Chapter 6 :Lessons Learned and Future Challenges

A large quantity of radioactive materials, mainly radioactive cesium and radioactive iodine, was released into the environment due to the TEPCO Fukushima Daiichi NPS Accident caused by the Great East Japan Earthquake, and radioactive materials spread widely to the whole area of the Tohoku and Kanto districts. (Special Decontamination Areas and Intensive Contamination Survey Areas (total) amounted to about 25,000 km^2, population of about 7 million residents).

In response to the massive pollution on a scale that was unprecedented in Japan, the national government decided to implement decontamination projects on a scale that was unparalleled worldwide.

The decontamination project was to be carried out based on the Act on Special Measures concerning the Handling of Environment Pollution by Radioactive Materials, enacted in August 2011. The Ministry of the Environment (MOE) established the structures and institutional arrangements necessary for decontamination work, including the related laws and decontamination guidelines, etc.

For decontamination work in Special Decontamination Areas (SDA), after the Self Defense Forces decontaminated key locations such as municipal offices in evacuated areas starting in December 2011, decontamination work was done municipality by municipality, by construction companies under contract with MOE. It started in January 2012, and was completed in March 2017.

The cumulative number of workers came to more than 13 million in total.

For decontamination work in Intensive Contamination Survey Areas (ICSA), starting around April 2011, municipalities receiving requests from residents triggered the decontamination of schools, kindergartens, nursery schools, and parks, etc., as a result of voluntary decontamination by residents. In response to the entry into force of the "Act on Special Measures," each municipality developed a decontamination implementation plan, and the construction companies contracted by the municipalities proceeded with the decontamination work based on the decontamination implementation plans. The work started in January 2012 and was completed in March 2018.

An enormous cumulative number of workers, over 17 million people in total, was involved in the decontamination work.

As a result, in Special Decontamination Areas, the evacuation orders could be lifted for an area of 780 km^2, about 70% of the approximately 1,150 km^2 of Areas under Evacuation Orders, and it was confirmed that the annual additional exposure dose for residents who returned to this area was about 1 mSv/y (maximum about 5 mSv/y).

In Intensive Contamination Survey Areas, it was confirmed that the annual additional exposure dose of residents living here was 1 mSv/y or less in 2016, and the long-term goal set in the basic policy of the Act on Special Measures was almost fully achieved, except in Areas where Returning is Difficult.

Meanwhile, it is also necessary to tackle new issues, including securing and prolonging Temporary Storage Sites, and disposal methods for removed soils, etc. Also, much of the knowledge and experience gained from these decontamination projects could be useful as lessons learned for the future.

The issues and lessons discussed by the Editorial Committee for the Paper on Decontamination Projects are indicated below.

This is valuable knowledge not only for Japan but also for the world, so this information should be reported and distributed as appropriate going forward.

6.1. Approach to Decontamination and Setting of Targets

(1) Relationship between Decontamination Targets and 1 mSv/y

1) Background

<Goal of Decontamination>

A statement entitled "On the basic idea on radiation protection for the future lifting of evacuation orders and reconstruction" (July 19, 2011, Nuclear Safety Commission) stated the following: "As a conservative reference level for the optimization of protection strategies, based on ICRP's recommendations, a lower dose of the range of 1 to 20 mSv/y annually applied to existing exposure situation, will be selected. An intermediate reference level can be set to gradually improve the situation, but in the long term, we aim for 1 mSv/y for the additional dose rate."

Based on this, the "Basic Policy for Emergency Response on Decontamination Work" (August 26, 2011, Nuclear Emergency Response Headquarters) indicated this as the goal: "As a long-term target, the government aims at reducing the additional exposure dose to 1mSv/y in areas with existing exposure situations (areas where the additional exposure dose is 20mSv/y or less per year, according to the current operation). The Basic Policy based on the Act on Special Measures concerning the Handling of Environment Pollution (November 11 2011), formulated subsequently, set an "additional exposure dose of 1 mSv/y or less per year as the long-term target" for areas where the additional exposure dose is less than 20 mSv/y.

The Fundamental Safety Principles (IAEA Safety Standards Series No. SF-1) include the "As Low As Reasonably Achievable" (ALARA principle): "Protection must be optimized to achieve the highest level of safety that can reasonably be achieved."

Meanwhile, regarding the TEPCO Fukushima Daiichi NPS accident, as described later in Section 6.3 (Challenges in the stages of implementing decontamination), the IAEA perspective could not be simply applied unchanged. The specific situation in Japan and Fukushima required that priority be given to restoring livelihoods on the premise of being safe from radiation. Also, it was necessary to make decisions in the context of limited knowledge and time available.

<Scope of decontamination>

Regarding the scope of decontamination, the "Basic Policy for Emergency Response on Decontamination Work" (August 26, 2011, Nuclear Emergency Response Headquarters) specifies that the scope for each region should correspond to the level of exposure dose.

① In regions under evacuation orders, the national government is mainly to implement decontamination.

② In areas where the additional exposure dose is generally between 1 to 20 mSv/y, municipalities are to formulate decontamination implementation plans and implement decontamination.

It was necessary to implement whole area decontamination in areas with relatively high dose rate, and in areas with relatively low doses it was important to implement decontamination in locations with locally high doses.

③ In areas where the additional exposure dose was generally less than 1 mSv/y, there was no need for municipal-level decontamination in terms of whole area decontamination, but locally high dose areas were to be decontaminated.

Based on these guidelines, in the second meeting of the Investigative Committee on Remediation (September 2011), the scope of designation of Special Decontamination Areas (areas where the national government implements decontamination under direct control) was deemed to be areas under evacuation orders (Restricted Areas and Deliberate Evacuation Areas).

It was also decided that an additional annual exposure dose exceeding 1 mSv/y would be the criterion level for the designation of Intensive Contamination Survey Areas and the criterion for formulating a decontamination implementation plan.

Actually, based on the fact that the results of survey measurements are usually obtained as an hourly value, for convenience, the value "individual annual additional exposure dose of 1 mSv/y" is converted to an hourly value 0.23 μSv/h based on an assumed specific life pattern (*), considered to be on the conservative side. Thus, the target that an additional exposure dose exceeds 0.23 μSv/h was substituted as the criterion for designation.

* It is assumed that a person spends eight hours outdoors and 16 hours indoors (assuming a wooden house shielding factor of 0.4).

This conversion method is based on the "Preliminary approach in deciding how to judge the use of school buildings and schoolyards in Fukushima Prefecture" (April 19 2011, Ministry of Education, Culture, Sports, Science and Technology), and in this document, the annual exposure dose of 20 mSv/y is converted into 3.8 μSv/h.

Regarding the criterion for designation, the Minister of the Environment consulted with the Chairman of the Radiation Council and received a report that it is reasonable. Later, it was indicated in the "Ministerial Ordinance that specifies the requirements for designation of contaminated waste management areas" (Ordinance of MOE No. 34, 2011).

Designations were made based on the average air dose rate of the subject area, and about 1,150 km^2 in 11 municipalities were designated as Special Decontamination Areas, and about 24,000 km^2 in 104 municipalities were designated as Intensive Contamination Survey Areas.

When considering the standards, numerical values were calculated conservatively, as there had not yet been a sufficient accumulation of knowledge for converting to radiation doses from air dose rates in the case of wide area contamination by radioactive materials. Opinions were voiced that for conservative calculations, the shielding effect should not be considered, while other opinions were voiced that more realistic coefficients should be introduced, for shielding effect and staying time.

<Implementation period of decontamination>

The Basic Policy of the Act on Special Measures concerning the Handling of Environment Pollution formulated in November 2011 aimed to conduct decontamination work until the end of March 2014 in areas other than areas with particularly high additional exposure doses in Special Decontamination Areas, so in areas where the additional radiation dose was particularly high, the national government initially conducted model projects, followed by decontamination activities with step by step approach.

Also, regarding the Intensive Contamination Survey Areas, it was decided to make plans considering the priorities and feasibility based on the real circumstances of each area.

2) Issues

<Goal of Decontamination>

As mentioned above, the annual additional exposure dose rate of 1 mSv/y as a long-term goal was determined by the Nuclear Safety Commission as a lowest value from the range of 1 to 20 mSv/y.

It was said that an interim reference level could be indicated, but no concrete numerical value was indicated and as it was difficult to provide a rational explanation to residents, 1 mSv/y became the long term target value.

As a result, it was confirmed that the annual additional exposure dose of the returned residents in areas where evacuation orders were lifted in Special Decontamination Areas was about 1 mSv (maximum about 5 mSv), and it was confirmed that the annual additional exposure dose of the inhabitants would be approximately 1 mSv or less in the Intensive Contamination Survey Areas.

Internal exposure after 2012 was also confirmed to be 1 mSv/y or less for all measurements.

Meanwhile, the value was the long-term target of whole government to be achieved not only for decontamination works but also by physical decay of radioactive materials, weathering effects, by understanding and managing exposure doses, and food safety management, etc.

Despite this, it was perceived as a goal to be accomplished through only by decontamination activities, resulting in some confusion in the field.

<Scope of decontamination>

The aforementioned conversion method is a simple method of estimation under assumptions on the safe side (that is, conservative assumption) to determine the scope of the Intensive Contamination Survey Areas.

The individuals' external exposure dose in actual life is considered to be lower than estimated value due to the reasons taken as examples as follows:

-In many cases, the time spent outside is often shorter than the assumed 8 hours

-The indoor shielding factor varies depending on the type of building etc. (e.g., the shielding factor of a concrete building is 0.2).

-The air dose rate will decreases with elapse of time and varies depending on where an individual stays and moves in daily life.

<Implementation period of decontamination>

The period of decontamination work was set to be finished by the end of March 2014 for areas other than the areas with a particularly high additional exposure dose in Special Decontamination Areas.

The decontamination work is an institution, which was necessary for local residents to understand and cooperate in each process such as field survey, implementation of decontamination, installation of temporary storage site. It took a certain amount of time, but as a result of their understanding and cooperation, whole area decontamination was completed in March 2017 in the Special Decontamination Areas and in March 2018 in the Intensive Contamination Survey Areas.

3) Lessons Learned

Initially, shortly after the accident, scientific knowledge was limited, and in light of the urgent need to

set targets and designation criteria for Intensive Contamination Survey Areas for the additional radiation dose, it seemed like a reasonable policy to use 1 mSv/y as a long-term goal, which was at the lower end of the ICRP reference level of 1 to 20 mSv/y for existing exposure situation.

On the other hand, in the event of a similar accident in the future, based on the above-mentioned ALARA principle, deeper discussion on the setting of target values would be expected, seeking scientific knowledge which emphasizes intermediate target values and individual doses, and in collaboration with related ministries and international organizations.

At the same time, as described in Section 6.4 (Communication with residents), it is necessary to carefully explain comprehensive measures, including risk management, to the residents and gain understanding in an early stage.

In addition, it is important to set up the construction period in advance based on workability, even though it may be difficult due to the necessity of making decisions with the limited information and limited time, and the necessity to coordinate with municipalities and stakeholders.

It is important to consider more effective and efficient measures for the planning of all the work as a whole, including goal setting and the project implementation systems, while taking into consideration the accumulation of scientific knowledge through model projects and demonstration trials.

6.2. Establishment of Framework for Decontamination, RoleS of Stakeholders

(1) Role Sharing for Decontamination Work

1) Background

The IAEA's Fundamental Safety Principles indicated that "The prime responsibility for safety[51] must rest with the person or organization responsible for facilities and activities that give rise to radiation risks" (IAEA Safety Standards Series No. SF-1).

On the other hand, concerning the accident of TEPCO Fukushima Daiichi NPS, there was a situation unique to Japan and Fukushima that cannot be sufficiently explained by simply applying the IAEA principle, as described in Section 6.3 (Challenges at the implementing stages of decontamination). Also, it was necessary to make decisions with limited knowledge and limited time.

Therefore, while the Basic Principles of the Act on Special Measures make the nuclear power company concerned (Tokyo Electric Power Company, TEPCO) unambiguously responsible, the principles also recognize the social responsibility of the national government for having promoted nuclear policy. Thus, the national government was made responsible to develop response measures, and in Areas under Evacuation Orders, to implement decontamination directly as Special Decontamination Areas.

Meanwhile, regarding Intensive Contamination Survey Areas, as each municipality is most familiar with the actual local circumstances, discussions proceeded on the understanding that, in principle, municipalities would be implementing the decontamination.

2) Issues

Regarding decontamination of Special Decontamination Areas, it was one of the realistic options for the

[51] The IAEA Basic Safety Principles state, "Safety measures include actions to prevent abnormal events and arrangements made to alleviate the effects of abnormal events if they occur."

national government to implement decontamination under the social situation of the time, including the fact that the municipal governments themselves were forced to evacuate, but there were suggestions that cooperation and information sharing with the municipalities could have been better.

Moreover, while the decontamination work under MOE was conducted to enable the early return of residents, there were some comments that efforts done in cooperation with other ministries and agencies had not been sufficient, including compensation and evacuation.

