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

Report 3: Status of IAEA's Independent Sampling, Data Corroboration, and Analysis

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Executive Summary

In 2021, the IAEA started its review of safety related aspects of handling ALPS (Advanced Liquid Processing System) treated water at TEPCO's Fukushima Daiichi Nuclear Power Station (FDNPS). 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 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.

Consistent with the relevant IAEA's Safety Standards, TEPCO is required to determine the characteristics and activity of the ALPS treated water (e.g., through the radiological environmental impact assessment) to be discharged into the sea, and to 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 granted by the NRA.

To conduct its safety review, the IAEA has organized the work of the Task Force into three main components, the assessment of protection and safety; regulatory activities and processes; and independent sampling, data corroboration, and analysis. The last component, and the focus of this report, serves the purpose of providing confidence in the accuracy of data provided by TEPCO and the Japanese authorities as part of the established monitoring programmes previously mentioned.

The IAEA's independent sampling, data corroboration, and analysis activities include three major components:

- Sampling, analysis and interlaboratory comparison for ALPS treated water from the FDNPS.
- Sampling, analysis and interlaboratory comparison for environmental samples (e.g., seawater, fish) from the surrounding environment of FDNPS.
- Assessment of the capabilities of dosimetry service providers involved in the monitoring of internal and external radiation exposure of workers at FDNPS.

This report summarizes the three major components of the IAEA's corroboration activities as well as provides an update on the progress demonstrated to date, and what future activities can be anticipated. This report focuses on the methodologies being employed for corroboration; future reports will be issued by the IAEA when data from the analysis of samples becomes available. These future reports will provide the details of the technical evaluation as well as guidance for the public to assist with understanding the data. Additionally, as the safety review continues before, during, and after the discharges of ALPS treated water, updates on the IAEA's corroboration activities will be shared with the public.

[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.

Part I

I.A. 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, in line with its statutory responsibility, 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 water. From this point of view, METI is included in the assessment of protection and safety component of the IAEA's review.

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 the NRA as the independent regulatory body 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 the analysis of documentation, conducting review missions and performing other verification activities. At the start of the review, the Government of Japan, the NRA and TEPCO provided several background materials with information pertaining to the proposed discharge of ALPS treated water, including all laws and regulations relevant to FDNPS. 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 NRA or TEPCO against the IAEA international safety standards, 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 to ensure that an inclusive and transparent approach is adopted.

With regard to the regulatory activities and processes, the Task Force will review the process implemented by the NRA for the authorization of the discharge of ALPS treated water from FDNPS, including the approach and criteria followed by the NRA in their review of TEPCO's REIA and Implementation Plan, and the interaction of the NRA with TEPCO. The Task Force will check the requirements placed by the NRA on TEPCO for source monitoring and environmental monitoring, and the provisions made by the NRA for an independent environmental monitoring programme. Finally, the Task Force will look at how the NRA provides information to, and engage in consultation with, parties affected by the regulatory decisions and, as appropriate, the public and other interested parties.

The IAEA's review will extend over several years, covering the entire process until full completion, 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 after each review mission. These reports, 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.

The IAEA will also establish information sharing mechanisms to distribute relevant data and updates through the IAEA's website. This information will be shared in real-time, and near real-time, to allow interested parties to maintain awareness of the status of and developments for the ALPS treated water discharges conducted by TEPCO.

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]

