY2021 had a range of 0.1-2.5 Bq/kg and were significantly lower than the 100 Bq/kg criterion for radioactive caesium concentration in ordinary foods. The radioactivity concentration of radioactive caesium in the crops grown directly in the removed soil was also well below the 100 Bq/kg standard.

Large scale (total land area of approx. 22ha) agricultural land development started in 2021 using removed soil to raise the height of agricultural land (see Figure XI).

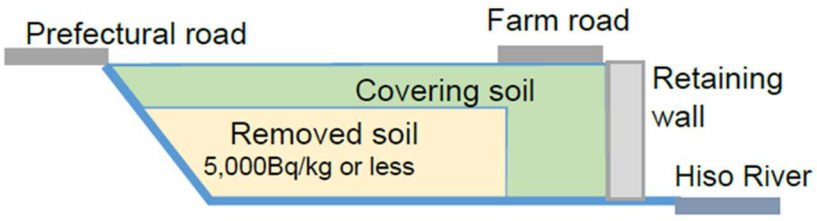


Figure XI Large-scale embankment cross section of the demonstration project in Nagadoro District, Iitate Village.

Four areas were identified for these developments. The embankments in the Areas No. 2, 3 and 4 have been completed and the first layer of covering soil added. Going forward, a second layer of covering soil will be added. Survey and design for the structure is underway in the Area No. 1.

The measured doses to the workers constructing the embankments in FY2021 and FY2022 were less than 1 mSv per year. The dose to the cultivation workers in FY2022 was less than 0.2 mSv *per year* . These measured doses include the background dose.

The results of these projects will be used to guide the creation of larger agricultural embankments as part of future policies and strategies for managing soil arising in Fukushima Prefecture. These agricultural embankments are long-term projects, so the removed soil will remain in the foundation of the embankments for a long period of time.

Observation

The team of experts observed that the demonstration project has been safely implemented and the demonstration projects have confirmed that the concept of the managed recycling is safe. The MOEJ will continue radiological monitoring to further accumulate data, which will contribute to encouraging public understanding and represent safety over the long term. The team of experts notes that as the radioactivity decays with time, the level of control that is needed can be reduced.

The courtesy visit to officials of Iitate Village, and residents of Nagadoro District gave the team of experts an opportunity to hear their views on the benefit for the process of reconstruction and revitalisation in the District, and the difficulties raised by the decision to host the demonstration project using recycled soil for agricultural purposes in the District.

The team of experts was able to observe the different demonstration projects and understand the importance of building and securing public confidence.

Conclusions of the team of experts for the section

- *The demonstration project in Nagadoro District has been safely implemented, in terms of the managed recycling of removed soil. It is very useful for long-term understanding of how removed soil can be safely recycled. It is recommended to continue the project, with associated monitoring to provide long-term safety data, which will contribute to public understanding.*
- *The experience of the demonstration projects in Fukushima Prefecture is allowing the MOEJ to develop the System for the managed recycling of removed soil.*
- *Safety of the demonstration projects has been confirmed from a radiological perspective, and it is considered that necessary scientific findings have been obtained to provide the basis for the System (the ministerial ordinance and the technical guidelines).*
- *Measurements by the MOEJ have confirmed that radioactive caesium in removed soil is hardly eluted into water.*

IV.6 - Demonstration project of road embankment

Japan position

A demonstration project of a road embankment has been constructed in the premises of the ISF (see Figure XII).

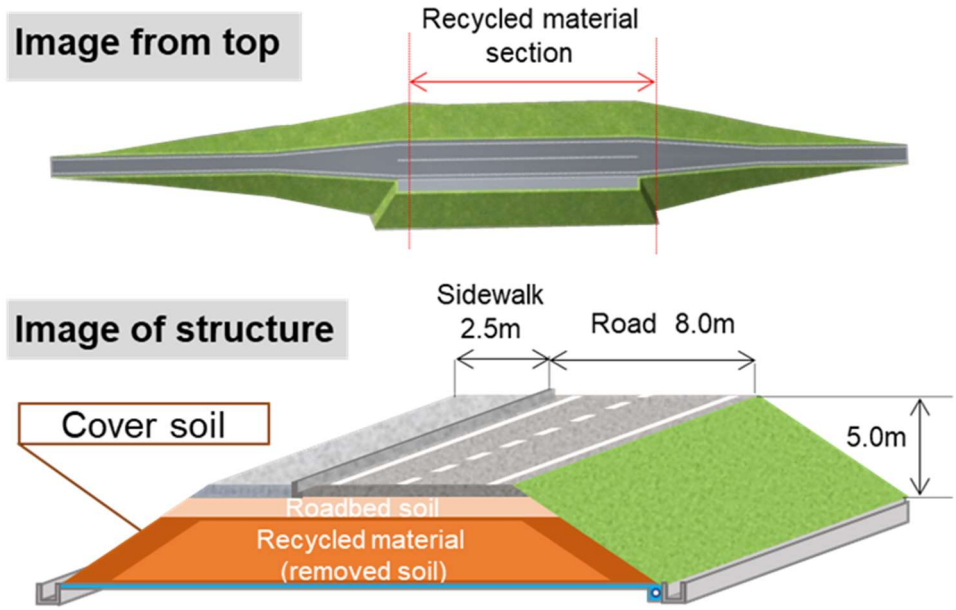


Figure XII Demonstration project of road embankment in the premise of the ISF.

After removing all debris and foreign materials from removed soil, the recycled materials with a radioactivity concentration of 8,000 Bq/kg or less are used for the foundation of a road embankment, then covered with soil, asphalt, concrete or similar material to block radiation. The covering layer is placed to prevent scattering and dispersion of the removed soil, taking the specifications of the road embankment into account, including even during general repair to a civil engineering structure. This covering layer also provides shielding which also results in the reduction of dose. The removed soil for the recycling may require addition of other material (quality adjustment) to ensure that it has the appropriate characteristics for use in the foundation of a road embankment.

The demonstration road embankment is built to a general road standard, Class 3-2 (traffic volume of 4,000 to 20,000 vehicles/day) structure with sidewalks. The structure was divided into four sections to determine whether there would be any difference in 'workability' and 'stability of the structure' depending on the quality adjustment and auxiliary construction method. Each section was built to one of the following four patterns:

- (A) [Single unit] Removed soil only
- (B) [Single unit] Removed soil + auxiliary method (geosynthetic reinforcement material)
- (C) [Improved soil] Removed soil + slag mixture + quicklime mixture
- (D) [Improved soil] Removed soil + slag mixture + quicklime mixture + auxiliary method (geosynthetic reinforcement material).

During construction monitoring showed that:

- The additional annual dose to workers during the filling work of the removed soil was confirmed to be less than 1 mSv.
- The air dose rate at the boundary of the construction site did not change before and after the filling of the removed soil.
- The concentration of radioactive materials in the air during the filling of the removed soil was below the detection limit.
- The concentration of radioactive materials in the leachate from the road embankment was below the detection limit.

Monitoring of air dose rate and concentration of radioactive materials in the air and leachate will continue during maintenance of the structure to confirm safety.

The performance of the demonstration road embankment will be evaluated, and the MOEJ will review the results of the project, to consider if the technique can be used at a larger scale to create embankments as part of future policies and strategies for the managed recycling by the end of FY2024. The demonstration road embankment will be dismantled when the project is completed.

Observation

The team of experts visited the demonstration project site of the road embankment. It noted that both this project and the agricultural embankment project were well managed and there were maps and signs at each location to explain the project. Encouraging the public to visit the projects will promote public understanding. The courtesy visit to officials of Okuma Town and Futaba Town, prior to visiting the ISF, gave the team of experts the opportunity to better understand the point of view of the local population regarding the ISF and the recycling projects being carried out on site.

The road embankment has a cover soil with thickness of 50 cm, but this may be a conservative thickness. A thin covering of soil may be needed to avoid removed soil becoming dispersed in the wind. Engineering design codes requires a top layer of 160 cm in some construction projects, which would eventually contribute to sufficient reduction of dose. The thickness of the cover soil should be determined in consultation with stakeholders such as operator of the structure.

It would be valuable to continue the project for more than one year to enable more data to be obtained on the performance of the road embankment.

Conclusions of the team of experts for the section

- *The road embankment project should be continued to further accumulate data on the stability of the structure over a longer time, for application to the large-scale projects to be implemented in more practical manner in the future.*
- *Safety of the demonstration projects has been confirmed from a radiological perspective, and it is considered that necessary scientific findings have been obtained to provide the basis for the System (the ministerial ordinance and the technical guidelines).*
- *Measurements by the MOEJ have confirmed that radioactive caesium in removed soil is hardly eluted into water.*

V - Final disposal of removed soil and waste

As already mentioned in this report, the removed soil and waste arising from decontamination activities unsuitable for the managed recycling are to be finally disposed of outside Fukushima Prefecture, within 30 years from the start of interim storage in the ISF. In all three IEMs, the MOEJ explained their current approach toward the realization of the final disposal, and the team of experts has recognized significant progress for its consideration during the three IEMs.

In the following sections in this Chapter, the discussions between the team of experts and the MOEJ were covered to summarize the observations and conclusions made by the team of experts, including measurements and initial safety case for the final disposal.

V.1 – Overall approach to the final disposal of removed soil and waste

Japan position

The Technical Development Strategy provides a basic approach for the final disposal of removed soil and waste generated by decontamination activities, after necessary measures (e.g., volume reduction and the managed recycling), to be completed outside Fukushima Prefecture within 30 years after the start of interim storage (by March 2045), in accordance with the relevant laws. For this reason, the MOEJ will formulate the ministerial ordinance on the final disposal of removed soil and waste by the end of FY2024, although the ministerial ordinance for the Specified Waste was already established under the Act on Special Measures.

The amount and specific radioactivity concentration of removed soil and waste transported to the ISF until the end of FY2022 (March 2023) is presented in the following figure (see Figure XIII). The figure shows that in total more than 12.3 mill. m³ of removed soil and waste was transported to the ISF, 94% of the material is soil, and approx. 24.5% of the material contains radioactivity concentration of above 8,000 Bq/kg (see Figure XIII). This would lead to an amount of more than 3 mill. m³ of removed soil and waste for the final disposal, although this number could be reduced according to the progress of volume reduction projects.