Regarding decontamination in Intensive Contamination Survey Areas, the "Basic Policy for Emergency Response on Decontamination Work" (Nuclear Emergency Response Headquarters, August 26, 2011), stated that "Systematic decontamination work on a community-wide basis would be the most effective solution because the residents still live in the community and the community grasps the individual situation and resident's needs." However, some local governments expressed the view that the national government should conduct decontamination in all these areas.

In addition, municipalities experienced problems with staffing, coordinating with other municipalities, including the national government, and the prefecture during the implementation stage.

Fukushima Prefecture Government decontaminated its own facilities and managed funds, but the role of the prefecture was also pointed out for matters requiring wide-area arrangements such as overall planning and waste treatment.

In this case, it was thought that if the polluter was to conduct decontamination, it would be extremely difficult to proceed with the decontamination work, considering the large scale of contamination, the fact that the polluter had to deal with both the decommissioning of reactors and decontamination, and residents' feelings toward the polluter.

In order to ensure that evacuation orders could be lifted, it was considered reasonable for the national and municipal governments to implement decontamination work with the burden of the polluter.

3) Lessons learned

It is thought that the response in this case was appropriate, considering the roles of the polluter, the national government, the prefectures and municipalities, considering the situation in Japan and Fukushima, in the context of limited time and, limited knowledge, based on international knowledge.

Various types of nuclear disasters could be considered, depending on cause, scale, released radionuclides and their quantity, so it is not easy to generalize. It is important, however, to summarize the outcomes and knowledge gained from this decontamination work in the sense of creating effective implementation systems, the role sharing of stakeholders and related organizations, information sharing, and collaboration, etc.

Currently, in Specified Reconstruction and Revitalization Bases within Areas where Returning is Difficult, under the Act on Special Measures for the Reconstruction and Revitalization of Fukushima, each project entity works based on a specific plan called a Reconstruction and Recovery Plan for a Zone Designated for Reconstruction and Recovery to cooperate with others in an unified and efficient way on decontamination, dismantlement and infrastructure work. This kind of approach may also be a helpful reference.

(2) Enhancing Verification Systems

1) Background

As for the verification of decontamination projects, as a whole, the Investigation Committee on the Progress of the Act on Special Measures concerning the Handling of Environment Pollution by Radioactive Materials reviewed the status of implementation, and MOE received IAEA missions and public review processes for government works projects.

In the municipalities with Special Decontamination Areas, a verification committee was established in each municipality, and the results of examinations were made public to the residents, and verification was also carried out by all-members council meetings of municipal assemblies, etc.

In the municipalities with Intensive Contamination Survey Areas, nothing like a verification committee was established, but for each municipality, the progress of decontamination and advisor's evaluations, etc., were opened to residents through public relations newsletters, etc.

In addition, for individual projects, the projects received verification from the Labor Bureau concerning issues such as work safety of decontamination workers, and from the Board of Audit regarding the appropriateness of contracts.

2) Issues

Regarding verification systems for decontamination projects, according to the IAEA General Safety Requirements (GSR) Part 3 "Radiation Protection and Safety of Radiation Source", "an independent regulatory body with functions and responsibilities clearly specified for the regulation of protection and safety (including radiation protection)" should be established under the law prescribed as a part of government, legal and regulatory framework for safety.

For this decontamination, the verification of whether or not work was done adequately would be carried out by various entities.

3) Lessons learned

In the future, it would be beneficial to clarify the entities to be involved in verification, and to establish a system to confirm work from a third-party perspective, right from the initial stage of implementation. Also, verification should look at not only radiation doses but also whether or not necessary and sufficient decontamination was done scientifically. Such an approach to verification might reduce inconsistencies in the extent of efforts and methods of decontamination work by the bodies implementing decontamination.

(3) Coordinating with Relevant Reconstruction Policies

1) Background

In the implementation of decontamination, in terms of requests from residents especially at the initial stage, there were many comments that before consent was sought to implement decontamination, they should have received an indication of the compensation and revision of area designations .

The Ministry of Education, Culture, Sports, Science and Technology and the Agency for Natural Resources and Energy were responsible for compensation, and Cabinet Office's Support Team for

Residents Affected by Nuclear Incidents (Nuclear Emergency Response Headquarters) was responsible for revising area designations, and these organizations offered explanations to the residents and others.

Also, in some cases the Ministry of Land, Infrastructure and Transport, the Reconstruction Agency, and prefectures, etc., carried out reconstruction work at the same locations where MOE had implemented decontamination.

2) Issues

Especially at the initial stage, residents had a sense of distrust, thinking that decontamination would go ahead without them having received the information they needed about compensation and the revision of area designations, etc.

Also, when reconstruction projects were conducted in the same locations after decontamination was implemented, there was some duplication and other issues with work between decontamination and reconstruction projects.

By coordinating the decontamination and reconstruction, the construction period could have been shortened.

In addition, as time elapsed after the accident, weeds grew in the soil of yards of homes and other properties and on unpaved roads, and brush and shrubs grew in fields, resulting in an increase in work for the weeding and cutting of brush and shrubs, compared with the initial decontamination work, etc.

3) Lessons learned

With this response, when it came to the stage of lifting the evacuation order at the end of the decontamination project, MOE was able to make the explanation to the residents in cooperation with the Cabinet Office's Support Team for Residents Affected by Nuclear Incidents, and other parties.

In the future, in the event of a similar accident, it will be important for the relevant ministries and agencies to cooperate on the response right from the initial stages.

Also, decontamination and infrastructure construction are currently both being implemented together in construction projects for Specified Reconstruction and Revitalization Bases in Areas where Returning is Difficult, implemented under the Act on Special Measures.

In the event of a similar accident in the future, it will be important that the related ministries and agencies, prefectures, and municipalities cooperate to closely link the decontamination work with the reconstruction work.

6.3. Challenges at the Implementation Stage of Decontamination

(1) The First Large-scale Decontamination Project in Japan

1) Background

This was the unique large-scale project and first experience for decontamination work to be done in such a populated area that required action despite not having adequate technical knowledge and systems in place.

MOE, in addition to its own experience administering national parks, benefited from the capabilities of ministries such as the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) and the Ministry of Agriculture, Forestry and Fisheries (MAFF), which have extensive experience with public projects. MOE utilized existing rules and frameworks as prescribed by the MLIT and MAFF to create the common specifications and estimation standards required for decontamination work, and strove to steadily improve implementation methods through trial and error, depending on the actual situation on the ground at decontamination sites.

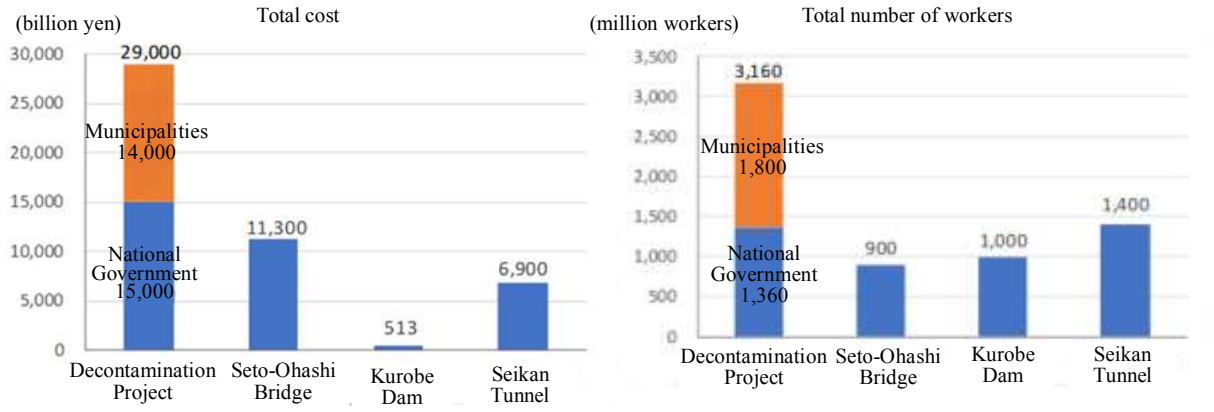

Figure 6-1 Decontamination and other major projects in Japan (copied from above)

Note: The total cost of decontamination indicated is as of September 2017, the total costs of other civil engineering works are as of the time of each project.
The numbers of decontamination workers in SDA as of the end of January 2018, and the numbers of decontamination workers in ICSA as of the end of November 2017.

Construction period of each project:

Decontamination Project: July 2012 - March 2017 (4 years 9 months)

Seto Ohashi Bridge: October 1978 - April 1989 (9 years 6 months)

Kurobe Dam: April 1956 - June 1963 (7 years 2 months)

Seikan Tunnel: May 1964 - November 1987 (23 years 7 months)

Source: Ocean Bridge Investigation Committee "Seto Ohashi Bridge Construction Document" (October 1988), Kansai Electric Power Company "Kurobegawa Fourth Power Station Construction History" (September 1965), Hokkaido Railway Company "Seikan tunnel in numbers"

2) Issues

Characteristics and issues of decontamination work after the accident of the TEPCO Fukushima Daiichi NPS were as follows.

① Extensive environmental pollution by radioactive materials had not been foreseen, so the institutional preparations were not in place in terms of legislative arrangements and recovery from an accident. Under such circumstances, it was necessary to deal with the situation despite a lack of enough knowledge on radioactivity, as well as training and organization, etc.

② The environmental pollution caused by radioactive materials was extensive, so many types of land use were affected, including residence, farmland and forest, and the affected population was large.

Table 6-1 Area, Population etc., of Special Decontamination Areas (SDA) and Intensive Contamination Survey Areas (ICSA)

	Area	Residential Population	Population Density
SDA	1,150 km^2	80 thousand people	approx. 70 people/km^2
ICSA	24,000 km^2	6.9 million people	approx. 290people/km^2

* Reference: The forced resettlement area in 1986 Chernobyl nuclear accident was 10,220 km^2, and the area where resettlement was encouraged was 19,070 km^2. Approximately 120,000 people evacuated immediately after the accident, and additional 200,000 were resettled between 1989 and 1995.[52]

③ In the 11 municipalities that had been designated as Restricted Areas and Deliberate Evacuation Areas and had been under governmental evacuation orders, the municipal administrative structure was maintained even after the evacuation orders were declared, and regional recovery and the early return of evacuees were required.

④ The rapid return of the evacuees as well as safety and security measures became the top priority for the national government, so there was not sufficient time available to prepare policies.

⑤ Environmental pollution from radioactive materials occurred together with damage from a major earthquake and tsunami (earthquake magnitude 9.0, and in Soma City, Fukushima Prefecture, the tsunami height was over 9.3 m (max.) and flooded area was 112 km^2). As a result, decontamination work had to be done together with the reconstruction from the earthquake and tsunami.

⑥ Control of internal exposure by thorough food inspection was effective.

⑦ Except for the initial period, radioactive cesium was the main radionuclide in pollution. Radioactive cesium adheres strongly to soil, etc., in contaminated areas, and impacts by dissolving into water and scattering back into the atmosphere are not large. Thus, the main task was to deal with gamma rays from the radioactive cesium that had settled.

⑧ It was not easy to find sites to dispose of waste contaminated with radioactive materials, due to Japan's limited land area.

[52] Source: IAEA-TECDOC-1240 Present and Future environmental impact of the Chernobyl accident

⑨ Because it was assumed that residents would return home and use buildings, roads, farmlands, etc. as they had used before the accident, it was not possible to adopt decontamination methods such as rebuilding, replacing roofing materials (roof tiles, etc.), and paving all roads, etc.

⑩ Wide area decontamination was possible with Japanese civil engineering technology.

At the beginning of whole area decontamination work, there were proposals for methods of decontamination using various existing techniques as well as new materials. Many types of work methods, equipment and materials were tested and evaluated through trials, and after repeated improvements, they were adopted as new technologies for decontamination.

Many of these methods were sequentially applied when the "Provisional Estimation Standards for Decontamination, etc." was revised.

Although the decontamination workers didn't have to have special abilities, their work themselves were the works were labor intensive. Therefore a large number of workers were required with the abilities to learn and repeat what they learned in the work.

Also, as described below, in acquiring Temporary Storage Sites and obtaining consent for decontamination work to be done, it was necessary for national and municipal officials to conduct repeated negotiations in each area.

3) Lessons learned

In the context of this being a first-time experience for decontamination to be done in a variety of settings including urban areas, roads, farmlands, rivers, and forests, implementation systems and decontamination techniques were developed and improved as work proceeded.

With so many stakeholders involved, including national and municipal governments, decontamination contractors (main and sub-contractors), residents, etc., the connection of people and trust among them became the key factors, and had an enormous impact on subsequent interactions.

These experiences and findings will serve as valuable source of knowledge and experience if a similar event occurs in the future not only in Japan but also elsewhere in the world.

(2) Preliminary Surveys and Acquisition of Consent

1) Background

Based on article 30, paragraph 2 (Special Decontamination Areas) and article 38, paragraph 2 (Intensive Contamination Survey Areas) of the Act on Special Measures, measures such as decontamination are to be carried out with the consent of the persons concerned (which means any person who has rights to be an obstacle to the implementation of decontamination of soils etc., that pertain the land or structures, trees or any other fixtures existing on the land to be decontaminated).