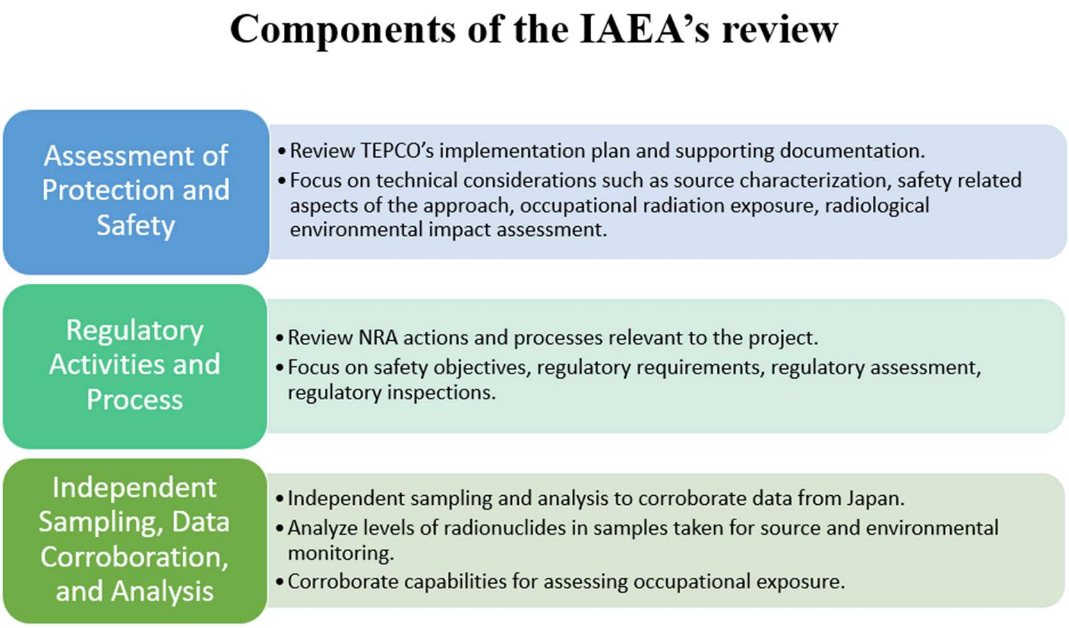

Fig. I–1. Three components of the IAEA's review of ALPS treated water discharge.

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

I.B. IAEA's Independent Sampling, Data Corroboration, and Analysis Activities

The IAEA's safety review of the handling of ALPS treated water at FDNPS includes the following three components: the assessment of protection and safety; the review of regulatory activities and processes; and independent sampling, data corroboration, and analysis activities. The third component, hereinafter referred to as "corroboration activities" or the "IAEA's corroboration," is included in the overall safety review to provide confidence in the accuracy of data provided by TEPCO and the Japanese authorities. Additionally, the corroboration activities will provide another layer of assurance that TEPCO and the Government of Japan are adhering to relevant IAEA safety standards. The IAEA's corroboration will not be exhaustive but rather is intended to allow interested parties to infer the accuracy of all the available data by validating the key data provided by the laboratories in Japan responsible for producing and publishing analytical results from the ALPS treated water discharge process. The IAEA's corroboration activities will complement the broader monitoring and verification regime that is the responsibility of the Government of Japan who maintains the overall responsibility for the safety of its nuclear facilities and activities. The IAEA's involvement is a critical element for demonstrating the accuracy and validity of data being reported by Japanese authorities related to the discharge of ALPS treated water, and therefore building confidence in the overall IAEA safety review.

Currently, the IAEA's independent sampling, data corroboration, and analysis activities include three major components:

- Sampling, analysis and interlaboratory comparison for ALPS treated water from the FDNPS.
- Sampling, analysis and interlaboratory comparison for environmental samples (e.g., seawater, fish) from the surrounding environment of FDNPS.
- Assessment of the capabilities of dosimetry service providers involved in the monitoring of internal and external radiation exposure of workers at FDNPS.

In this corroboration, the IAEA will involve several of its own laboratories; the details are provided in Parts II and III of this report. These IAEA laboratories have significant experience in analysing different types of samples to conduct a radiological characterization as well as in coordinating the involvement of many different laboratories in a single project. Furthermore, the IAEA was directly involved in the analysis of different types of samples after the accident at the FDNPS and is familiar with the history and current status of the site and surrounding areas. However, in order to ensure the IAEA's review benefits from the best combination of international expertise, the IAEA will also include independent third-party laboratories in the analysis of samples. The participating third-party laboratories have demonstrated significant technical competence in the necessary analytical techniques and represent a diverse global perspective including from the region.

This is the third report issued under the IAEA's review of safety related aspects of handling ALPS treated water at TEPCO's FDNPS. The purpose of this report is to inform interested parties about the IAEA's existing and planned corroboration activities. This report includes the broad concept for corroboration, how results will be analysed and reported, and details on current progress and planned activities.

I.C. 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.