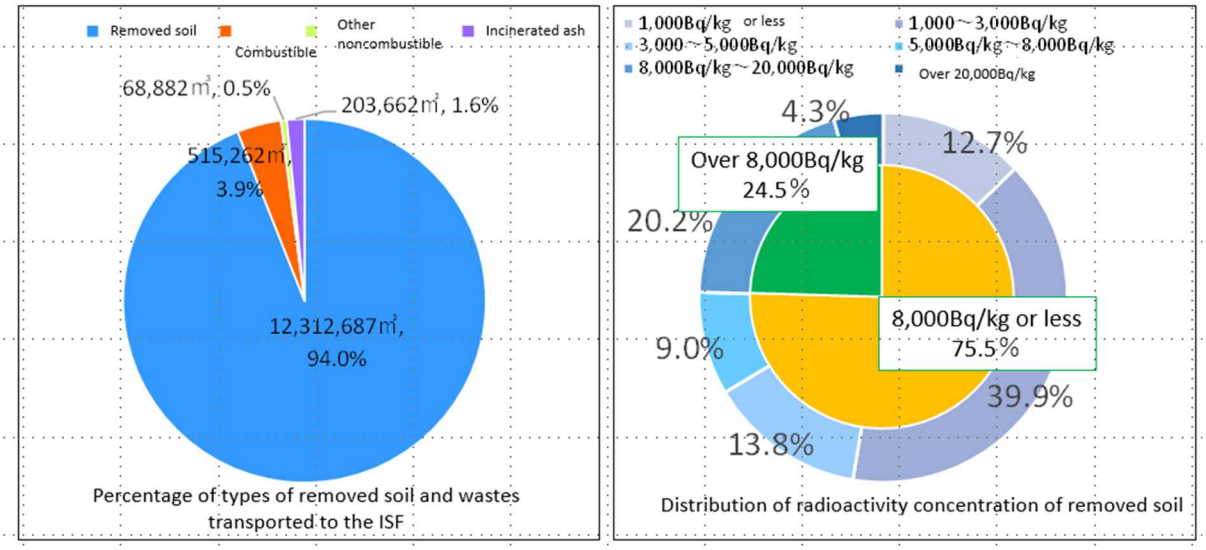


Figure XIII Amount and radioactivity concentration of removed soil and waste transported to the ISF (as of March 2023).

The MOEJ considers three existing types of final disposal facility (or facilities) as good references, for consideration of specific structure of the final disposal facility (or facilities) of the removed soil and waste (see Figure XIV to XVI). With FY2024 as the strategic target, the MOEJ will proceed with the development of volume reduction and recycling technology and present several feasible options for the required area and structure of the final disposal facility (or facilities).

Figure XIV: Image of the final disposal facility for the removed soil and waste, which has no concern about groundwater pollution.

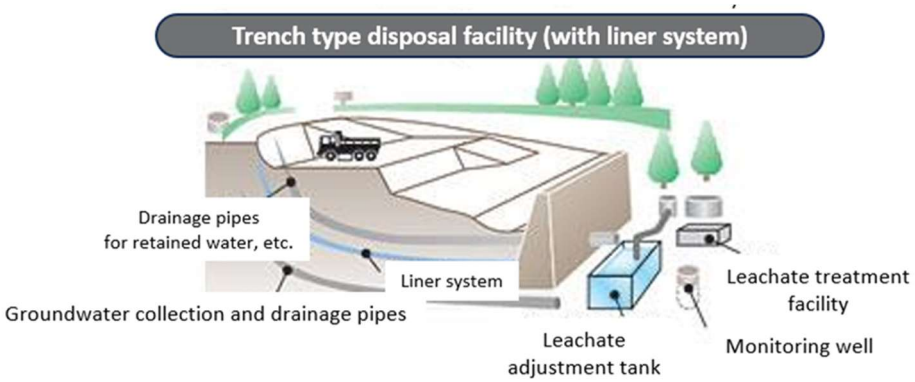


Figure XV Image of the final disposal facility for the Specified Waste with radioactivity concentration of 100,000 Bq/kg or less.

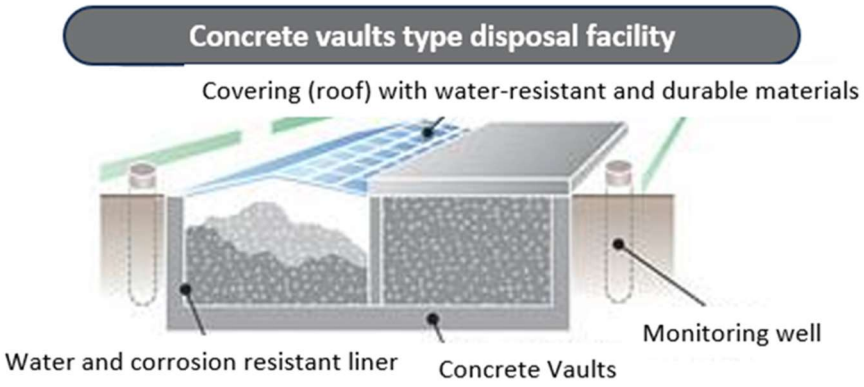


Figure XVI Image of the final disposal facility for the Specified Waste with radioactivity concentration of more than 100,000 Bq/kg.

The second type of the final disposal facility (trench with liner) has been in operation for the Specified Waste in Tomioka Town, Fukushima Prefecture since 2017.

As described in the Chapter IV, treatment options are being considered for the removed soil that does not meet the screening levels (8,000 Bq/kg or less). For each treatment option, the volume of waste for the final disposal and the radioactivity concentration in the waste are calculated. Based on these factors, the MOEJ will consider the structure and the size of the final disposal facility (or facilities).

The radioactivity concentration is estimated by the MOEJ to range up to a couple of 10 - 100 kBq/g, which is allocated as LLW or VLLW according to IAEA Safety Standard GSG-1: Classification of Radioactive Waste (see Figure XVII).

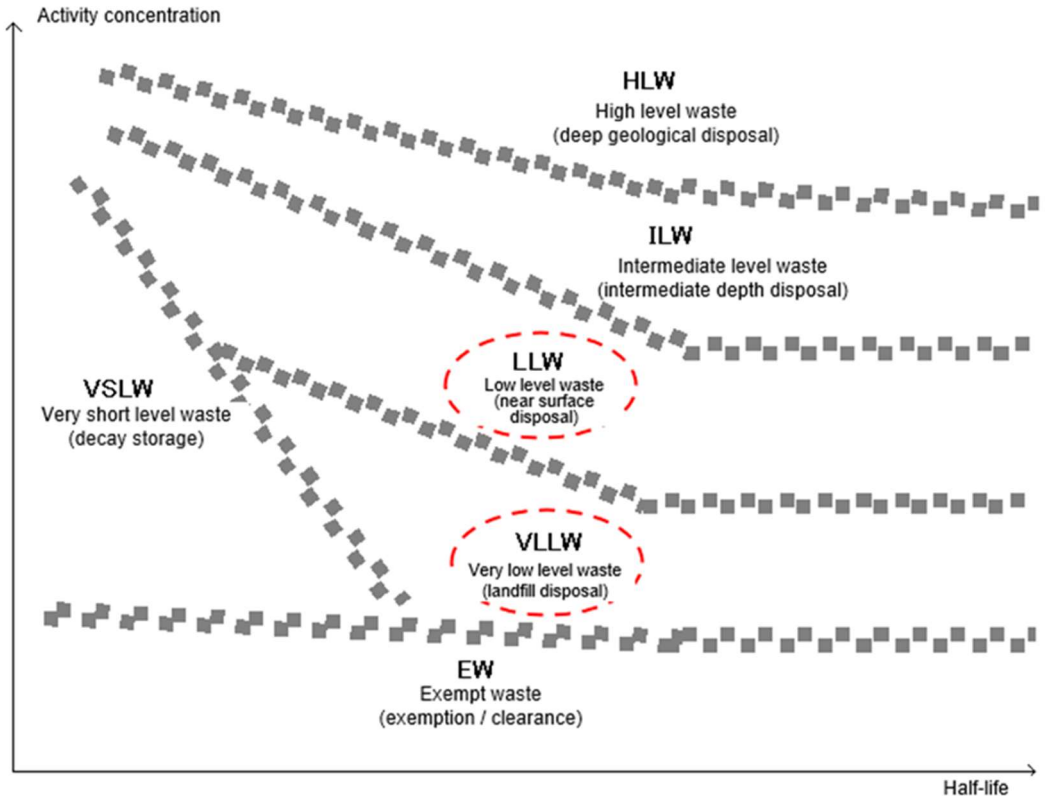


Figure XVII Conceptual illustration of the waste classification scheme (IAEA GSG-1).

Based on the different measures for treatment of soil three cases were discussed by the MOEJ (see Figure XVIII).

	Case 1	Case 2	Case 3
Volume reduction method	Classification	+ Heat treatment	+ Fly ash cleansing
Type of disposed material	Soil	Waste (cement solidified)	Waste (cement solidified)
Average radioactivity concentration (Bq/kg) *1	31,000	150,000	28,000,000
Facility type	Trench type (without liner system)	Concrete vault type	Concrete vault type
Landfill volume (m^3)	1,000,000	250,000	2,500

Figure XVIII Case study of results after different treatment steps.

This study demonstrates that in case of a full treatment of the soil (case 3) the volume waste for the final disposal is reduced by several orders of magnitude. Hence, only a small disposal facility is needed.

Observations

The timeline of the development, operation and closure of a near surface disposal facility is illustrated in the following Figure XIX.

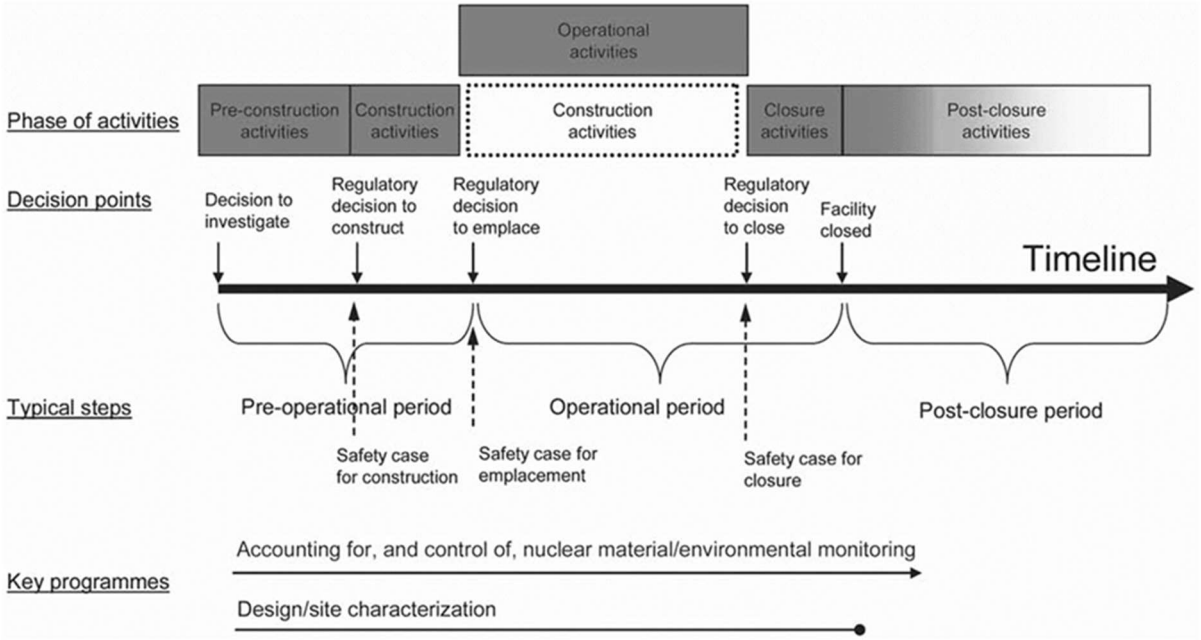


Figure XIX Timeline to illustrate the development, operation and closure of a near surface disposal facility described in the SSG-29 of the IAEA.