2) Issues

Acquisition of consent in Special Decontamination Areas was extremely difficult under circumstances where residents forced to evacuate by scattering all over the country.

In addition, in some situations not all residents were amenable to decontamination, which meant that

decontamination could not be done at a specific location, and could not begin decontamination beyond that location.

In municipal decontamination, where consent could not be obtained by municipal officials despite numerous attempts, consent was eventually obtained in many cases with additional cooperation from nearby residents.

In cases where stakeholders had already evacuated to distant locations, in some cases the municipal officials travelled there to obtain consents.

In some cases the current landowner was not known due to the fact that the name on title had not been changed when the previous owner died, or in some cases, even if the landowners were identified, it was difficult to negotiate to obtain consent for decontamination, etc., and to explain subsequently due to the involvement of dozens of stakeholders (inheritors) to a single property.

3) Lessons learned

When decontamination involves access to private land, obtaining consent from landowners is seen as a necessity in the event a similar accident happens to occur in the future.

Thus, when it comes to preliminary surveys and obtaining consent, based on this knowledge, it is important to conscientiously explain the effects of decontamination and to engage in activities in cooperation with the municipalities where the residents belong, and neighboring residents.

(3) Securing and Prolonged Management of Temporary Storage Sites

1) Background

In implementing decontamination, it was necessary to set up Temporary Storage Sites to temporarily store the removed soils, etc. In order to gain understanding of landowners and neighboring residents, the cooperation of the municipalities and administrative districts was important.

Many temporary storage sites were secured from 2012 to 2014, but at that time, the removed soils, etc., in Fukushima Prefecture were supposed to be transported to the Interim Storage Facility within about three years, and the lease periods in contracts for the land of TSS were also limited to three years.

2) Issues

In securing TSS, due to the evacuation of landowners and concerns about the safety, it took a considerable amount of time to gain the understanding of landowners and neighboring residents. It had been resolved, however, during the repeated dialogue by MOE and municipalities with residents

Transportation to the Interim Storage Facility began on a trial basis in 2015, and it became clear that the use of Temporary Storage Sites will be prolonged.

For this reason, between 2015 and 2017 it became necessary to renew the lease contracts for TSS.

Municipalities received criticism from landowners and neighboring residents that actions differed from what was promised, but there were no major problems thanks to the cumulative effects of risk communication until then and the achievement of management of temporary storage sites etc., which made it possible to renew most of the contracts.

In addition, in 2017, due to the progress of transportation of removed soils, there were some temporary

storage sites where stored soil was entirely removed due to the consolidation from small to large temporary storage sites and loading areas, etc., so the stage reached to the restoration of those sites to original conditions, and studies such as making rules to restore sites to the original conditions are under way.

3) Lessons learned

It is necessary to summarize the findings of this decontamination work. For example, air dose rates in TSS were lower than the surrounding areas by decontamination and site preparation when some Temporary Storage Sites were developed, and increases in air dose rate were prevented by installing shielding soil.

On the other hand, it became clear that it would be difficult to gain the understanding of landowners and residents through the typical one-way flow of information.

By not only providing scientific explanations about the safety of the TSS but also sharing information about radiation and contamination condition of the area, as well as the seeking of solutions through dialogue to address common challenges in the area, it became possible to obtain the residents' cooperation and secure and manage the TSS.

(4) Methods of Disposal of Removed Soil, etc.

1) Background

At decontamination sites, a large quantity of removed soil, etc., was generated because of the many targets of decontamination, although efforts were made to minimize the generated amount of removed soil.

Removed soil, etc., generated in Special Decontamination Areas and Intensive Contamination Survey Areas in Fukushima Prefecture have been stored mainly in large container bags and stored at Temporary Storage Sites and at decontamination sites, and transportation to Interim Storage Facility began in FY2015.

This removed soil, etc., is to be finally disposed outside of Fukushima Prefecture within 30 years after the start of the interim storage.

On the other hand, removed soil, etc. that was generated outside Fukushima Prefecture is currently being stored properly in accordance with storage standards, and is to be disposed of according to disposal methods specified by MOE in the future.

2) Issues

The disposal methods of removed soil, etc., were not stipulated initially, since scientific knowledge such as the behavior of radioactive cesium in the soil was limited. The Review Committee on Volume Reduction and Recycling Utilization Technology Development Strategies for Removed Soil, etc., in Interim Storage has been established and is currently studying volume reduction and recycling for removed soil, etc., within Fukushima Prefecture.

For removed soil outside of Fukushima Prefecture, the Investigative Committee on Remediation has begun to study disposal methods.

3) Lessons learned

In the event of a similar accident in the future, before commencing decontamination work, it will be important to prepare the standards necessary for implementation, including disposal methods of removed

soil, etc. The preparations should make use of what was learned from the Fukushima experience, including the fact that radioactive cesium has been absorbed in soil, etc.

In addition, a large amount of removed soil, etc., was generated due to this accident, so it is important to consider decontamination methods that minimize the amount of removed soil.

Soil is inherently a valuable resource, so even when removed soil, etc., is generated, it might be conceivable to separate out soil with a low radioactivity concentration using the appropriate pretreatment and volume reduction technologies, and to utilize it only in certain public projects where the management bodies and responsible authorities are clearly identified.

The above-mentioned Review Committee on Volume Reduction and Recycling Utilization Technology Development Strategies for Removed Soil, etc., in ISF developed a "Volume Reduction and Recycling Utilization Technology Development Strategy" and "Process Chart" as a mid- to long-term policy of volume reduction and recycling of removed soil in April 2016, and the "Basic Approach for Safe Usage of Removed Soil Made as Recycled Materials" in June 2016.

Efforts for advancing the reuse of the removed soil, etc., should be steadily proceeded mainly by the Committee in line with its work to date.

(5) The Smooth Implementation of Decontamination Project in Farmland

1) Background

Farmers in Areas under Evacuation Orders strongly requested topsoil stripping, with the concern that radioactive cesium would remain in paddies and fields,.

In this context, on September 14, 2011, the Ministry of Agriculture, Forestry and Fisheries summarized the results of research to date and announced its approach, saying, "On farmland with of radioactive cesium concentrations at 5,000 Bq/kg or lower, it is appropriate to take measures, as necessary, to reduce the migration to agricultural crops and reduce the air dose rates, by inversion tillage etc."

In Special Decontamination Areas, MOE offered options for farmland with relatively low concentrations, such as deep plowing and deep tillage, and in the farmland where concentrations were not low, topsoil removal was implemented.

In Intensive Contamination Survey Areas, outside of Fukushima Prefecture, deep plowing and deep tillage were done, while within Fukushima Prefecture, in some cases topsoil stripping was selected by municipalities.

2) Issues

When topsoil stripping was carried out for decontamination of farmland, a large amount of removed soil was generated, which led to the problem that decontamination could not be performed unless expansive Temporary Storage Sites were secured.

3) Lessons learned

"The TEPCO Fukushima Daiichi Accident, Report by the Director General" (IAEA 2015) points out that "Remediation strategies need to take account of the effectiveness and feasibility of individual measures and the amount of contaminated material that will be generated in the remediation process.

Having established reference levels for residual radiation doses and contamination levels, it is essential to control carefully the amount of contaminated material generated by implementing the remediation strategy in order to minimize the amount of waste to be managed."

Particularly, by farmland topsoil stripping, a large amount of removed soil is generated and quality of the soil is lost. Therefore, in consideration of exposure of farm workers and adsorption of cesium into crops, it is important to conduct decontamination taking into consideration the advantages and disadvantages of each method, such as ploughing, inversion tillage, and topsoil stripping.

Furthermore, much knowledge was obtained at universities and research institutes, etc., regarding the relationship between decontamination methods and the transfer of radioactive materials to animals and plants.

(6) Initiatives for Proper Implementation of Decontamination

1) Background

During decontamination work, issues arose such as scattering and discharge into road gutters of waste water during high-pressure washing, as well as illegal dumping and illegal burying of removed soil, etc.

2) Issues

In the decontamination work, despite inadequate arrangements for the procedures and items to be considered, it was necessary to gather a large number of workers in a short period, so every effort was needed to ensure the properness of the that work.

For example, since some of the gathered workers included less experienced civil engineering construction workers or completely inexperienced workers, a novice mark seal was affixed to the helmet of these workers to identify them, and consideration was made to have them work with veterans in the same working group.

In addition, in order to ensure compliance with laws and regulations, special trainings were offered by decontamination contractors on an ongoing basis, including at the time of starting at a new site, regular-basis such as monthly trainings, and as needed basis such as work procedure trainings, as well as on an irregular basis such as for critical issues troubleshooting. In addition, education and awareness-raising activities were done for JV officials, cooperating companies and workers, and quality patrols and safety patrols were conducted on a day-to-day basis to ensure work was being done properly.

In addition to these efforts, decontamination contractors implemented their own curriculums to raise awareness by explaining the significance of the decontamination work, and provided education to be conscious of local considerations.

3) Lessons learned

MOE has offered the trainings and education and summarized the measures to prevent improper decontamination. Going forward, MOE and decontamination contractors will continue to make constant efforts by making use of this experience.

Since a great number of workers are involved in decontamination work, there is a need to have education for workers as well as project management and compliance systems for everyone, including subcontractors, and efforts are also needed for consideration of local circumstances.

6.4. Communication with Residents

(1) Explaining the Impacts of Radiation

1) Background

At the time of the accident, the general public was not knowledgeable about the impacts and risks of radiation but was repeatedly presented with confusing explanations that the impacts of radiation do not immediately affect the human body. The result was an increase in public anxiety and distrust of the government.

It was difficult to convince residents simply by one-sided scientific and technical explanations provided by government officials and experts.

What was needed was for government staff, residents and experts to gather face-to-face for dialogue, to share accurate information on the situation of the accident and pollution, as well as to study together about radiation, the health impacts of radiation, and radiation protection, etc. to deepen the understanding to rebuild a relationship of trust. In effect, what was needed was risk communication in the original intention.

Under these circumstances, MOE and Fukushima Prefecture jointly established the Decontamination Information Plaza (currently the Environmental Restoration Plaza) in January 2012 as a base for the dissemination of accurate information on radiation and decontamination. The Plaza personnel can engage in activities such as public relations about decontamination, dispatching experts to public briefing sessions and speak from a different position from the government. They ended up playing roles as experts and facilitators, etc., in radiation risk communication.

In addition, various ideas were tried to explain in a clear way, including the creation of teaching materials such as pictures and models, and visual explanatory materials.

2) Issues

In the context of intense public critical scrutiny of the nuclear accident and strong sense of anxiety about radiation, an enormous amount of time was spent to foster a sense of confidence in information.

In addition, there was a growing call for decontamination to aim for targets on the safe side, with the awareness that only through decontamination work could achieve an additional exposure dose of 1 mSv/y (and 0.23 μSv/h which is the value substituted for the sake of convenience as the air dose rate with conservative assumptions of specific lifestyle patterns)

3) Lessons learned

Related organizations need to cooperate to widely communicate decontamination policies, scientific knowledge on decontamination and radiation, etc., to residents in an accurate and easy-to-understand manner. Also it is important to establish basic risk management systems, including education about radiation during regular times, and information dissemination and sharing systems in times of emergency.

In addition to comprehensive measures to achieve long-term goals for additional exposure dose, it is important to make information comprehensible and to effectively promote communications obtained through to the progress of work, including the effect of decontamination, the relationship between the air dose rates, and individual exposure, etc.

In that effort, in order to broadly promote decontamination work by creating a good relationship with

residents, it is important to deepen trust and understanding not only through information dissemination but also through community dialogue based on information.

Specific examples of conscientious risk communication include information disclosure of measurement results, dialogue including questions and answers to help people understand the information, enhancement of education on radiation (including the understanding of natural radiation and medical exposure), and inviting participation in ascertaining and managing risk, etc.

In addition, for local communities this was an important experience of public participation in policy development, and a review of the sociological significance and outcomes of these experiences is expected to be valuable for future community development.

(2) Resident Participation

1) Background

In starting decontamination, MOE and decontamination contractors conducted individual explanations to stakeholders and residents' briefing sessions in order to obtain consent for decontamination and to secure Temporary Storage Sites.

After decontamination work was done, reports on decontamination results were sent.

Meanwhile, at decontamination sites, many people showed their appreciation to decontamination workers by giving them cold tea in the hot summers, and warm can coffee in the cold winters.

There was also high school students who painted a wall mural at a Temporary Storage Site in a town , attempting to improve the image of the Temporary Storage Site even a little.

Under such understanding and cooperation, the decontamination work has been progressed.

2) Issues

In the implementation of decontamination, at residents' briefing sessions in early stage, there were many comments saying that before consent was sought they should have received an indication of compensation and the revision of area designations.

Residents had a sense of distrust, thinking that decontamination would go ahead without receiving such information.

