IAEA Review of Safety Related Aspects of Handling ALPS-Treated Water at TEPCO's Fukushima Daiichi Nuclear Power Station

Report 1: Review Mission to TEPCO and METI (February 2022)

IAEA
International Atomic Energy Agency

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Executive Summary

The IAEA conducted its first review mission to Japan's Tokyo Electric Power Company Holdings, Inc. (TEPCO) and the Ministry of Economy, Trade and Industry (METI) in 13–19 February 2022. This mission was conducted under the terms of reference for the IAEA's assistance to Japan on the Review of Safety Aspects of ALPS (Advanced Liquid Processing System) Treated Water at TEPCO's Fukushima Daiichi Nuclear Power Station (FDNPS) and formed part of the review component relating to the assessment of protection and safety. The mission conducted was the first mission in a series of missions that will be conducted in the coming months and years. The review team, coordinated and led by a senior IAEA official, included 15 members. The review team members are comprised of international experts who are designated members of the Task Force and experts from the IAEA Secretariat.

Consistent with the request from the Government of Japan, the IAEA Statutory Functions and the mandate of the Task Force, the scope of the IAEA review is tailored to assessing safety related aspects of the implementation of Japan's *Basic Policy on Handling of ALPS Treated Water at the Tokyo Electric Power Company's Holdings' Fukushima Daiichi Nuclear Power Station* against the IAEA's International Safety Standards[1]. The current approach outlined in the Basic Policy is to conduct a series of controlled discharges of ALPS treated water into the sea ('batch discharges') over a period of approximately 30 years. This mission was conducted focusing on the specific approach outlined in the Basic Policy, controlled discharge to the sea, consistent with the request from the Government of Japan.

To implement this approach, TEPCO has proposed amendments to its Implementation Plan (i.e. its regulatory authorization to conduct decommissioning activities), including conducting a safety assessment and developing a radiological environmental impact assessment (REIA). The mission scope covered: the proposed discharge system and process equipment, the tanks containing ALPS treated water that will be connected to the discharge system (i.e. K4 tank group), the associated operational and engineered safety controls, the safety assessment of the discharge including a prospective REIA conducted by TEPCO, and the radiation protection programme established and maintained by TEPCO. In general, the site's comprehensive decommissioning activities were considered outside the scope of this mission and the IAEA's overall safety review.

The review against the relevant IAEA international safety standards was organized into the following eight technical topics:

1. Crosscutting requirements and recommendations
2. Characterization of discharge/source term
3. Safety related aspects of systems and processes for controlling discharges
4. Radiological environmental impact assessment (REIA)
5. Regulatory control and authorization for discharges
6. Source and environmental monitoring programmes
7. Involvement of interested parties
8. Occupational radiation protection

During the mission, the Task Force received the full cooperation from counterparts in TEPCO and METI and noted a commitment to the successful completion of the IAEA's review. In preparation, TEPCO and the Government of Japan provided the Task Force with a self-evaluation of their activities against the requirements and recommendations established in the IAEA Safety Standards that are applicable to the handling of ALPS treated water. Additionally, presentations were provided to the Task Force for

[1] The international safety standards established by the IAEA constitute the global reference for protecting people and the environment. They contribute to a harmonized high level of safety worldwide. The process of developing, reviewing, and establishing the IAEA standards involves the IAEA Secretariat and all IAEA Member States. The IAEA does this in consultation with the competent organs of the United Nations and with the specialized agencies concerned.

each technical area to summarize the information provided in the reference materials and to provide additional explanations on complex topics. Over the course of the week a wide range of technical topics were discussed, and the details of these discussions are included in Part II of this report. Several high-level observations from the Task Force are summarized as follows:

- Many Safety Requirements that are relevant to the IAEA's review are overarching and crosscutting in nature (e.g. governmental framework, responsibility for safety, optimization of protection and safety of workers and members of the public). The Task Force will continue assessing Japan's compliance with these requirements and will draw final conclusions at the end of the review process once all relevant information has been considered and a holistic assessment can be performed.

- The Task Force developed a more robust understanding of the key technical documents relevant to this review, such as the REIA and the revised Implementation Plan. Several areas for further discussion and clarification were identified during the mission, such as the characterization of the source term (i.e. the ALPS treated water being discharged), how the concept of optimization is being addressed in different stages of the process, the application of a dose constraint and discharge limits, and how abnormal events and external hazards, and their impacts, are considered.

- In addition, the Task Force was also able to witness the early design and preparations taking place at the FDNPS site, including the planned construction of the infrastructure needed for discharging the water, which will comprise a water dilution facility, a discharge shaft as well as an undersea tunnel carrying the treated water into the sea.

- The Task Force noted that the development of the source and environmental monitoring programmes are still in progress through discussions with the regulatory body and other government ministries. The Task Force will continue to follow the development of these monitoring programmes and take them into account in the development and implementation of the IAEA's independent sampling, data corroboration and analysis activities.

- METI provided a detailed explanation of how interested parties and the public have been consulted so far during the process leading up to, and following, the issuance of the Basic Policy. The Task Force noted the significant efforts made so far and will continue observing how interested parties are involved in the process moving forward.

The Task Force noted significant progress from the review mission and highlighted its satisfaction with the next steps identified by TEPCO, METI and the review team. The work is still in progress and the IAEA Task Force will continue its thorough review in order to be able to provide its conclusions.

A second mission to TEPCO and METI is currently planned for the second half of 2022. This second mission will provide an opportunity to follow up on TEPCO and METI's progress on technical topics, and to review the updated versions of the REIA and the Implementation Plan.

This mission report reflects the discussions between the Task Force and Japan and documents observations from the Task Force. This report was written and approved by the IAEA Task Force and has been published by the IAEA on its public website. This report, and other mission reports under the IAEA's review, is intended to serve as a progress report and final conclusions will not be drawn while the IAEA's review is still ongoing. Prior to the discharge of the ALPS treated water starting, the IAEA will issue a full report containing the combined conclusions of the Task Force across all aspects of the IAEA's review. This full report will include the final findings and conclusions of the Task Force.

I. Part I

I.1. Introduction and Background

In April 2021, Japan announced the *Basic Policy on Handling of ALPS Treated Water at the Tokyo Electric Power Company's Holdings' Fukushima Daiichi Nuclear Power Station*, which includes a plan to discharge the treated water from the advanced liquid processing system (ALPS) into the sea surrounding the plant, subject to domestic regulatory approvals. Soon after, the Japanese authorities requested assistance from the IAEA to monitor and review those plans and activities relating to the discharge of the treated water to ensure they will be implemented in a safe and transparent way and they will be in accordance with the IAEA's international safety standards[2]. The IAEA welcomed and accepted the request made by Japan.

In July 2021, the IAEA and the Government of Japan signed the Terms of Reference for IAEA Assistance to Japan on Review of Safety Aspects of ALPS Treated Water at Tokyo Electric Power Company Holdings, Inc. (TEPCO) Fukushima Daiichi Nuclear Power Station (FDNPS). These terms of reference set out the broad framework that the IAEA will use to implement its review. In September 2021, the IAEA sent a team to Tokyo, for meetings and discussions to finalize the agreement on the scope, key milestones and approximate timeline for the Agency's review. The team also travelled to the FDNPS to discuss technical details with experts at the site and to identify key activities and locations of interest for the Agency's review.

The Agency's assistance to Japan will consist of a technical review to assess whether the operation to discharge the treated water over the coming decades is in accordance with the IAEA international safety standards. The IAEA will also undertake activities for the corroboration of the source and environmental monitoring programmes of TEPCO before, during and after the discharges. This review will be conducted on the basis of reference materials submitted by Japan and the outcomes of review missions. The IAEA will examine key safety elements of Japan's plan, including the following:

- The radiological characterization of the treated water to be discharged.
- The safety-related aspects of the treated water discharge process, including the equipment to be used and the criteria to be applied and observed for operations.
- The assessment of the radiological environmental impact related to ensuring the protection of people and the environment.
- The environmental monitoring associated with the discharge.
- The regulatory control, including authorization, inspection and ongoing assessment of the discharge plan.

The IAEA's review will be organized into the following three major components to ensure all key safety elements are adequately addressed:

- **Assessment of Protection and Safety** – This component is focused on reviewing technical aspects of the Implementation Plan, radiological environmental impact assessment (REIA), and other supporting materials prepared by TEPCO as part of their submission for regulatory approval of the discharge of ALPS treated water. This component will primarily be coordinated with TEPCO and the Ministry of Economy, Trade, and Industry (METI)[3] and will look at the

[2] The international safety standards established by the IAEA constitute the global reference for protecting people and the environment. They contribute to a harmonized high level of safety worldwide. The process of developing, reviewing, and establishing the IAEA standards involves the IAEA Secretariat and all IAEA Member States. The IAEA does this in consultation with the competent organs of the United Nations and with the specialized agencies concerned.

[3] METI, as a government ministry, is the competent authority for overseeing the decommissioning of the FDNPS. Prior to the announcement of the Basic Policy, METI took a leading role in conducting studies for the handling of ALPS treated

expected actions to be performed by TEPCO throughout the process, as defined in the relevant IAEA international safety standards.

- **Regulatory Activities and Processes** – This component is focused on assessing whether the Nuclear Regulation Authority's (NRA) review and approval process is conducted in accordance with the relevant IAEA international safety standards. This component will primarily be coordinated with NRA as the independent regulatory body responsible for nuclear safety within Japan; it will focus only on the regulatory aspects relevant for NRA's review of the discharge of ALPS treated water from the Fukushima Daiichi Nuclear Power Station.

- **Independent Sampling, Data Corroboration and Analysis** – This component includes all activities associated with the IAEA's independent sampling and analysis that will be performed to corroborate the data from TEPCO and the Government of Japan associated with the ALPS treated water discharge. Samples will be analysed by IAEA laboratories as well as independent third-party laboratories. Additionally, this component also includes the corroboration of occupational exposure.

To implement the IAEA's review in a fully transparent and inclusive manner, the IAEA Director General established a Task Force. The Task Force operates under the authority of the IAEA and is chaired by a senior IAEA official. The Task Force includes internationally recognized experts with extensive experience from a wide range of technical specialties and experts from the IAEA Secretariat. These experts will support the review and serve on the Task Force in their individual professional capacity to help ensure the IAEA's review is comprehensive, benefits from the best international expertise and includes a diverse range of technical viewpoints.

The IAEA will conduct its review through a combination of review and analysis of documentation, and review missions and verification activities. At the start of the review, the Government of Japan and TEPCO provided several background materials with information pertaining to the proposed discharge of ALPS treated water. Subsequently, additional materials have been provided upon request by the Task Force, or when ready for submission by TEPCO to the relevant Japanese authorities. This information is carefully reviewed by the Task Force members and forms the basis for the review missions with relevant authorities. The purpose of the review missions is to review the reference materials submitted by the Government of Japan or TEPCO, seek clarification on technical issues, request additional information and observe on-site activities, as appropriate. Additionally, to support the independent sampling and analysis activities, the Task Force will conduct discussions and on-site sampling activities as needed; these activities will include independent third-party laboratories, when possible, to ensure that an inclusive and transparent approach is adopted.

The IAEA's review will extend over several years, and progress will be reported in different ways. The primary means by which progress will be shared with external interested parties is through formal reports. Reports issued after review missions will reflect discussions between the Task Force and Japan as well as document observations from the Task Force. The reports will be released approximately two months after each review mission. These reports, written and approved by the IAEA Task Force, will be published by the IAEA on its public website. However, these reports are intended to serve as progress reports and final conclusions will not be drawn while the IAEA's review is still ongoing. Prior to the discharge of the ALPS treated water starting, the IAEA will issue a full report containing the collected conclusions of the Task Force across all aspects of the IAEA's review. This full report will include the final conclusions and findings of the Task Force.

water. From this point of view, METI is included in the assessment of protection and safety component of the IAEA's review.

Additional information on the IAEA's review, as well as background information, documents, reports, and other publications can be found online at the dedicated website for the IAEA's Fukushima ALPS review.[4]

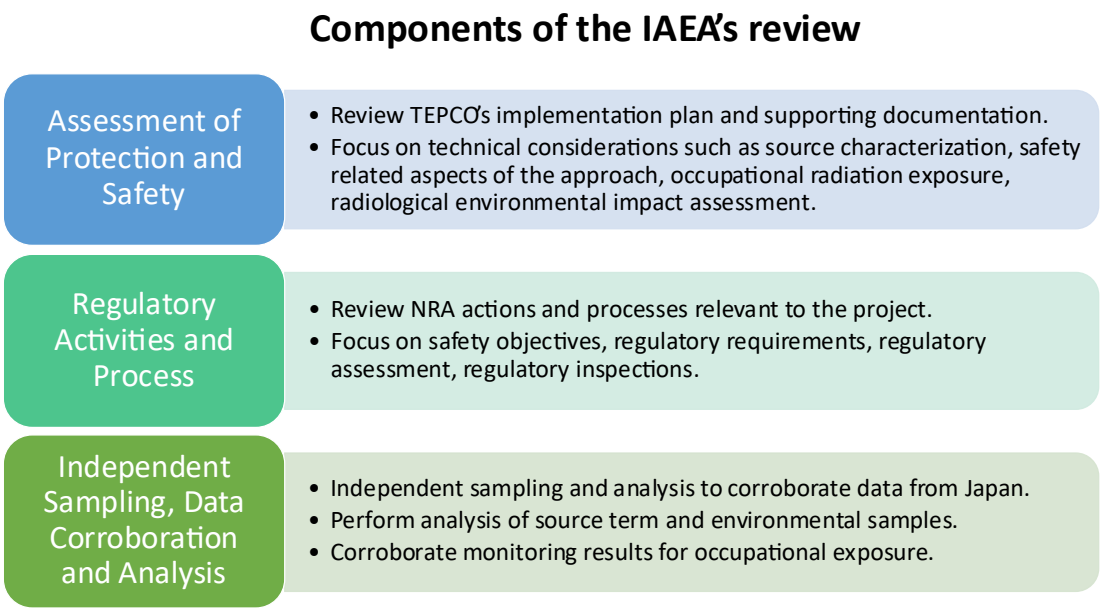

Fig. I–1. Three components of the IAEA's review of ALPS treated water discharge.

[4] https://www.iaea.org/topics/response/fukushima-daiichi-nuclear-accident/fukushima-daiichi-treated-water-discharge

I.2. Application and Description of Relevant IAEA's International Safety Standards

The IAEA's Statute authorizes the Agency to "establish or adopt… standards of safety for protection of health and minimization of danger to life and property" — standards that the IAEA must use in its own operations, and which Member States can apply by means of their regulatory provisions for nuclear and radiation safety. The IAEA does this in consultation with the competent organs of the United Nations and with the specialized agencies concerned. A comprehensive set of high-quality safety standards under regular review is a key element of a stable and sustainable global safety regime, as is the IAEA's assistance in their application.

The IAEA commenced its safety standards programme in 1958. The emphasis placed on quality, fitness for purpose and continuous improvement has led to the widespread use of the IAEA standards throughout the world. The Safety Standards Series now includes unified Fundamental Safety Principles, which represent an international consensus on what must constitute a high level of protection and safety. However, standards are only effective if they are properly applied in practice. Therefore, the IAEA is working to promote the global acceptance and use of its standards.

The IAEA's safety services encompass design, siting and engineering safety, operational safety, radiation safety, safe transport of radioactive material and safe management of radioactive waste, as well as governmental organization, regulatory matters and safety culture in organizations. These safety services assist Member States in the application of the standards and enable valuable experience and insights to be shared. Regulating safety is a national responsibility, and many States have decided to adopt the IAEA's standards for use in their national regulations. For parties to the various international safety conventions, IAEA standards provide a consistent, reliable means of ensuring the effective fulfilment of obligations under the conventions.

Fig. I–2. The hierarchy of the IAEA safety standards.

The IAEA international safety standards are also applied by regulatory bodies and operators around the world to enhance safety in nuclear power generation and in nuclear applications in medicine, industry, agriculture and research. Safety is not an end in itself but a prerequisite for the purpose of the protection of people in all States and of the environment — now and in the future. The risks associated with ionizing radiation must be assessed and controlled without unduly limiting the contribution of nuclear energy to equitable and sustainable development. Governments, regulatory bodies and operators everywhere must ensure that nuclear material and radiation sources are used beneficially, safely and ethically. The IAEA international safety standards are designed to facilitate this, and all Member States are encouraged to make use of them.