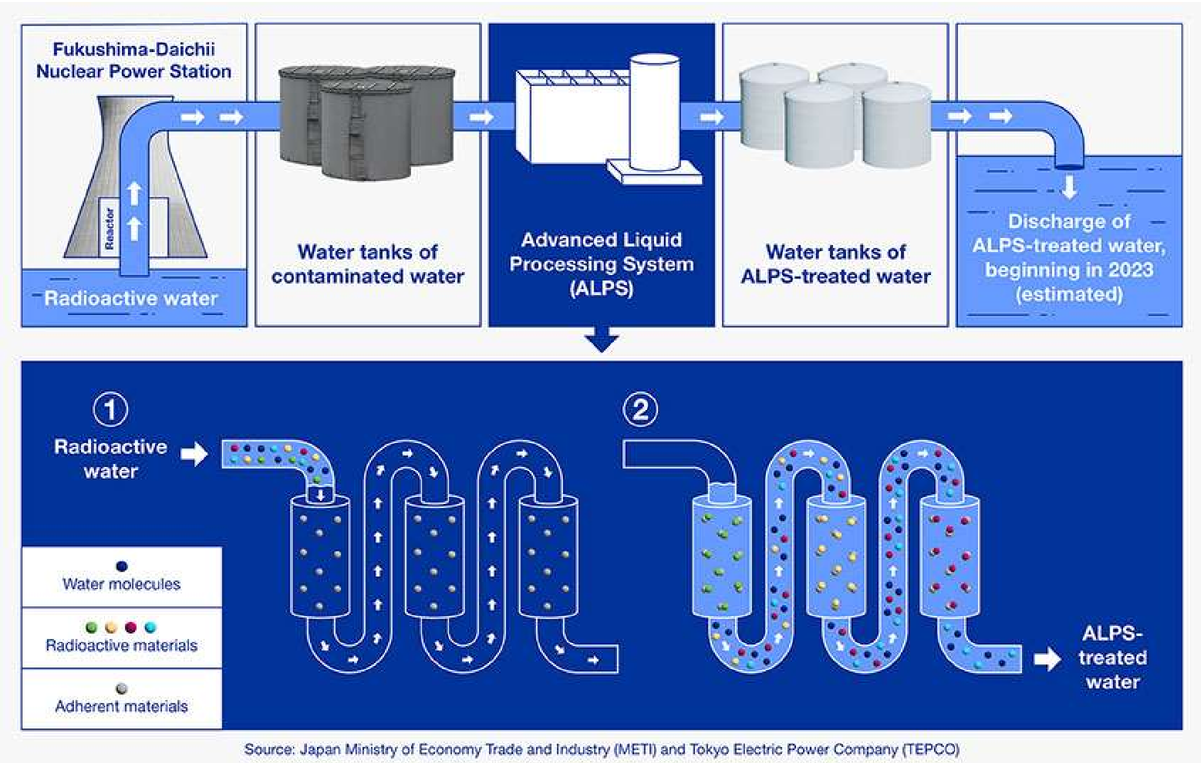

Fig. I–2. Overview of the ALPS treated water discharge system.

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 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 online at TEPCO's and METI's websites [1, 2, 3].

Fig. I–3. Storage tanks of ALPS treated water at FDNPS (Source: Website of Tokyo Electric Power Company Holdings, Inc.).

Part II

II.A. Corroboration of Source and Environmental Monitoring Related to ALPS Treated Water at FDNPS

The corroboration of a representative subset of the radioactivity measurement results reported by TEPCO and relevant Japanese authorities during both the pre-operational and the operational phases of discharge of ALPS treated water to the sea, and a review of the methods for related sampling and analysis used by TEPCO and relevant Japanese authorities is being undertaken by the IAEA. This corroboration provides an independent check of the veracity of the radiological data resulting from source and environmental monitoring programmes related to the ALPS discharges upon which the safety related aspects of the discharges of ALPS treated water are being reviewed. The scope of the corroboration includes an independent check of the radiological characterization of the discharges. A primary objective is to promote transparency and provide sound information to enable interested parties to evaluate the radiological data used as the basis for planning the discharges of ALPS treated water into the sea.

The IAEA corroboration of source and environmental monitoring related to discharges of ALPS treated water from FDNPS is comprised of three distinct elements (see also Figure II-1):

1. Review of sampling and analytical methods for source and environmental monitoring related to ALPS treated water at FDNPS used by TEPCO and relevant Japanese authorities[5].
2. Corroboration of source monitoring undertaken by TEPCO, including a comprehensive radiological characterization of ALPS treated water samples.
3. Corroboration of environmental monitoring undertaken by TEPCO and relevant Japanese authorities.

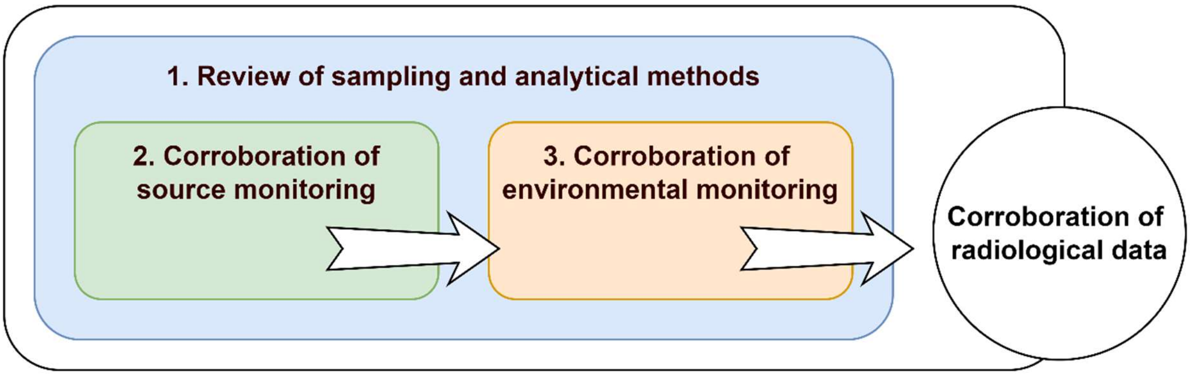

Figure II-1: A schematic overview of the elements of the corroboration being undertaken by the IAEA laboratories and the links between these elements.