Also, decontamination contractors made an effort to respond as best they could to inquiries from stakeholders, within the scope of decontamination projects, and they did so while reporting to and consulting with MOE. They made an effort to establish good relationships with residents, but in some cases came up with the requests about things they could not address in the context of decontamination work, such as the repair of damaged houses, conversion from paddy fields to crop field, and improvements of access roads, etc.

3) Lessons learned

It is important to plan responses (evacuation areas, compensation, and decontamination according to radiation dose) based on scenarios prepared prior to the occurrence of an accident, in cooperation with the related agencies. in charge of compensation and reviews of areas under evacuation orders.

Also, it is important to develop consensus to implement projects while listening carefully to local voices,

well explaining the scope and effectiveness of decontamination while building relationships of trust with the local people.

Meanwhile, decontamination achieved certain results as a large-scale undertaking accomplished through the cooperation of the national government, prefectures, municipalities, residents, and the related nuclear power companies, and the foundation of those results was the local residents' understanding and cooperation with regard to decontamination, plus a variety of voluntary efforts to reduce radiation exposure.

Recording and organizing how these efforts have been done is important as a form of preparation for future large-scale disasters.

Above all, above and beyond government measures, the fact that decontamination and other measures to deal with radioactive pollution were an effort by many citizens acting voluntarily and proactively to restore the land is something to be told with pride to future generations.

[Reference] Related Committee Comment

The main comments related to this chapter from individual committee members are provided below. Please note that these are their personal comments.

Comments for Section 6.1 (1) "Relationship between the decontamination targets and 1 mSv/y"

Comments for <Goal of Decontamination>

- As far as I understand, before the decontamination implementation system was in place, the government had set a long term target of 1 mSv/y and a deadline, and work was proceeding in that context, through trial and error. I think it is important to review whether or not it was most appropriate to set a target and approach in such a limited time.
- It is important to properly explain the thinking behind the standard for additional exposure dose, the reasons why the long-term target was set at 1 mSv/y, and doses actually dropped by decontamination and measures to be taken forward.
- Although it was required to lower the target dose as much as possible, I think that it was not necessarily easy to reduce the dose in some cases.
- Some municipalities are implementing decontamination with a target of 5 mSv/y for now, rather than 1 mSv/y.

  It could also be considered setting targets stepwise between 1 and 20 mSv/y. IAEA and other bodies say that "Protection must be optimized to achieve the highest level of safety that can reasonably be achieved" (ALARA principle), and the lesson learned is that this should be clearly stated as a policy of decontamination.
- It may be a problem that 1 mSv/y was perceived as the target for decontamination, rather than as a long-term goal to reach as a result of various initiatives.
- IAEA adopts a range of 1 to 20 mSv/y, so it is difficult to show an interim target. In that sense, the long-term exposure target 1 mSv/y may be suitable in the Japanese sense.

  Rather, maybe it was a problem that the numerical value of 0.23 μSv/h, set as the target based on certain assumptions, was perceived as the goal of decontamination.
- I think there was confusion on the site, since nobody knew how long the "long-term" of the long-term

target would be.
・We do not know how much scientific knowledge will be gathered in the future about the impacts of low dose exposure.
・In discussions about the long-term goal, people were told that it would be lower than from other medical exposure, but from the viewpoint of residents, they can obtain merits from medical exposure, while there is no merit of radiation exposure from an accident, so people think that the less risk the better.
・It is necessary to remember that decontamination in Japan was conducted on the premise that it would result in an environment where residents could return and live immediately.
・It should be stated clearly that, in contrast to overseas cases, in Japan it was assumed that people will return home and live there again.

Comments for <Scope of decontamination>
・Although some areas were initially designated as Intensive Contamination Survey Areas, in some municipalities the designation was lifted without a decontamination plan being made, because subsequent measurements found that the dose was already low.
・Regarding the relationship between 1 mSv/y and the air dose rate, the standard of 0.23 μSv/h is not unreasonable. On the other hand, there are scientific findings that the actual exposure dose is even lower (than 1 mSv/y under the environment of 0.23 μSv/h), and for example about 0.5 μSv/h (could correspond to the 1 mSv/y).
・It is important to clarify that the 0.23 μSv/h as the area designation and 1 mSv/y as the long-term target are different from the decontamination target.

Comments for <Setting of work period>
・With decontamination of Areas under Evacuation Orders, I understand that it was originally planned that evacuees could return within three years, but in fact, decontamination and their return were delayed.
・Since decontamination began at the same time in Areas under Evacuation Orders and in municipalities where people evacuated, some people may think that and decontamination was delayed in municipalities where people evacuated, the evacuees' reduction of exposure to radiation was also delayed.

Comments for Section 6.2 (1) "Role sharing for decontamination work"

Comments for <Overall division of roles>
・Decontamination in municipalities where residents were living is considered to have been relatively successful because each municipality was tuned in to the residents' feelings as it did the work.
Even where the residents had been evacuated and the national government took direct charge of decontamination, in some cases decontamination was done conscientiously as a result of interactions with the residents who had evacuated.
・This time, with the exception of local governments where evacuation orders had been issued, municipalities were assigned to do the decontamination work, but if similar circumstances arise in the future, it could be considered that municipalities could entrust the work to the prefecture.
・It is important to have balance in the sense of ownership between the development of overall plans and

the implementation by the municipalities and the communities. The responsibilities of the implementing side should also be clarified.

Comments for <Role of the national government>

・If all of the work is done under the direct jurisdiction of the national government, the problem is that it will be impossible to pay attention to detail. It is necessary to review what kind of system worked the best.

・Initially, each ministry and agency implemented its own efforts and there was no mechanism to implement things systematically, so an integrated approach was not possible.

・Due to the fact that the national government was responsible for decontamination, I think local governments and citizens as a whole found it difficult to assume a share of responsibility and develop a shared understanding and awareness.

Comments for <Role of the prefectural government>

・Disaster prevention was being done by municipalities, but decontamination is difficult for municipalities to do. They cannot coordinate things in a wide area. The prefectural government definitely had a role, such as developing a plan for the entire prefecture.

・In Fukushima Prefecture, when it was decided that municipalities would prepare their own decontamination implementation plans, it was expected that there would inevitably be differences in the progress and content of activities. If that was going to be a problem, it might have been an option for the prefecture to develop an overall plan for a wide area.

・Because of the nature of the decontamination work, costs will vary as the project moves ahead, making the necessary costs difficult to predict. Therefore, the method of the prefecture creating a fund based on subsidies from the national government and making it available to municipalities was good in that it permitted a flexible response.

・In the municipalities that did decontamination work while residents were living there, it was difficult to gain residents' acceptance for temporary storage sites, and for in-situ storage where it was hard to ensure the temporary storage sites. There may have been a role for the prefecture as a local government for a broader region, including the management of stored soil, for example, the time of transferring from in-situ storage to temporary storage sites, and consolidation to loading areas.

Comments for <Role of municipalities>

・It was a good thing to have municipalities conduct decontamination as their proximity to the community allowed them to respond well to residents, but I think it was a heavy load for municipal personnel due to a shortage of people.

・It would have been better for a bigger entity to develop the overall plans and then have municipalities carry out the decontamination.

・For emergency decontamination activities, there were some merits of having municipalities decontaminate at first, but I think there were issues such as the disposal of waste.

・After the whole area decontamination has been completed and municipal departments that were in charge

are downsized, I think problems may arise in dealing with spot decontamination or other issues that become evident in the future.

Comments for <Polluter pays principle>

・The IAEA standard approach is that the polluter conducts the decontamination, and regulatory agencies conduct approvals and reviews. On the other hand, Fukushima accident was enormous in scale, and so if the polluter worked alone on decontamination it would never have been worked.

・Because the pollution of this time was on a large scale and the national government also had some responsibility, the national government carried out decontamination, etc. However, there is some question whether the national government should always do this, including cases where the pollution is on a small scale.Consideration should be given to IAEA's principle that "The prime responsibility for safety must rest with the person or organization responsible for facilities and activities that give rise to radiation risks."

Comments on Section 6.2 (2) "Enhancing verification systems"

・It is important to clearly explain why the municipal verification committee was necessary, including the background. There are differences in approaches taken by various municipalities.

・There were some good examples of verification committees in some towns. For example, in one case a member explained the situation from the farmers' perspective and got the committee to understand.

・Since there were no uniform standards, verification was difficult, but it was important to conduct verification based on the actual situation in each municipality.

Comments on Section 6.2 (3) "Coordinating with relevant policies (reconstruction, etc.)"

・For decontamination of Areas under Evacuation Orders, I understand that initially it was planned for evacuees to return within 3 years, but in reality decontamination and return were delayed.

・In the wake of regrettable cases in which hospitalized patients underwent significant hardships when they were evacuated, one local government did not do an emergency evacuation and instead, conducted thorough decontamination and limited the patients' exposure. In the future, such methods should also be considered.

・Because of delays in developing recovery plans, the decontamination methods had to be undertaken, in accordance with the land use before the disaster, regardless of the land use policy after the restoration (whether or not it would be farmland use, etc.). If land use policy was already determined at the time decontamination was being done, it may have been possible to limit the amount of waste generated. I think that a rational approach should be used for decontamination, based on long-term consideration of evacuee return and reconstruction.

・Although the decision was made later to demolish some buildings due to the deterioration of the houses, I think it should have been considered right from the beginning.

・I think it is important to formulate rational decontamination plans that are matched with the pace of reconstruction and recovery plans, taking the reductions of observed doses into account.

・Even if they do decontamination and explain, there is no guarantee that people will return to the area, so

you also need to assume that some people will not return.

- The return rate decreases over time. What the national government can do is to decontamination rapidly and create an environment that will increase the return rate. The judgment of whether to return or not is ultimately to be done by the residents.
- Even after the decontamination work has ended, weeds and small trees are growing in residential areas and farmland over time, so weeding is required again. Even after the decontamination has ended, the residents cannot immediately return home, so it is a problem that no one can manage and preserve the land.

Comments on Section 6.3 (1) "The first large-scale decontamination project in Japan"

- Decontamination work is labor-intensive, and it is difficult to mechanize and automate the work. Knowledge about radiation is also necessary. In addition to technology, relationships and response to the local community are also important.
- It is important to build trusting relationships, and there are cases where people were actively hired from the local community and they worked together on decontamination.
- Among all government ministries it was decided that MOE would be in charge of decontamination, and this was the first large scale decontamination project in Japan.
- Since this was an enormous decontamination project on a scale never experienced before, I believe there were initially some problems with certain management and monitoring methods on the site.
- There was some technical development using ideas from contractors (construction companies) for decontamination methods and equipment. Examples include the development of large high-pressure washing vehicles and cleaning paved roads using dry ice.
- As time passes, willow trees would grow in the paddy fields, etc., so it has been a need for not only weeding but also tree and root removal.
- As decontamination project got long-standing, it became difficult to get effective results as time passed. It is necessary to choose a flexible method considering the passage of time.
- Although the decision was made later to demolish some buildings due to the deterioration of the houses, I think it should have been considered right from the beginning.
- When doing decontamination while people still live in the area, communication with landowners is crucial.
- In Chernobyl, people were forcibly emigrated because relocation was cheaper than decontamination. The United States has had many accidents at military facilities in the desert, but they were far away from where residents live. Unlike these cases, Japan cannot forcibly relocate people, and there is no place to relocate them.
- Decontamination on a massive scale was possible thanks to Japan's civil engineering expertise.

Comments on Section 6.3 (2) "Preliminary surveys and acquisition of consent"

- The consent of stakeholders (landowners, building owners, managers, etc.) related to the decontamination is important in planning decontamination projects and starting actual work.
- There were many cases where a large number of landowners together owned a property targeted for

decontamination, where the rights holders were complex, or where the actual landowners were unknown, and that could make it difficult to identify the stakeholders in some cases.

- To obtain consent in Special Decontamination Areas, it was necessary to visit the places for the explanations where evacuees were staying. In the ICSA, it was necessary to visit the decontamination site, where the landowners live to give explanations.
- It was possible to obtain consent because the situation was relatively calm as the nuclear reactors were in a cold stop, rather than immediately after a disaster. In the case of real emergency, however, the consent will not be obtained. I think it is necessary to consider whether a consent process is really necessary.

Comment on Section 6.3 (3) "Securing and prolonged management of Temporary Storage Sites"

- There are cases progress was made in gaining understanding by asking residents to visit the actual temporary storage sites, and making it easier to obtain consent.
- Initially, it was assumed that national forests would be used to set up temporary storage sites in order to use land of the national government, but in that case, it would have been necessary to revoke protected forest designations and to level the land. That is why many temporary storage sites were located outside of national forests.
- Regarding the securement of temporary storage sites, the situation may have been a little different, if the correct knowledge about radiation and health had been more common among prefectural citizens from the beginning, and public understanding had been well promoted that it would have been more effective in terms of exposure dose reduction and safety measures when consolidating the removed soil rather than having in different locations.
- In the municipalities that conducted decontamination work while residents were living there, it was considered to be difficult to gain residents' acceptance for temporary storage sites, and for in-situ storage where temporary storage sites could not be found.
- While the terms of temporary storage sites and on-site storage have been extended, there were also problems with underground storage due to nearby expansions and land transactions, and so relocation became necessary in some cases.
- Restoration of temporary storage sites to their original state is important not only in terms of form but also function, so it important to have long-term oversight of these sites from the landowner's perspective.
- It is important to consider the standardization of identification tags on flexible container, whether it be for decontamination under the national government or decontamination by municipalities, standardization during decontamination and transportation, and the collection of data at the time of decontamination, in anticipation of transportation (weight of flexible containers, etc.).
- Since the tags on flexible containers were not standardized, it was necessary to replace the tags or examine the information at the time of transportation. Deeper discussions will be necessary when setting standards.