For the purpose of this review, the Task Force identified several IAEA international safety standards that are relevant for the proposed discharge of ALPS treated water into the sea. These standards address radiation protection and the safety of radiation sources, regulatory control over radioactive discharges to the environment, the structure and content of radiological environmental impact assessments, and methods for conducting environmental and source monitoring. While all IAEA international safety standards will be consulted as needed by the Task Force, the following are the primary safety standards referenced during this review:

- IAEA Safety Standards Series No. SF-1, Fundamental Safety Principles: Safety Fundamentals [1];
- IAEA Safety Standards Series No. GSR Part 3, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards [2];
- IAEA Safety Standards Series No. GSG-7, Occupational Radiation Protection [3];
- IAEA Safety Standards Series No. GSG-9, Regulatory Control of Radioactive Discharges to the Environment [4];
- IAEA Safety Standards Series No. GSG-10, Prospective Radiological Impact Assessment for Facilities and Activities [5];
- IAEA Safety Standards Series No. RS-G-1.8, Environmental and Source Monitoring for Purposes of Radiation Protection [6].

I.3. Overview of the Mission Scope and Structure

Consistent with the request from the Government of Japan, and the mandate of the Task Force, the scope of the IAEA review is tailored to assessing safety related aspects of the implementation of Japan's *Basic Policy on Handling of ALPS Treated Water at the Tokyo Electric Power Company's Holdings' Fukushima Daiichi Nuclear Power Station*. Within the Basic Policy, the Government of Japan outlines a plan to discharge ALPS treated water into the sea. The Task Force will conduct its review on the specific approach outlined in the Basic Policy, controlled discharge to the sea, consistent with the request from the Government of Japan. The Task Force acknowledged that the domestic regulatory review of the proposed approach is still ongoing within Japan.

The IAEA conducted its first review mission to METI/TEPCO in 13-19 February 2022. The review team comprised officially designated international experts who are members of the Task Force and experts from the IAEA Secretariat (see Annex I). The mission formed part of the IAEA review component relating to the assessment of protection and safety and included discussions with officials and experts from TEPCO and METI.

The review team held discussions with officials of METI and TEPCO (see Annex II) at the METI headquarters in Tokyo, Japan. The review team also visited the Fukushima Daiichi Nuclear Power Station in the Fukushima Prefecture, where the team received on-site briefings and explanations relating to the planned discharge of ALPS treated water. The review team visited key points of interest on-site, including the ALPS treatment building, the K4 tank storage yard, the proposed site for the mixing and dilution well, the seawater intake point, and the proposed piping pathways.

Prior to the mission, the Task Force agreed with TEPCO and METI on a structure to ensure key technical topics were adequately covered and organized (see Annex III). The review against the relevant IAEA international safety standards was organized into 8 technical topics:

1. Crosscutting requirements and recommendations
2. Characterization of discharge/source term
3. Safety related aspects of systems and processes for controlling discharges
4. Radiological environmental impact assessment (REIA)
5. Regulatory control and authorization for discharges
6. Source and environmental monitoring programmes
7. Involvement of interested parties
8. Occupational radiation protection

The proposed discharge system and process equipment, the tanks containing ALPS treated water that will be connected to the discharge system (i.e. K4 tank group), associated operational and engineered safety controls, the safety assessment of the discharge including a prospective REIA conducted by TEPCO, radiation protection programme established and maintained by TEPCO, and other changes or enhancements to the site that are envisaged as necessary to accommodate the proposed discharge were included within the review mission's scope. When necessary, documentation and explanations regarding the broader decommissioning effort were requested and reviewed to provide a holistic understanding for the Task Force; however, in general, the site's comprehensive decommissioning activities were considered outside the scope of this mission and the IAEA's overall safety review.

To support the IAEA review, TEPCO and the Government of Japan provided the Task Force with background reference materials and supporting data on key technical and operational considerations of the discharge system, such as data on contaminated water, its generation mechanisms, and status of treatment; engineering and process information for the ALPS system; characterization of ALPS treated water and measurement methods. In November and December 2021, respectively, TEPCO formally

submitted an REIA and proposed revised Implementation Plan to NRA for regulatory approval; this information was published publicly, and its translation was made available to the Task Force.

To support this review mission, TEPCO and the Government of Japan also provided the Task Force with a self-evaluation of their activities against the requirements and recommendations established in the IAEA international safety standards that are applicable to the handling of ALPS treated water. In addition, during the mission, TEPCO provided presentations for each technical area to summarize the information provided in the reference materials and to provide additional explanations on complex topics.

The mission started with an opening session attended by high-level officials from Japan who conveyed opening remarks, and the press was also in attendance. On the first day, the review team provided an overview presentation conveying their initial feedback and observations based on the Task Force's review of reference materials prior to the mission. The mission was organized around the eight technical topics that had been previously agreed with TEPCO and METI (see list of topics above). For each technical topic, TEPCO or METI, as appropriate, provided an overview presentation that summarized the information included in the reference materials and additional clarifications on issues that the Task Force had previously identified. The review team and TEPCO/METI then engaged in an open discussion to further a shared understanding of how the actions taken by TEPCO or METI comply with national regulatory requirements and with the IAEA international safety standards. At the end of the week, the review team summarized the initial observations from the review mission in a brief presentation for TEPCO/METI and engaged in follow up discussions to ensure all participants in the mission had a shared understanding of the outcomes. The major discussion themes and observations noted by the Task Force are summarized in the 'Discussion' subsections of Part II of this report.

A second mission to TEPCO and METI is currently planned for the second half of 2022. This second mission will provide an opportunity to follow up on TEPCO and METI's progress, and to review updated versions of the REIA and the Implementation Plan.

I.4. Overview of the Basic Policy and the Proposed Discharge Approach

The *Basic Policy on Handling of ALPS Treated Water at the Tokyo Electric Power Company Holdings' Fukushima Daiichi Nuclear Power Station* was issued on 13 April 2021 under the authority of the Inter-Ministerial Council of Japan for Contaminated Water, Treated Water, and Decommissioning Issues. The Basic Policy contains the Government of Japan's basic premise, relevant background and an outline for pursuing discharge of ALPS treated water into the sea. In the Basic Policy the Government of Japan notes: "In order to safely and steadily proceed with decommissioning and management of contaminated water and treated water at Fukushima Daiichi NPS, based on the ALPS subcommittee report and opinions received from parties concerned, the ALPS treated water will be discharged on the condition that full compliance with the laws and regulations is observed, and measures to minimize adverse impacts on reputation are thoroughly implemented."

The Basic Policy further notes that "…[the] discharge of ALPS treated water into the sea will be implemented at Fukushima Daiichi NPS, on the premise to make best efforts to minimize the risks by taking measures such as purification and dilution based on the ALARA principle, under strict control." In support of this decision, the Basic Policy provides background and supporting justification such as the importance of risk reduction, protecting people and the environment and ensuring that reconstruction of Fukushima can be supported. Furthermore, the Basic Policy highlights the work of the Inter-Ministerial Council in assessing other technologies for handling and managing ALPS treated water stored at the Fukushima Daiichi Nuclear Power Station.

The current approach outlined in the Basic Policy is to conduct a series of controlled discharges of ALPS treated water into the sea ('batch discharges') over a period of approximately 30 years. To implement this approach, TEPCO has proposed amendments to its Implementation Plan (i.e. its regulatory authorization to conduct decommissioning activities), including conducting a safety assessment and developing an REIA. The details of the proposed discharge approach are currently under regulatory review by the NRA and therefore may change based on the results of the domestic review.

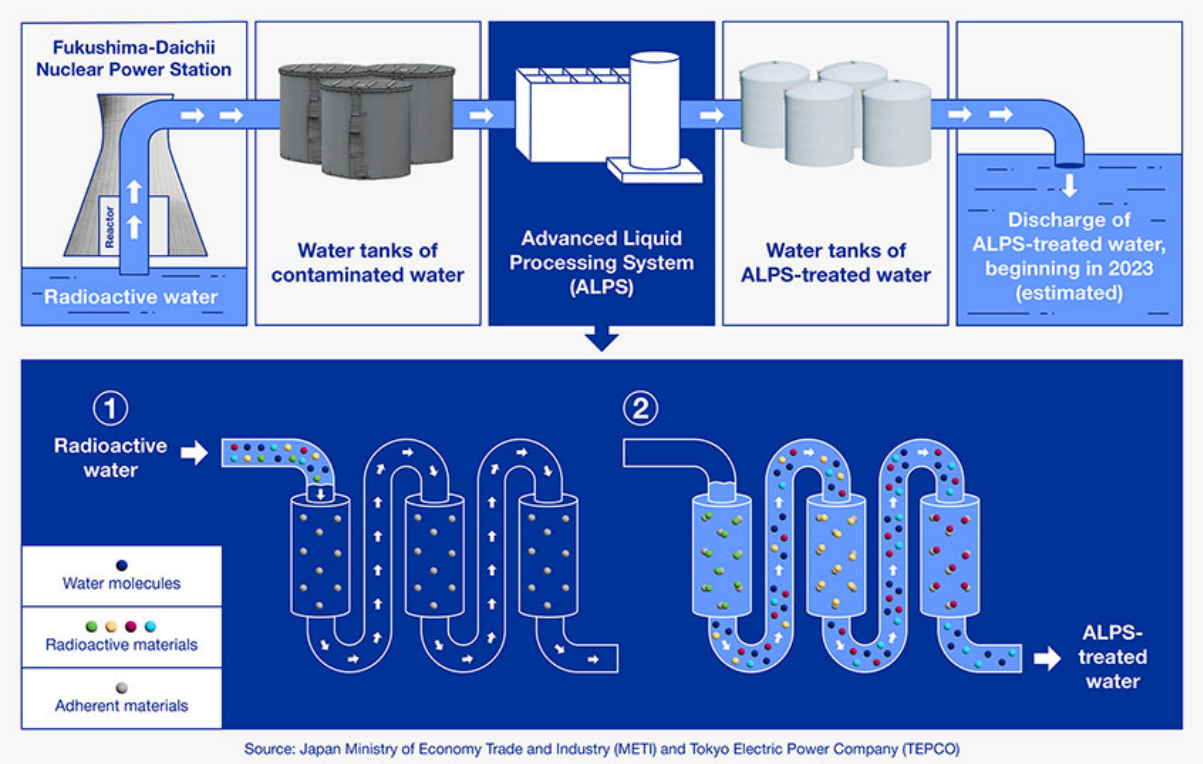

Fig. I–3. Overview of the ALPS treated water discharge system.

TEPCO is proposing to discharge ALPS treated water, after it has been analysed and after it has been confirmed that the radionuclide inventory is in accordance with the regulatory discharge limits set in the authorization. Existing ALPS treated water varies in its radiological composition due to a variety of factors including the time when it was first generated and with what generation of ALPS treatment it was originally processed. Therefore, a secondary ALPS treatment process line will be established that will treat water currently stored on site. This water will be processed through the ALPS facility until it meets the criteria for discharge included in the authorization. To verify this, TEPCO will organize the existing K4 tank group into three sets of 10 tanks each. Each tank set will be assigned to one of three rotating functions: receiving water from the ALPS process line, holding water that is pending analysis results and confirmation of its content, and holding water that is ready for discharge.

The water that is deemed ready for discharge will be connected to piping that transfers the water down to sea level where it will be mixed with incoming sea water. Sea water will be pumped in through the old Fukushima Daiichi Nuclear Power Station Unit 5 water intake port. The sea water and the ALPS treated water will be mixed in a bounded horizontal mixing well in a seawater pipe header and then discharged through an undersea tunnel out to approximately 1 km from the shoreline. The discharge point identified by TEPCO is located in a zone restricted for commercial fishing. The chosen operational parameters for the discharge include an annual limit of 22 TBq of tritium, and a concentration limit of 1,500 Bq/L tritium in the discharges. Additional information on the Basic Policy and proposed discharge of ALPS treated water can be found in Refs [7–8].

Fig. I–4. Storage tanks of ALPS treated water at FDNPS (Source: Website of Tokyo Electric Power Company Holdings, Inc.).

II. Part II

II.1. Crosscutting Requirements and Recommendations

(a) Overview

SF-1 [1] states the fundamental safety objective and ten associated safety principles, and briefly describes their intent and purpose. The following safety principles are considered in the development of requirements applicable to discharges:

- **Principle 1, Responsibility for safety**: The prime responsibility for safety must rest with the person or organization responsible for facilities and activities that give rise to radiation risks.
- **Principle 5, Optimization of protection**: Protection must be optimized to provide the highest level of safety that can reasonably be achieved
- **Principle 6, Limitation of risks to individuals:** Measures for controlling radiation risks must ensure that no individual bears an unacceptable risk of harm
- **Principle 7, Protection of present and future generations**: People and the environment, present and future, must be protected against radiation risks.

GSR Part 3 [2] sets requirements for establishing a governmental, legal and regulatory framework for safety for the regulation of activities that give rise to radiation risks. These requirements are applicable to the regulatory body as well as to registrants or licensees. These requirements include the establishment of dose limits for workers and the public, optimization of protection and safety of workers and members of the public, including dose constraints applied to occupational and public exposure in planned exposure situations, establishment of an authorization process, as well as requirements for operational performance. In accordance with these requirements, a prospective radiological impact assessment is required to be conducted and to be used to estimate doses to the representative person.

GSR Part 3 [2] includes further detail regarding the specific importance of ensuring the protection of people and environment in global and long-term perspective, which is of particular relevance to the IAEA's review of the handling of ALPS treated water. Paragraph 1.32 of GSR Part 3 [2] states:

> "In a global and long-term perspective, protection of people and the environment against radiation risks associated with the operation of facilities and the conduct of activities – and in particular, protection against such risks that may transcend national borders and may persist for long periods of time – is important for achieving equitable and sustainable development."

The specific responsibility for safety is also addressed in paragraph 2.39 of GSR Part 3 [2] as "The person or organization responsible for any facility or activity that gives rise to radiation risks shall have the prime responsibility for protection and safety, which cannot be delegated."

The concepts of a graded approach to addressing radiation risks, and optimization of protection across a range of technical activities are also covered in GSR Part 3 [2]. Focusing on radiation protection, GSR Part 3 [2] states that "Parties with responsibilities for protection and safety shall ensure that the principles of radiation protection are applied for all exposure situations." Further, para. 2.12 of GSR Part 3 [2] states that "The application of the requirements for the system of protection and safety shall be commensurate with the radiation risks associated with the exposure situation."

(b) Discussion

TEPCO provided the Task Force with presentations and reference materials on the plans for handling of treated water stored at the FDNPS prior to and during the mission. These materials set the basis for the IAEA review and facilitated the understanding of the Task Force regarding key safety concepts such as who has the primary responsibility for safety, how the current approach proposed by Japan considers the protection of current and future generations and the environment, the overall authorization and regulatory approach, as well as how certain topics such as a graded approach and optimization of protection are factored into the proposed plan for discharges. The Task Force noted that during the mission they received the full cooperation from counterparts in TEPCO and METI and noted TEPCO's and METI's commitment to the successful completion of the IAEA's review.

The Task Force noted the importance of the sustainability[5] of this approach and of the long-term management to this project considering that the proposed water release is intended to last for 30 years under current assumptions. Sustainability and long-term management are crosscutting topics that apply to many different technical areas considered in the IAEA review. The Task Force noted that it is important to have in place a system to identify and consider unanticipated developments over the lengthy operational period that may pertain to the current assumptions regarding risk, impacts to people and the environment and the authorization process.

Discussions on specific requirements and recommendations of the IAEA international safety standards applicable to the review are presented in the relevant sections of this report (e.g. Section II.3 covers safety related aspects of systems and processes, Section II.8 covers occupational radiation protection). Additionally, concepts relevant to the regulatory process (e.g. dose constraints, optimization of protection, graded approach, structure of the authorization process) are addressed in greater detail in Section II.5 and are part of the mission to NRA (March 2022) that will cover the regulatory activities and processes under the IAEA review.