The team of experts notes that according to the illustration of the timeline in Figure XIX, the following processes could be anticipated within the next 21 years regarding the design and development of the new facility (or facilities) for the final disposal outside Fukushima Prefecture:

- Definition and implementation of the site selection process (a desktop exercise could be helpful as a starting point);
- Successful completion of the site selection process;
- Planning and optimization of one or more disposal facility and delivery of a safety case; and
- Construction and operation of the disposal facility (or facilities).

The team of experts notes that optimisation of protection means that the MOEJ should consider different options for the design of the disposal facility (or facilities), for example, different cap thicknesses or liner thicknesses. The MOEJ should understand the advantages and disadvantages of the different options in terms of societal, environmental and economic factors as well as the associated radiological safety.

The team of experts notes that the MOEJ has initiated a generic safety assessment for the final disposal including sensitivity analyses to understand the key processes and parameter values that determine safety. This would enable the MOEJ to reduce uncertainties for the design of disposal facility (or facilities).

The team of experts notes that waste disposal methodologies and standards for waste treatment and disposal are closely inter-related. The treated waste will need to be confirmed to be suitable for the disposal facility (or facilities), in line with the disposal standards based on the safety case. Therefore, it needs to be packaged, as appropriate, and transported to and disposed of in the disposal facility (or facilities) taking into account regulations for recordkeeping and dissemination of information.

The baseline for the observations by the team of experts is mainly the IAEA principles, standards, and guidelines. The team of experts notices that for fulfilling the IAEA Principle 7 in the SF-1: Protection of present and future generations, it is necessary to keep the generation of radioactive waste to the minimum practicable level by means of appropriate design measures and procedures, such as the recycling and reuse of material (Principle 7, para 3.29).

The team of experts expects that the removed soil and waste that will be sent for the final disposal, including waste as a result of different treatment measures like heating and fly ash cleaning, can be assigned as LLW or VLLW according to the IAEA´s classification scheme. Therefore, the final disposal concept of a near surface disposal facility as illustrated by the MOEJ is appropriate.

The volume reduction methods described in Fig. V and XVIII could offer the possibility of a reduction of the radioactive waste up to 2,500 m^3 (case 3).

For relatively small volumes of VLLW, there are cases, for example, in Belgium and UK, in which they are disposed of in specific existing landfills. The team of experts considers that this option as well as construction of new disposal facility (or facilities) outside Fukushima Prefecture could be considered.

The MOEJ should understand the advantages and disadvantages of the different treatment options in terms of safety and societal, environmental and economic factors as well as the associated reduction in volume of waste to be disposed of.

Conclusions of the team of experts for the section

- *Important progress has been made for consideration of final disposal options, including implementation of a generic safety case for the management period of the final disposal. The MOEJ has initiated a generic safety assessment including sensitivity analyses, taking into account the low-level or very low-level radioactivity of the removed soil and waste. Towards the future, there are a lot of challenges to be addressed to realize the final disposal outside Fukushima Prefecture by March 2045.*
- *The MOEJ should conduct additional site-specific sensitivity analyses at an appropriate stage to reduce uncertainties for the design of disposal facility (or facilities).*
- *It is suggested that a holistic strategy and timeline for the final disposal outside Fukushima Prefecture should be defined by the MOEJ.*
- *In order to meet requirement for optimization of radiological protection, the MOEJ should consider different options for design of the final disposal facility (or facilities), in due time before implementation. The MOEJ should understand the value of the different options in terms of societal, environmental and economic factors as well as safety.*
- *The final disposal concept of a near surface disposal facility as illustrated by the MOEJ is consistent with the IAEA Safety Standards, because the removed soil and waste that will be sent for the final disposal can be assigned as LLW or VLLW according to the IAEA´s classification scheme defined in the GSG-1.*
- *8,000 Bq/kg is a derived level in good accordance with other national criteria (for example in Germany) and suitable to differentiate between LLW and VLLW or between VLLW and Exempt Waste as defined in the IAEA´s classification of waste (IAEA GSG-1).*

- *The MOEJ's approach for volume reduction and recycling of removed soil is in line with the IAEA fundamental principle on protection of present and future generations[6], but the MOEJ should understand the advantages and disadvantages of the different treatment options in terms of safety and societal, environmental and economic factors.*

V.2 – Measurement of radioactivity concentration

Japan position

Radioactivity concentration will be measured to decide the treatment method when the removed soil is excavated from the Soil Storage Facilities in the ISF, with appropriate record keeping. Because of the large volume of removed soil handled, a continuous measuring system of the radioactivity concentration is required. An example of such a system that the MOEJ is considering is a conveyor belt and detector system similar to that used at the ISF Soil Separation Facilities (see Figure XX). There is a correlation between the radioactivity concentration and the total gamma activity, and therefore the total gamma activity was measured by using detectors (such as plastic scintillators or NaI scintillators) and converted to the nuclide-specific radioactivity concentration of the removed soil. The detectors were regularly calibrated with samples of known radioactivity concentration, and the measurements were highly accurate and practical.

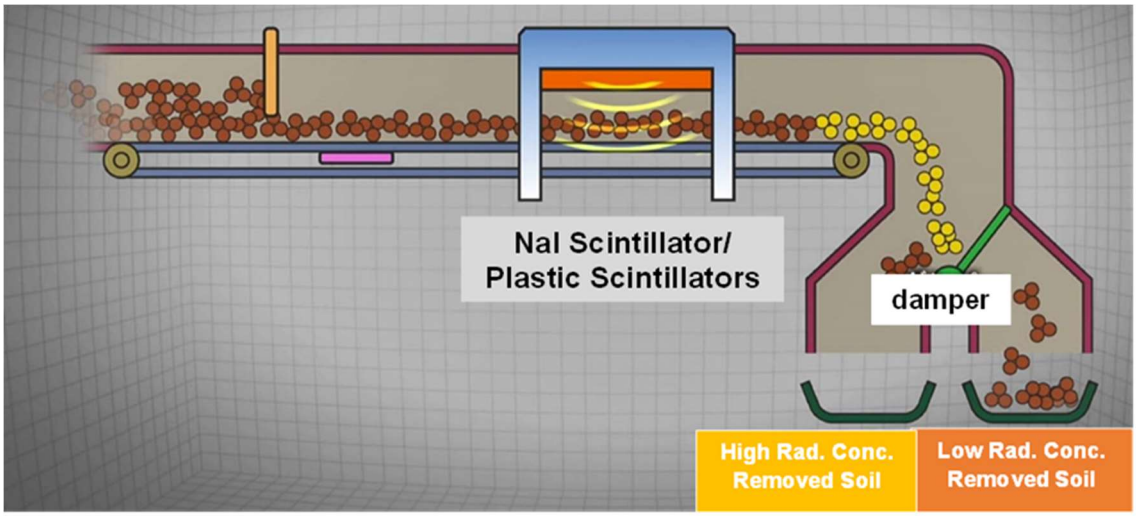


Figure XX Conceptual illustration of facility for measurement of radioactivity concentration.

Observations

The team of experts notes that the MOEJ will measure with sufficient accuracy the removed soil excavated before treatment.

[6] Protection of present and future generations: It is necessary to keep the generation of radioactive waste to the minimum practicable level by means of appropriate design measures and procedures, such as the recycling and reuse of material (Principle 7, para 3.29).

Following the treatment, the waste intended for the final disposal should be characterized to provide sufficient information to ensure compliance with waste acceptance requirements and criteria. Arrangements have to be put in place to verify that the waste and waste packages sent for the final disposal comply with these requirements and criteria (Specific Safety Requirements (SSR)-5, para. 5.3).

The team of experts notes that a continuous measuring system using a conveyor belt and NaI scintillators or other similar detectors is a proven and well-developed method for characterising large quantities of removed soil. Plastic scintillators would enable a high throughput of removed soil. NaI scintillators or similar detectors could be more appropriate if a nuclide-specific measurement of different key nuclides is needed. However, in this case, measurements of individual container also have to be performed.

Measurement of individual waste container is necessary to characterise solidified radioactive waste after treatment of soil before it is sent to the planned disposal facility (or facilities). The MOEJ has described other methods for measurement of waste which have been already applied for the measurement of the treated waste prior to its transport for disposal (e.g., measurements of radioactivity on a lot basis using Germanium semiconductor detector or NaI scintillators).

As discussed in Section IV.1, this type of continuous measurement approach could be applicable to the system of the managed recycling, to identify the removed soil to be recycled. Continuous measuring systems are used for measurements of clearance levels and since the basic compliance process for clearance is the same as for the screening levels for the managed recycling or the final disposal, the same type of sorting system can be used.

Conclusions of the team of experts for the section

- *The MOEJ will measure with sufficient accuracy the removed soil excavated before treatment.*
- *The MOEJ has already developed a measuring method for treated soil that will be used for further measurement before transport to the managed recycling sites or final disposal facility (or facilities).*

V.3 - Safety case including generic safety assessment

Japan position

The following safety measures during operational period for the final disposal of removed soil and waste are developed as draft and discussed in the Japanese expert committees:

- Prevention of scattering and leakage
- Prevention of groundwater pollution, as necessary
- Conservation of the living environment (e.g., odor, noise, vibration)
- Surrounding enclosures (e.g., fences) and sign
- Landfill Capping
- Measurement of air dose rate

・Keeping records

This also includes a dose concept for the additional exposure to the public as well as to the workers during operation and in case of accidents.

An initial generic safety assessment was carried out with sensitivity analysis for the operational period of the final disposal to confirm the feasibility of each final disposal option. Regarding the annual exposure dose to the public in the neighbourhood during landfill work and after landfill disposal, the maximum external exposure route for residents (children as conservative group) in the neighbourhood during landfill work is about 0.1 mSv per year, and in all cases, the additional exposure dose to the public in the neighbourhood of the facility is well below 1 mSv per year.

The proposed safety measures to be stipulated in the ministerial ordinance for the final disposal of removed soil and waste are using the results of the generic safety assessment for the operational period, and cover essential elements to ensure safety during the construction and maintenance period.

The safety case will be developed and updated by the MOEJ according to the phase of the final disposal (e.g., site selection, survey and design, construction, operation, post-closure), in line with IAEA Safety Standards.

Observations

The different tasks and responsibilities of government, regulatory body and operator are explained in the SSR-5. A safety case and supporting safety assessments are required to be prepared and updated by the operator, as necessary, at each step in the development of a disposal facility, in periods of operation and post-closure. The safety case and supporting safety assessments are required to be submitted to the regulatory body according to the IAEA Safety Standards (SSR-5 Req. 3). These steps should be defined in relevant documents, so that it makes clear when the operator function of the MOEJ should seek permission from the regulatory function of the MOEJ to proceed to the next step.