Comments on Section 6.3 (4) "Disposal method of removed soil, etc. "

- The treatment of removed materials (soil and waste) generated by decontamination is extremely important and affects the entire treatment process

Comments on Section 6.3 (5) "Farmland decontamination work for the smooth implementation of the projects"

- It gets cheaper and leads to the conservation of topsoil, compared with stripping when conducting inversion tillage, but I think more soil stripping was done in many areas to be on the safety side. As a result, amount of removed soil increased, the area needed for temporary storage sites increased, and the storage period was lengthened. It is also crucial to develop consensus about these tradeoffs.
- Although it is cheaper to buy all the land when considering the trade-offs, the national government decided on decontamination based on policy. The cost in Japan will be a reference for policies in other countries.

Comments on Section 6.3 (6) "Initiatives for proper implementation of decontamination"

- Fraud in the decontamination business and violations of laws and regulations are also one of the issues.
- There were cases such as inflated billing and overpayments, etc.
- Regarding the occurrence of accidents and problems, it is necessary to pay attention to the fact that the decontamination work involved managing up to about 20,000 workers a day.

Comments on Section 6.4 (1) "Explaining the impact of radiation"

- It is important to note in records that there was a strong sense of anxiety about radiation, that in some cases it was difficult to operate with existing systems, and that the responses were an attempt to deal with these conditions.
- Adequately disseminating correct knowledge about radiation at an early stage is an important measure to smoothly carry out a variety of subsequent work.
- The goal of decontamination was not well communicated, so it was that long-term targets were perceived by residents as the goal of decontamination. Correct knowledge and correct information transmission are important.
- It is difficult to make a transition from decisions that were initially made, into reasoned judgment at a later time when scientific knowledge accumulates. It is necessary to carefully examine the modes of communication and decision making.

Comments on Section 6.4 (2) "Resident participation"

- There are guidelines on decontamination, but in comes some cases further decontamination was required at decontamination sites because special action was necessary or the dose did not decline.
- As an action to be on the safe side, topsoil stripping was carried out in many areas.
- Since decontamination was promoted under decontamination implementation plans developed by each municipality, differences emerged in the content and progress of efforts by municipalities.

Afterword

This committee was established to consider and discuss this report's composition, topics, contents, issues and lessons learned, and to prepare the report. The members of the Editorial Committee are indicated below.

This document is a compilation and summary of the experiences, lessons learned and knowledge obtained in decontamination work implemented in Japan, with a focus mainly on the efforts of MOE.

We believe it is important for not only MOE but also other relevant ministries, local governments, research institutions and organizations to summarize and archive their documents and data as a resource in the event of another nuclear power station accident, and for related research and efforts.

< Editorial Committee for the Paper on Decontamination Projects >

(Chair)	Motoyuki Suzuki	Professor Emeritus, The University of Tokyo
	Tadashi Inoue	Research Advisor Emeritus, Central Research Institute of Electric Power Industry
	Masahiro Osako	Director, Center for Material Cycles and Waste Management Research, National Institute for Environmental Studies, Japan
	Takashi Omura	General Research Programme Manager / Secretary General, Institute for Global Environmental Strategies
	Keiichi Kawase	Section Leader, Project Engineering Management Section, Fukushima Environmental Safety Center, Fukushima Research Institute, Sector of Fukushima Research and Development, Japan Atomic Energy Agency
	Kencho Kawatsu	Project Professor, Faculty of Symbiotic Systems Science, Fukushima University,
	Yuko Sakita	Journalist, Environmental Counselor
	Akira Suzuki	Director, Decontamination Countermeasure Division, Social Affairs and Environment Department, Fukushima Prefecture
	Masatoshi Morita	President, Society for Remediation of Radioactive Contamination in Environment
	Yoshio Oshino	Interim Storage and Decontamination Committee, Japan Federation of Construction Contractors (Kajima Corporation)
	Masao Konishi	Interim Storage and Decontamination Committee, Japan Federation of Construction Contractors (Okumura Corporation)
	Kazuo Sato	Interim Storage and Decontamination Committee, Japan Federation of Construction Contractors (Taisei Corporation)
	Kunio Nishi	Interim Storage and Decontamination Committee, Japan Federation of Construction Contractors (Hazama Ando

		Corporation)
	Masaru Noda	Interim Storage and Decontamination Committee, Japan Federation of Construction Contractors (Obayashi Corporation)
	Shintaro Hayashi	Interim Storage and Decontamination Committee, Japan Federation of Construction Contractors (Maeda Corporation)
	Ken Watanabe	Interim Storage and Decontamination Committee, Japan Federation of Construction Contractors (Shimizu Corporation)

(Secretariat)	Office of Director for Environmental Regeneration, Environmental Regeneration and Material Cycles Bureau, MOE
	Nippon Koei Corporation

【Attachment】 Chronology of major events

Stage	Year/ Month	Legislation and Regulations	Policies, Guidelines, etc.	Decontamination and Municipal Actions, etc.
Emergency Response Stage	Mar 2011	3/11 Nuclear Power Station Accident Associated with the Tohoku District Off the Pacific Ocean Earthquake 3/12 Evacuation orders within 20 km radius of TEPCO Fukushima Daiichi NPS (NERHQ: the Act on Special Measures concerning Nuclear Emergency Preparedness) 3/15 Order to remain indoors within a radius between 20 and 30 km of TEPCO Fukushima Daiichi NPS		
	Apr	4/21 Designation of area within 20 km radius of TEPCO Fukushima Daiichi NPS as a Restricted Area 4/22 Designation of certain areas outside a 20 km radius of TEPCO Fukushima Daiichi NPS as Deliberate Evacuation Areas and Evacuation-Prepared Areas in Case of Emergency	4/19 Preliminary Approach in Deciding How to Use School Buildings and Schoolyards in Fukushima Prefecture (MEXT)	4/21 Start of decontamination demonstration tests on the grounds of elementary schools (Date City) 4/27 Start of topsoil removal work at schoolgrounds and other areas (Koriyama City)
	May		5/2 Handling of Disaster Waste in Fukushima Prefecture for the Time Being (MOE)	
	Jun	6/16 Designation of individual areas as Specific Spots Recommended for Evacuation	6/23 Policy on Disposal of Disaster Waste in Fukushima Prefecture (MOE)	
	Jul		7/15 Guidance for Reduction of Air Dose in Living Space (Fukushima Prefecture) 7/19 Basic Policy on Radiation Protection for Termination of Evacuation and Reconstruction (NSC)	
	Aug	8/30 the Act on Special Measures concerning Handling of Environment Pollution by Radioactive Materials promulgated	8/2 Formulation of Comprehensive Monitoring Plan for radiation (NRA) 8/9 Basic concept on the Review of Areas Under Evacuation Orders (NERHQ) 8/12 EURANOS Data Sheet (AESJ) 8/26 Basic Policy for Emergency Response on Decontamination Work (NERHQ) 8/26 Guidelines for Municipal Decontamination Work (NERHQ)	

Stage	Year/ Month	Legislation and Regulations	Policies, Guidelines, etc.	Decontamination and Municipal Actions, etc.
Decontamination Preparation Stage	Sep	9/30 Cancellation of Evacuation-Prepared Areas in Case of Emergency outside the 20 km radius of TEPCO Fukushima Daiichi NPS	・Establishment of MOE Decontamination Team 9/14 Hosting the 1st meeting of Committee on Environmental Remediation (MOE) 9/30 Announcement of Appropriate Methods, etc. for Decontamination of Forests (NERHQ) 9/30 Announcement of the Appropriate Methods for Decontamination of Farmland (MAFF)	
	Oct		10/29 Basic Policy on Interim Storage and Other Facilities Required for the Handling of the Environmental Pollution from Radioactive Materials Associated with the Accident at the Tokyo Electric Power TEPCO Fukushima Daiichi Nuclear Power Station (MOE)	
	Nov	11/11 Cabinet Decision on the Basic Policy per the Act on Special Measures concerning the Handling of Environment Pollution by Radioactive Materials	11/15 IAEA International Mission Final Report on Decontamination (IAEA) 11/22 Decontamination Technical Catalogue (Cabinet Office)	11/7 Start of detailed monitoring 11/7 Start of Cabinet Office (JAEA) Decontamination Model Demonstration Project ・Start of Fukushima Prefecture Whole Area Decontamination Model Project ・Inauguration of Society for Remediation of Radioactive Contamination in Environment
	Dec	12/28 Designation of Special Decontamination Areas (SDA), Intensive Contamination Survey Areas (ICSA), etc.	12/14 Formulation of Decontamination Guidelines (1st edition) (MOE) 12/22 Promulgation of Regulation on Prevention of Ionizing Radiation Hazards related to Work such as Decontamination, release of Guidelines on Prevention of Radiation Hazards for Workers Engaged in Work such as Decontamination (MHLW) 12/26 Basic Concepts and Future Issues for Reviewing Restricted Areas and Areas Where Evacuation Orders Have Been Issued Where Step 2 Has Been Completed (NERHQ) 12/27 Formulation of Waste Guidelines (1st edition)	12/7 Start of Decontamination of Municipal Offices by the Japan Self-Defense Forces

Stage	Year/ Month	Legislation and Regulations	Policies, Guidelines, etc.	Decontamination and Municipal Actions, etc.
Decontamination Start Stagr	Jan 2012	1/1 Enforcement of the Act on Special Measures concerning the Handling of Environment Pollution by Radioactive Materials 1/1 Enforcement of Ionizing Radiation Ordinance for Decontamination	1/26 Policy for Decontamination in Special Decontamination Areas (Decontamination Roadmap) (MOE) 1/31 Technical Guidelines for Decontamination Operations (Fukushima Prefecture)	1/4 Establishment of Fukushima Environmental Restoration Office 1/6 Start of preliminary decontamination (Naraha Town) 1/20 Installation of Decontamination Information Plaza
	Feb			
	Mar	3/31 Enforcement the Act on Special Measures for the Reconstruction and Revitalization of Fukushima	3/12 Guidelines on Handling Local Areas Contaminated by Radioactive Materials (MOE) 3/29 Handbook for Whole Area Decontamination (Fukushima Prefecture)	・Start of advance decontamination (Tamura City, Tomioka Town, Okuma Town, Kawamata Town, Kawauchi Village, Katsurao Village)
	Apr	4/1 Reorganization of Preparation Areas for Lifting of Evacuation Orders (Tamura City), Habitation Restricted Areas and Preparation Areas for Lifting of Evacuation Orders (Kawauchi Village) 4/13 Formulation of Decontamination Implementation Plans in Special Areas (Naraha Town, Tamura City) 4/16 Reorganization as Areas where Returning is Difficult, Habitation Restricted Areas, and Preparation Areas for Lifting of Evacuation Orders (Minamisoma City) 4/18 Formulation of Decontamination Implementation Plans in Special Areas (Minamisoma City)		4/12 End of Detailed Monitoring 4/25 Inauguration of the Nikken Decontamination Committee 4/27 End of advance decontaminatio (Tamura City)
	May	5/24 Formulation of Decontamination Implementation Plans in Special Areas (Iitate Village)		5/22 Start of advance decontamination(Minami soma City)
	Jun		6/29 Final report on the Decontamination Model Demonstration Project in the Restricted Areas and Deliberate Evacuation Areas, etc. (MOE, JAEA)	・End of Cabinet Office (JAEA) Decontamination Model Demonstration Project ・Start of advance decontamination (Namie Town, Iitate Village)
	Jul	7/17 Reorganization as Areas where Returning is Difficult, Habitation Restricted Areas, and Preparation Areas for Lifting of Evacuation Orders (Iitate Village)		7/5 Start of whole area decontamination (Tamura City) 7/25 Start of whole area decontamination (Naraha Town) 7/30 Start of whole area decontamination (Kawauchi Village)
	Aug	8/10 Formulation of Decontamination Implementation Plans in Special Areas (Kawamata Town) 8/10 Reorganization as Preparation Areas for Lifting of Evacuation Orders (Naraha Town)		・Release of inspection at National Highway No. 6 at J Village Mae
	Sep	9/28 Formulation of Decontamination Implementation Plans in Special Areas (Katsurao Village)		9/25 Start of whole area decontamination (Iitate Village) 9/28 End of advance decontamination (Kawamata Town)