(c) Summary and Follow Up

The requirements covered in this section are inherently crosscutting and represent broad concepts that pertain to multiple aspects of the IAEA review. The Task Force will continue addressing these crosscutting topics in different components of its review until final conclusions are drawn. These will be documented in the full report prior to the discharge of ALPS treated water. The Task Force did not request any specific additional information from METI and TEPCO relevant to the requirements and recommendations included in the IAEA's international safety standards applicable to the review (see Appendix I). However, concepts identified in this section could be raised during the next review mission to TEPCO and METI, as appropriate.

[5] In 1987, the United Nations Brundtland Commission defined sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs".

II.2. Characterization of Discharge and Source Term

(a) Overview

In accordance with the authorization process for discharges described in GSG-9 [4], it is recommended that the applicant seeking an authorization for the discharge of ALPS treated water, characterize the discharges. This characterization, and the subsequent identification of the main exposure pathways, ensures an adequate assessment of the exposure of the representative person.

In accordance with the IAEA international safety standards, the applicant is recommended to conduct a pre-operational analysis to identify the inventories of radionuclides in ALPS treated water and the amounts that will be discharged to the environment, in accordance with the graded approach. This analysis includes data on the expected activity inventory, the types and activities of radionuclides that will be discharged, their physical and chemical forms, the methods and routes of discharge and the rates of discharge.

(b) Discussion

TEPCO presented information on the radiological characterization of treated water at various stages of the processing and discharge process, including at the ALPS outlet, in the storage tanks and after secondary treatment.

The Task Force commented on the importance of defining the source term for the discharge of ALPS treated water in a sufficiently conservative yet realistic manner, as this is fundamental for the conduct of the REIA. If the source term is clearly described, it can be more easily understood by interested parties.

TEPCO presented the methodology used to identify the 62 fission and neutron activation radionuclides targeted for removal by ALPS. These 62 radionuclides as well as ^{3}H and ^{14}C (which are not removed by ALPS) were included in the source term for the REIA.

The methodology for the identification of fission and neutron activation radionuclides involved the calculation of fuel isotopic compositions and subsequent depletion and decay using the Oak Ridge Isotope GENeration (ORIGEN) code[6]. Assumptions and decisions made at various stages while undertaking this modelling were also described. TEPCO had initially assumed a reactor cool down period of 30 days, but at the time of the review mission, they were adjusting the methodology to include the assumption of a much longer reactor cool down period of 12 years. TEPCO stated that they planned to conduct a reassessment based on this refined assumption, which is expected to result in the exclusion from the source term of many short-lived radionuclides that could not possibly still be present when discharges start (in 2023), as significant fission and neutron activation has not taken place since 2011.

The adoption of a 12-year cool down period would also address concerns expressed by the Task Force that only a subset of radionuclides listed in the REIA have so far been analysed in samples of actual ALPS treated water from the storage tanks. Of the 63 nuclides (other than ^{3}H) listed by TEPCO only ^{134}Cs, ^{137}Cs, ^{90}Sr, ^{60}Co, ^{125}Sb, ^{106}Ru, ^{129}I, ^{99}Tc, ^{14}C and gross α and gross β have been routinely measured over the past ten years.

The Task Force encouraged TEPCO to provide more information on how the source term was developed, including how the fuel isotopic compositions of each reactor were identified and all decisions and assumptions applied in executing the ORIGEN code to evaluate the depletion and decay of the radionuclides included.

TEPCO explained that they were also considering additional radionuclides for inclusion in the source term (other than those considered in the REIA). These radionuclides included long-lived, high-yield fission and neutron activation products[7], and isotopes of uranium and transuranics, including isotopes of Np, Pu, Am, and Cm. TEPCO showed the results of analyses of these radionuclides in samples collected at various locations throughout the ALPS processing stream, as well as in the caesium removal

[6] https://www.ornl.gov/project/origen

[7] Cl-36, Se-79, Zr-93, Pd-107, Ca-41, Fe-55, Ni-59, Nb-93m, Mo-93, Sn-121n, Ba-133.

units and the evaporation–enrichment system, at various times since 2011. TEPCO stated that, in general, the activity levels of these radionuclides are below the relevant Japanese regulatory limits and, based on this preliminary information, will most likely not be added to the source term.

TEPCO explained that, through measurements of radionuclide levels in individual storage tanks and at different points throughout the ALPS processing stream in combination with scheduling data describing processing and tank fill dates, a pseudo-representative dataset of the radiological concentrations in all tanks is available. TEPCO confirmed that they plan to conduct measurements for the characterization of the contents of the water which will be transferred from individual storage tanks and then stored at K4 tanks prior to discharge. These measurements are planned to take place as part of TEPCO's process for analysis and confirmation in the K4 tanks before discharge.

The Task Force noted that, once the selection of radionuclides by modelling has been finalized, TEPCO needs to conduct a comprehensive radiological characterization, based on sampling and laboratory analyses of the actual contents of the tanks. This is needed to inform the REIA and evidence-based plans for source and environmental monitoring, including establishing a robust baseline for environmental monitoring.

The Task Force did not consider it necessary to fully characterize each batch of ALPS treated water stored in the K4 tanks and ready for discharge. However, they noted that the characterization needs to be realistic but tending towards being conservative to ensure that the input to the REIA support an adequate assessment of doses to the public.

The Task Force encouraged TEPCO to conduct measurements for the determination of alpha emitters, particularly uranium isotopes and transuranics; and those radionuclides with a potentially global impact following discharge into the sea, including ^{3}H, ^{14}C, ^{129}I and ^{99}Tc.

TEPCO used gross alpha screening methods for measurements, and, in the REIA, assumed that the activity concentrations of all individual alpha emitting radionuclides are equal to the total alpha activity concentration. The Task Force agreed with this approach as it is conservative enough for the REIA and fully acceptable for confirming that discharges are below authorized limits for routine source monitoring.

However, as the source term is fundamental to the REIA, a more detailed and robust approach was suggested by the Task Force for improving the understanding of interested parties and enhancing transparency. This includes determination of the activity concentrations of important individual alpha emitting radionuclides (e.g. ^{239}Pu) using a suitable radionuclide-specific analytical technique and comparing with the results of the current assessment (based on gross counting). The Task Force noted that it is important to undertake these measurements at least once, acknowledging that it is not necessary to measure the activity concentrations of all individual alpha-emitting radionuclides or to undertake these measurements for routine source monitoring. The Task Force explained that the reason for suggesting that measurements of uranium isotopes and transuranics be carried out is to confirm the expected concentrations. TEPCO explained that uranium isotopes were not included in the list of 62 radionuclides targeted for removal by ALPS processing (their activity concentrations were assessed to be less than 1% of relevant authorized regulatory limits) and consequently they were not included in the source term used in the REIA.

TEPCO also presented information on the chemical characteristics of the treated water in the storage tanks assessed by sampling one tank group each financial year between 2013 and 2018. The chemical characterization had been undertaken by TEPCO for environmental protection purposes. The measurements showed that the chemical substances were far below the Japanese regulatory limits set in the Water Pollution Control Law[8]. The Task Force noted that additional information is needed on the physical and chemical properties of the radionuclides in the ALPS treated water that will be discharged (including the speciation of tritium) and how these properties could affect the behaviour of

[8] TEPCO measures chemical parameters (such as pH, suspended solids, chemical oxygen demand) and chemical substances (such as ammonia, nitric compounds, heavy metals) in the ALPS treated water.

radionuclides in the environment. Determination of pH and solubility for the case of liquid discharges is of particular importance.

The rationale for the speciation of ^{3}H used (tritiated water rather than organically bound tritium) was also discussed. TEPCO explained that, from samples of ALPS treated water analysed for biochemical oxygen demand, the organic content is known to be low and that this supports their opinion that 100% tritiated water is a valid assumption. The Task Force noted that, even if this is the case, it is important to include tritium in the organically bound tritium form in the REIA and as part of the environmental monitoring programme to verify the validity of the assumptions made by TEPCO.

(c) Summary and Follow Up

The Task Force agreed with the rationale presented by TEPCO regarding their plan to develop a sufficiently conservative, yet realistic, source term and to revise the REIA. The Task Force noted that the characterization of the source term needs to be finalized and resubmitted, to allow time for review and approval by the regulatory body. The Task Force highlighted the importance of maintaining a strong connection between the characterization of the source term and the design of source and environmental monitoring programmes. This will ensure that a priori assumptions can be verified and that the REIA can be refined as appropriate. TEPCO noted that based on the source characterization and REIA, they will select the radionuclides to be monitored in the sea.

II.3. Safety Related Aspects of Systems and Processes for Controlling Discharges

(a) Overview

Requirement 13 of GSR Part 3 [2] states that: "**The regulatory body shall establish and enforce requirements for safety assessment, and the person or organization responsible for a facility or activity that gives rise to radiation risks shall conduct an appropriate safety assessment of this facility or activity.**"

In accordance with the requirements established in GSR Part 3 [2], the licensee is required to conduct an appropriate safety assessment for the discharge of ALPS treated water from the Fukushima Daiichi nuclear power station and submit it for subsequent review and assessment by the regulatory body prior to authorization.

The safety assessment aims to identify the ways in which exposures could be incurred, to determine the expected likelihood and magnitudes of exposures in normal operation and to assess the adequacy of the provisions for protection and safety.

The safety assessment is required to include a review of the operational limits and conditions for the operation of the discharge; the ways in which structures, systems and components relating to protection and safety might fail, and the consequences of such events; the ways in which external factors could affect protection and safety; the ways in which operating procedures relating to protection and safety might be erroneous, and the consequences of such errors.

(b) Discussion

Based on the information provided to the Task Force by METI and TEPCO, the safety assessment for the discharge of ALPS treated water to the sea was conducted by TEPCO in accordance with the requirements established by NRA and forms part of the implementation plan.

In the development of the design criteria for the system for the discharges, TEPCO took into account the inclusion of redundant and diverse safety features and safety measures to detect and prevent events that could lead to releases of undiluted ALPS treated water to the environment. For the purpose of the assessment, the equipment was considered to be grouped as follows: (1) facilities for measurement and confirmation: consisting of the three tank groups; (2) transfer equipment: for the transfer of the ALPS treated water to the point of dilution; (3) dilution equipment: including the sea water pumps and the discharge shaft. For example, as a result of the analysis, TEPCO established criteria for the location of the emergency valves and for the selection of their type.

The detailed system configuration and the operating procedures relating to protection and safety incorporate the results of the safety assessment to prevent erroneous operation of the discharge process.

TEPCO conducted fault tree analysis to identify the events that could lead to failure of the system for controlling discharges (single failure events). The consequences of all selected events were assessed, preventive measures were identified, and the results were included in the radiological impact assessment. Initial assessments showed that potential exposures will be substantially lower than the regulatory criteria. As part of this analysis, the event with the highest consequences was identified: unintentional discharge of ALPS treated water to the sea without satisfying the conditions stipulated in the implementation plan.

After review of the safety assessment by the regulatory body, TEPCO will ensure that all aspects considered in the safety assessment will be adequately reflected in the company's manuals and operating procedures. TEPCO is also committed to updating the safety assessment, as needed.

The Task Force acknowledged that TEPCO followed a systematic and methodical approach in identifying the single failure events and their potential consequences. As a result of the assessment, TEPCO successfully incorporated prevention measures in the design of the facility as well as in the associated operating procedures.

In accordance with GSR Part 3 [2], the purpose of the safety assessment includes identifying the ways in which exposures could be incurred, determining the expected likelihood and magnitudes of exposures in normal operation and, to the extent reasonable and practicable, making an assessment of potential exposures. Potential exposure includes prospectively considered exposures (i.e. hypothetical or postulated) from a source due to an event or sequence of events of a probabilistic nature, including those resulting from an accident, equipment failures, operating errors, natural phenomena and inadvertent human intrusion. Potential exposure means that the exposure is not expected to be incurred with certainty but that might potentially result from an anticipated operational occurrence or accident at a source or owing to an event or sequence of events of a probabilistic nature, including equipment failures and operating errors. The Task Force noted that to support the establishment of acceptance criteria and operational limits and conditions for the implementation of discharges, the assessment of the impact of external events and of abnormal events, TEPCO would have to assess the potential exposure of members of the public and of workers.

The Task Force discussed a number of key points on the safety related aspects of the system and the processes for discharge that are summarized below:

Abnormal events: TEPCO used a master logic diagram, an abbreviated fault tree analysis, to analyse the occurrence of abnormal events, identify their root cause, assign the event to a category and identify prevention measures. The Task Force noted that TEPCO could also demonstrate how the likelihood of potential abnormal events can be restricted (e.g. by assigning probabilities and failure rates to the identified events).

External events: External events are defined as events unconnected with the operation of a facility or the conduct of an activity that could have an effect on the safety of the facility or activity. TEPCO selected a design taking into account a potential tsunami, selecting a location for the installation in an area of the facility that would not be expected to be subject to damage due to a tsunami. The Task Force noted that the safety assessment is required to include the ways in which external factors could affect protection and safety and encouraged TEPCO to expand the safety assessment to cover external events that could lead to uncontrolled release of the ALPS treated water from the measurement and confirmation tanks. The Task Force suggested that TEPCO could select a reasonable number of limiting cases (bounding or enveloping scenarios), that present the greatest possible challenge for the acceptance of the design, and evaluate these scenarios on the basis of whether they require special emergency measures off the site or the limitation of the release of a specific radionuclide. The Task Force proposed to use a hypothetical extreme scenario for the assessment of the associated doses. This hypothetical scenario could be considered as the initiating event that might lead to damage of the K4 tanks.

Acceptance criteria: TEPCO incorporated into the design redundant and diverse safety features and safety measures to detect and prevent events that could lead to releases of undiluted ALPS treated water to the environment. The Task Force suggested that TEPCO consider formulating acceptance criteria (probabilistic or deterministic) for the system to determine the safety level of the design before moving on with construction. The acceptance criteria need to be formulated as specified bounds on the value of a functional indicator or condition used to assess the ability of a structure, system or component to perform its design function.

Operational limits and conditions: In accordance with para. 3.32 of GSR Part 3 [2], the safety assessment is required to include the operational limits and conditions for the operation of the system for the discharge of ALPS treated water. The operational limits and conditions are defined as a set of

rules setting forth parameter limits, the functional capability and the performance levels of equipment and personnel approved by the regulatory body for safe operation of an authorized facility. The Task Force suggested that TEPCO include the relevant operational limits and conditions in the safety assessment of the system of discharge of ALPS treated water. TEPCO noted that many operational limits and conditions are under discussion with NRA, the regulatory body, as they work through the domestic review and approval process.

Instrumentation and control: The safety assessment needs to describe the instrumentation and control systems and components that are qualified for their intended function, during their service life, as well as how the applicable design criteria are addressed, taking into account the importance of the system to safety. During the meeting, TEPCO presented information showing how the design of the system and the equipment was developed to ensure reliable operation, prevent errors and prevent malfunction. The Task Force encouraged TEPCO to take into consideration the reliability of the instrumentation and control, including the human errors and the computer-based software planned to be implemented during the operation of the facility.

Sustainability: The Task Force emphasized that the operations for the discharges are expected to span over a period of 30 years and, therefore, it is important to take into account the sustainability of the system for discharge. Based on the information provided by TEPCO, the Task Force noted that aspects relating to sustainability have already been taken into account for the design of the facility by TEPCO (e.g. choice to construct an underwater tunnel rather than a pipe for the release of the discharge into the sea would limit corrosion and reduce maintenance). The Task Force encouraged TEPCO to clearly document, noting many clarifications were provided verbally to the Task Force, how sustainability considerations were incorporated in the design of the facility to demonstrate their compliance with the IAEA international safety standards. For example, the safety assessment could be expanded to include written descriptions that cover ageing of system components and management of human resources.

(c) Summary and Follow Up

The Task Force recognized the enormous amount of analysis performed by TEPCO for the conduct of the safety assessment, the level of detail, its comprehensive approach, as well as the fact that a large number of potential single failure events were taken into consideration for the development of the design criteria for the discharge of ALPS treated water.

TEPCO explained the reasons for selecting specific scenarios for abnormal events, accidents and external events. The Task Force noted that TEPCO would be expected to ensure that all aspects considered for the safety assessment, including the methodology and the data used, be sufficiently documented in the safety assessment.