In the SSG-29, it is clearly mentioned that while safety assessments are indeed “stepwise” in terms of more detailed assessments being undertaken (and submitted for approval) at different stages of the programme, they are also iterative in the sense that the safe end point needs to be considered from the very beginning to avoid redundant effort. As the SSG-29 notes:

> ‘The safety case has to be progressively enhanced as construction, operation and closure are carried out, so that all safety related issues are identified and the actions taken are recorded. At all times, up to date documentation of the safety case should be available that demonstrates that the facility is safe and can be expected to remain safe over the long term, and that guides the management and operation of the disposal facility.’ (emphasis added)

Figure XXI from SSG-29 sets out the main aspects included in the safety assessment of the waste disposal site, and it is clear that the post-closure radiological impact is central throughout – it is not undertaken at the very end in case the proposed facility fails to meet the long-term safety requirements.

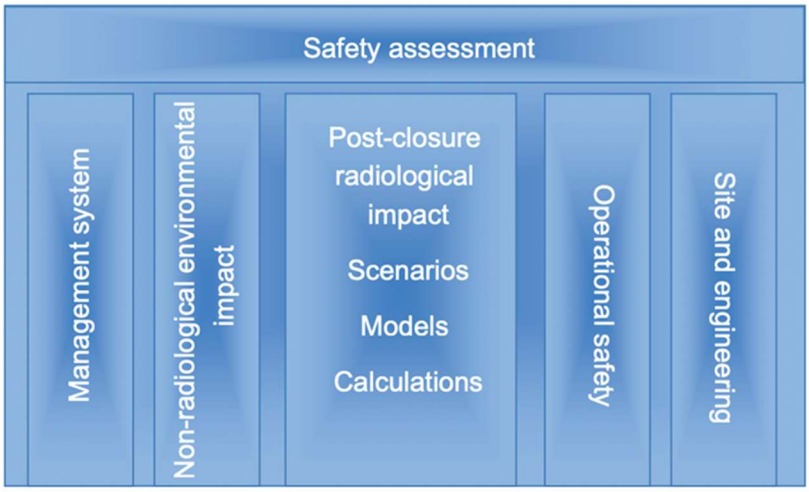


FIG. 4. Aspects included in the safety assessment.

Figure XXI Main aspects included in the safety assessment of waste disposal.

A study by MINARI, E., at el.,(2023)[7] conducted a preliminary safety assessment, which examined the potential impact of disposing highly concentrated soil. The assessment considered the annual exposure dose resulting from the ingestion of well water directly beneath the repository. It estimated an exposure dose of 5.57 $\times 10^{-5}$mSv/year if the soil was disposed of in the disposal facility.

Most importantly, the authors note that:

> "To facilitate effective consensus-building and ensure transparency, it is important to quantify and communicate the impact of final disposal outside Fukushima Prefecture based on the results of safety assessments, such as the ones conducted in this study. By providing quantitative data and safety assessments, stakeholders can make informed decisions and engage in meaningful dialogue regarding the disposal options…
>
> ... Safety assessments and cost evaluations will be continuously refined, considering uncertainties and potential changes in the results. Indeed, presenting and discussing a variety of options, as demonstrated in this study, is a valuable approach to foster consensus building. By providing multiple options, stakeholders can have a comprehensive understanding of the available choices and their implications. This allows for a more inclusive and participatory decision-making process."

Post closure safety assessment should be included in the safety case from the outset to inform public and stakeholder engagement and to reassure local communities and other stakeholders of the long-term safety of the proposed method for final disposal of removed soil and waste.

The generic safety assessment for the final disposal is moving forward in the right direction with a graded approach as described in the IAEA Safety Standards, taking into account LLW or VLLW radioactivity of the removed soil and waste.

[7] Source: Minari E., YAMADA, K., ENDO, K., OSAKO, M.,
Preliminary Study on Treatment/Disposal Scenario Building and Comprehensive Evaluation Toward the Final Disposal of the Radioactively Contaminated Waste Outside Fukushima Prefecture

The basic design of the final disposal facility (or facilities) has so far been developed considering the operational period. Other detailed measures that are important for long-term safety of the final disposal facility (or facilities) (e.g., geological requirements for the site, geotechnical requirements including thickness and structure of cover and base, technical requirements including the structure of the facility (or facilities), monitoring system) need to be defined at an early stage based on the post-closure safety case. These will be input into the design of the final disposal facility (or facilities).

A generic safety assessment for the final disposal of removed soil and waste is completed for the operational period. This generic safety assessment will be extended to cover the post-closure period by the MOEJ.

The MOEJ will need to ensure and explain that the generic safety case and the subsequent management of the final disposal facility (or facilities) will follow international good practice.

Measurement and monitoring systems to be introduced are strongly dependent on the list of nuclides to be measured. The team of experts notes that this list of nuclides will be based on the results of the long-term safety assessment which calculates the possible dose to the public after the closure of the final disposal facility (or facilities). The result of a generic safety assessment represents that contribution to dose of radionuclides like strontium and alpha-emitters are much less than that of radioactive caesium.

Conclusions of the team of experts for the section

- *The design of the disposal facility (or facilities) has so far mainly been done considering the operational and maintenance period. The proposed safety measures to be stipulated in the ministerial ordinance of landfill disposal for removed soil and waste covers essential elements to ensure safety during the construction and maintenance period.*
- *The team of experts stresses the importance of designing the final disposal facility (or facilities) on the basis of post-closure safety together with operation and maintenance safety. The team of experts notes that safety case and safety assessment on post-closure safety has been initiated and will be further addressed in the continuation of the design development of the final disposal facility (or facilities).*
- *Post-closure safety case including safety assessment from the outset would reassure local communities and other stakeholders of the long-term safety of the final disposal of removed soil and waste.*
- *Specific documents need to be developed in due time, to make it clear, which situations and eventualities require the operator function of the MOEJ (for the final disposal facility (or facilities)) to inform the regulatory function of the MOEJ and to seek their advice, review and agreement before proceeding with to the next stage in the development of the final disposal facility (or facilities).*
- *The MOEJ will continue considering the impact of relevant radionuclides for the safety of disposal.*

TERMINOLOGY CHECK / Authorization

The IAEA Nuclear Safety and Security Glossary, 2022 (Interim) Edition, defines authorization as “The granting by a regulatory body or other governmental body of written permission for a person or

organization (the operator) to conduct specified activities. Authorization could include, for example, licensing (issuing a licence), certification (issuing a certificate) or registration. […] Authorization is generally a more formal process than approval. “

SSR-5: Disposal of Radioactive Waste precises that for a disposal facility, “The pre-operational period includes concept definition, site evaluation (selection, verification and confirmation), safety assessment and design studies. It also includes the development of those aspects of the safety case for safety in operation and after closure that are required in order to set the conditions of authorization, obtain the authorization and proceed with the construction of the disposal facility and the initial operational activities. The monitoring and testing programmes that are needed to inform operational management decisions are put in place.”

VI – Public communication and stakeholder engagement

Public communication and stakeholder engagement for the managed recycling and the final disposal of removed soil and waste were discussed at all three IEMs. The team of experts recognizes that good progress has been made by the MOEJ between the first IEM and the third IEM. The discussions between the team of experts and the MOEJ, as well as the observations and conclusions made by the team of experts, by also referring to the IAEA relevant documents[8], are described here under broad topic headings.

VI.1 - Overall approach to public communication and stakeholder engagement

Japan position

The MOEJ's position is that it is necessary to build public understanding nationwide of the issues and efforts to both reduce the volume and also recycle removed soil, as well as to reduce the volume of waste to be disposed of. The MOEJ's strategy is to promote public understanding of recycling technology development, as well as of the current approach and proposed methods for the managed recycling of removed soil. Improved public understanding of radiation safety is also part of the strategy.

The MOEJ established the Communication Promotion Team to implement activities for public understanding with the cooperation of a number of academic experts and researchers. Based on the Web-based survey in FY2022, it is understood that roughly 65 % of those surveyed in Fukushima Prefecture and 88 % outside Fukushima Prefecture have never heard about the managed recycling of removed soil or have only heard of it with little information and comprehension. The MOEJ is making further efforts to disseminate information about the managed recycling plans.

As described earlier in the Chapter III, eight main steps lead toward the final disposal of removed soil and waste outside Fukushima Prefecture by March 2045 (see Figure I). The MOEJ's objective leading up to the strategic target year of FY2024 is to foster public understanding through information dissemination about the managed recycling of removed soil with relatively low radioactivity

[8] References:

IAEA Nuclear Energy Series No. Nw-T-1.16 "Communication and Stakeholder Involvement in Radioactive Waste Disposal" (IAEA 2022)

IAEA Safety Standards. General Safety Guide GSG-6 "Communication and Consultation with Interested Parties by the Regulatory Body" (IAEA 2017)

concentration, and the final disposal of removed soil and waste with relatively higher radioactivity concentration (i.e., above 8,000 Bq/kg) outside Fukushima Prefecture.

The MOEJ acknowledges that the focus of the main communications and targets for the final disposal outside Fukushima Prefecture by March 2045 will change depending on the process adopted.

The MOEJ describes the current public communication target (context setting – see Figure XXII below) as:

- The policy for the final disposal outside Fukushima Prefecture
- The safety and the need for volume reduction and recycling of removed soil.

After 2024 up to 2045 – the public communication target will shift to focus on:

- Final disposal site planning, selection and construction outside Fukushima Prefecture
- Ways of communicating with and explaining benefits to local stakeholders related to the (as yet undetermined) candidate sites.