Stage	Year/ Month	Legislation and Regulations	Policies, Guidelines, etc.	Decontamination and Municipal Actions, etc.
Decontamination Implementation Stage	Oct	・Partial revision of Decontamination Implementation Plans in Special Areas (Naraha Town)	10/23 Decontamination Promotion Package (MOE)	10/31 End of advance decontamination (Naraha Town)
	Nov	11/21 Formulation of Decontamination Implementation Plans in Special Areas (Namie Town)		11/30 End of advance decontamination (Katsurao Village)
	Dec	12/10 Reorganization as Areas where Returning is Difficult, Habitation Restricted Areas, and Preparation Areas for Lifting of Evacuation Orders (OkumaTown) 12/28 Formulation of Decontamination Implementation Plans in Special Areas (Okuma Town)		12/6 Start of whole area decontamination (Okuma Town)
	Jan 2013		1/18 Program for Proper Decontamination (MOE) 1/18 Effects of Decontamination Techniques in Decontamination Projects Implemented to Date by National and Local Governments (MOE)	
	Feb		2/22 Technical Manual for Decontamination of Farmland (MAFF)	2/28 Fukushima Environmental Restoration Office, Opening of Naraha Town branch
	Mar	3/22 Reorganization as Areas where Returning is Difficult, Habitation Restricted Areas, and Preparation Areas for Lifting of Evacuation Orders(Katsurao Village) 3/25 Reorganization as Areas where Returning is Difficult, Habitation Restricted Areas, and Preparation Areas for Lifting of Evacuation Orders (Tomioka Town)		3/28 End of advance decontamination (Minamisoma City)
	Apr	4/1 Reorganization as Areas where Returning is Difficult, Habitation Restricted Areas, and Preparation Areas for Lifting of Evacuation Orders (Namie Town)		4/25 Start of whole area decontamination (Kawamata Town, Katsurao Village)
	May	5/28 Reorganization as Areas where Returning is Difficult and Preparation Areas for Lifting of Evacuation Orders (Futaba Town)	5/17 Publication of Collection of Best Practices in Decontamination (MOE)	
	Jun	6/26 Formulation of Decontamination Implementation Plans in Special Areas (Tomioka Town)		6/28 End of whole area decontamination (Tamura City)
	Jul			
	Aug	8/8 Cancellation of Deliberate Evacuation Areas, reorganized as Habitation Restricted Areas and Preparation Areas for Lifting of Evacuation Orders (Kawamata Town)		8/1 Start of preparatory accommodation (Tamura City) 8/26 Start of whole area decontamination (Minamisoma City) ・Start work between JR Joban Line Hirono Station and Tatsuta Station ・Seven Eleven resumes business in the 20 km radius (Naraha Town)
	Sep		9/10 Overall Check on Progress of Decontamination (MOE)	
	Oct			
	Nov			11/26 Start of decontamination verification committee (Naraha Town)

Stage	Year/ Month	Legislation and Regulations	Policies, Guidelines, etc.	Decontamination and Municipal Actions, etc.
				11/27 Start of whole area decontamination (Namie Town)
	Dec	12/20 Cabinet Decision on Accelerating the Reconstruction of Fukushima From the Nuclear Disaster 12/26 Partial revision of Decontamination Implementation Plans in Special Areas (Minamisoma City, Iitate Village, Kawamata Village, Katsurao Village, Namie Town, Tomioka Town)	12/26 Effects (on Air Dose Rate) of Decontamination in Decontamination Projects Implemented by the National Government and Local Governments (MOE) 12/26 Review of the Decontamination Implementation Plans in Special Areas (MOE)	12/28 Start of special accommodation during year-end and new year (Naraha Town)
Decontamination Acceleration Stage	Jan 2014		1/23 Final report: The Follow-up IAEA International Mission on Remediation of Large Contaminated Areas Off-site the TEPCO Fukushima Daiichi Nuclear Power Station（IAEA）	1/8 Start of whole area decontamination (Tomioka Town)
	Feb		2/13 Unified Basic Materials regarding Health Effects, etc. Caused by Radiation (First Edition) (MOE, NIRS)	2/22 Reopening of Joban Expressway Hirono IC to Tokiwa Tomioka IC
	Mar			3/24 End of advance decontamination (Tomioka Town) 3/28 End of whole area decontamination (Naraha Town) 3/31 End of whole area decontamination (Kawauchi Village)
	Apr	4/1 Cancellation of Preparation Areas for Lifting of Evacuation Orders (Tamura City)		4/15 Restart of juvenile salmon release in the Kido River (Naraha Town) 4/26 Start of preparatory accommodation (Kawauchi Village)
	May			5/15 Commencement of residents monitoring of Temporary Storage Sites (TSS) (Naraha Town) 5/29 Declaration of decision about returning town (Naraha Town)
	Jun		6/10 Report on Results of Decontamination Model Demonstration Projects in Areas where Returning is Difficult (MOE) 6/15 Meeting to Exchange Views with Knowledgeable Persons regarding Decontamination (MOE)	6/1 Resumed operation of JR Joban Line Hirono Station to Tatsuta Station 6/26 Start of decontamination verification committee (Naraha Town)
	Jul	7/15 Formulation of Decontamination Implementation Plans in Special Areas (Futaba Town)		7/10 Start of decontamination verification committee (Kawauchi Village) 7/29 Start of additional decontamination (Naraha Town) 7/31 End of advance decontamination (Kawauchi Village) 7/31 Opening of temporary commercial facility

Stage	Year/ Month	Legislation and Regulations	Policies, Guidelines, etc.	Decontamination and Municipal Actions, etc.
				"Kokonara Shotengai" (Naraha Town)
	Aug		8/1 Interim Report of Study Group of National Government and Four Cities concerning Decontamination in Municipalities (MOE)	8/29 End of advance decontamination (Namie Town)
	Sep			9/15 Traffic restrictions lifted and full line opening of National Highway No. 6
	Oct	10/1 Cancellation of Preparation Areas for Lifting of Evacuation Orders, reorganized as Habitation Restricted Areas into Preparation Areas for Lifting of Evacuation Orders (Kawauchi Village)		10/31 End of whole area decontamination (Okuma Town)
	Nov			12/5 Establishment Hamadori Office for Interim Storage Facilities
	Dec			12/5 Establishment Hamadori Office for Interim Storage Facilities 12/24 End of advance decontamination (Iitate Village)
	Jan 2015			1/31 Start of alternate bus service between JR Joban Line Tatsuta station and Haranomachi Station
	Feb			2/23 Start of whole area decontamination (Futaba Town)
	Mar		3/5 Report of Decontamination Verification Committee (Naraha Town) ・Report on Decontamination FY2014 (MOE)	3/1 Opening of all lines of Joban expressway and opening of Naraha PA (Naraha Town) 3/13 Start of pilot transport (Okuma Town) 3/25 Start of pilot transport (Futaba Town)
	Apr			4/6 Start of preparatory accommodation (Naraha Town) 4/10 Start of pilot transport (Tamura City) 4/16 Start of decontamination verification committee (Kawamata Town)
	May			5/26 Start of pilot transport (Tomioka Town)
	Jun	6/12 Cabinet Decision on Accelerating the Reconstruction of Fukushima From the Nuclear Disaster (revision)		・Start of pilot transport (Naraha Town, Namie Town, Kawauchi Village, Katsurao Village)
	Jul			
	Aug		8/31 TEPCO Fukushima Daiichi NPS Director General's Report (IAEA)	8/31 Start of preparatory accommodation (Kawamata Town, Katsurao Village)
	Sep	9/5 Cancellation of Preparation Areas for Lifting of Evacuation Orders (Naraha Town)	9/30 Summary of Status of Enforcement of the Act on Special Measures concerning the Handling of Environment Pollution by Radioactive Materials (MOE)	9/1 Start of decontamination verification committee (Tomioka Town)
	Oct			10/10 Holding of Futaba World in Naraha (Naraha Town) ・Full revival of salmon fishery

Stage	Year/ Month	Legislation and Regulations	Policies, Guidelines, etc.	Decontamination and Municipal Actions, etc.
				in Kido River (Naraha Town)
	Nov			・Start of pilot transport (Iitate Village, Minamisoma City, Kawamata Town)
	Dec		12/21 Approach to Supplemental Decontamination (MOE)	12/31 End of whole area decontamination (Kawamata Town, Katsurao Village)
	Jan 2016			
	Feb			・Opening of prefectural clinic (Naraha Town)
	Mar			3/29 Recommendations by decontamination verification committee (Kawamata Town) 3/31 End of whole area decontamination (Futaba Town) ・Lifting of rice shipment restrictions (Naraha Town)
	Apr			
	May			・Restart of full-scale farming (Naraha Town)
	Jun	6/12 Cancellation of Habitation Restricted Areas and Preparation Areas for Lifting of Evacuation Orders (Katsurao Village) 6/14 Cancellation of Habitation Restricted Areas (Kawauchi Village)		6/3 Start of decontamination verification committee (Namie Town)
	Jun	7/12 Cancellation of Habitation Restricted Areas and Preparation Areas for Lifting of Evacuation Orders (Minamisoma City)		7/12 Resume operation of JR Joban Line Haranomachi Station to Kodaka Station
	Aug		8/31 Approach on the Handling of Areas where Returning is Difficult (NERHQ)	8/11 Start of special accommodation (Okuma Town)
	Sep			9/17 Start of preparatory accommodation (Tomioka Town)
	Oct			10/4 Recommendations by decontamination verification committee (Tomioka Town)
	Nov			11/1 Start of preparatory accommodation (Namie Town)
	Dec	12/10 Cabinet Decision on Basic Policy for Accelerating the Reconstruction of Fukushima From the Nuclear Disaster		12/21 Recommendations by decontamination verification committee (Minamisoma City) 12/31End of whole area decontamination (Iitate Village)
	Jan 2017			1/31 End of whole area decontamination (Tomioka Town)
	Feb	2/10 Cabinet Decision on the Act on Special Measures for the Reconstruction and Revitalization of Fukushima (revision)		2/8 Start of decontamination verification committee (Iitate Village)
	Mar	3/31 Cancellation of Habitation Restricted Areas and Preparation Areas for Lifting of Evacuation Orders (Namie Town, Iitate	3/3 Current Situation, Outcomes and Prospects of Decontamination, Interim Storage Facilities, and	3/31 End of whole area decontamination (Minamisoma City, Namie Town)

Stage	Year/ Month	Legislation and Regulations	Policies, Guidelines, etc.	Decontamination and Municipal Actions, etc.
		Village, Kawamata Town)	Radioactive Contaminated Waste Disposal (MOE)	
	Apr	4/1 Cancellation of Habitation Restricted Areas and Preparation Areas for Lifting of Evacuation Orders (Tomioka Town)		
	May	5/19 Enforcement of the Act on Special Measures for the Reconstruction and Revitalization of Fukushima (revision)		
	Jun			6/23 Recommendations by decontamination verification committee (Iitate Village)

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Note: An asterisk (*) indicates multiple listings of the document.

Index / Glossary

[A]

◆ Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors (P 11)

Legislation that regulates not only nuclear reactors but also the handling of nuclear material in general (Act No. 166 of 1957). As a result of the occurrence of a major accident at the TEPCO Fukushima Daiichi Nuclear Power Station, the act was reexamined significantly as part of strengthening safety regulations of nuclear facilities such as nuclear reactors for power generation.

The Nuclear and Industrial Safety Agency and Nuclear Safety Commission were abolished as regulatory organizations, and the Nuclear Regulation Authority was established on September 19, 2012 as a new organization that unified responsibility for safety regulatory administration.

◆ Act on Special Measures concerning Nuclear Emergency Preparedness (P 1, 2, 11)

This is legislation with the purpose to purpose of this Act is to strengthen nuclear disaster control measures, by providing special measures for the obligations, etc. of nuclear operators concerning nuclear disaster prevention, the issuance of a declaration of a nuclear emergency situation and the establishment, etc. of nuclear emergency response headquarters, and the implementation of emergency response measures and other matters relating to a nuclear disaster, taking into consideration the particularity of a nuclear disaster, thereby protecting the lives, bodies and properties of citizens from a nuclear disaster (Act No. 156 of December 17, 1999).

◆ Act on Special Measures for the Reconstruction and Revitalization of Fukushima (P 36, 72, 141, 389)

This act promotes the reconstruction and revitalization of Fukushima, which has sustained serious and vast damage due to the nuclear disaster, are achieved based on the specific circumstances of the prefecture and under the social responsibility of the national government, which has proactively promoted its nuclear energy policy. It includes creating an environment where people can live with peace of mind and give birth to and raise children, respecting the opinions of a diverse range of residents, revitalizing the local economy, restoring and maintaining strong bonds among local communities in Fukushima, enabling each and every resident to overcome the disaster and live a fulfilling life, respecting the independence and autonomy of local governments in Fukushima, preserving local communities, providing accurate information, etc. (Act No. 25 of 2012)

◆ Act on Special Measures concerning the Handling of Environment Pollution by Radioactive Materials（P 16, 18, 19, 36, 45, etc.）

The full name is the Act on Special Measures concerning the Handling of Environmental Pollution by Radioactive Materials Discharged by the Nuclear Power Station Accident Associated with the Tohoku District Off the Pacific Ocean Earthquake That Occurred on 11 March 2011 (Act No. 110 of August 30, 2011)

Act was promulgated on August 30, 2011 for the purpose of promptly alleviating the impacts on human

health or the living environment due to pollution of the environment, by specifying measures, etc., to be taken by the national government, local governments, and related nuclear power companies, etc., regarding dealing with pollution of the environment caused by diffusion of radioactive substances accompanying TEPCO Fukushima Daiichi NPS accident.