In addition, the Task Force mentioned the importance of making a comprehensive assessment considering all failure modes and identifying the different initiators that might lead to the discharge of undiluted ALPS treated water. Although some of these aspects are partly presented in the radiological impact assessment, additional documentation of the explanations is needed to justify the design criteria for the system for discharges.

II.4. Radiological Environmental Impact Assessment

(a) Overview

GSR Part 3 [2] sets requirements for establishing a governmental, legal and regulatory framework for safety for the regulation of activities that give rise to radiation risks. These requirements are applicable to both the regulatory body and registrants or licensees. These requirements include the establishment of dose limits for workers and the public, optimization of protection and safety of the public, including dose constraints applied to public exposure in planned exposure situations, establishment of an authorization process, as well as requirements for operational performance. In accordance with these requirements, a prospective radiological impact assessment is required to be conducted and to be used to estimate doses to the representative person.

The regulatory control and authorization of discharges is covered in Section II.5 of this report, where it is further explained that the establishment of an authorization for discharges should take into account the results of a prospective assessment of the radiological environmental impacts; such an assessment is usually called a Radiological Environmental Impact Assessment (REIA).

The responsibilities placed on the registrants or licensees when applying for an authorization for discharges to the environment are given in GSR Part 3 [2]. Paragraph 3.9 of GSR Part 3 [2] states that:

> "Any person or organization applying for authorization:
>
> (e) Shall, as required by the regulatory body, have an appropriate prospective assessment made for radiological environmental impacts, commensurate with the radiation risks associated with the facility or activity"

and paragraph 3.15 of GSR Part 3 [2] states that:

> "Registrants and licensees:
>
> (d) Shall, for the sources for which they are authorized and for which the regulatory body requires a prospective assessment to be made for radiological environmental impacts, conduct such an assessment and keep it up to date;"

As part of undertaking a prospective assessment of the radiological environmental impacts, paragraph 3.132 of GSR Part 3 [2] states:

> "Registrants and licensees, in cooperation with suppliers, in applying for an authorization for discharges, as appropriate:
>
> (a) Shall determine the characteristics and activity of the material to be discharged, and the possible points and methods of discharge;
>
> (b) Shall determine by an appropriate pre-operational study all significant exposure pathways by which discharged radionuclides could give rise to exposure of members of the public;
>
> (c) Shall assess the doses to the representative person due to the planned discharges;
>
> (d) Shall consider the radiological environmental impacts in an integrated manner with features of the system of protection and safety, as required by the regulatory body;
>
> (e) Shall submit to the regulatory body the findings of (a)–(d) above as an input to the establishment by the regulatory body, … of authorized limits on discharges and conditions for their implementation."

In applying the principle of optimization of protection and safety in the design, planning, operating and decommissioning of a source, paragraph 3.126 of GSR Part 3 [2] states:

> "Registrants and licensees …, shall take into account:
>
> (a) Possible changes in any conditions that could affect exposure of members of the public, such as changes in the characteristics and use of the source, changes in environmental dispersion conditions, changes in exposure pathways or changes in values of parameters used for the determination of the representative person;
>
> (c) Possible buildup and accumulation in the environment of radioactive substances from discharges during the lifetime of the source;
>
> (d) Uncertainties in the assessment of doses, especially uncertainties in contributions to doses if the source and the representative person are separated in space or in time."

Under Requirement 9 in GSR Part 3 [2] on the responsibilities of registrants and licensees for protection and safety in planned exposure situations, paragraph 3.15 states:

> "Registrants and licensees:
>
> (e) Shall assess the likelihood and magnitude of potential exposures, their likely consequences and the number of individuals who may be affected by them…"

GSG-9 [4] and GSG-10 [5] provide recommendations on undertaking an REIA to meet the requirements established in GSR Part 3 [2]. Figure 4.1 shows the components of an REIA for protection of the public, the endpoint being the assessment of dose to the representative person for comparison with dose constraints and dose limits (fig. 2 in GSG-10 [5]). In order to make the assessment of doses, the behaviour of radionuclides in the environment and the estimation of activity concentrations in food and the environment are needed. The doses are assessed for a representative person, a person who is representative of the more highly exposed individuals in the population.

The requirements on the system of protection and safety in GSR Part 3 [2] generally provide for appropriate protection of the environment from harmful effects of radiation. Paragraph 1.33 of GSR Part 3 [2] states that:

> "… international trends in this field show an increasing awareness of the vulnerability of the environment. Trends also indicate the need to be able to demonstrate (rather than to assume) that the environment is being protected against effects of industrial pollutants, including radionuclides, in a wider range of environmental situations, irrespective of any human connection. This is usually accomplished by means of a prospective environmental assessment to identify impacts on the environment, to define the appropriate criteria for protection of the environment, to assess the impacts and to compare the expected results of the available options for protection. Methods and criteria for such assessments are being developed and will continue to evolve."

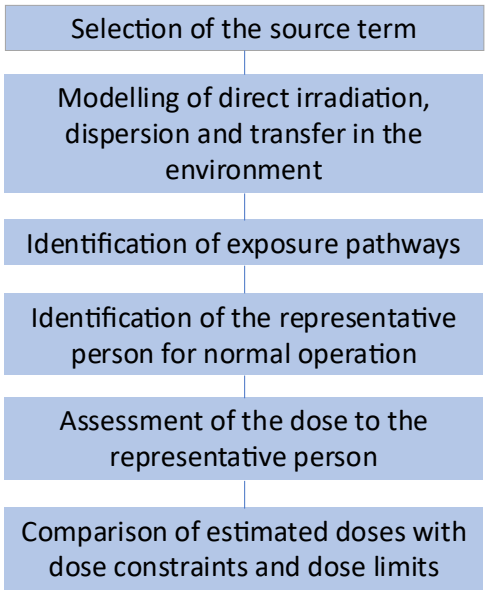

FIG. 4.1. Components of an REIA for protection of the public in normal operation (fig. 2 of GSG-10 [5]).

A generic methodology for assessing exposure of flora and fauna is provided in GSG-10 [5] and it is based on the ICRP approach for the protection of the environment (see Ref. [9]). The need for the explicit assessment of the protection of flora and fauna is subject to the national or internationally applicable regulations and depends on the characteristics of the facility or activity and the environmental conditions under consideration (paragraph I-2 in GSG-10 [5]).

For the generic methodology described, the representative organism is selected directly from the ICRP reference animals and plants (see Ref. [9]) relevant for the specific major ecosystem (e.g. terrestrial, marine, freshwater) assumed to be located in the area where the exposure conditions lead to the highest doses.

Figure 4.2 (fig. I-2 of IAEA GSG-10 [5]) shows the components of a generic assessment for protection of flora and fauna to illustrate the elements of the assessment, the endpoint being the assessment of dose rates to reference animals and plants for comparison with derived consideration reference levels. Similarly to the assessment of doses to the public, the behaviour of radionuclides in the environment and the estimation of activity concentrations in the environment are needed. In accordance with the concept of representative organisms, the dose rate to be estimated in the assessment of the impact on populations of flora and fauna is the dose rate that is characteristic of the dose rates received by a group of individual organisms located in the area where the highest exposures may occur.

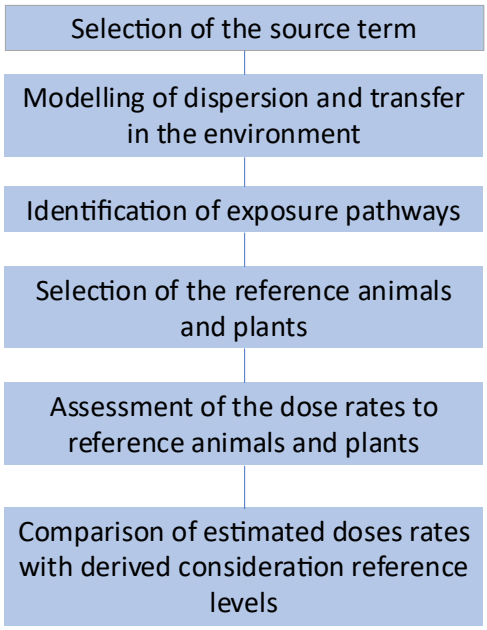

FIG. 4.2. Components of a generic assessment for protection of flora and fauna (fig. I-2 of GSG-10 [5]).

(b) Discussion

TEPCO provided an overview of the REIA methodology that they considered for protection of the members of public. The methodology is consistent with the approach described in paragraph 5.8 of GSG-10 [5] which illustrates the main components of such an assessment as shown in Fig 4.1. TEPCO indicated that the REIA was conducted in accordance with the GOJ Basic Policy.

Source term used for the REIA

Paragraph 5.20 of GSG-9 [4] provides recommendations on the characterization of the discharges for input to the REIA. It recommends that a pre-operational analysis be carried out to identify the inventories of radionuclides that would result in discharges during the operation of the facility, the possible discharge routes and the amounts that would be discharged to the environment. Paragraph 5.9 of GSG-10 [5] provides more details regarding this characterization, identifying that the composition and amount of relevant radionuclides, from a radiation protection point of view, should be selected, as should the discharge path and the physical properties (i.e. gas, aerosol or liquid) and chemical properties relevant for environmental transfers and dosimetry of the radionuclides. Paragraph 5.11 of GSG-10 [5] clarifies that the total discharge for each radionuclide should be integrated over the period required by the regulatory body; for the discharge of ALPS treated water, the planned discharge period is approximately 30 years. Paragraph 5.11 also explains that the discharge is generally given in terms of activity released per year of operation.

TEPCO described the procedures, methodologies and assumptions used to select the source terms used in the REIA and to characterize the discharge; this is covered in detail in Section II.2. TEPCO considered a number of source terms, along with a number of assumptions regarding their composition. The Task Force noted that the source term needs to reflect the radionuclides that are reasonably expected to be present in the ALPS treated water at the time of the actual discharge. The Task Force added that it is important to include all the radionuclides discharged to then be able to identify those that have an impact on dose. As input to the REIA, IAEA international safety standards recommend that discharges be expressed in terms of Bq/year for each radionuclide.

TEPCO explained that ALPS treated water will be discharged at the bottom of the sea approximately 1 km off the coast of FDNPS and that they have performed different dispersion simulations for different discharge points to determine the optimum distance from the coastline. TEPCO presented the results of the simulations showing that the considered discharge point (1 km offshore) will result in lower concentrations around FDNPS compared to the other points. The Task Force advised that TEPCO document their rationale for the choice of location of the point of discharge in the REIA, explaining why it is the best under the prevailing circumstances.

Characterization of exposure scenarios

In the REIA, the exposure pathways that are considered relevant for discharges to the environment for each particular scenario and the relative importance of different exposure pathways is dependent on the nature and route of the discharges and the physical and chemical characteristics of the radionuclides. In the case of discharges to water, consideration needs to be given to the uses of the water, such as consumption, fisheries and production of aquatic food, irrigation, and recreation (paragraph 5.27 of GSG-10 [5]).

In paragraph 5.30 of GSG-10 [5], it is explained that, depending on the exposure scenarios and the site characteristics, not all the possible exposure pathways may need to be included in the assessment because the contribution of an exposure pathway to the overall dose depends on the radionuclides involved, the habit data, the time spent at a location and other characteristics of the population being considered. Therefore, some exposure pathways may be excluded from the assessment on the grounds that the doses associated with them are evaluated to be non-existent or negligible. However, paragraph 5.30 in GSG-10 [5] clarifies that the decision to exclude particular exposure pathways from consideration should be justified.

In the REIA presented by TEPCO, a number of internal and external exposure pathways were identified that were considered relevant for the ALPS treated water discharges to the sea, as shown in Table 4.1.

TABLE 4.1. EXPOSURE PATHWAYS CONSIDERED BY TEPCO IN THE REIA

External exposure pathways	Internal exposure pathways
External exposure received from: • The sea surface • The ship hull • Immersion in water • The beach sediments • The fishing nets	Ingestion of seafood (fish, molluscs and seaweed)

TEPCO presented in the REIA the assessment of doses for both internal exposure and external exposure for three age groups: adults, children and infants. The estimated doses showed that the contribution from ingestion of seafood to the overall dose was the highest compared to the other exposure pathways included in the assessment.

The Task Force noted that although the dominant exposure pathway is ingestion of seafood, TEPCO needs to demonstrate in the REIA that all plausible exposure pathways have been considered, even if the doses are expected to be very low. A list of possible exposure pathways for releases to surface waters (typically for nuclear installations such as nuclear power plants) is given in paragraph 5.27 of GSG-10 [5]. The Task Force identified the minor exposure pathways of inhalation of resuspended materials (e.g. sea-spray, beach sediments), beta doses to the skin from handling fishing nets and inadvertent ingestion of sediments, that could be considered for completeness.

Following the discussions with the Task Force, TEPCO agreed that they would consider other minor exposure pathways in accordance with GSG-10 [5] and potentially also look at other exposure pathways

listed in other national or international guidelines. TEPCO agreed to document their assessment of the doses from the minor exposure pathways in the revision of the REIA for completeness and provide the relevant documents to the IAEA Task Force.

Behaviour of radionuclides in the environment and estimation of activity concentrations in food and the environment

Paragraphs 5.13, 5.14 and 5.16 in GSG-10 [5] describe how a variety of models and data are used to predict the dispersion and transfer of radionuclides through the environmental media and to the representative person. In accordance with GSG-10 [5], the processes that are more relevant to dose estimation should be identified, and a conceptual model should be elaborated in the form of a representation that captures the behaviour of the released radionuclides in the environment. Mathematical models can be used to estimate the activity concentrations in environmental compartments (e.g. air, sediments, soil, water, biota) resulting from the postulated discharges. The models selected should be suitable for simulating the dispersion, dilution, transfer and accumulation of radionuclides and their decay or other removal mechanisms, as necessary, with account taken of the characteristics of the releases expected. Paragraph 5.16 of GSG-10 [5] specifically mentions aquatic dispersion of radionuclides in surface water (fresh water, brackish water or marine water) and accumulation and subsequent remobilization of radionuclides in aquatic sediments of relevance to the discharges.

In the REIA report, TEPCO used a quite advanced complex marine dispersion model taking into account the meteorological and hydrological conditions in the vicinity of the site. The model is called Regional Ocean Modelling System (ROMS, www.myroms.org), and it was validated using environmental monitoring measurements for the caesium concentrations in seawater after the FDNPS accident. This is in accordance with paragraphs 5.2 and 5.3 of GSG-10 [5] that state that the models used for dispersion and transfer of radionuclides in the environment should be appropriate for the situation in which they are being applied and verified, when possible, by undertaking validation in which the results of calculations made using the models are compared with actual data resulting from measurements for similar exposure scenarios.

TEPCO states that the dispersion simulations from this model were used and applied to tritium, then calculations for the concentrations of the rest were conducted using the abundance ratios in each source term, based on the assumption that all the radionuclides in the ALPS treated water discharged are water soluble and will disperse together. Sedimentation has not been considered in the dispersion simulations. They explained that assuming that all the radionuclides are in the water is a conservative approach.

The Task Force suggested that TEPCO demonstrate that it is appropriate to assume that the modelled dispersion of ^{3}H in the ocean is the same as for Cs and, subsequently that it is appropriate to assume that all other radionuclides in the discharge source term disperse in the same way as ^{3}H.

When radionuclides are continuously discharged, they accumulate in the environment up to the point at which equilibrium conditions can be assumed. Paragraph 5.22 of GSG-10 [5] explains that estimates of radiation doses from the discharges to the environment should be calculated for the time at which the highest radiation exposure is expected. The activity concentrations in environmental media that are used to estimate these radiation doses need to be representative of the conditions when accumulation can be assumed to be a maximum. For example, as the ALPS discharge is expected to be operational for 30 years, the dose should be assessed for the 30th year to take into account the maximum accumulation or buildup of long-lived radionuclides and the ingrowth of radioactive progeny in the environment. When long lived radionuclides are discharged, the maximum exposures can occur well after operations cease, for example as a result of slow migration processes of radionuclides in the environment beyond the period of operation. The Task Force explained that the assessment needs to take this possibility into account.