The corroboration of source and environmental monitoring will be based on interlaboratory comparisons (ILCs). ILCs, along with proficiency tests (PTs), are standard methods for laboratories to assess the quality of their measurement results in comparison with those of other participating laboratories, and to identify any potential improvements. PTs involve the evaluation of performance against pre-established criteria whereas ILCs involve the organization, performance and evaluation of

[5] TEPCO has sole responsibility for source monitoring at FDNPS. All environmental monitoring related to the nuclear accident at FDNPS is conducted according to the Comprehensive Radiation Monitoring Plan (CRMP) [4]. TEPCO and other relevant Japanese authorities have responsibilities under the CRMP. In practice, sampling and analysis are often carried out by contracted laboratories. Within this report it is assumed that TEPCO and the other relevant Japanese authorities as defined in the CMRP have responsibility for reporting the results of the monitoring for which they are responsible. However, the participants in the ILCs could be the laboratories that have contracts in place to undertake analyses.

measurements on the same or similar items by two or more laboratories in accordance with predetermined conditions [5].

For the corroboration of source monitoring, samples of ALPS treated water that is considered by TEPCO to be ready for dilution and discharge – pending final confirmation by analyses – are being collected from tanks at FDNPS. For the corroboration of environmental monitoring, samples of seawater, sediment and marine biota are being collected from locations on the east coast of Japan around FDNPS. Sample collection and pre-treatment activities undertaken by TEPCO, and relevant Japanese authorities will be facilitated and observed by the IAEA. The homogeneity of all samples will be ensured. These samples will be split, and sub-samples will be provided to the laboratories participating in the ILCs for the analysis of the activity concentrations of a range of relevant radionuclides.

Analyses are being undertaken at the following three participating IAEA Nuclear Sciences and Applications Laboratories:

- IAEA Marine Environment Laboratories, Radiometrics Laboratory (RML), Monaco;
- Terrestrial Environmental Radiochemistry Laboratory (TERC), Seibersdorf, Austria;
- Isotope Hydrology Laboratory (IHL), Vienna, Austria.

TEPCO and laboratories contracted by relevant Japanese authorities involved in radioactivity monitoring are also participating in the ILCs.

Additionally, under the coordination of the participating IAEA laboratories, selected third-party laboratories, members of the network of Analytical Laboratories for the Measurement of Environmental Radioactivity (ALMERA) [6] (the list of ALMERA members can be found at this reference) with demonstrable competence in the methods required, are also conducting analyses of samples as participants in the ILCs. ALMERA is a network comprising 190 member laboratories[6] globally that is coordinated jointly by RML and TERC. It provides a platform for maintaining and developing capability on the determination of radionuclides in air, water, soil, sediment and vegetation that can be used for both routine and environmental emergency monitoring in the IAEA Member States.

The ILCs are being complemented by a review of the sampling and analytical methods used by TEPCO, and, for environmental monitoring related to the discharges of ALPS treated water, by TEPCO and relevant Japanese authorities contributing to the Comprehensive Radiation Monitoring Plan (CRMP) [4]. The results of this review, which is being conducted by the IAEA laboratories drawing on extensive knowledge and experience of analytical methods, Good Laboratory Practice[7] and quality management systems, will help to contextualize the results of the ILCs and will support the interpretation of any potential lack of comparability in the activity concentrations measured by the participating laboratories. The review will be conducted both on-site and remotely through document review and virtual engagement. IAEA proficiency testing that provides further assessments of measurement quality will also be conducted.

As represented in Figure II-1, there are interdependencies between the different elements of the corroboration. For example, the analytical capability required for both source and environmental monitoring is dependent on the chemical composition and the radionuclide activities in the ALPS treated water.

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[6] https://nucleus.iaea.org/sites/ReferenceMaterials/Shared%20Documents/ALMERA/List_ALMERA_Network_Laboratories_March_2022.pdf

[7] Good Laboratory Practice is "a managerial concept covering the organisational process and the conditions under which laboratory studies are planned, performed, monitored, recorded and reported. Its principles are required to be followed by test facilities carrying out studies to be submitted to national authorities for the purposes of assessment of chemicals and other uses relating to the protection of man and the environment"[7]

The initial results of the IAEA's corroboration activities will be made available in 2023, before the discharges of ALPS treated water begin. Additional data from subsequent sampling and analysis will continue to be published when available, both before the discharges start, and afterwards.