◆ Additional exposure dose (P 17, 19, 52, 53, 54, etc.)

In addition to the radiation originally found in nature, the radiation dose due to radiation added by radioactive material released by this nuclear accident.

◆ Air dose rate (P 2, 6, 12, 13, 15, etc.)

Radiation dose (intensity) in air per unit of time.

Ambient radiation generally present in the air, including α (alpha), β (beta), and γ (gamma) rays from the ground, as well as cosmic rays, etc.

◆ Areas where Returning is Difficult (P 6, 7, 15, 36, 66 etc.)

A category of area designated by reviewing evacuation areas.

On December 26, 2011, the Nuclear Emergency Response Headquarters (NERHQ) compiled the "Basic Concept and Future Tasks in Review of the Restricted Areas and Areas under Evacuation Orders after the Completion of Step 2. (December 26, 2011)," and even after five years have passed since the accident, the annual cumulative dose may not fall below 20 mSv/y and the annual cumulative dose exceeds 50 mSv/y. In principle, it is necessary to restrict residence in the future, so the designation of these areas is fixed for five years.

[B]

◆ Basic Act on Reconstruction in Response to the Great East Japan Earthquake (P 72)

In consideration of the fact that the Great East Japan Earthquake caused an unprecedented national crisis due to extensive damage affecting a vast area and with all the characteristics of a compound disaster consisting of an earthquake, tsunami and nuclear accident, the purpose of this Act is to promote a smooth and prompt reconstruction following the Great East Japan Earthquake and the revitalization of a vibrant Japan by way of setting forth basic principles on reconstruction in response to the Great East Japan Earthquake, securing financial resources for the reconstruction, creating a System of Special Zones for Reconstruction and deciding on other fundamental issues so as to create an economy and society where current and future generations can lead safe and prosperous lives and by way of deciding on basic guidelines regarding the establishment of a Reconstruction Headquarters in Response to the Great East Japan Earthquake and a Reconstruction Agency. (Act No. 76, 2011)

◆ Basic Environment Law (P 11, 20, 57, 73)

The purpose of this act is to comprehensively and systematically promote policies for environmental conservation to ensure healthy and cultured living for both the present and future generations of the nation

as well as to contribute to the welfare of humanity, through articulating the basic principles, clarifying the responsibilities of the national government, local governments, corporations and citizens, and prescribing the basic policy considerations for environmental conservation. (Act No. 91, November 19, 1993)

◆ Basic Policy for Emergency Response on Decontamination Work (P 17, 19, 26, 52, 58, etc.)

This policy showed that in areas under evacuation orders, the national government conducts decontamination, that the long-term goal in these areas is 20 mSv/y or less and the national government aims for additional exposure dose of 1 mSv/y or less, and the national government provides technical and financial support for the creation and implementation of decontamination plans for municipalities.
It was announced by the NERHQ on August 26, 2011.

◆ Basic Policy for the Act on Special Measures concerning the Handling of Environment Pollution by Radioactive Materials（P 18, 45, 134）

This is based on the Act on Special Measures, and covers basic or important matters concerning the Handling of Environment Pollution by Radioactive Materials, in addition to the basic direction on dealing with environmental pollution caused by radioactive materials derived from accidents in Japan, monitoring and measuring the situation of pollution of the environment by accident-derived radioactive material, treating waste contaminated with radioactive material, measuring such as decontamination of soil, collection, transportation, storage and disposal of removed soil, and dealing with environmental pollution by radioactive substances derived from other accidents.

◆ Bq (Becquerel) (P 12, 38, 40, 47, 93, etc.)

Unit of strength of radiation.

[C]

◆ Cesium (P 12, 15, 29, 38, 39, etc.)

An artificial radioactive material. In case of contamination due to an accident at a nuclear power station, two kinds of radioactive cesium are problematic: cesium-134 and cesium-137. Cesium-137 has a long half-life of about 30 years, while the half-life of cesium-134 is about 2.1 years.

◆ Cleanup program (P 48)

A program to clean up environmentally polluted sites by the Environmental Management Bureau of the US Department of Energy (DOE) following the end of the Cold War nuclear weapons production.

◆ Comprehensive Handbook for Residential Area Management (P 96)

This is one of the outcomes of the EURANOS project that the European Union (EU) Commission conducted for the purpose of preparing for emergency situations involving radiation such as nuclear power accidents.

The Japan Atomic Energy Society translated this Handbook and announced it as the "EURANOS Data Sheet" on August 12, 2011.

◆ Controlled final landfill site (P 12)

A disposal facility that has the function of safely storing waste (with waterproofing to prevent the contamination of groundwater and public waters by leachate from waste (by covering the side and bottom of the landfill site with plastic sheets, etc.)), with a water collection facility that collects leachate, and a final disposal site that can also process any leachate collected.

[D]

◆ Declaration of a Nuclear Emergency Situation (P 1)

An emergency declaration issued by the Prime Minister based on the Act on Special Measures concerning Nuclear Emergency Preparedness.

◆ Decontamination Countermeasure Business Grant (P 80, 94, 114)

Grants to be delivered by Fukushima Prefecture within the budget in order to promote the decontamination of municipalities that need to remove contamination by radioactive substances due to the accident at the Tokyo Electric Power Fukushima Daiichi Nuclear Power Station caused by the Great East Japan Earthquake, to the municipality, according to the definition of "Regulations concerning delivery of subsidies etc. of Fukushima prefecture" (Fukushima Prefecture Regulation No. 107 of 1970) and the "Decontamination countermeasure project grant payment summary outline."

◆ Decontamination Guidelines (P 22, 27, 32, 78, 96, 106, etc.)

Materials specifically describing the Ordinance of the Ministry of the Environment, etc. that determine the criteria for measures such as decontamination of soil, etc. and the standards for treatment of removed soils based on the Act on Special Measures concerning the Handling of Environment Pollution by Radioactive Materials.

The first edition came out in December 2011, and it was revised thereafter.

◆ Decontamination Information Site (P 25, 27, 221, 288)

A portal website operated by MOE that aggregates and disseminates information and tools related to decontamination work.

◆ Decontamination implementation plans (P 6, 17, 18, 23, 31, etc.)

Implementation plans for the national government to conduct decontamination in Special Decontamination Areas (SDA) and municipalities to conduct decontamination in Intensive Contamination Survey Areas (ICSA), specifying the implementation of surveys and measurement on the status of pollution, as well as areas, the entities, and the methods of implementing decontamination.

◆ Decontamination Model (Demonstration) Projects (P 22, 44, 59, 66, 72, etc.)

Projects conducted for demonstration testing of technologies, etc., necessary for effective implementation of decontamination. The results and achievements were utilized for decontamination work.

◆ Decontamination Promotion Package (P 23, 31, 79)

In order to further accelerate work and resolve anxiety concerning decontamination as the foundation of Fukushima's reconstruction and revitalization, MOE compiled measures and released this document on October 23, 2012.

◆ Decontamination Technical Catalog (P 18, 96)

On November 22, 2011 the Cabinet Office publicly released the "Decontamination Technical Catalogue" based on the results of decontamination activities and the "EURANOS Data Sheet" prepared by the Japan Atomic Energy Society.

This technical catalogue describes the decontamination techniques for 23 types of decontamination targets.

◆ Deliberate Evacuation Areas (P 2, 4, 5, 12, 63, etc.)

A category of evacuation areas designated immediately after the accident at TEPCO Fukushima Daiichi Nuclear Power Station.

These were areas with a cumulative dose of up to 20 mSv/y within a period of one year after the power station accident, where deliberate evacuation was requested to another location within approximately one month.

[E]

◆ Evacuation-Prepared Areas in Case of Emergency (P 2, 4, 5, 8)

A category of evacuation areas designated immediately after the accident at the TEPCO Fukushima Daiichi Nuclear Power Station.

In the area within the radius of 20 km to 30 km from the power station, areas where sheltering indoors or and evacuation could be requested in case of an emergency, so preparations had to be made to be always ready to shelter indoors or evacuate in the case of an emergency.

◆ Evidence (P 95)

Rationale or basis to prove a fact.

◆ Existing exposure situation (P 17, 51, 52, 59, 385, etc.)

The International Commission on Radiological Protection (ICRP) establishes standards of protection in the following three situations: normal circumstances where human exposure can be managed systematically (planned exposure situation), emergency situations such as accidents and nuclear terrorism (emergency exposure situation), and situations such as during recovery and reconstruction after an accident (existing exposure situation).

Situations such as during recovery and reconstruction (existing exposure situation) are situations where the source or sources already exist when decisions to control them are taken, and the reference level is in a low dose range of 1 to 20 mSv/y.

[F]

◆ Flexible container (P 101, 104, 186, 222, 226, etc.)

Medium containers made of soft material such as woven fabric or resin film, with straps for lifting, and an opening for filling and emptying the contents.

The soil etc. removed by decontamination is put into flexible containers or large container bags, etc. Next, it is placed on a water-impermeable layer (a waterproof sheet such as a water-impermeable sheet), and the upper part is covered with a waterproof sheet or the like. In some cases these are abbreviated in Japanese as "flecon."

◆ For Accelerating the Reconstruction of Fukushima From the Nuclear Disaster (P 33, 36, 92, 140, 295)

With the aim of adding and expanding necessary measures such as early return and new life support to accelerate the reconstruction and restoration of Fukushima from the nuclear disaster of the TEPCO Fukushima Daiichi NPS, on December 20, 2013, this statement was announced by the Nuclear Emergency Response Headquarters and was subsequently revised.

◆ Fukushima Prefecture Whole Area Decontamination Model Project (P 22, 96, 98)

A model project conducted by Fukushima Prefecture in the Onami district of Fukushima City. Following decontamination methods indicated in the Decontamination Guidelines, in an area with an additional exposure dose of 1 mSv/y to 20 mSv/y, it aims to decontaminate a certain whole area to verify the effect of reducing the radiation dose, and to compile the findings obtained in this model project as a handbook.

◆ Fukushima Revitalization Acceleration Grants (P 139)

In order to accelerate reconstruction, these are grants to support collective measures, from supporting long-term evacuees to responding to their early return.

The target of the grants consist of five items: the establishment of an environment for evacuees to return; the formation of living bases for long-term evacuees (community revival subsidies); emergency support such as Fukushima settlement (child revitalization grants); supporting removal and treatment of sediments in gutters of roads, etc.; and improvement of basic facilities such as dissemination of nuclear disaster information.

[G]

◆ General public (P 17, 33, 47, 51, 59, etc.)

People other than those people who deal with radiation as part of work.

International Commission on Radiological Protection (ICRP) sets dose limits according to the

circumstances of human exposure for the general public and radiation workers.

◆ Guidelines for Municipal Decontamination Work (P 18, 98)

These guidelines were announced by the NERHQ on August 26, 2011 to stipulate the decontamination implementation plans necessary for each municipality, to implement decontamination efficiently and effectively, including decontamination work, installation and management of Temporary Storage Sites, and response after implementation of decontamination, etc.

◆ Guidelines for Waste (P 22, 32, 106)

Based on the Act on Special Measures concerning the Handling of Environment Pollution by Radioactive Materials, these guidelines explain the regulations of the Act on Special Measures concerning the Handling of Environment Pollution by Radioactive Materials and relevant ministerial ordinances and concrete methods, etc., about the survey, storage, collection, transportation and disposal of waste contaminated with accident-derived radioactive substances, in an easy-to-understand manner, for entities that dispose of waste, including waste emitters, municipalities, etc.

The first version was announced in December 2011 and the second version was announced in March 2013.

[H]

◆ Habitation Restricted Areas (P 6, 33, 36, 78, 136, etc.)

A category the area designated by reviewing evacuation areas.

Areas where the NERHQ compiled the “Target of Step 2” on December 26, 2011, where there was a danger that the annual cumulative dose may exceed 20 mSv/y, and the continuation of evacuation was sought from the viewpoint of reducing residual exposure dose. Decontamination and reconstruction of infrastructure were promoted here with the aim of enabling residents to return home in the future and rebuild the community.

◆ Half-life (P 39, 363)

The physical half-life is the time until the atomic nucleus of a certain radioactive substance changes to another nucleus by releasing radiation and the original radioactive substance is reduced to half.

◆ High-pressure water washing (P 14, 99, 100, 105, 116, etc.)

One method of decontamination. Washing with high pressure (e.g., 15 megapascals) of water jet.

[I]

◆ Improper decontamination (P 31, 32, 87, 109, 263, etc.)

Activity that violate the Act on Special Measures concerning the Handling of Environment Pollution by Radioactive Materials, etc. The MOE has established the “Headquarters for Promoting Proper Decontamination,” conducts surveys, and compiles measures to prevent recurrence of improper

decontamination.