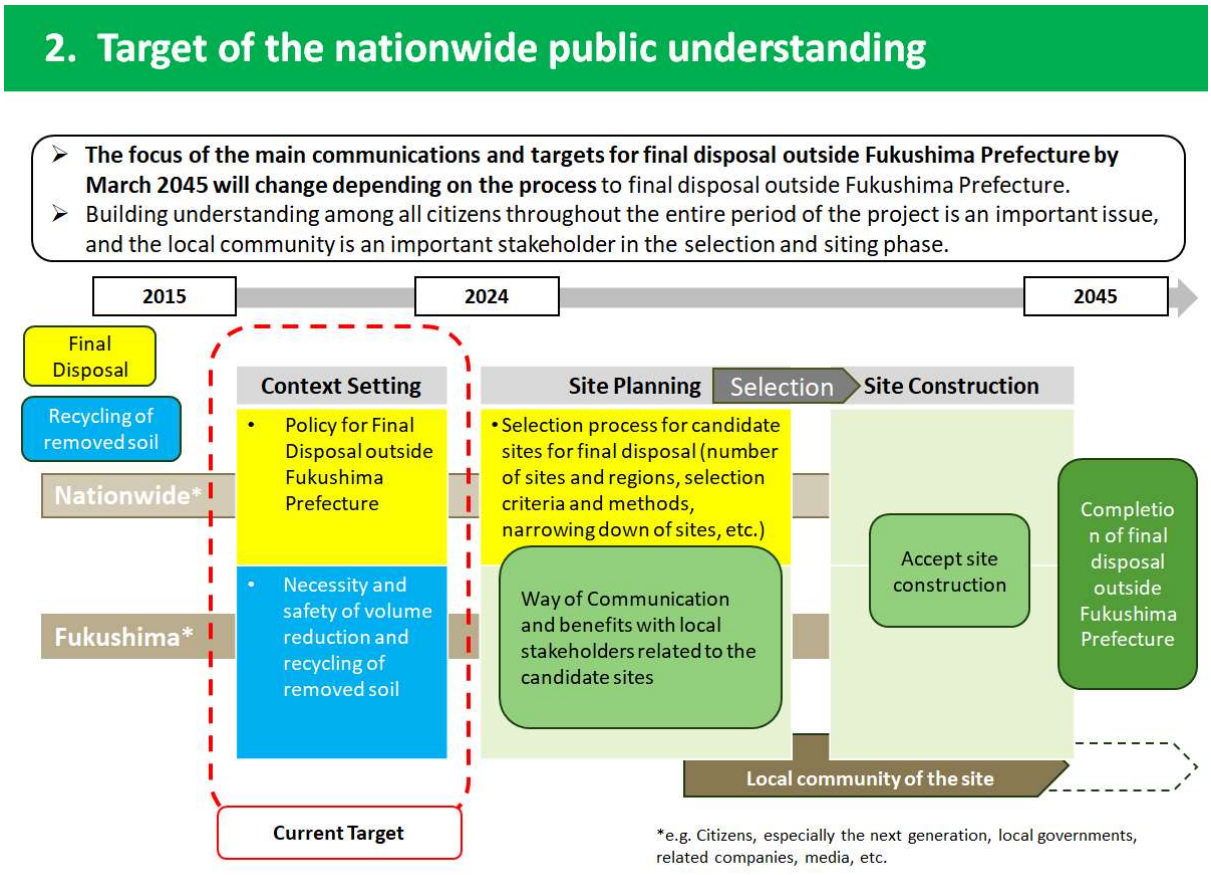


Figure XXII Target of public understanding.

Observations

The team of experts emphasised the need to see a clear master plan including stakeholder engagement and communication that explains how the various communication elements fit together

for the forthcoming stages of the project from FY2025 onwards. This is particularly important. From Step 5 the master plan should identify who will be engaged, on what topics, how, and when.

It is important to include the various options for treatment (volume reduction) and disposal to be put forward.

There remains a need for an overall master plan including for key stakeholders like local community and wider public engagement for Step 5 onwards (from FY2025 onwards).

In implementing that plan, the following good practices in risk communication should be useful:

- Keep communication material clear and simple;
- Use consistent terminology;
- Explain the (direct and indirect) social benefits as well as the safety considerations;
- Undertake research into community and stakeholder expectations and their consultation needs;
- Pilot-test communication materials; and
- Consider providing training for communicators.

Conclusions of the team of experts for the section

- *The MOEJ has made significant progress in the area of public and stakeholder engagement since the first IEM and should continue to develop and refine its approach as the project progresses.*
- *Efforts undertaken by the MOEJ to actively disseminate information about Japan's initiatives for the managed recycling and the final disposal are highly evaluated, and also need to be continued for maintaining trust and confidence in both the MOEJ and in the long-term safety of the projects.*
- *The findings of the advanced efforts for the managed recycling of removed soil can be used as a useful case study for reference by other countries. Dissemination to international society, through international forums, publications and media, including cooperation with the IAEA, is encouraged.*
- *The MOEJ is expected to accelerate the work from FY2025 regarding on-site identification and selection for the final disposal in order to meet the challenging timelines set by the JESCO Law, taking fairness and transparency into account. The implications for timing and implementation of stakeholder engagement programme need to be understood and addressed.*

VI.2 – Promotion of nationwide understanding

Japan position

Communication with stakeholders

Research of the group of experts (AIST, Hokkaido University and Osaka University, representative: Prof. YASUTAKA Tetsuo) on communication with stakeholders regarding the managed recycling of removed soil was described regarding research information during the second and third IEM including how to identify key stakeholders and key factors for social acceptance, and how to build consensus at each step of the managed recycling and the final disposal programme.

Some key research findings were that:

- Trust for the national government and local governments, and intergenerational expectations are critical factors influencing the acceptability of the final disposal (SHIRAI et al., (2023)[9], TAKADA et al., (2024)[10]. Additionally:
    - Social benefits increase acceptability;
    - Personal benefits have limited impact; and
    - Risk perception (Dread factors) decreases acceptability.

Numerous information dissemination activities have been undertaken by the MOEJ, with the support of the Communications Promotion Team seeking to foster an improved level of understanding among key stakeholders. These include a range of activities such as a variety of face-to-face events and also web based approaches.

The MOEJ described the range of activities in their current plan which involves a variety of stakeholders including the younger generation to foster improved understanding. These include information dissemination and participatory activities. Approximately 3 per year "Dialogue Forums" have also been held over the past 3 years with both in person and on-line attendance, including the period of the COVID-19 pandemic (See Figure XXIII summarising the Dialogue Forums)

The MOEJ also described how it has continued with important engagement to raise awareness, and to share experience with the international community regarding recovery activities in Fukushima Prefecture and lessons learned.

Source:

[9] SHIRAI, K., TAKADA, M., MURAKAMI, M., OHNUMA, S., YAMADA, K., OSAKO, M., & YASUTAKA, T. (2023). Factors influencing acceptability of final disposal of incinerated ash and decontaminated soil from TEPCO's Fukushima Daiichi nuclear power plant accident. Journal of Environmental Management, 345, 118610

[10] TAKADA, M., MURAKAMI, M., OHNUMA, S., SHIBATA, Y & YASUTKA, T. (2024). Public Attitudes toward the Final Disposal of Radioactively Contaminated Soil Resulting from the Fukushima Daiichi Nuclear Power Station Accident. Environmental Management 73, 962–972 (2024)

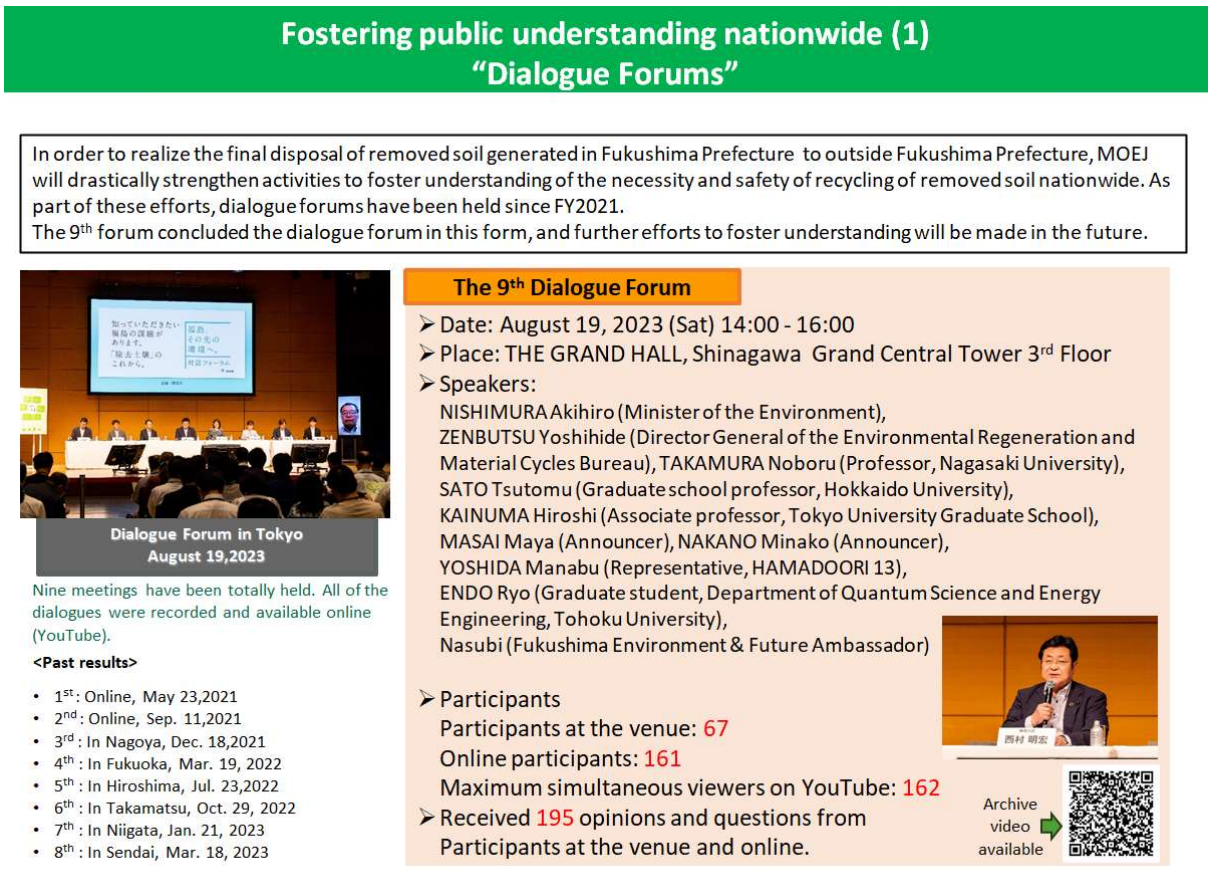


Figure XXIII Overview of the Dialogue Forums.

Community development

Community development has centred around the demonstration project in Nagadoro District of Iitate Village in collaboration with local residents and local experts. This was described by the MOEJ as an example of good practice, and communication patterns of potential benefit for other communities have been studied and compiled in a booklet. It is understood that a focus on the benefits associated with the project will form an important part of the way forward.

The MOEJ will develop a plan for communicating with the public regarding the managed recycling and the final disposal. The plan includes the use of social media as well approaching target audiences through site visits to the ISF and the demonstration project site in Nagadoro district for:

- Local governments in and outside Fukushima Prefecture;
- Companies interested in Fukushima and environmental restoration; and
- Domestic and foreign media, international organizations.

In the second and the third IEM additional research information was provided by Prof. YASUTAKA regarding public and stakeholder engagement and the need of the future research for an evidence-based policymaking to the development of the MOEJ programme moving forward (see Figure XXIV).