Each of the three elements of the IAEA corroboration will be elaborated in detail in the following subsections.

Review of the Sampling and Analytical Methods Used by TEPCO and Relevant Japanese Authorities for Source and Environmental Monitoring Related to ALPS Treated Water at FDNPS

The IAEA is conducting a review of the sampling and analytical methods used by TEPCO and, for environmental monitoring related to the discharges of ALPS treated water, by TEPCO and relevant Japanese authorities contributing to the CRMP against the applicable IAEA safety standards [8, 9]. The use of quality assurance is required by the IAEA Safety Standards Series No. GSR Part 3, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards [8] and should be an integral part of programmes for source monitoring and environmental monitoring (RS-G-1.8 [9] para 9.1). Good Laboratory Practice and/or ISO/IEC17025 [10] accreditation meet the qualification requirements of analytical laboratories undertaking radioanalytical measurements. These specific conditions should be incorporated into quality assurance programmes (GSG-9 [11], para 5.83). Good Laboratory Practice is designed to qualify and promote the development of quality test data and provide tools and methodologies that ensure a sound approach to managing laboratory studies. The ultimate goal is to be able to ensure that the results obtained in one laboratory can be accurately compared to those obtained in other laboratories. The principles of Good Laboratory Practice will be utilised for this review as a definition of qualification for the sampling and analytical methods utilised by TEPCO and, for environmental monitoring related to the discharges of ALPS treated water, by TEPCO and relevant Japanese authorities (GSG-9 [11], para 5.83).

The scope of the review includes relevant procedures for sampling and analysis used for source and environmental monitoring related to ALPS treated water and a representative sample of relevant technical records. Supporting documentation for record maintenance and reporting (as referred to in paras 5.88 and 5.89 of GSG-9 [11]) is also included in the review.

The review will be based on general auditing techniques commonly used for assessments of Good Laboratory Practice.

The review will initially concentrate on the methods implemented by TEPCO. While the IAEA is not undertaking a formal audit of TEPCO's quality system, it is assessing whether its sampling and analytical methods comply with the quality assurance requirements set out in the IAEA international safety standards (e.g., qualification of Good Laboratory Practice). In addition, by providing review in light of Good Laboratory Practice, this review is enabling the IAEA to collect information on the sampling and analysis methods selected by TEPCO and their implementation with regard to source and environmental monitoring related to ALPS treated water. This knowledge will support the other elements of corroboration and will help to contextualise the results of the ILCs and to facilitate the resolution of any inconsistencies in the results from participating laboratories that may arise.

Corroboration of Source Monitoring (Including a Radiological Characterisation of Samples of ALPS Treated Water)

According to its design stage REIA [12] and as summarised in section I.C, TEPCO has selected a "batch discharge" methodology. Safety Guide RS-G-1.8 para 5.18 [9] states: "In the case of batch discharges, the material for discharge is adequately 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".

In a description of the ALPS discharge facility, also included in its REIA, TEPCO has provided details of its source monitoring plan. Prior to discharge, ALPS treated water will be transferred from tanks at the FDNPS site into measurement and confirmation facilities – three operating in parallel – into which volumes of ALPS treated water will be transferred. Circulation and agitation will be applied in each measurement and confirmation facility to ensure homogeneity of the ALPS treated water prior to collecting representative samples and performing confirmatory measurements to ensure that the sum of ratios of the legally required activity concentrations of radionuclides other than ^{3}H is less than one. Each volume of ALPS treated water transferred to each measurement and confirmation facility is a 'batch' (according to RS-G-1.8 para 5.18). The total radionuclide content of all batches discharged per annum defines the source which is compared to authorized limits on discharges (in Bq/year).

The corroboration of source monitoring is being conducted based on a series of ILCs. These ILCs facilitate comparisons of the measurement results of TEPCO with those of the IAEA laboratories. Thus, an independent check of TEPCO's results is being undertaken. Further independent verification and transparency is provided by the participation of other laboratories and the intercomparison of their results.

For each ILC, the IAEA is observing the collection of samples of ALPS treated water from tanks at FDNPS for which the contents have been identified by TEPCO as being ready for discharge, pending the results of final confirmatory analyses. The samples for the ILC therefore comprise ALPS treated water, prior to dilution, and not contaminated water (i.e., water still requiring ALPS treatment or re-treatment).