◆ Individual dose record book (P 132, 243, 247)

A passbook issued based on a "radiation dose registration and management system for decontamination workers, etc." in order to conduct unified tracking of exposure doses of decontamination workers. It contains a worker's registration number, exposure history, health checkup, and radiation protection education history, etc.

◆ Intensive Contamination Survey Areas (P 17, 26, 28, 43, 52, etc.)

Based on the Act on Special Measures concerning the Handling of Environment Pollution by Radioactive Materials, targeting municipalities including areas with 0.23 μSv/h or more, areas designated based on opinions of relevant municipalities and others. The designated municipalities decide their decontamination implementation plans based on survey measurement results, etc., of the pollution situation, and decide on the areas where decontamination is to be carried out.

◆ International Atomic Energy Agency (IAEA) (P 11, 35, 42, 48, 51, etc.)

It was launched on July 29, 1957 with the aim of promoting the peaceful use of nuclear power and preventing nuclear power from being diverted from peaceful use to military use.

◆ Interim report of the efforts of the four cities (P 326)

In order to solve issues of dose reduction by decontamination and relieve residents' anxiety, issues were raised from four cities (Fukushima City, Koriyama City, Soma City and Date City), and a workshop was held by the national government and the four cities, and this interim report was announced in August 2014.

◆ Interim Storage Facility (P 18, 69, 75, 77, 91, etc.)

Facilities for safe intensive management and storage during the final disposal of soil removed by decontamination or waste contaminated with radioactive materials (more than 100,000 Bq/kg) in Fukushima Prefecture.

◆ International Commission on Radiological Protection (ICRP) (P 11, 48, 51, 59, 329, etc.)

It was reorganized from the International X-ray and Radium Protection Committee in 1950, and recommended the basic framework of radiation protection and protection standards.

It consists of the main commission and five standing committees (Radiation Effects, Doses from Radiation Exposure, Protection in Medicine, Application of the Commission's Recommendations, and Radiological Protection of the Environment).

ICRP stands for "International Commission on Radiological Protection."

◆ Inversion tillage (P 112, 113, 152, 159, 164, etc.)

One method of decontamination, used to turn over the soil using plows (agricultural tools used in tilling

work etc.) so that the contaminated surface layer is placed in the lower layer and the soil without contamination of the lower layer is placed on the surface layer. The cultivation depth of inversion tillage is generally 30 centimeters.

◆ Investigative Committee on the Status of Enforcement of the Act on Special Measures（P 35, 297, 298, 299）

The full name is the "Investigative Committee on the Status of Enforcement of the Act on Special Measures concerning the Handling of Environment Pollution by Radioactive Materials."

A review committee established by MOE to examine the Status of Enforcement of the Act on Special Measures concerning the Handling of Environment Pollution by Radioactive Materials

◆ Iodine (P 38, 39, 40, 47, 335, etc.)

Iodine-131 is an artificial radioactive material.

Its half-life is as short as about 8 days, but if it enters the body, 10 to 30% accumulates in the thyroid gland.

◆ Isotope Labo. (P 90)

Isotope laboratories, research institutes and laboratories.

[J]

◆ J Village (P 88)

It was the first facility opened as Japan's first football and national training center in 1997, and it is under suspension as a result of the Great East Japan Earthquake that struck and the TEPCO Fukushima Daiichi NPS accident.

After the TEPCO Fukushima Daiichi NPS accident, it was used as a screening venue and TEPCO "Fukushima Reconstruction Headquarters," etc., and use will be resumed in the spring of 2018.

[L]

◆ Leachate (P 126, 127, 226, 35, 243, etc.)

Water from rain that has fallen on a Temporary Storage Sites, has penetrated through seams in covering sheets, and leached out.

[M]

◆ Mower (P 116, 118, 187, 194, 195, etc.)

Measures necessary prior to decontamination of grasslands, lawns and forests. Cutting away weeds, shrubs, etc. by chain saws, hanging-type mowers, etc.

[N]

◆ NaI scintillation type survey meter (P 53)

A type of external radiation measurement equipment. It is suitable for gamma ray and air dose measurements on the order of 10 μSv/h from the environmental level.

◆ Nuclear Safety Commission (P 12, 51, 52, 59, 385, 387)

Based on the Atomic Energy Basic Act, the Act for Establishment of the Japan Atomic Energy Commission and the Nuclear Safety Commission, and Act for Establishment of the Cabinet Office, this is one of the commissions established in the Cabinet Office for the purpose of deciding the basic approach to safety regulation by the national government, in an independent neutral position and playing the role of instructing administrative agencies and business operators. It was abolished in September 2014 and transferred to the Nuclear Regulation Authority.

◆ Nuclear Damage Compensation and Decommissioning Facilitation Corporation (P 92)

In the event of large-scale nuclear damage, in order to promptly and appropriately implement compensation for nuclear damages and secure a stable supply of electricity by conducting business such as issuing necessary funds for compensation of damage by nuclear power companies, the Nuclear Damage Compensation Facilitation Corporation was established on September 12, 2011.

Thereafter, from August 18, 2014, it was restructured as the Nuclear Damage Compensation and Decommissioning Facilitation Corporation, with added responsibilities to ensure proper and steady implementation of decommissioning of nuclear reactors.

◆ Nuclear Emergency Response Headquarters (NERHQ) (P 1, 2, 4, 5, 6, etc.)

In order to promote emergency measures to address a nuclear emergency in relation to the accident at TEPCO Fukushima Daiichi Nuclear Power Station, this was established within the Prime Minister's official residence on March 11, 2011 based on the Act on Special Measures concerning Nuclear Emergency Preparedness.

[O]

◆ Obtaining consent (P 23, 32, 44, 45, 46, etc.)

Obtaining consent from landowners, etc. (about decontamination work and Temporary Storage Sites installation).

◆ Official gazette (P 149)

A daily agency publication issued by National Printing Bureau, Independent Administrative Institution in order for the national government to inform the general public of legislation, treaties, budgets, notifications, parliamentary affairs, personnel affairs, and appointments, etc.

◆ Overall check on progress of decontamination (P 32)

In order to confirm the progress of the decontamination work, MOE conducted a comprehensive review on the progress of decontamination in Special Decontamination Areas and Intensive Contamination Survey Areas designated under the Act on Special Measures concerning the Handling of Environment Pollution by Radioactive Materials. It was announced on September 10, 2013.

[P]

◆ Plutonium (P 38, 39, 40, 47, 48)

Plutonium-238, -239, and -240 are artificial radioactive materials.
Their half-lives are about 88 years, 24,100 years, and 6,540 years, respectively.

◆ Policy for Decontamination in Special Decontamination Areas (Decontamination Roadmap) (P 23, 63, 65, 66, 68, etc.)

As a decontamination policy for Special Decontamination Areas, this policy shows the flow of model demonstration projects, advance decontamination, and whole-area decontamination, and the work flow in each area. MOE announced it on January 26, 2012.

◆ Post decontamination monitoring (P 94, 285, 286, 288, 289, etc.)

After decontamination, to verify whether decontamination effects are maintained, periodically and continuously monitoring and measuring the air dose rate.

◆ Preparation Areas for Lifting of Evacuation Orders (P 6, 78, 241, 254, 273, etc.)

An area confirmed to be sure that the annual accumulated dose will be 20 mSv/y or less, among the areas where NERHQ summarized the “goal of step 2” on December 26, 2011 and that the cumulative dose for one year after the accident could exceed 20 mSv/y.

◆ Principle of justification (P 328)

One of the three principles of protection of International Commission on Radiological Protection (ICRP). The principle that actions using radiation are acceptable only when the benefits provided exceed the radiation risk.

◆ Protected forest (P 408)

Forest designated by the Minister of Agriculture, Forestry and Fisheries (MAFF) or the prefectural governor in order to achieve specific public benefit objectives, such as recharging of water sources, and preventing the collapse of earth and sand or other disasters, as well as the conservation and formation of the living environment, etc.

[R]

◆ Radioactive materials (P 1, 6, 11, 12, 13, etc.)

The ability to emit radiation is called “radioactivity,” and substances with this ability are called “radioactive materials.”

“Radiation” is similar to light rays, has the ability to penetrate material, and includes α (alpha) rays, β (beta) rays, γ (gamma) rays, X-rays, and neutron beams, etc.

◆ Removed soil, etc. (P 19, 26, 31, 69, 101, etc.)

Wastes generated by decontamination, etc., such as decontamination soil and soil, etc.

◆ Risk communication (P 24, 27, 28, 31, 32, etc.)

Information on chemical substances such as environmental risk is shared by all actors, including citizens, industry, governments, etc., with the aim of achieving communication and mutual understanding through the exchange of opinions.

◆ Restricted Area (P 2, 3, 4, 5, 6, etc.)

A category of evacuation areas designated immediately after the accident at TEPCO Fukushima Daiichi Nuclear Power Station.

These were areas within a radius of 20 km radius from the power station where entry was prohibited or an order was made to leave for all persons except those engaged in emergency response measures, except for cases where the municipal mayor temporarily approved entry.

[S]

◆ Silt (P 314)

This has an intermediate grain size between sand and clay, which is 1/16 to 1/256 mm in geological terms and 0.02 to 0.002 mm in soil sciences. What is commonly referred to as mud includes silt and clay.

◆ Special Decontamination Areas (P 6, 23, 25, 32, 58, etc.)

Based on the Act on Special Measures concerning the Handling of Environment Pollution by Radioactive Materials, a designated area as a region where the national government formulates decontamination plans and advances decontamination work.

Basically, this means “Deliberate Evacuation Areas” where the cumulative dose for one year after the accident exceeds 20 mSv/y and “Restricted Areas” within the radius of 20 km from Tokyo Electric Power Fukushima Daiichi Nuclear Power Station.

◆ Specific Spots Recommended for Evacuation (P 2, 4, 5, 29)

Locations that are outside the Deliberate Evacuation Areas and Restricted Areas, where the cumulative radiation dose for one year after the accident is estimated to exceed 20 mSv/y, although the regional extent is not large enough for them to be designated as Deliberate Evacuation Areas.

◆ Stakeholders (P 44, 48, 134, 323, 324, etc.)

Persons who are entitled to impede the implementation of measures such as decontamination of soil and the like with respect to the land on which the measures such as decontamination of soil etc. are to be carried out or on the workpieces, standing trees and other objects existing in the land, which are to be implemented on the land.

◆ Strontium (P 38, 39, 40, 47)

Strontium-90 is an artificial radioactive material. The physical half-life is about 29 years. Since its half-life is long and chemical properties are similar to calcium, it accumulates in bone if it enters the body.

◆ Sv (Sievert) (P 2, 3, 6, 7, 8, etc.)

Unit of radiation exposure dose in Sieverts (Sv) received by a person per unit time.

[T]

◆ Technical Document for Decontamination of Farmland (P 98, 111, 135)

A document by the Ministry of Agriculture, Forestry and Fisheries (MAFF) with the aim of contributing to the appropriate and efficient implementation of decontamination of agricultural land, and compiling information on criteria such as survey, design, accumulation and work management required for decontamination of agricultural land, based on the results of demonstration projects of measures for decontamination of agricultural land. MAFF published it as a technical document in February 2013.

◆Tellurium (P 38, 39)

Tellurium-129 is an artificial radioactive material. Its half-life is about 34 days.

◆ Temporary Storage Sites (P 17, 19, 24, 29, 45, etc.)

A place to temporarily store bags of removed materials such as soil and grass collected by decontamination work.

◆ Topsoil removal (P 13, 14, 15, 112, 212, etc.)

One method of decontamination. A method of removing the topsoil thinly and removing radioactive material accumulated in the soil surface layer.

[U]

◆ UNSCEAR (P 329)

Abbreviation for “United Nations Scientific Committee on the Effects of Atomic Radiation.”

This committee was established for the purpose of evaluating reports on the observed levels of ionizing radiation and radioactivity in the environment and reports on the effects of ionizing radiation on people and their environment, and reporting to the UN General Assembly, as a scientific committee under

jurisdiction of the United Nations, in accordance with the UN General Assembly resolution of 1955.

[W]

◆ Water collection tank (P 226, 234)

At Temporary Storage Sites, the tanks used to store leachate.

When a certain amount of water has accumulated in the catchment tank, the radioactive cesium concentration (Cs) is to be checked, and if it is below the control value (Cs-134 concentration / 60 + Cs-137 concentration / 90 ≦ 1), it can be discharged.

◆ Whole area decontamination (P 22, 23, 24, 26, 27, etc.)

Based on demonstration projects and advance decontamination in decontamination work, whole-area full-scale decontamination conducted by the national government and municipalities.

◆ Whole body counter (P 82, 246, 306, 319)

Measuring device that from the outside of the human body detects gamma rays emitted from radioactive materials deposited inside the human body. Radionuclides to be measured are gamma ray emitting nuclides, such as manganese-54, cobalt-60, and cesium-137, etc.

[X]

◆ Xenon (P 38, 39, 40)

Xenon-133 is an artificial radioactive material. The half-life is short at about five days, and even if it is taken into the body by respiration, it does not stay in the body.

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