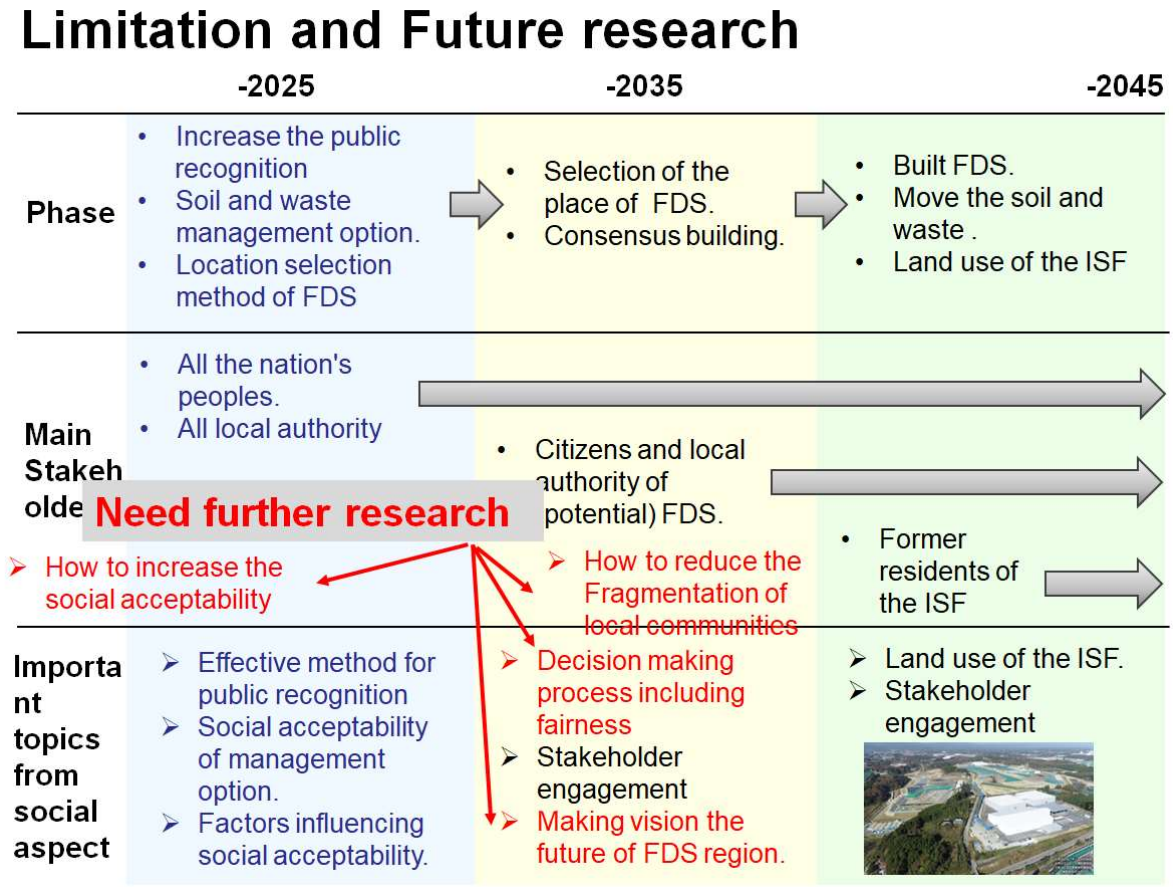


Figure XXIV Future research planning from social aspect presented by Prof. YASUTAKA.

An impressive presentation from Prof. TAKAMURA highlighted the importance of effective risk communication for building confidence with local communities concerned about radiation.

Finally, a 3-D mapping tool which enabled viewers to visualise developments in the landscape was demonstrated.

Potted plants using removed soil

23 potted plants using removed soil from Fukushima Prefecture are placed, to foster public understanding, in 17 facilities including the MOEJ buildings, as well as the Prime Minister's office, the Reconstruction Agency, the Shinjuku Gyoen National Garden, the National institute for Environmental Studies and other locations, as of August 2023.

The potted plants (see Figure XXV) are constituted of 5 kg of removed soil surrounded by 5 cm of ordinary soil.

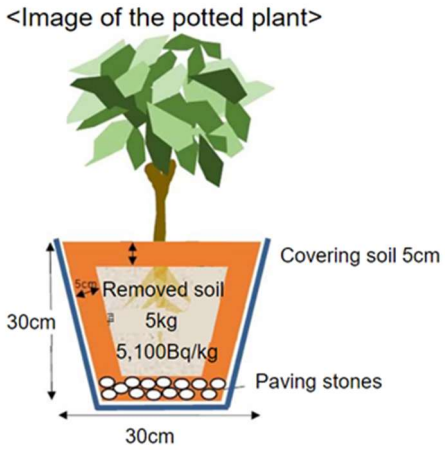


Figure XXV Overview of potted plants.

Air dose rate around the potted plants is constantly monitored and the MOEJ observed that the air dose rate in the locations of the potted planted did not change after their installation. Safety of the potted plants was ensured by following the existing ministerial ordinance for storage and transportation of removed soil. The removed soil in the plant pots will be transported back to the ISF after its use.

Observations

The team of experts noted that the target of improved nationwide public understanding is challenging. Numerous ways have been used internationally as well as in Japan. The team of experts encourages use of the Great East Japan Earthquake and Nuclear Disaster Memorial Museum to encourage public understanding as one very good resource. Other similar education centres would help.

While the MOEJ is focusing on the improvement of the general public's understanding of the management of soil and waste arising from decontamination activities in Japan, a clearer focus on developing effective communication with key stakeholders is beneficial for improving the joint understanding of the issues faced.

The MOEJ has developed a good relationship with affected local communities in Fukushima. It is, however, important that ongoing efforts still need to be continued to explain nationwide the need for the managed recycling of removed soil and as well as the final disposal. The team of experts advised that further clarity on the plans not only for the managed recycling but also for the long-term final disposal outside Fukushima Prefecture would be essential for the communication strategy. This will be needed to support key stakeholders, including Prefecture representatives and officials, industry groups, universities as well as local community groups.

Public confidence is central to the long-term success of this project and requires a clear, long-term vision of the overall solution. As earning trust and building confidence is not purely technical but is also emotional, then addressing concerns of interested parties, for example, by measuring nuclides other than radioactive caesium, could be useful. Even if there is established scientific evidence demonstrating that this is a very low proportion of the radionuclide contributions (other than radioactive caesium), it would make the current focus appear more rational and therefore supportable.

Separately, the MOEJ has begun to collate measurements of radioactivity concentration of nuclides other than radioactive caesium – such as Sr-90, Pu-238 – in the removed soil – with the intention of using this data to better inform third parties that all potential radioactive contamination is being addressed.

Having said that, risk comparisons need to be sensitive to people's perceptions, and some advantage could be taken by comparing the proposals with other more familiar radiation exposures and also non-radioactivity related activities and hazards to put the level of risk in context.

In this regard, the team of experts considered that co-ordination with related central government and local government departments will be necessary to support projects for the managed recycling of removed soil, as the Nagadoro Project Operating Council indicates.

Site visits are effective means to disseminate information about the safety, practicality and benefits of the managed recycling projects. This is true not only for the general public and for students, but especially for key stakeholder representatives and other influential people.

At the same time, more emphasis on the benefits, not just the risks of the managed recycling projects would also be helpful. This includes direct benefits of employment and investment in local infrastructure, as well as the wider social benefit of "doing the right thing" morally and environmentally for a sustainable future.

The team of experts welcomed that the efforts have been undertaken by the MOEJ to actively disseminate information about Japan's initiatives for the managed recycling and final disposal of removed soil and waste and will continue to be disseminated domestically and internationally.

The team of experts noted that efforts to recycle removed soil generated from decontamination work also contribute to reconstruction and revitalization in Fukushima Prefecture. The findings of the advanced efforts for the managed recycling of removed soil can be used as a useful case study for reference by other countries and dissemination through international forums, publications and media, including cooperation between the IAEA and the MOEJ, is encouraged.

The team of experts was pleased to learn of the developing range of stakeholder engagement and associated research activity. The team of experts noted that the MOEJ makes a distinction between general public and other stakeholders, and for the use of targeted engagement methods with key stakeholders including local communities. The team of expert noted that targeting engagement with younger generations as one of key elements of the programme is effective to encourage public understanding. Different audiences require different engagement materials from descriptive, visual and analytical point of view, for example, and different techniques – face to face, on-line, working groups, citizens' panels and so on.

The team of experts was pleased to see an evidence-based (research-informed) approach to understanding public and key stakeholder concerns and to support effective communication. The team of experts also welcomed efforts that are being made to ensure reliability and transparency of data of, such as the ISF management, demonstration projects for the managed recycling of removed soil.

Managing expectations and maintaining trust

All communications should ensure a clear distinction between:

a. The managed recycling of removed soil with the radioactivity concentration of 8,000 Bq/kg or less; and

b. Removed soil more than 8,000 Bq/kg that it is proposed to be sent for the final disposal outside Fukushima Prefecture (some of which could be treated (e.g., volume reduction) before the final disposal)

Care should be taken to distinguish between these two elements of the projects in all stakeholder engagement. Consistent terminology is needed when describing the final disposal facility (or facilities) that are under consideration for the effective safe management of the material to be disposed of.

The team of experts notes that there are many different dose criteria, (e.g., Dose rate for the area designation, dose rate for management of the removed soil and waste) and it is important to explain its difference to the public.

The team of experts considers that it is important to carefully explain to local communities in Fukushima Prefecture that the managed recycling of removed soil can be implemented, for example, for horticultural, agricultural or road embankments in Fukushima Prefecture as well as elsewhere in Japan, which could contribute to reconstruction of the affected areas.

The Nagadoro demonstration project is very good for long-term understanding of how recovered soil can be safely recycled and the team of experts recommend that it continues.

Overall, the team of experts was pleased to see the extent of work being undertaken in stakeholder engagement and communication. However, there is much to do in a very short period of time in preparing for the next steps (step 5 - 8).

For the managed recycling projects to be planned inside and outside Fukushima Prefecture from FY2025 onwards, sufficient time for public communication and stakeholder engagement effort will be important. The public may question why this place has been selected and ask what the financial and social benefits associated with hosting the project are. Concerns about radiation management (e.g., monitoring), prevention of run-off soils from heavy rain, typhoon etc. will be important to be addressed, if necessary, even though radiation risk from potential natural disaster events during the managed recycling of removed soil is not deemed to be high.

Building trust

Confidence of key stakeholders, e.g., local community and public, will be central to the success of the project. Trust in the process will rely upon demonstrating:

- Accountability;
- Honesty, openness and transparency;
- Listening and responding to concerns;
- Being consistent in what you say; and
- Following technical best practice.

Good ways of building trust include:

- Working closely with other trusted third parties such as respected community leaders, doctors, high school teachers, university professors;
- Maintaining a local presence for the duration of the project (so that you are not seen as an “outsider”; and
- Responding quickly to questions and requests

The team of experts noted that the MOEJ understands that maintaining and developing public and stakeholder trust and confidence in the future programme both within and outside Fukushima Prefecture is essential. This will benefit from compliance with the IAEA Safety Standards.

As discussed in Section III.5, the importance of independence of regulatory functions from operational functions, from the perspective of supporting public and stakeholder confidence, is mentioned in the section of independence of regulatory functions.