TEPCO's ALPS discharge facility, including the measurement and confirmation facilities described above, is under construction, due for completion in 2023. Once complete, samples for the ILC will be collected from the measurement and confirmation facilities according to normal practice under TEPCO's source monitoring plan. In the interim period, samples are being collected using alternative method as described in Section II.D, while at all times ensuring inter sample homogeneity and, thus, suitability for the provision of comparable results of analyses.

The samples are split and provided to all laboratories participating in the ILC for analysis for a range of radionuclides. When analyses are completed, activity concentrations and related uncertainties for radionuclides in the samples, plus key information about the analytical methods used (e.g., sample preparation and counting methods, detection limits) will be submitted to the IAEA. The IAEA will then carry out a compilation of the results submitted and an evaluation.

The evaluation is comprised of two components:

1. **Quantitative comparisons of the results of analyses using statistical methods to assess any differences between TEPCO's results and those of the IAEA laboratories and the participating third-party laboratories**.

   Individual comparisons will be undertaken for each of the radionuclides that TEPCO has currently identified as requiring measurement and assessment within its source monitoring plan[8] [13] plus ^{3}H. The specific radionuclides are listed in Table II-1. The results will be statistically evaluated according to the methodology described in Section II-C.

   Apart from TEPCO, it is not necessary that measurement results for all radionuclides listed in Table II-1 be reported by all participating laboratories due to resource constraints and the implausibility of any single laboratory having the capability to analyse for all possible radionuclides. However, subject to the analytical capability and resources available in each participating laboratory, reporting for as many radionuclides as possible has been encouraged by the IAEA.

[8] It should be noted that TEPCO's source monitoring plan, like all aspects of its implementation plan for the handling of ALPS treated water at FDNPS, needs to be approved by the NRA and is thus subject to change.

2. **A qualitative interpretation of activity concentrations or detection limits reported by any participating laboratory for other radionuclides for which the samples have been analysed.**

   The IAEA laboratories will analyse the ALPS treated water samples as comprehensively as possible for additional radionuclides for which they have analytical capability and has asked all participating laboratories to do likewise. Of particular interest are high yield activation and fission products, and actinides that might reasonably be expected to be present in cooling water from a nuclear facility such as FDNPS. For guidance, all participating laboratories have been provided with information derived from the results of past sampling and analysis at various points of the ALPS processing stream by TEPCO and by other resources related to radionuclide source terms in other nuclear facilities and decommissioning activities.

   These results will not be statistically evaluated; rather any activity concentrations or detection limits reported for radionuclides other than those included in Table II-1 will simply be reported as information values, with reference to relevant authorised discharge limits as appropriate.

   This comprehensive radiological characterization of samples of ALPS treated water is being conducted but it is not expected that any significant (or detectable) amounts of these radionuclides will be present in the samples analysed. The IAEA considers that it is necessary, however, to ensure that a robust, independent, and comprehensive assessment of the radiological content of ALPS treated water samples, availing of the broad collective analytical capacity of all participating laboratories, is undertaken and to enhance transparency and promote confidence in TEPCO's source monitoring.

   It can also be noted that prior to the discharge of ALPS treated water to the sea, a pre-operational analysis should be carried out to identify, *inter alia*, "the inventories of radionuclides that would result in discharges during the operation of a facility or the conduct of an activity" (para. 5.20 of GSG-9). This comprehensive radiological characterization will serve to verify that this aspect of the pre-operational analysis has been carried out adequately by TEPCO.

Laboratories participating in the ILC have been given the freedom to determine activity concentrations of radionuclides by any appropriate method of their choice. Approximate activity concentrations (i.e., prior to homogenisation of ALPS treated water in the measurement and confirmation facility at FDNPS) of common radionuclides (^{60}Co, ^{90}Sr, ^{106}Ru, ^{125}Sb, ^{129}I, ^{134}Cs, ^{137}Cs, ^{3}H , ^{14}C and ^{99}Tc) in the tanks from which samples will be collected has been published by TEPCO[9]. This data can be used by participating laboratories to inform selections of analytical methods. For other radionuclides, the authorised limits for discharge can be taken as an upper bound when evaluating the target detection limit for each radionuclide[10] [14].

Participating laboratories have been requested to submit a single measurement result for each radionuclide that can be analysed, and decay corrected to the relevant sampling date. The measurement result is assumed to be comprised of an activity concentration and its uncertainty or the detection limit, as appropriate, all expressed in Bq/L.