The Task Force agreed that the fundamental quantity for checking compliance with the international safety standards is the dose due to external exposure in a year plus the committed dose from intakes of radionuclides in that year, i.e. the total dose received by an individual during his or her lifetime expected to result from the intakes.

The Task Force noted that in order to take into account build-up and accumulation of radionuclides in the environment during the operation of the facility, the concept of 'dose commitment' can be used. Namely, the total dose that would eventually result from the discharges of radioactive substances. Figure 4.3 represents the 'dose commitment' as follows: (a) from first the year of release A + B + C + D + E, (b) from the second year of release (shaded area) A + B + C + D + E, and (c) under conditions of constant discharge (the time T could initially taken to be infinite and then adjusted to the maximum time of release).

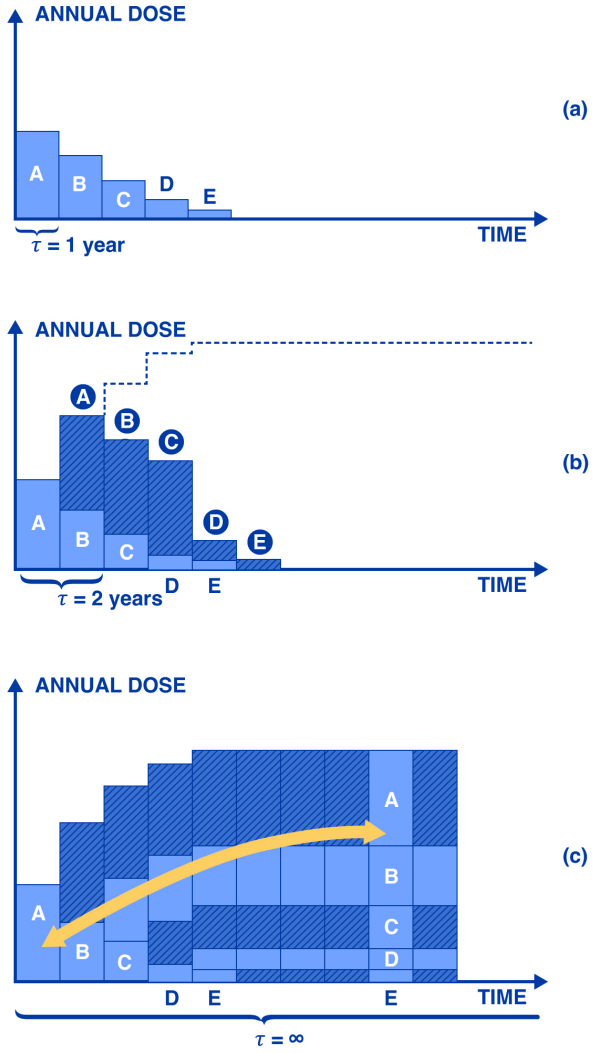

FIG. 4.3. Dose commitment over time due to build-up and accumulation of radionuclides in the environment.

Dose commitment is therefore the same as the committed effective dose to the representative person in the final year of discharge taking into account build-up and accumulation of radionuclides in the environment.

In the REIA presented by TEPCO, committed effective doses are currently calculated from 1 year's discharge. The Task Force noted that these calculations need to take account of the proposed discharge period of 30 years and the fact that, during this 30 year period, some radionuclides may accumulate in the environment (e.g. in the sediments). The Task Force added that the committed effective dose to the representative person in the final year of the discharge, taking into account build-up and accumulation of radionuclides in the environment, needs to be calculated in the REIA. If this approach is followed, the committed dose to the representative person in the planned final year of discharge will take account of the bioaccumulation in the environment over the total discharge period and beyond the period of discharge.

TEPCO explained the assumptions they made in calculating doses to the public over the proposed discharge period. TEPCO assumed that the equilibrium state, as stated in IAEA Technical Reports Series No. 422, Sediment Distribution Coefficients and Concentration Factors for Biota in the Marine Environment [10] as well as the concentration in the seawater will not be affected by the sedimentation and/or adsorption process occurring between the seawater and the sediment. TEPCO noted that following this approach in their assessment results in a dose estimate for the first year comparable to the highest dose shown in Figure 4.3 (corresponding to the 30th year).

The Task Force discussed with TEPCO that the choice of parameter values used in the REIA to determine transfer of radionuclides in the environment and the exposure of the public (e.g. concentration factors, distribution coefficients) need to be clearly explained and site-specific values need to be used, where appropriate.

TEPCO explained that they plan to document the assumptions made in the calculation of doses very clearly in the revised REIA and to provide evidence of the conservative nature of their assumptions. This will include the assumptions made on accumulation of radionuclides in the sediment and the identification of the exposure situations for which accumulation of radionuclides in the environment is accounted for in the REIA. TEPCO also agreed to look at the impact on their model predictions of bioaccumulation of radionuclides in the ocean sediments over the period of the discharge and whether this needed to be included in the revised REIA.

Identification of the representative person

In accordance with paragraph 5.32 of GSG-10 [5], the dose to the representative person should be calculated using characteristics selected from a group of individuals representative of those more highly exposed in the population. GSG-10 [5] explains that the characteristics of the representative person should be specified by the applicant in accordance with national regulations and in agreement with the regulatory body.

An important characteristic when assessing doses to the representative person is the assumed location of the representative person (e.g. his or her distance and direction from the point of release of radionuclides) as described in paragraph 5.34 of GSG-10 [5]. The location where the representative person lives can be based on an actual person or a group of persons, or on a postulated person or group of persons living at a location selected using cautious assumptions (e.g. at a point where the highest concentrations in the area can be expected).

TEPCO stated in the REIA report that the characteristics of the representative person were set in accordance with "Public dose assessment guideline for safety review of nuclear power light water reactor". Habit data, such as consumption rates of food for the representative person, used in the assessment were based on national statistical datasets (National Health and Nutrition Survey in Japan). Table 4.2 summarizes the characteristics of the representative person as described by TEPCO in the REIA report.

TABLE 4.2. HABIT DATA USED IN THE REIA BY TEPCO

Parameter	Adult [Representative person]	Child	Infant
Ingestion rates [g d^{-1}][a]			
Fish	58(190)	29(97)	12(39)
Invertebrate	10(62)	5.1(31)	2(12)
Seaweed	11(52)	5.3(26)	2.1(10)
Occupancies for the representative person [hr y^{-1}]			
Beach	500		
Fishing	2880		
Handling fishing nets	1920		
Swimming	96		

[a] Ingestion rates of seafood for the representative person are based on national statistical datasets for Japan. Two scenarios were considered in the assessment: one for a person who ingests seafood at the average values and the other for a person who ingests a large amount of seafood (mean + 2σ).

For the purposes of calculating doses to the representative person, TEPCO used the marine dispersion model to calculate activity concentration in sea water in a 10 km x 10 km area around the discharge point and these activity concentrations were then used to estimate doses from all the exposure pathways considered. TEPCO explained that this was a conservative assumption as members of the public cannot live or undertake activities close to the coastline within the 'difficult to return zone' or the 'no claim for fishing zone' (see Fig. 4.4). The Task Force questioned whether the average concentration used is conservative given the higher concentrations in the sea predicted along the coast due to the sea currents both within the 'difficult to return zone' and just outside it.

The assumption of where the representative person is assumed to be located relative to the discharge point was also discussed within the context of the assumption of using the average concentration in seawater rather than potentially higher predicted concentrations of radionuclides along the coastline, both within the 'difficult to return zone' and the fishing ports just outside it to the north and south. The Task Force suggested that TEPCO further consider the possible locations of the representative person both at the current time with restrictions in place and also for the future, if people return to the area and have access over the proposed 30 years of discharge, including use of beaches and areas for local fishing.

TEPCO agreed to explain their rationale for taking the average concentration in sea water in a 10 km x 10 km sea area and why it is appropriate (and conservative) for all exposure pathways. TEPCO will describe in more detail the habits of people living in the area to explain that it is consistent with regional data available. TEPCO will also consider in more detail possible locations for the representative person along the coastline in the revised REIA, even if the probability of people returning to the area is low.

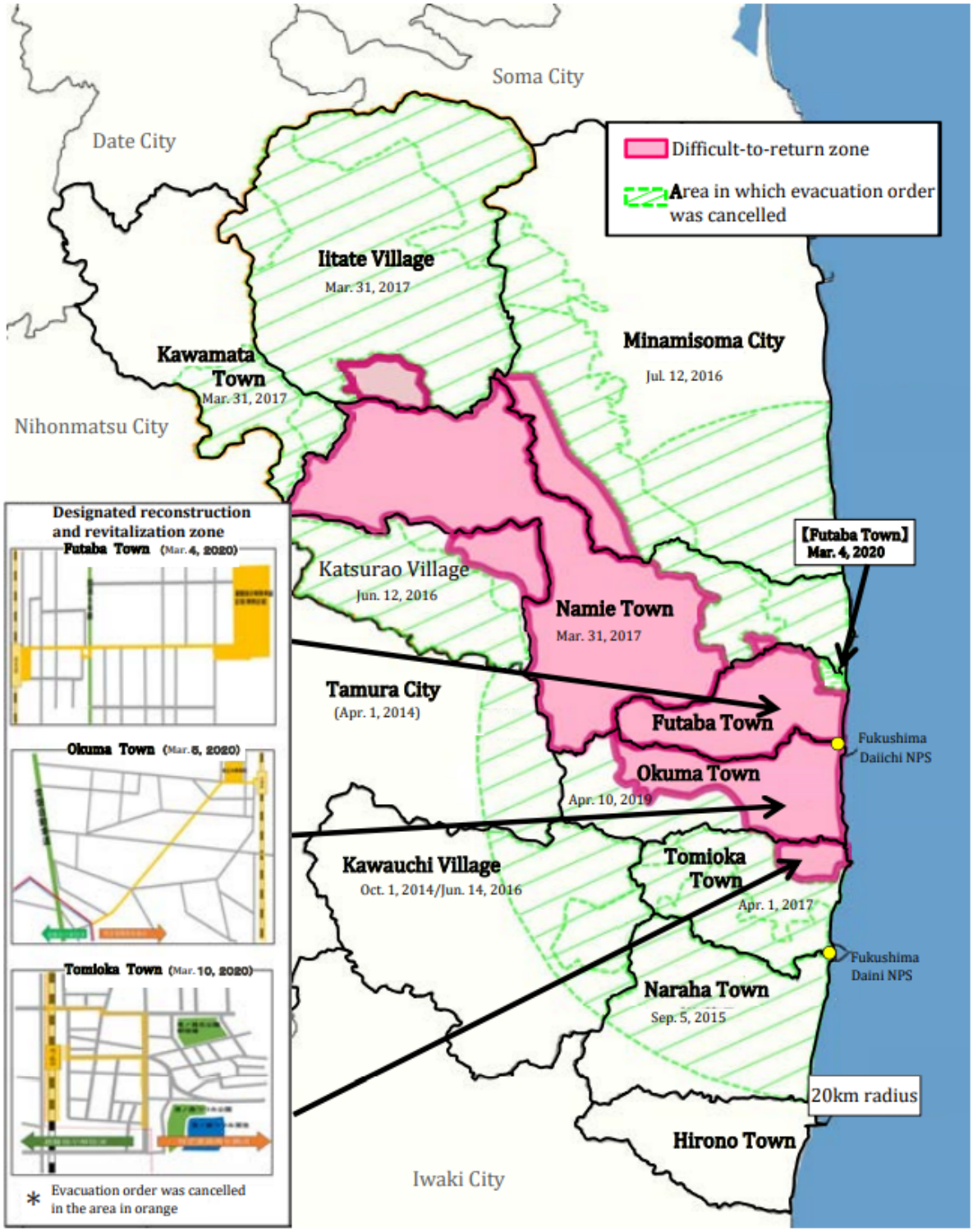

FIG. 4.4. Status of the areas around FDNPS.

(Source: https://fhms.jp/fhms/uploads/03_10yr_chapter1_en.pdf)

Assessment of doses to the representative person and endpoints (including transboundary endpoints)

Paragraph 5.36 of GSGS-10 explains that the individual effective dose to the representative person is the sum of the committed effective dose from intakes of radionuclides (i.e. from internal exposure by ingestion and inhalation) and the effective dose from external exposure. Doses from internal exposure are calculated using dose coefficients from intakes of radionuclides by ingestion and inhalation, which provide the committed effective dose per unit activity of intake, expressed in units of sieverts per becquerel (Sv/Bq). Tabulated values of dose coefficients applicable for members of the public are available in GSR Part 3 [2]. Standard models exist to calculate the effective dose from external exposure, as well as compilations of dose coefficients.

TEPCO presented the committed effective doses calculated in the REIA to the representative person for the different exposure pathways and different age groups considered. The age groups and dose coefficients used for calculating committed effective doses for adults and children were in accordance with those provided in GSR Part 3 [2].

TEPCO explained that the highest estimated effective dose received by the representative person considering the different age groups and source terms is very low and in the order of a few μSv per year; they are approximately a factor of 50 times lower than the dose constraint (50 μSv) specified by NRA for the ALPS treated water discharge. TEPCO noted that ingestion of seafood, fish in particular, is the exposure pathway contributing most to the overall dose.

For estimating the ingestion doses from tritium to the representative person, TEPCO assumed that all tritium is in the form of tritiated water (HTO). The Task Force advised that it is also important to include tritium in the organically bound form with respect to consumption of food, even if the doses from the tritium discharged are not an important contributor to the overall dose.

The Task Force acknowledged that based on the current REIA, the consideration of organically bound tritium in the estimates of doses was unlikely to impact the overall doses estimated but that it is very important that TEPCO demonstrates that it has considered the different chemical forms of tritium in the environment in the REIA. TEPCO agreed to include a discussion of how organically bound tritium will be addressed in the revised REIA.

In paragraph 5.24 of GSG-9 [4] it is identified that if a discharge could cause significant public exposure outside the territory or other area under the jurisdiction or control of the State in which the discharge takes place, the operating organization should make an assessment of the radiological impacts of the discharges on the public and the environment in these areas.

The Task Force discussed with TEPCO that there are radionuclides in the source term that could have an impact for global circulation in the oceans (e.g. ^{129}I, ^{14}C, ^{99}Tc, ^{3}H) and that circulation of radionuclides in the oceans has to be considered in the REIA to avoid unexpected observations. The Task Force explained that even though doses from global dispersion and circulation in the oceans are likely to be very small, doses to neighbouring countries from global circulation are of interest to the international community and so need to be considered in the REIA. TEPCO noted that the flow of sea currents was taken into account within the model and the estimated activity concentrations of tritium in the ocean were low and, that it would be difficult, or impossible, to detect tritium from the ALPS treated water at large distances from the point of discharge.

Assessment of doses from potential exposures

As part of the safety assessment for facilities and activities, various types of accident are postulated to identify engineered safety features and operational actions to reduce their likelihood and, if an accident does occur, to mitigate its consequences (paragraph 5.44 of GSG-10 [5]). In accordance with the recommendations provided in GSG-10 [5], a prospective assessment of potential exposures should use estimates of doses to members of the public resulting from postulated accidents having identified the potential exposure scenarios on the basis of the safety assessment. The representative person for potential exposures needs to be identified and an assessment of the dose to the representative person estimated and compared with the applicable established criteria.

TEPCO presented the assessment that had been carried out of the potential doses from an identified accident scenario that could occur once discharges of ALPS treated water have started. This was described in Reference A of the REIA report. The Task Force noted that only one exposure pathway had been considered, that of external exposure from the sea surface. The Task Force discussed with TEPCO that it is important to calculate the doses from all exposure pathways without consideration of protective measures or mitigation measures that could be implemented if such an accident occurred. In particular, the Task Force emphasized that the REIA needs to include marine food consumption, even if it is expected that marine products in the restricted zone would in practice be banned and all radionuclides in the potential source term need to be considered or represented in the relevant calculations.

Assessment of doses to flora and fauna and endpoints

Paragraph 5.81 of GSG-10 [5] provides an example of a methodology for assessing the impact on flora and fauna in normal operation, based on the ICRP approach for the protection of different ecosystems in the environment (see Ref. [9]), that can be used for national or international frameworks in which the explicit consideration of the protection of flora and fauna is required.