Effective consultation

Effective communication and meaningful stakeholder engagement are essential for the success of the next stages of the project. It is important for the MOEJ to ensure a sufficiently resourced programme of public and stakeholder engagement activities to support the project from FY2025 onwards.

Specific communications for local representatives are expected to address their needs and expectations:

- The team of experts received strong messages from local representatives that they expect all removed soil and waste to be disposed of outside Fukushima Prefecture, in accordance with the relevant laws. However, the team of experts understood from the discussions and visits during the first IEM that, although disposal outside Fukushima Prefecture is the final disposal solution in accordance with the laws, this does not preclude the beneficial use of recycled soil in Fukushima Prefecture (the managed recycling).
- There is a need to emphasize that recycling of soil is one of several potential volume reduction techniques to give communities within and outside Fukushima Prefecture the holistic picture, so that recycling is not isolated from all the many technologies that have been used.
- Current local communication initiatives could be used more systematically, for example, utilising trusted, independent experts like the university associated professor who is currently helping Futaba Town more broadly in the programme. A useful source reference describing different initiatives is IAEA Nuclear Energy Series No. Nw-T-1.16 “Communication and Stakeholder Involvement in Radioactive Waste Disposal” (IAEA 2022).

The team of experts was particularly encouraged to see the use of an evidence-based approach to the development of the MOEJ programme moving forward. It also noted that risk communication differs from “education”. Risk communication is also about listening to public concerns and engaging them in close communication to build an improved joint understanding of the way forward.

The team of experts was impressed by the 3-D mapping tool. This tool has excellent potential for communicating and making transparent the effects of both the managed recycling of removed soil and the final disposal projects for local communities. Making clear in the 3-D mapping tool, the different environmental effects during construction, operation and post closure – against a pre-construction baseline for example – has potential to greatly assist in public and community understanding.

Potted plants using removed soil

The potted plants using removed soil are dispatched in key locations. No additional exposure was observed. The team of experts considered that the initiative represents a good communication tool. The team of experts also noted that it is important to consider the next use or return to the ISF of the soil in the plant pots to ensure the continued safety and to build nationwide understanding. The teams of experts understands that the MOEJ currently plans for the removed soil in the potted plants to be transported back to the ISF.

Conclusions of the team of experts for the section

- *The Great East Japan Earthquake and Nuclear Disaster Memorial Museum is one good example of how to encourage public understanding, and other similar public information centres would help.*
- *Regarding potential options for the final disposal, it is important for the MOEJ to make the consequences and trade-offs between different options clear for the public and key stakeholders (e.g., in relation to lower activity / higher volume disposal as opposed to higher activity / lower volume options).*
- *All communications should ensure a clear distinction between soil used for the managed recycling and soil sent for final disposal. Furthermore, it needs to be carefully communicated that the managed recycling can be done inside and outside Fukushima Prefecture, whereas the final disposal of material unsuitable for recycling must be only done outside Fukushima Prefecture, as specified in the JESCO Law.*
- *Consistent and careful use of units throughout communication is important for public and stakeholder understanding of radiological safety. This will enable improved comprehension of the relative impact of the proposed safety measures.*
- *Communicating the potential associated benefits of proposals for the managed recycling and the final disposal of removed soil and waste should include not just financial considerations, but other factors such as supporting reconstruction, long-term sustainability and so on.*
- *Initiatives such as potted plants including flower growing are helpful communication tools for increasing general day-to-day familiarity with the safety of removed soil. Expanding such approaches should be considered to help encourage nationwide public acceptance of the managed recycling of removed soil.*

VI.3 – Promotion of regional social acceptance

Japan position

The MOEJ described the engagement which has been undertaken with communities close to the ISF. The MOEJ also described empirical work / questionnaire studies undertaken in relation to what key factors influence public acceptance of proposals to manage removed soil.

The MOEJ is developing its approach to the selection of sites for the final disposal outside Fukushima Prefecture. The main principles underpinning its potential approach to the site selection for the final disposal, and forming part of its discussions with the recently-formed Working Group (The WG for measures to secure regional social acceptance for the managed recycling and the final disposal), are shown in Figure XXVI below.

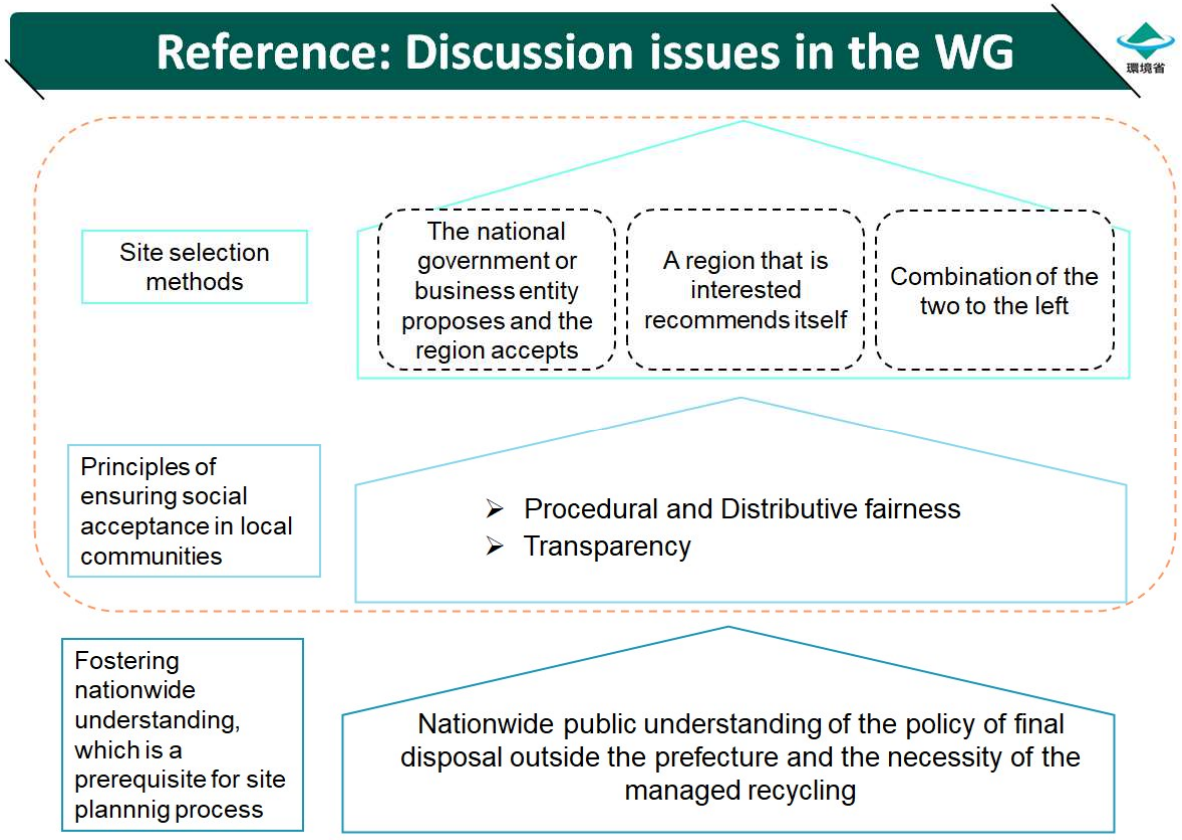


Figure XXVI Topics under discussion in the Working Group.

The MOEJ outlined 'avenues' for site selection for the final disposal in terms of either a proposal from the national government or relevant organizations approach on the one hand, or a more consultative approach on the other.

Observations

The team of experts agreed that it is important to maintain the Working Group's objectivity and ability to deliver honest opinions regarding the MOEJ's approach to public and stakeholder engagement, site selection and risk communication. This will enhance the credibility of both the Working Group and the MOEJ with the public and key stakeholders. The Working Group has provided valuable input for the

implementation of the projects led by the MOEJ, and it is important to continue to hold opportunities to discuss these issues with the MOEJ.

The make-up of the Working Group should, as appropriate, include a range of skills, expertise and experience, in response to topics to be discussed, which are changing over time. This will enable it to provide necessary input, in a timely manner, to the MOEJ's policy on stakeholder engagement programmes for the managed recycling and the final disposal.

Research findings appear to stress the importance of transparency and procedural and distributive fairness. Further research is required to 'drill down' into what these high-level concepts mean. For example, in term of distributive fairness – further information is needed regarding what is to be proposed and what is the likely acceptable balance between the distributed risks (as per the safety assessment outcome) and benefits (as per community investments, environmental improvements and recovery).

There is extensive international experience in site selection and screening for the final disposal upon which the MOEJ can draw. For example, the use of siting factors (such as land ownership, topography, geological and hydrological characteristics, population density, transport requirements, current land-use *inter alia*) and multi-attribute decision analysis for site selection for the final disposal. Furthermore, options assessment techniques such as Best Practical Environmental Options (BPEO) studies could enable stakeholders to weigh the relative advantages and disadvantages of different design options in terms of their effects on safety, the environment and human health.

Experience shows that these studies take considerable time, need effort to obtain the relevant data, subject it to sensitivity analysis, and prepare the results in a form suitable for public and especially key stakeholder engagement in order to support decision making. However, they improve transparency and help make decisions to follow a clear auditable trail that can help build public and stakeholder support.

The MOEJ should proceed with the work on site identification and selection for the final disposal, while promoting the managed recycling of removed soil, in order to meet the challenging timelines stipulated in the JESCO Law. An approach that engages with local prefectures and local communities in order to establish interest and eventual support in hosting the final disposal facility (or facilities) is generally to be recommended. An approach which imposes the project upon a community unilaterally will not carry public, stakeholder and community support. The implications of this for stakeholder engagement – careful timing, preparation and implementation – are important, and need to be understood and addressed within the MOEJ's future planning.

Conclusions of the team of experts for the section

- *The team of experts welcomes the progress of the engagement of stakeholders by establishing a new Working Group to discuss approaches for communication with local stakeholders and regional co-prosperity for the managed recycling and the final disposal.*
- *The MOEJ is expected to continue developing a master plan for its public and stakeholder engagement strategy. The approaches for communication and engagement for the final disposal may well be different from that of the managed recycling of removed soil.*
- *The MOEJ is expected to clarify the main 'avenues' for site selection for the final disposal and describe which route it intends to follow – proposal from the national government or business*

entity or in partnership with local government / prefectures. This will allow elucidation and clarification of the advantages or disadvantages of a partnership arrangement. Engagement with key stakeholders and local communities will be essential to command public confidence in the long-term safety of the proposals.