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[9] TEPCO's measurements of activity concentrations in around 1000 of the 3000 ALPS storage tanks at FDNPS: https://www.tepco.co.jp/en/decommission/progress/watertreatment/images/tankarea_en.pdf
Measurements undertaken at the ALPS outlet (i.e. after processing to remove fission and activation radionuclides) can be accessed here:
https://www.tepco.co.jp/en/decommission/progress/watertreatment/images/exit_en.pdf

[10] It should be noted that these limits have been established assuming that radionuclides are discharged individually and in a single chemical form (water). In real cases in which multiple radionuclides are discharged simultaneously (and potentially to both the atmosphere and to water), the sum of the ratios of the activity concentration of each radionuclide to the respective limit should not exceed 1.

Participating laboratories have been asked to provide the following additional information for each radionuclide for which results will be reported, in addition to the activity concentration and uncertainty:

(a) A short description of the analytical method applied for the sample analysis.
(b) The type of calibration applied.
(c) The software used for the counting/spectrometric systems.
(d) The nuclear data used (e.g., half-life, energy, intensity of gamma emission) in the determination of the results.[11]
(e) The detection limit and decision threshold.
(f) The uncertainty budget with components including the following, as relevant:
    (i) Statistical counting uncertainty, including any background subtraction.
    (ii) Uncertainty of the detector efficiency, including the uncertainty of the calibration source, as applicable.
    (iii) Uncertainty of chemical yields, as applicable.
    (iv) Uncertainty of mass measurements.
    (v) Uncertainty of corrections applied, for instance for true coincidence summing or for decay correction.
    (vi) Measurement repeatability uncertainty.

The IAEA has recommended that samples are prepared using gravimetric measurements to minimise uncertainties. The value of the density of the sample used to convert from gravimetric to volumetric activity concentrations (i.e., from Bq/kg to Bq/L) should be reported as necessary.

The results of the ILCs will be reported as described in Section II.C. Descriptions of the collection and analysis of test samples[12] and those for three ILCs for corroboration of source monitoring are provided in section II.D.

[11] The use of the Decay Data Evaluation Project (DDEP) [16] data is being encouraged, subject to data being available for each specific radionuclide.
[12] In this context, "test samples" refers to the first samples of ALPS treated water that were collected in February 2022. These samples are not intended to be used as part of an ILC but rather are being used to verify the analytical methods established by the IAEA laboratories for conducting analyses of future ALPS treated water samples.

TABLE II-1: RADIONUCLIDES FOR WHICH ACTIVITY CONCENTRATIONS WILL BE INTERCOMPARED WITHIN ILCs FOR CORROBORATION OF SOURCE MONITORING

Nuclide	**Half-life (years)**	**Discharge limit[13] (Bq/L)**
^{3}H	12	60000
^{14}C	5700	2000
^{54}Mn	0.85	1000
^{60}Co	5	200
^{63}Ni	100	6000
^{79}Se	356000	200
^{90}Sr	29	30
^{99}Tc	210000	1000
^{106}Ru	1	100
^{113m}Cd	14	40
^{125}Sb	3	800
^{129}I	16000000	9
^{134}Cs	2	60
^{137}Cs	30	90
^{144}Ce	0.78	200
^{147}Pm	2.60	3000
^{151}Sm	90.0	8000
^{154}Eu	8.60	400
^{155}Eu	4.80	3000
^{234}U	245500	20
^{238}U	4468000000	20
^{237}Np	2144000	9
^{238}Pu	88	4
^{239}Pu	24000	4
^{240}Pu	6600	4
^{241}Pu	14	2
^{241}Am	430	5
^{243}Cm	29	6
^{244}Cm	18	7

Note: ^{90}Y and ^{125m}Te have also been identified by TEPCO as requiring measurement and assessment within its source monitoring plan but are in secular equilibrium with ^{90}Sr and ^{125}Sb, respectively.

Note: TEPCO's source monitoring plan, like all aspects of its implementation plan for the handling of ALPS treated water at FDNPS, needs to be approved by the NRA and is thus subject to change.

[13] Noting that these limits have been established assuming that radionuclides are discharged individually and in a single chemical form (water). In real cases in which multiple radionuclides are discharged simultaneously (and potentially to both the atmosphere and to water), the sum of the ratios of the activity concentration of each radionuclide to the respective limit should not exceed one.

Corroboration of Environmental Monitoring

The main objective of this element is to corroborate the results of environmental monitoring undertaken by TEPCO and relevant Japanese authorities that specifically addresses the discharges of ALPS treated water from FDNPS. All environmental monitoring related to the nuclear accident at FDNPS is conducted according to the CRMP. This plan defines the sampling locations, matrices, collection frequencies, and the radionuclides to be analysed for each sample. It is reviewed and updated on an annual basis. In 2022 the CRMP was augmented to specifically address requirements imposed by the Government of Japan for monitoring of the marine environment related to the planned discharges of ALPS treated water. These changes included increased monitoring of seawater for ^{3}H at a range of distances from the ALPS treated water discharge point and marine biota for organically bound tritium (OBT), free water tritium (FWT), ^{14}C and ^{129}I.