TEPCO calculated doses to flora and fauna, represented by the marine environment reference organisms, flatfish, crab and seaweed, using the assessment approach for a generic environmental impact assessment for the protection of flora and fauna outlined in annex I of GSG-10 [5]. The Task Force noted that TEPCO has included in the REIA an assessment for protection of flora and fauna in-line with the generic methodology provided in the IAEA international safety standards.

Consideration of uncertainties

In accordance with paragraph 6.7 of GSG-10 [5], sensitivity studies should be carried out to identify the most important sources of uncertainty and the processes contributing most to the uncertainty. On this basis, further research, modelling or collection of experimental data may be carried out, if the reduction of the level of uncertainty is deemed necessary.

TEPCO presented their approach for assessing uncertainties associated with the REIA. They identified the data, parameters and assumptions used in the REIA that were subject to uncertainty and the potential impact of these on the doses calculated to the representative person. TEPCO concluded that due to the choice of the source term and the conservative assumptions made, there is not any significant likelihood that the assessment results will exceed the dose constraint.

The Task Force discussed with TEPCO the approach described in the REIA for taking into account uncertainties and the use of the described conservative assumptions made. The Task Force advised that undertaking a sensitivity analysis (i.e. evaluating how varying each of the key assumptions influences the doses) would provide confidence to interested parties that uncertainties have been considered in the REIA. The Task Force added that the sensitivity analysis could also be used to inform future discussions on optimization. TEPCO explained that they will consider this topic further following feedback from

the Task Force, particularly looking at the sensitivity of the doses estimated to the assumptions made and parameter values chosen, and these considerations will be included in the revised REIA.

(c) Summary and Follow Up

A comprehensive REIA has been undertaken by TEPCO and was published in November 2021. During the mission, detailed discussions were held between the Task Force and TEPCO on the REIA. The discussions aimed at providing clarifications on the modelling, assumptions and data used by TEPCO in the REIA. The Task Force and TEPCO agreed that in the REIA, a more detailed and thorough written description of these modelling, assumptions and data is needed to reflect the work that TEPCO has done and to provide confidence in the results of the REIA. TEPCO agreed to take into account the feedback from the Task Force in a revised REIA.

The Task Force noted that the REIA produced by TEPCO indicates that, using conservative assumptions, the doses to the assumed representative person are expected to be very low and significantly below the dose constraint set by the regulatory body (NRA). The Task Force acknowledged the comprehensive and detailed assessment that was undertaken in the conduct of the REIA. The Task Force emphasized that the REIA needs to be well documented, contain clear explanations of the methodology and data used, and should be translated throughout the process, and when finalized, to enable it to be understood by a broader audience.

Several key assumptions in the REIA regarding the behaviour of radionuclides in the environment and the calculation of prospective estimates of the dose to members of the public, including from potential exposures, represented by the ‘representative person’, were discussed and the Task Force and TEPCO agreed that further evaluation is needed to provide evidence that the assumptions made are appropriate and are as conservative as presented by TEPCO in the REIA.

II.5. Regulatory Control and Authorization of Discharges

(a) Overview

IAEA Safety Standards Series No. GSR Part 3 [2], Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, sets requirements for establishing a governmental, legal and regulatory framework for safety for the regulation of activities that give rise to radiation risks. These requirements are applicable to the regulatory body as well as to registrants or licensees.

Authorization of discharges

For facilities or activities that might present potentially higher radiation risks, it may be appropriate for the regulation of the releases from such facilities or activities to be managed by means of an authorization (registration or licensing, as relevant) that establishes stringent technical and regulatory conditions, including for the adequate management and control of these discharges and their radiological consequences. In accordance with the requirements established in GSR Part 3, discharges are required to be properly managed by the licensee in order to ensure the optimized protection of the public and the environment.

Paragraph 3.132 of GSR Part 3 [2] states that:

> "Registrants and licensees, in cooperation with suppliers, in applying for an authorization for discharges, as appropriate:
>
> (a) Shall determine the characteristics and activity of the material to be discharged, and the possible points and methods of discharge;
>
> (b) Shall determine by an appropriate pre-operational study all significant exposure pathways by which discharged radionuclides could give rise to exposure of members of the public;
>
> (c) Shall assess the doses to the representative person due to the planned discharges;
>
> (d) Shall consider the radiological environmental impacts in an integrated manner with features of the system of protection and safety, as required by the regulatory body;
>
> (e) Shall submit to the regulatory body the findings of (a)–(d) above as an input to the establishment by the regulatory body, in accordance with para. 3.123, of authorized limits on discharges and conditions for their implementation."

Optimization of protection and safety

Requirement 31 of GSR Part 3 [2] on radioactive waste and discharges states that "**Relevant parties shall ensure that radioactive waste and discharges of radioactive material to the environment are managed in accordance with the authorization.**"

Paragraph 3.119 of GSR Part 3 [2] specifies that "The government or the regulatory body shall establish and enforce requirements for the optimization of protection and safety for situations in which individuals are or could be subject to public exposure." Paragraph 3.120 of GSR Part 3 [2] states that "The government or the regulatory body shall establish or approve constraints on dose and constraints on risk to be used in the optimization of protection and safety for members of the public."

Paragraph 3.22(c) of GSR Part 3 [2] states that "The government or the regulatory body: …Shall establish or approve constraints…on dose…or shall establish or approve a process for establishing such constraints, to be used in the optimization of protection and safety."

Requirement 11 of GSR Part 3 [2] states that "**The government or the regulatory body shall establish and enforce requirements for the optimization of protection and safety, and registrants and licensees shall ensure that protection and safety is optimized.**"

Dose limits and dose constraints are established for the doses received by the public due to the authorized releases of discharges. Dose constraints are used for optimization of protection and safety, the intended outcome of which is that all exposures are controlled to levels that are as low as reasonably achievable, economic, societal and environmental factors being taken into account. Dose constraints

are set separately for each source under control and they serve as boundary conditions in defining the range of options for the purposes of optimization of protection and safety. Dose constraints are not dose limits: exceeding a dose constraint does not represent non-compliance with regulatory requirements, but it could result in follow-up actions.

For public exposure in planned exposure situations, the government or the regulatory body ensures the establishment or approval of dose constraints, taking into account the characteristics of the site and of the facility or activity, the scenarios for exposure and the views of interested parties. After exposures have occurred, the dose constraint may be used as a benchmark for assessing the suitability of the optimized strategy for protection and safety (referred to as the protection strategy) that has been implemented and for making adjustments as necessary. The setting of the dose constraint needs to be considered in conjunction with other health and safety provisions and the technology available.

Discharge limits

The regulatory body establishes discharge limits for facilities and activities to control the exposures to the public and ensure that protection of members of the public is optimized from the radiation protection perspective. The discharge limits also protect the environment from the effects of ionizing radiation. This approach is based on the conclusion that the environment is protected by means of the conditions under which the practice is authorized. Some Member States consider that, in addition to the optimization of the protection of the public, there may be a need to assess more explicitly the protection of the environment, including, for instance, estimation of the impact of radiation exposure on populations of flora and fauna.

Paragraph 3.123 of GSR Part 3 [2] establishes the following requirements relating to the control of discharges:

> "The regulatory body shall establish or approve operational limits and conditions relating to public exposure, including authorized limits for discharges. These operational limits and conditions:
>
> (a) Shall be used by registrants and licensees as the criteria for demonstration of compliance after the commencement of operation of a source;
>
> (b) Shall correspond to doses below the dose limits with account taken of the results of optimization of protection and safety;
>
> (c) Shall reflect good practice in the operation of similar facilities or activities;
>
> (d) Shall allow for operational flexibility;
>
> (e) Shall take into account the results of the prospective assessment for radiological environmental impacts that is undertaken in accordance with requirements of the regulatory body".

GSR Part 3 [2] establishes requirements and GSG-9 [4] provides recommendations on the regulatory control and authorization of discharges for both the regulatory body (NRA) and the licensee (TEPCO). In the context of this mission, the Task Force reviewed the application of these requirements by the licensee (TEPCO). Appendix I presents the applicable requirements and recommendations that were taken into consideration by the Task Force during their review of the regulatory control and authorization of discharges.

(b) Discussion

During the mission, the Task Force received information from TEPCO on the actions and activities that they are implementing to comply with the relevant regulatory requirements for the control and authorization of discharges. TEPCO presented the relevant details contained in the implementation plan, and the REIA.

Authorization of discharges

TEPCO and METI, described the existing regulatory framework pertaining to the Fukushima Daiichi Nuclear Power Station, Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors, under which FDNPS has been designated as a specified nuclear facility and special provisions for FDNPS as such a facility have been established. METI and TEPCO explained that no additional regulatory requirements or laws were established to regulate the proposed discharge of the ALPS treated water. The Task Force noted the complexities present at FDNPS that need to be taken into account when reviewing the compliance of TEPCO with the IAEA international safety standards.

In accordance with the regulatory framework, TEPCO is required to submit an application to NRA for approval to amend the implementation plan for FDNPS as a Specified Nuclear Facility. This application addresses the handling of ALPS treated water and the amendment to the implementation plan includes: the details of the design for the discharge facility and related facilities, specific measures to ensure safety of the facility and the radiological impact assessment.

The type of information submitted by TEPCO to NRA is in accordance with the requirements established in para. 3.132 of GSR Part 3 [2] for licensees when applying for an authorization of discharges.

As part of the regulatory approval process, TEPCO and NRA participate and discuss in review meetings on a regular basis after the submission of the application. TEPCO provided an overview of the discussions held during these meetings and noted that some of the issues raised by the Task Force during the review mission had also been raised by NRA and TEPCO plans to address them in future revisions of the implementation plan and the REIA.

Dose constraint and discharge limit

Reviewing the documentation provided by METI and TEPCO, the Task Force noted that the concept of a dose constraint does not exist in Japanese law. However, TEPCO indicated that for the discharge of ALPS treated water they use the 'dose control target' of 0.05 mSv/y for the public in the vicinity of light water reactor facilities to assess whether the assessed impact for the representative person is sufficiently low.

In the GOJ Basic Policy for the discharge of ALPS treated water, a discharge limit of 22 TBq of tritium per year was established as well as an operational discharge concentration for tritium of 1,500 Bq per litre. This operational discharge concentration was established as a result of discussions by the GOJ after the GOJ communicated with TEPCO and interested parties. TEPCO used the discharge limit (22 TBq tritium per year) as an input to the REIA.

Paragraph 5.13 of GSG-9 [4] provides recommendations on the steps of the authorization process for setting discharge limits and Figure 3 of GSG-9 [4] identifies the actions of the applicant (reproduced in Fig. 5.1). In accordance with these recommendations, TEPCO should characterize the discharges and the main exposure pathways identified, in order to assess adequately the exposure of the representative person; should present the measures to be used for the optimization of protection and safety of the public and should assess the doses to the representative person.

The Task Force noted that to be in line with the IAEA international safety standards, the dose constraint needs to be used as in input to the REIA to calculate the maximum discharge rate and to inform the NRA's decision about the establishment of the discharge limits.

After discussions between the Task Force and METI/TEPCO, the Task Force suggested that the value of 0.05 mSv per year – which is the operational target for nuclear power stations in Japan – could be used in the place of a dose constraint for the discharge of the ALPS treated water. The Task Force advised TEPCO to revise the REIA using this dose (0.05 mSv per year) as an input to the REIA to demonstrate whether the discharge limit for tritium is appropriate and to inform discharge limits for other radionuclides where appropriate.

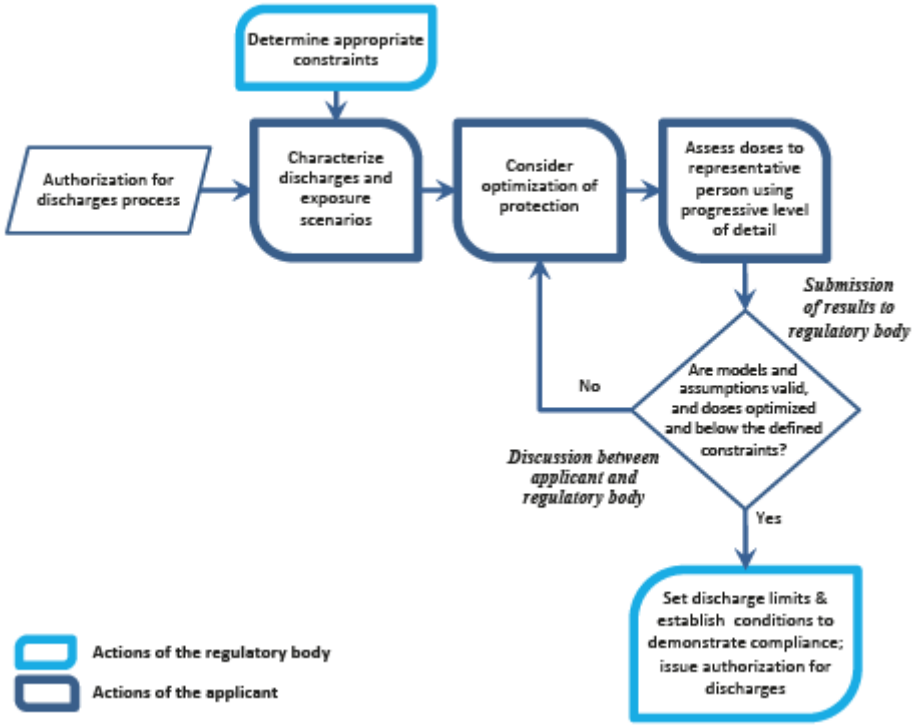

Fig. 5.1: Steps in setting discharge limits, indicating those responsible (fig. 3 of GSG-9 [4]).

The Task force noted that the optimized discharge limits derived from the revision of the REIA might indicate a higher discharge rate for tritium (i.e. the amount of tritium discharged annually that results in a dose to the representative person at or below the dose constraint is greater than 22 TBq per year). This would help TEPCO demonstrate whether the protection of the public is optimized, thus building the confidence of interested parties in the protection of people and the environment and demonstrating that a discharge above 22 TBq/y of tritium would still meet the dose constraint which would be a positive message.

Optimization of protection

In the Implementation Plan, TEPCO uses a fixed discharge rate for tritium that equates to the discharge limit established by the GOJ Basic Policy. The Task Force recognized that the value of 22 TBq/y is fixed and has been chosen independently of the results of the dose to the representative person calculated in the REIA. The Task Force noted that this discharge rate is likely to be conservative when considering doses to the public from the discharge in isolation and taking into account other relevant factors such as the understanding of interested parties.

The Task Force advised that optimization of protection be carried out, for the prevailing circumstances, taking into consideration all relevant discharge parameters (e.g. rate, point and time of discharge), as well as other relevant factors. One of the key discharge parameters that can be varied is the discharge rate. The starting point for optimization would be the maximum discharge rate as indicated by the REIA (the amount of each radionuclide discharged annually that will result in a dose to the representative person at or below the dose constraint of 0.05 mSv per year).

The Task Force advised that TEPCO document their approach for the optimization of protection, the parameters to be varied and the factors to be considered, and that TEPCO note how interested parties are engaged in the process (see Section II.7. of this report).

The Task Force suggested that the other factors considered in the optimization of protection could include the following:

- Effort required to manage risks from water stored on site
- Impact of stored water on rate of decommissioning and the management of hazardous materials like spent fuel across the wider Fukushima site
- Non-radiological environmental impacts of measures employed to reduce dose (e.g. impacts on ecological systems and habitats associated with water intake)
- Occupational exposures associated with construction, operation and maintenance of plant required for the discharge
- Carbon budget
- Societal concern (local, national, international) regarding discharges versus maintenance of tanks on site

Understanding the impact of varying different key parameters, such as the discharge rate, on relevant factors considered in the optimization of protection for the FDNPS site would help to identify the optimal parameters for the discharge of ALPS treated water and thus the optimal dose to members of the public.

As a general comment, the Task Force noted that while a significant amount of work and analysis appears to have been conducted in support of the proposed ALPS treated water discharge, this effort needs to be clearly explained and documented, in writing, in the context of the IAEA international safety standards to help demonstrate compliance with relevant requirements. The Task Force noted that further discussions are needed to clearly define how the approach followed for the establishment of dose constraints and discharge limits complies with the requirements and recommendations outlined in the relevant IAEA international safety standards.