- *It is important to involve stakeholders from the early stage when the managed recycling and the final disposal options are considered. The MOEJ is expected to repeat / maintain / enhance its dialogue with local communities. This early involvement is an effective way of disseminating information, and the MOEJ is encouraged to look for such early opportunities in the next stages for the managed recycling and disposal options outside Fukushima Prefecture.*

Annexes

Annex 1: Agenda of the first IEM

Day 1: May 8th (Mon.) 2023

- Session 1: Current status of the Fukushima environmental restoration project
- Session 2: Stakeholder involvement & communication on volume reduction and the managed recycling of removed soil
- Session 3: Rationale for radioactivity concentration of 8,000 Bq/kg for the managed recycling of removed soil
- Session 4: Strategy for volume reduction and the managed recycling of removed soil
  - Outline of the Interim Storage Facility
  - Technology Development Strategy for Volume Reduction and Recycling of Removed Soil from Interim Storage

Note: Day 2 (May 9th) and Day 3 (May 10th): Site visits in Fukushima Prefecture (See the below reference)

Day 4: May 11th (Thu.) 2023

- Session 5: Q&A Session
  Discussion about additional questions raised during the meetings (e.g., models and parameters used for dose assessment)
- Session 6: Environmental restoration projects and initiatives of other countries related to the managed recycling of removed soil, and explanation of the IAEA Safety Standards

Day 5: May 12th (Fri.) 2023

Session 7: Summary of the first IEM, etc.

(Reference)

Day 2: May 9th (Tue.) 2023

- Courtesy visit to the Regional Environmental Office in Fukushima, the MOEJ
- Visit to the demonstration project site of the managed recycling of removed soil in Nagadoro District, Iitate Village
- Courtesy visit to the Mayor and Vice Mayor of Iitate Village
- Exchange opinions with Iitate Village officials and residents of Nagadoro District

Day 3: May 10th (Wed.) 2023

- Courtesy visit to the Mayor of Futaba Town
- Courtesy visit to the Mayor of Okuma Town
- Site visit to the Interim Storage Facility
- Visit to the Great East Japan Earthquake and Nuclear Disaster Memorial Museum

Annex 2: Agenda of the second IEM

Day 1: October 23rd (Mon.) 2023

- Session 1: General Overview of the Strategy and the progress made for initiatives for volume reduction and the managed recycling of removed soil after the first IEM
- Session 2: Regulations and regulatory aspects
    - Institutional arrangements and regulatory aspects for the managed recycling and the final disposal of removed soil and waste
    - Graded approach to regulation of exemption
    - Regulations about specific clearance

Day 2: October 24th (Tue.) 2023

- Visit to the Soil Sorting Facility at Nuclear Engineering Seibersdorf, Austria
- Session 3: Clearance measurements

Day 3: October 25th (Wed.) 2023

- Session 4: Communication and stakeholder engagement
    - Progress made after the first IEM
    - Research on communication with stakeholders regarding the managed recycling of removed soil
    - Building trust with key stakeholders and the public
- Session 5: Final disposal
    - Progress made after the first IEM
    - Key parameters influencing the results of dose assessments

Day 4: October 26th (Thu.) 2023

- Session 6: Discussion about additional questions raised during the meetings
- Session 7: Discussion of preliminary observations based on the first and second IEM

Day 5: October 27th (Fri.) 2023

- Session 8: Summary of the second IEM, etc.

Annex 3: Agenda of the third IEM

Day 1: February 5th (Mon.) 2024

- Session 1: General Overview of the Strategy and the progress made for initiatives for volume reduction and the managed recycling of removed soil after the second IEM
- Session 2: Managed recycling of removed soil
    - Guidance on the application of the Screening Levels introduced in GSG-18
    - Current status on the institutional and technical aspects of the managed recycling and volume reduction

Day 2: February 6th (Tue.) 2024

- Session 3: Final disposal and technology development
    - Institutional and technical aspects of the final disposal
- Session 4: Stakeholder engagement
    - Current status on the stakeholder engagement
    - Efforts on information dissemination about off-site remediation to the international society
    - Case studies of stakeholder engagement
- Session 5: Session with stakeholders relevant to the reconstruction of Fukushima

Day 3: February 7th (Wed.) 2024

- Session 6: Consistency with the IAEA Safety Standards
    - Discussion on terminology check
    - Discussion on consistency with the IAEA Safety Standards
    - Safety of Disposal Facilities
- Session 5 (continued): Session with Fukushima Prefecture stakeholders
    - Efforts on stakeholder engagement in Fukushima

Day 4: February 8th (Thu.) 2024

- Session 8: Summary of the third IEM, Discussion about additional questions raised during the meetings, etc.

Day 5: February 9th (Fri.) 2024

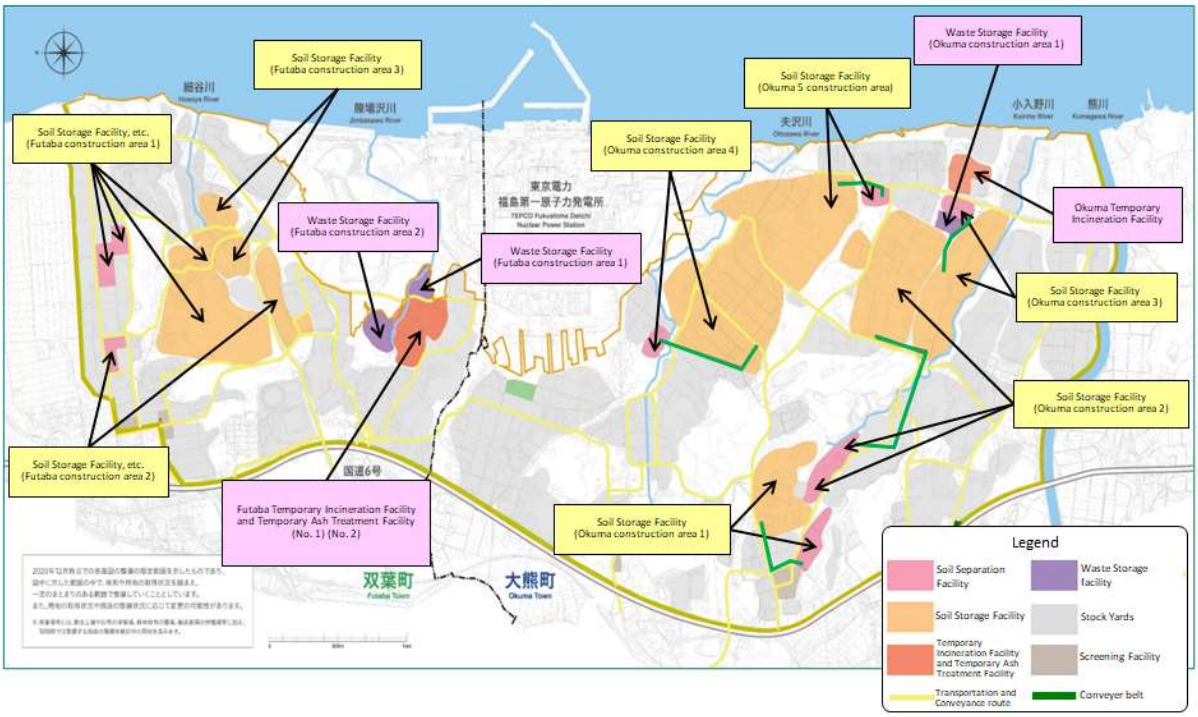
- Session 8 (continued): Summary of the third IEM and Conclusion

Annex 4: Summary of site visits organised during the three IEMs

Technical visit to the Interim Storage Facility (ISF)

A technical visit of the ISF, straddling Okuma and Futaba Towns was organised during the first IEM. The team of experts visited the following facilities:

- Information Centre of the ISF
- Soil Separation Facilities
- Soil Storage Facilities
- Waste Storage Facilities
- Temporary Incineration Facilities
- Recycling project of road embankment
- Test Facility for Fly Ash Cleaning Technology



Management of the ISF, covering an area of 16 square kilometers, falls under the responsibility of the MOEJ. It was built to provide a safe, centralized place to manage and store removed soil, waste and ash until they will be permanently disposed of. According to the Technology Development Strategy (estimate of 2019):

- Incinerated ash represents about 300,000 cubic meters
- Removed soil represents about 13 million cubic meters
- Removed soil is estimated to consist of about 7 million cubic meters of sandy soil (mainly from residential areas, public facilities such as schools and parks, and commercial facilities) and about 6 million cubic meters of cohesive soil (mainly from farmland, forests, etc.)

Demonstration project of agricultural embankments, Nagadoro District, Iitate Village

During the first IEM, the team of experts visited the environmental regeneration project in Nagadoro District of Iitate Village. This project aims to create embankments for farmland using removed soil after removing foreign objects from the removed soil with radioactivity concentration of 5,000 Bq/kg or less to create recycled soil used for embankments that will be covered with soil ordinary used for farming.

Tests have been conducted on small areas in Nagadoro District in order to confirm safety and soil productivity. Test cultivation of flowers, vegetables and resource crops have been performed. The project has been carried out by the MOEJ with the close involvement of local residents and has been ongoing since 2017.

Courtesy visits to officials of the MOEJ, Okuma Town, Futaba Town, Iitate Village as well as residents of Nagadoro District

During the site visits of the first IEM, the team of experts visited the Regional Environment Office in Fukushima and learned specific approaches for remediation measures implemented by the MOEJ, including ways in which the MOEJ is engaging interested parties. The team of experts was able to discuss the MOEJ's understanding of stakeholder concerns and expectations.

The courtesy visit to officials of Iitate Village, and residents of Nagadoro District gave an opportunity to exchange views with some of the interested parties in person regarding the reconstruction of these areas and the difficulties raised by the decision to host the demonstration project using recycled soil for agricultural purposes.

The courtesy visit to officials of Okuma Town and Futaba Town, prior to visiting the ISF was the occasion to better understand the point of view of the local municipalities and population regarding the ISF, including the difficult decision to accept the ISF, and the recycling projects being carried out on site.

Great East Japan Earthquake & Nuclear Disaster Memorial Museum

The Great East Japan Earthquake and Nuclear Disaster Memorial Museum is located in Futaba Town. The team of experts had an opportunity to visit the memorial museum during the first IEM. The memorial museum opened in September 2020 and has about 200 items related to the Great East Japan Earthquake, tsunami and nuclear disaster on permanent exhibition. This memorial museum shows how Fukushima has dealt with a complex and unprecedented disaster and its ongoing consequences, and communicates lessons for the future on the importance of disaster prevention and mitigation. It is an excellent resource for increasing public understanding. The team of experts was guided during the visit by Prof. TAKAMURA Noboru, from Nagasaki University, director of the memorial museum.

Soil Sorting Facility at Nuclear Engineering Seibersdorf, Austria

A site visit was conducted to the Nuclear Engineering Seibersdorf facility, where sorting and disposal of radioactive waste have been implemented in Austria, during the second IEM. It provided an

overview of sorting activities of radioactive waste implemented in Austria. Presentations on the overall facility and the specific sorting facility, including a video were given, before the guided visit to the facility. Experiences, technologies and procedures on clearance measurements and sorting of soil in Belgium and in the USA were presented and discussed as well as the MOEJ progress on the demonstration projects for the managed recycling of the removed soil.

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