(c) Summary and Follow Up

The Task Force reviewed the relevant provisions under this section, focusing on the requirements that pertain to the licensee (TEPCO). However, the Task Force recognizes the interconnected nature of this section with Sections II.2 and II.4 of this report and noted that additional discussions with the regulatory body will be needed to clarify a number of potentially applicable requirements. Furthermore, the results of the ongoing domestic regulatory review may result in changes to certain parameters and approaches which the Task Force will need to reassess in the future.

II.6. Source and Environmental Monitoring Programmes

(a) Overview

Requirement 14 of GSR Part 3 [2] on monitoring for verification of compliance states that **"Registrants and licensees and employers shall conduct monitoring to verify compliance with the requirements for protection and safety."**

In accordance with paragraph 3.38 of GSR Part 3 [2], all monitoring activities are required to adhere to established criteria for quality assurance covering, *inter alia*, the design and implementation of the monitoring programmes, including properly maintained and calibrated equipment, sampling locations, suitably qualified and trained personnel and documented procedures.

In accordance with paragraph 3.137 of GSR Part 3 [2], the licensee is required to do the following:

- Establish and implement monitoring programmes to ensure that public exposure due to the discharges is adequately assessed and that the assessment is sufficient to verify and demonstrate compliance with the authorization;
- Maintain appropriate records of the results of the monitoring programmes;
- Report or make available to the regulatory body the results of the monitoring programme at approved intervals;
- Report promptly to the regulatory body any levels exceeding the operational limits and conditions relating to public exposure, including authorized limits on discharges, in accordance with reporting criteria established by the regulatory body;
- Report promptly to the regulatory body any significant increase in dose rate or concentrations of radionuclides in the environment that could be attributed to the discharges, in accordance with reporting criteria established by the regulatory body;
- Establish and maintain a capability to conduct monitoring in an emergency in the event of unexpected increases in radiation levels or in concentrations of radionuclides in the environment due to an accident or other unusual event attributed to the discharges;
- Verify the adequacy of the assumptions made for the assessment of public exposure and the assessment for radiological environmental impacts.

In accordance with GSG-9 [4], it is recommended to determine the requirements for monitoring, including frequency, by the assessed level of risk of radiological impact.

With regard to environmental monitoring, GSG-9 [4] provides recommendations on conducting a pre-operational analysis (before the discharges start) to determine the existing levels of background radiation in the environment surrounding the facility prior to the first discharge and to establish a baseline. In accordance with RS-G-1.8 [6], more frequent and detailed environmental measurements may be needed in the early stages of operation and all monitoring programmes are recommended to be subject to periodic review to ensure that measurements continue to be relevant for their purposes.

(b) Discussion

<u>Monitoring at the source of the discharge</u>

Monitoring at the source of the discharge involves measuring activity concentrations at the discharge point and its main objective is to verify compliance with the authorized limits on discharges. TEPCO is planning to follow the approach of 'batch discharges' for ALPS treated water, where the treated water in these batches is homogenized to ensure consistent radiological characteristics. That is, the material for discharge is characterized by the volume of the batch and the radionuclide composition of a sample taken at the reservoir from the homogenized batch prior to discharge. Source monitoring is planned to be based on continuous and intermittent sampling and laboratory measurements of activity concentrations in the sample.

TEPCO described its proposed methodology for discharging and confirming, through measurements, that each batch of ALPS treated water proposed for discharge complies with the authorized discharge

limits. This methodology for discharge is interconnected with that for source monitoring and can be summarized (for each group of 10 tanks in the measurement and confirmation facility) as follows:

1. Tanks in the measurement and confirmation facility are filled.
2. Homogeneity is achieved through agitation (intra-tank) and circulation (inter-tank)[9].
3. A single sample is taken for confirmatory analyses (all 64 radionuclides, including ^{14}C and ^{3}H – see Appendix II).
4. If the data indicates compliance, valves are opened for dilution and discharge.

The samples collected from the measurement and confirmation facility will be the focus of the IAEA's corroboration of source monitoring.

TEPCO informed the Task Force that when discharges are operational, daily monitoring of ^{3}H in samples of diluted ALPS treated water collected from the vertical discharge shaft will also be undertaken to ensure that ^{3}H levels comply with the discharge limit (1500 Bq/L). This sampling point will be closest to the discharge point and, being diluted, the samples will be identical to the ALPS treated water actually released in the environment.

The IAEA intends to include this monitoring in its corroboration of source monitoring as a complement to the main activities focused on the measurement and confirmation facility.

Monitoring in the environment

Monitoring of the environment involves the measurement of radionuclide concentrations in environmental media (including water, sediments, foodstuffs and drinking water). The objectives of environmental monitoring are to verify the results of source monitoring and the associated modelling used to predict doses to ensure that the predictions are consistent and that dose limits are not exceeded. Additional reasons for environmental monitoring are to facilitate detection of any unpredicted changes in activity concentrations and to evaluate long term trends; to provide data to enable the assessment of actual or prospective dose to the reference person; and to provide information to the public. Environmental monitoring needs to be conducted off-site. Both source related, and people related environmental monitoring is usually conducted. The activity concentrations detected in environmental monitoring are normally lower than those estimated by conservative models, and, consequently, retrospective dose calculations are often based on source monitoring data and appropriate modelling.

TEPCO and the related ministries provided a detailed description of the current activities undertaken for environmental monitoring. Extensive monitoring of the marine environment around the FDNPS is carried out by different organizations as part of Japan's regularly revised "Comprehensive Radiation Monitoring Plan", which is coordinated by the Ministry of the Environment and NRA. Sea Area Monitoring is carried out according to "Proceeding with Sea Area Monitoring" (see appendix of Comprehensive Radiation Monitoring Plan) which includes details of sampling locations, including depths, frequency of sampling, detection limits and responsibilities of the organizations involved. Monitoring comprises sampling and analysis of seawater, sediment and marine biota (fish, shellfish and seaweed) and is separated into zones at varying distances from the accident site: the sea area close to FDNPS; the coastal area; the off-shore area; and the outer sea area. This plan aims to ensure a comprehensive overview of the radiological situation in the marine environment and the data provides an adequate basis for assessments of radiation exposures from marine pathways.

In addition to its responsibilities within the Sea Area Monitoring plan, TEPCO implements its own "Unique Monitoring Plan" in the marine environment.

METI and TEPCO presented enhancements to both of these existing environmental monitoring plans to specifically address the discharge of ALPS treated water. These can be summarized as follows:

[9] At the time of the start of the review mission this agitation and circulation methodology was subject to testing.

- TEPCO's own "Unique Monitoring Plan" in which the planned, additional ALPS-specific monitoring includes ^{3}H in seawater at increased sampling frequency and at additional sampling locations, ^{3}H in fish (in addition to radio caesium) and ^{3}H and ^{129}I in seaweed (in addition to gamma-emitting radionuclides) and at additional sampling locations.
- GOJ's Sea Area Monitoring Plan that consists of TEPCO's monitoring programme and the monitoring programme undertaken by governmental agencies will also include monitoring of ^{3}H in seawater at increased frequency plus the identified "seven major radionuclides" quarterly. Monitoring of organically bound tritium (OBT), free-water tritium (FWT) and ^{129}I in aquatic organisms, ^{14}C in fish and ^{129}I in seaweed is also planned.

The Task Force were informed that this enhanced marine monitoring is scheduled to start imminently (approximately one year before discharge is scheduled to start). The results of the monitoring will be disclosed promptly and additional sampling and analysis by third parties will be facilitated for greater transparency.

The Task Force welcomed the plans for enhanced environmental monitoring and stressed that high quality, representative monitoring programmes – both source and environmental – for assessing the potential impact of discharges of ALPS treated water on people and the environment are a requirement for regulatory control. Furthermore, the Task Force emphasized that demonstrably high-quality data – sufficiently accurate and precise – are vital for facilitating transparency and communicating with relevant stakeholders.

After discussions with the Task Force, TEPCO agreed that baseline survey programmes need to be established, reviewed and conducted as soon as possible to ensure that any seasonal influences during the year prior to the start of discharges of ALPS treated water are captured.

Further discussions focussed on the estimated annual discharges of radionuclides that had been detected in monitoring up to the time of the mission. While for ^{3}H, annual discharges will be below the discharge limit of 22 TBq, the annual discharges for other radionuclides are relatively low (of the order of 10^{8} – 10^{9} Bq for ^{14}C, ^{129}I and ^{99}Tc). TEPCO clarified that all of these radionuclides, with the exception of ^{99}Tc in the environment, are included in current plans for source and environmental monitoring.

The Task force advised that TEPCO needs to describe how the design of the enhanced environmental monitoring programme reflects the important radionuclides and the dominant exposure pathways identified in the REIA.

(c) Summary and Follow Up

Based on the information provided for source monitoring, the Task Force noted that there is a need for a clearly defined and definitive plan for source monitoring covering sampling and analysis at the measurement and confirmation facility; the vertical discharge shaft; and any other relevant locations.

The Task Force welcomed the plans for enhanced environmental monitoring by TEPCO and the GOJ. The Task Force noted their interest in further clarifications as to the role of TEPCO as FDNPS operator within the GOJ plan for environmental monitoring. The Task Force also stressed the importance of linking the environmental monitoring programme to the results of the REIA, so it is focussed on the most important radionuclides and exposure pathways contributing to the doses to the public.

The Task Force pointed out that as several organizations are undertaking monitoring activities, criteria for confirmatory analyses need to be defined, taking into consideration the measurement uncertainties.

II.7. Involvement of Interested Parties

(a) Overview

In accordance with GSR Part 3 [2], the government or the regulatory body are required to provide information to, and engage in consultation with, parties affected by its decisions and, as appropriate, the public and other interested parties.

In the IAEA international safety standards, the term interested parties is used in a broad sense to mean a person or group having an interest in the activities and performance of an organization. In the context of radioactive discharges to the environment, 'interested parties' typically include individuals or organizations representing members of the public; industry; government agencies or departments whose responsibilities cover public health, nuclear energy and the environment; scientific bodies; the news media; environmental groups; and groups in the population with particular habits that might be affected significantly by the discharges, such as local producers and indigenous peoples living in the vicinity of the facility or activity under consideration.

Paragraph 5.99 of GSG-9 [4] states: "Because the regulatory control of radioactive discharges takes into account both operational and societal aspects, such as radioactive waste management in the facility and the optimization of the level of protection of the public, there are a number of different interested parties whose views should be considered, as appropriate. A process resulting in the granting of an authorization for discharges is likely to necessitate an exchange of information between the regulatory body, the applicant, and other interested parties. Some interested parties may be located in other States, especially in neighbouring States."

Paragraph 5.101 of GSG-9 [4] further notes that "In some cases, there may be specific requirements for the exchange of information with interested parties before the authorization for discharges has been finalized… Among other things, the results of the prospective radiological environmental impact assessment should be a focal point of the discussions."

Any exchange of information relating to the control of discharges may form part of other decision making processes. Such exchange of information should include consideration of societal aspects, for example public concern over the risks associated with radiation exposure, and consideration of the doses to the public that might result from discharges during operation.

(b) Discussion

METI provided an overview of the primary means through which the Government of Japan and TEPCO engage with interested parties. These include briefing sessions for diplomatic missions in Tokyo (more than a hundred such sessions had been held since 2011), bilateral interactions through various forms of communication with other Governments or authorities, including those of neighbouring countries and regions, conduct of site tours, presentations at technical conferences, public reports that detail the progress of the site decommissioning and presentation of environmental monitoring results, publishing information in international periodicals to ensure the public is made aware of developments.

METI noted that the Government of Japan has been engaging with the public on the issue of handling ALPS treated water for many years; however, the past year has seen many opportunities to share relevant updates and developments with interested parties. METI also noted that some outreach to neighbouring countries has been conducted in the native language of those countries to facilitate a better understanding and exchange of views.

The Task Force commented on the efforts of Japan and the different engagement opportunities with interested parties. In particular, the Task Force noted the cooperation between TEPCO and METI towards the engagement and communication involving a diverse set of interested parties.

The Task Force noted that it is important for the Government of Japan and TEPCO to engage with interested parties in an effective manner, and to facilitate their understanding of the relevant issues. METI noted that owing to intense communication efforts over the past 10 years, the public is reasonably

familiar with safety concepts and how these relate to the decommissioning of the Fukushima Daiichi Nuclear Power Station. However, more nuanced concepts such as risk reduction and optimization of decommissioning, which are also relevant to the handling of ALPS treated water, are still not widely understood by the general public.

The Task Force requested from METI and TEPCO to provide examples of how engagement with interested parties has produced comments or views that TEPCO has responded to and/or acted on. METI and TEPCO explained that in the initial formulation of the revised implementation plan, some known issues had been addressed through changes to the monitoring plan as well as the discharge limits. For example, the discharge limit for tritium (1,500 Bq/L) was selected to alleviate concerns expressed by local communities. The Task Force noted that they would be interested to receive more information on how TEPCO and METI respond to the questions and comments received as part of the public comment period for the REIA and the implementation plan.

The Task Force noted that the involvement of interested parties can improve the understanding of the characteristics of the representative person and the acceptability of resulting estimated dose with site-specific habit data provided by relevant interested parties, and that involvement of interested parties is seen as an important input to the optimization process. The Task Force also noted that the long-term nature of the proposed discharge could present unique or different communication needs and TEPCO could consider elaborating a plan to describe the involvement of the interested parties throughout the duration of the project. In particular, the Task Force stressed the importance of maintaining awareness of changes in the local area (e.g. use of the land) and population habits as that could have a direct impact to the assumptions in the REIA and the definition of the representative person.

The Task Force highlighted the importance for the Government of Japan to continue its engagement with governments of neighbouring countries throughout the duration of the water discharge.

The Task Force expressed their interest to see how the implementation plan and other documents/plans, which are reviewed and potentially approved by the NRA, will factor into or benefit from, the involvement of interested parties.

(c) Summary and Follow Up

METI and TEPCO provided a detailed overview of the wide range of public engagement activities that have been conducted since the announcement of the Basic Policy. METI explained that the interested parties involved in their activities include local communities, the general public, as well as national governments. The Task Force commended TEPCO on the approach they follow for the engagement of different groups of interested parties. Additionally, the Task Force acknowledged the significant efforts made by METI and TEPCO that demonstrate their commitment to transparent communication by making publicly available much of the information and data associated with the proposed discharge of ALPS treated water.

The Task Force noted that they are interested to continue receiving information on the approach followed by TEPCO, METI, and the broader Government of Japan regarding the involvement of interested parties throughout the duration of the IAEA's review. Elements of interest to the Task Force include identifying a clearly articulated policy or approach highlighting the role of interested parties in regulatory and operational aspects of the ALPS discharge process, a long-term plan for considering the involvement of interested parties, and receiving and noting the results of the public comment process for key documents such as the REIA and the revised Implementation Plan. METI explained that the role of interested parties in regulatory and operational aspects of the ALPS discharge process is documented in the Action Plan for the Continuous Implementation of the Basic Policy on Handling of ALPS Treated Water that was published December 2021. METI noted that this Action Plan will be translated into English. The Task Force will review such additional information submitted by METI or TEPCO to respond to specific issues identified during the mission and will follow up on these points during the next review mission to METI/TEPCO.

II.8. Occupational Radiation Protection

(a) Overview

GSR Part 3 [2] sets requirements for establishing and maintaining organizational, procedural and technical arrangements for the designation of controlled areas and supervised areas, for local rules and for monitoring of the workplace, in a radiation protection programme for occupational exposure (Requirements 24). In most practices, doses received by workers are well below the relevant dose limits in GSR Part 3 [2], and only a small fraction of the workforce will potentially be affected by the requirements for dose limitation. The requirements for optimization should be the principal impetus for the establishment and implementation of radiation protection programme, including, in many cases, measures to prevent or reduce potential exposures and measures to mitigate the consequences of accidents.

In accordance with paragraph 3.49 of GSG-7 [3], general objective of the radiation protection programme for occupational exposure is to fulfil the management's responsibility for protection and safety through the adoption of management structures, policies, procedures, and organizational arrangements that are commensurate with the nature and extent of the risks.

Paragraph 5.3 of GSG -7 states that:

> "Contamination of areas can arise from facilities and activities that are subject to regulatory control in terms of the requirements for planned exposure situations, as a result of authorized activities such as discharges, the management of radioactive waste and decommissioning. An exposure situation resulting from such contamination is controlled as part of the overall practice and is, therefore, a planned exposure situation and not an existing exposure situation."

Radiation protection of workers is only one element in ensuring the overall health and safety of workers and should be established and managed in close cooperation with those responsible for other areas of health and safety such as industrial hygiene, industrial safety and fire safety (para 3.50 of GSG-7 [3]).

(b) Discussion

TEPCO explained that the entire site is designated as controlled area and arrangements are in place for control, individual and workplace monitoring of occupational exposure according to the Radiation Controlled Area Measuring Guide and Guide for Management of Setting, Releasing and Changing of Controlled Areas and Managed Areas, and continuous (online) monitoring (dose rate and dust monitors) is conducted with periodic review (once a month). Approximately 4,000 workers[10] (as of March 2022) are working on-site to develop and implement decommissioning activities at FDNPS, including contractors. TEPCO have a radiation protection programme of the Fukushima site and all workers at FDNPS are under routine individual monitoring programme for external exposure. An individual monitoring programme for exposure from intakes of radionuclides is conducted for identified workers who are exposed over recording levels due to contamination as well as those who use respiratory protective equipment. TEPCO explained that occupational exposure data for workers, including contractors, is gathered, stored and maintained by TEPCO and submitted to a central database. Also, a programme for workers' health surveillance is conducted in the FDNPS, consisting of medical checks every 6 months with necessary record keeping arrangement based on the "Health Monitoring Manual" and the "Long-term Healthcare Manual".

TEPCO informed the Task Force that the recording level for internal dose is 2 mSv in accordance with the dose control guideline. TEPCO can measure values below but only those above 2 mSv are recorded and retained. The Task Force noted that the recording level for an intake of a radionuclide could be set to correspond to a committed effective dose of 1 mSv from intakes over the course of a year and could

[10] https://www.tepco.co.jp/en/hd/decommission/information/committee/pdf/2022/roadmap_20220224_01-e.pdf

also be set at 0.1 mSv as the lowest value with the limitation of the minimum detectable limit of the method or measurement technique and specific to the radioisotope (e.g. ^{3}H).

The Task Force highlighted that the radiation protection programme needs to be related to all phases of the ALPS system (i.e. from design characteristics through construction and operation or process control of ALPS). The Task Force requested information on the total number of workers who will be directly responsible for the construction and operation of ALPS, including contractors. The Task Force was especially interested in the construction activities around the discharge facilities (e.g. changing filters) that could potentially incur higher doses. The Task Force requested TEPCO to provide data on the log normal distribution of the doses of workers (separately due to internal and external exposure). The Task Force noted that they would need to agree with TEPCO on the starting point for reporting of doses, as workers are already involved in construction work for the ALPS system, and that it would be helpful to have a group of workers dedicated to ALPS to have confidence that the dose profiles are for ALPS only. TEPCO responded that it would be difficult to decide how to separate out ALPS work from dose control from all work. The Task Force asked TEPCO to provide more information about their policy and arrangements for the protection of contractors (including their collaboration with, expectations of and assurance) regarding contractor employers. The Task Force requested TEPCO to provide in writing the approach followed specifically for ALPS.

TEPCO provided information explaining that the requirement for dose assessment and optimization applies only where the doses of workers are likely to exceed certain levels and therefore only a small proportion of the workforce would need to be assessed. In addition, TEPCO will carry out further workplace and individual monitoring programmes, as appropriate, for dose assessment purposes and for providing warning of changing exposure conditions. TEPCO explained that for all work conducted in the facility, there are radiation control plans in place, submitted by the responsible organization (including contractors) and validated by TEPCO. Meetings to discuss control of exposure in work plans ('ALARA' meetings) are organized in advance at the planning stage. Once the design has been determined, plans are formulated to control exposures (e.g. number of personnel that work in a particular zone) and the area of work is monitored in advance to check whether doses are above what has been designed such that adjustments can be made. The Task Force requested a comprehensive explanation of how TEPCO is meeting compliance with dose limits and optimization of protection for workers, and, more specifically, on monitoring and dose assessment as essential inputs to the optimization process.

The Task Force requested information from TEPCO on the dose assessment methodology and whether they use any dose optimization software. TEPCO explained that for existing facilities, they conduct calculations based on the dose rate and the number of hours of work in a specific area. The Task Force suggested that administrative measures (such as design and procedures) should take precedence in the control of exposure over time constraints and the use of personal protective equipment.

Following questions by the Task Force on internal exposure of workers, TEPCO explained that internal doses due to ^{3}H are low. ^{3}H is measured as HTO in water and then its concentration in the air is estimated. TEPCO added that all workers wear appropriate personal protective equipment and hence there is no exposure due to inhalation.

The Task Force inquired whether TEPCO use any other method apart from whole body counting to calculate dose to workers due to internal exposure. TEPCO explained that whole body counting is used only for detecting gamma emitting radionuclides. TEPCO conducts a smear test from nose and mouth, and if the estimated dose due to alpha or beta radiation is found to be above 2mSv then they conduct bioassay measurements.

The Task Force inquired whether TEPCO plan to assess internal exposures from accidental scenarios as well as external. TEPCO replied that all work on site is conducted with the workers wearing personal protective equipment and there is no exposure pathway due to inhalation.

The Task Force noted that TEPCO relies on the use of personal protective equipment for all workers at FDNPS and advised TEPCO to set out the approach they follow for the control of occupational exposure specific to ALPS in a systematic way – using the hierarchy of controls (design, procedures, use of personal protective equipment). The Task Force asked to receive information on the use of dose limits and dose constraints regarding the exposure of workers, as well as on the investigation levels for individual exposures.

(c) Summary and Follow Up

TEPCO provided a detailed overview of the Radiation Protection Programme, however the Task Force noted that further information is needed on the approach for the reassessment of ALPS site on a periodical basis taking into consideration the evolution of the radiological conditions in the relevant areas and during operation. The task Force continued that it would be useful for TEPCO to present separately the programme of monitoring and assessment of occupational exposure, including individual monitoring, workplace monitoring, assessment of exposure, investigation levels, recording levels.

The Task Force asked TEPCO to clearly describe the procedure they follow for optimization of protection and safety of ALPS. The Task Force requested a comprehensive explanation of how TEPCO is meeting dose limits and optimizing doses to workers and further information for arrangements of work permits and training of staff who will be responsible for the operation of ALPS.

APPENDIX I. APPLICABLE IAEA INTERNATIONAL SAFETY STANDARDS

This appendix contains a list of the IAEA international safety standards applicable to radioactive discharges in the environment.

Section	Safety Standard	Paragraphs
II.1. Crosscutting requirements and recommendations	GSR-Part 3	1.7, 1.8, 1.32, 1.33–1.35, 2.12, 2.39, 2.40, 3.5, 3.9, 3.13, 3.15(c–f, j), Req. 29, 3.119, 3.120(a, c–d), 3.121, Req. 30, Req. 31, 3.131(c–f)
	GSG-9	5.35(d)
	GSG-10	5.7
II.2. Characterization of discharge and source term	GSG-9	5.13(b), 5.20, 5.21
	RS-G-1.8	5.12(a, b), 5.15, 5.18–5.20, 5.22
II.3. Safety related aspects of systems and processes for controlling discharges	GSR-Part 3	Req. 13, 3.29–3.31, 3.32(a–d), 3.33(a, b, d), 3.34, 3.122, 3.127(d)
II.4. Radiological Environmental Impact Assessment (REIA	GSR-Part 3	3.123(c), 3.124(a), 3.126(a, c, d)
	GSG-9	5.13(d, e), 5.22, 5.24, 5.43, 5.44, 5.46, 5.48, 5.51–5.58
	GSG-10	4.2–4.5, 4.9, 4.13, 5.2, 5.4, 5.6, 5.8, 5.9, 5.11-5.17, 5.19, 5.20, 5.22–5.26, 5.27(a–i), 5.30, 5.32–5.34, 5.36, 5.37, 5.43–5.81, 6.2–6.7
II.5. Regulatory control and authorization of discharges	GSR-Part 3	1.7, 1.15, 1.17, 1.22, 1.23, 1.25, 1.28, 3.22–3.28, 3.120, 3.123(a), 3.124(b), 3.126, 3.132(a, b, d, e), 3.133, 3.134
	GSG-9	5.1, 5.2, 5.5, 5.8, 5.9, 5.13(a, c, f, g), 5.14–5.18, 5.23, 5.25, 5.26, 5.30(b–e), 5.31–5.34, 5.35(c, e–g), 5.36, 5.39–5.42, 5.50, 5.51, 5.59–5.62, 5.66–5.69, 5.73, 5.74, 5.76, 5.82, 5.99–5.101
	GSG-10	4.11, 5.29, 5.38–5.42
II.6. Source and environmental monitoring programmes	GSR-Part 3	Req. 14, 3.37, 3.38, 3.127(f–g), Req. 32, 3.135(a, c–f), 3.137(a–e, g, h)
	GSG-9	5.13(b), 5.23, 5.74–5.76, 5.78–5.81, 5.84
	RS-G-1.8	5.1–5.3, 5.5, 5.6, 5.8, 5.9, 5.11, 5.12(c–i), 5.13, 5.16–5.18, 5.21, 5.23–5.30
II.7. Involvement of interested parties	GSR-Part 3	3.124(c)
	GSG-9	5.99–5.102

Section	Safety Standard	Paragraphs
II.8. Occupational Radiation Protection	GSR-Part 3	1.17, 1.22–1.24, 1.26, 2.35, 2.40(b), 2.41(b), 3.19, 3.26, 3.28, 3.34–3.38, 3.40, 3.42–3.44, 3.47, 3.68–3.71, 3.73–3.75, 3.76(a, d, e), 3.78, 3.79, 3.87–3.110
	GSG-7	2.9–2.13, 2.15, 2.16, 2.18, 2.19, 3.49–3.52, 3.60–3.66, 3.75–3.88, 3.90—3.110, 3.112–3.120, 3.122, 3.129, 3.132, 3.133–3.139, 3.141–3.146, 3.149, 3.150, 3.151, 10.1–10.6, 10.8, 10.9, 10.11–10.24, 10.28

APPENDIX II. LIST OF 64 RADIONUCLIDES

This appendix presents the 64 radionuclides selected by TEPCO for assessment: ^{3}H, ^{14}C and the 62 radionuclides to be removed by ALPS.

	Radionuclide	Half-life		Radionuclide	Half-life
1	H-3	12.3 a	**33**	Te-129m	33.6 d
2	C-14	$5.73x10^{3}$ a	**34**	I-129	$1.57x10^{7}$ a
3	Mn-54	312 d	**35**	Cs-134	2.06 a
4	Fe-59	44.5 d	**36**	Cs-135	$2.30x10^{6}$ a
5	Co-58	70.8 d	**37**	Cs-136	13.1 d
6	Co-60	5.27 a	**38**	Cs-137	30.0 a
7	Ni-63	96.0 a	**39**	Ba-137m	153 s
8	Zn-65	244 d	**40**	Ba-140	12.7 d
9	Rb-86	18.6 d	**41**	Ce-141	32.5 d
10	Sr-89	50.5 d	**42**	Ce-144	284 d
11	Sr-90	29.1 a	**43**	Pr-144	0.288 h
12	Y-90	2.67 d	**44**	Pr-144m	432 s
13	Y-91	58.5 d	**45**	Pm-146	5.53 a
14	Nb-95	35.1 d	**46**	Pm-147	2.62 a
15	Tc-99	$2.13x10^{5}$ a	**47**	Pm-148	5.37 d
16	Ru-103	39.3 d	**48**	Pm-148m	41.3 d
17	Ru-106	1.01 a	**49**	Sm-151	90.0 a
18	Rh-103m	0.935 h	**50**	Eu-152	13.3 a
19	Rh-106	30.1 s	**51**	Eu-154	8.80 a
20	Ag-110m	250 d	**52**	Eu-155	4.96 a
21	Cd-113m	13.6 a	**53**	Gd-153	242 d
22	Cd-115m	44.6 d	**54**	Tb-160	72.3 d
23	Sn-119m	293 d	**55**	Pu-238	87.7 a
24	Sn-123	129 d	**56**	Pu-239	$2.41x10^{4}$ a
25	Sn-126	$1.00x10^{5}$ a	**57**	Pu-240	$6.54x10^{3}$ a
26	Sb-124	60.2 d	**58**	Pu-241	14.4 a
27	Sb-125	2.77 a	**59**	Am-241	$4.32x10^{2}$ a
28	Te-123m	120 d	**60**	Am-242m	$1.52x10^{2}$ a
29	Te-125m	58.0 d	**61**	Am-243	$7.38x10^{3}$ a
30	Te-127	9.35 h	**62**	Cm-242	163 d
31	Te-127m	109 d	**63**	Cm-243	28.5 a
32	Te-129	1.16 h	**64**	Cm-244	18.1 a

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III. Part III – Annexes

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ANNEX II. LIST OF PARTICIPANTS – JAPAN

METI – Nuclear Accident Response Office, Agency for Natural Resources and Energy

- Keiichi YUMOTO Director-General for Nuclear Accident Disaster Response
- Yuki TANABE Director for international issues
- Atsushi WAKUI Deputy Director
- Chiaki IIZUKA Deputy Director
- Satoru YASURAOKA Deputy Director
- Yuko HONZAWA Assistant Director

TEPCO – Fukushima Daiichi D&D Engineering Company

- Junichi MATSUMOTO Chief Officer for ALPS treated water management

Planning Radioactive/Chemical Analysis & Evaluation for Treated Water Project Group, ALPS treated water program Department, Fukushima Daiichi Nuclear Power Station

- Hiroaki SANESHIGE Group Manager
- Hideo KIYOOKA Deputy Manager

Mechanical Equipment for Treated Water Installation Project Group, ALPS treated water program Department, Fukushima Daiichi Nuclear Power Station

- Tadashi YAMANE Group Manager
- Disaster Prevention and Radiation Center, Fukushima Daiichi Nuclear Power Station
- Atsutoshi MAKIHIRA Center Superintendent
- Tomomi OKAMURA Sea Area Monitoring Officer

Mid- and Long-Term Planning Group, Project Management Office

- Gaku SATO Group Manager
- Katsuhisa MATSUZAKI D&D Communications Center
- Etsushi KASHIWAGI Deputy Center Superintendent

ALPS treated water program Department, Fukushima Daiichi Nuclear Power Station

- Kenji SHIMIZU General Manager

Radiation and Environmental Department, Disaster Prevention and Radiation Center, Fukushima Daiichi Nuclear Power Station

- Toshiyuki HAYASHIDA General Manager

Business Management Office, Fukushima Daiichi Nuclear Power Station

- Masaaki NISHIWAKI General Manager

TEPCO Nuclear Power & Plant Siting Division

Radiological Health And Safety Center, Nuclear Safety Management Department

- Hideaki KANEHAMA Manager

ANNEX III. MISSION AGENDA

First Review Mission to METI/TEPCO

13-19 February 2022

Monday 14 February 2022 (at METI)	
09:00 – 10:00	Opening Session
10:00 – 12:00	Topic 1: Crosscutting requirements and recommendations
12:00 – 13:00	Lunch
13:00 – 15:00	Topic 2: Characterization of the source term
15:00 – 17:00	Topic 3: Safety related aspects

Tuesday 15 February 2022 (in Fukushima)	
09:00 – 12:00	FDNPS tour Witnessing of sampling
12:00 – 13:30	Lunch
13:30 – 17:00	Topic 8: Occupational radiation protection

Wednesday 16 February 2022 (in Fukushima)	
09:00 – 12:00	Topic 4: Radiological Environmental Impact Assessment
12:00 – 13:00	Lunch
13:00 – 17:00	Topic 5: Regulatory control and authorization of discharges

Thursday 17 February 2022 (in METI)	
09:00 – 12:00	Topic 7: Involvement of interested parties
12:00 – 13:00	Lunch
13:00 – 17:00	Topic 6: Source and environmental monitoring programmes

Friday 18 February 2022 (in METI)	
09:00 – 12:00	Wrap-up meeting
12:00 – 13:00	Lunch
13:00 – 16:00	Further discussions

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