As in the case of source monitoring, the corroboration of environmental monitoring is being conducted using ILCs. Two ILCs are envisaged initially. The first, in 2022 before discharges of ALPS treated water have begun, serves to test the readiness of participating laboratories for post-release environmental monitoring according to the CRMP and to corroborate the results of baseline monitoring. The second ILC will be organized in 2023 after discharges will have begun and will corroborate the results of initial environmental monitoring for assessing any changes in the levels of relevant radionuclides in the marine environment relative to the baseline. The participants in these ILCs include TEPCO and relevant Japanese authorities, the IAEA laboratories and third-party laboratories selected from members of the IAEA ALMERA network.

The IAEA has developed a sampling plan for the ILCs for corroboration of environmental monitoring, in cooperation with counterparts in the NRA which coordinates marine monitoring under the CRMP. This sampling plan is based on the additional sampling and analysis which has been added to the CRMP to address the planned discharges of ALPS treated water. The sample types, radionuclides and sampling locations that will be included in the ILCs are presented in Table II-2. The sampling locations included in the ILC are presented in Figures II-2 – II-4 in the context of all sampling locations included in the CRMP.

For each ILC, samples are being collected off the coast of the Fukushima Prefecture with observation by IAEA staff. The sampling methods routinely employed for marine monitoring within the CRMP are being used [16]. The bulk sample media collected will be pre-prepared, homogenised and split in laboratories in Japan to ensure that all participants receive identical samples for analysis. The samples will be analysed by participating laboratories by any appropriate method.

The results of analyses plus relevant additional information will be submitted by participating laboratories to the IAEA for evaluation, using a reporting form that will be provided. The results will be statistically evaluated according to the methodology described in section II-C. The results of the ILCs will be reported as also described in section II-C.

As is also the case for source monitoring, for corroboration of environmental monitoring it is important to note that the IAEA will not corroborate every measurement undertaken by Japanese laboratories. Instead, a representative number of samples of each type is being selected for corroboration.

The corroboration of environmental monitoring complements a separate project – NA3/38 Marine Monitoring: Confidence Building and Data Quality Assurance – addressing the quality of data from marine monitoring undertaken in Japan following the accident at FDNPS [17]. Through project NA3/38, which has been implemented since 2014, the IAEA is assisting the Government of Japan in ensuring that sea area monitoring carried out under the regularly updated CRMP is comprehensive, credible and transparent and is helping to build confidence of the stakeholders in the accuracy and quality of the marine monitoring data. Within project NA3/38, the IAEA has organized a series of ILCs and PTs to test the sampling and analytical performance of the Japanese laboratories for the analysis of radionuclides in seawater, sediment and fisheries samples. A general conclusion that may be drawn from the results of these PTs and ILCs is that Japanese laboratories monitoring seawater, marine sediment and fish from near FDNPS are producing reliable data.

Proficiency Testing

PTs are a vital complement to the corroboration of source and environmental monitoring that is being conducted using ILCs. PTs are based on laboratory-developed samples in which both the activity concentrations of radionuclides added, the so-called 'assigned values', and the sample matrix are known to a very high degree of certainty. (In contrast, ILCs are based on 'real-world' samples in which the results of analyses of activity concentrations of radionuclides reported by all laboratories, including the IAEA laboratories, are best estimates and thus subject to greater uncertainty.) PTs therefore offer a means to test unambiguously the measurement performance of each participating laboratory for relevant analytical methods. The comparison of the results submitted by participating laboratories with the assigned values facilitates evaluation of the accuracy and precision of the specific analytical method implemented, rather than any effect from the matrix of the sample being analysed.

The three IAEA laboratories involved in the corroboration of source and environmental monitoring related to ALPS treated water at FDNPS organize PT at regular intervals based on fully characterised, synthetic samples to test the analytical capability of participating laboratories.

Since 2014, at the request of the NRA as part of project NA3/38, RML have organized PTs to test the performance of participating laboratories in analyses of radionuclides in seawater. These exercises were initiated to support laboratories in analyses of ^{3}H, radiostrontium, radiocaesium and other gamma emitters in seawater. These are radionuclides that would be expected to be detectable in the marine environment in the case of an accident involving radioactive releases or through routine operations at nuclear facilities.

TERC provides an annual PT to more than 400 laboratories, including over 100 ALMERA member laboratories[14]. The PTs contain a wide range of sample matrices and radionuclide levels. Recent sample sets have included water, solid and contaminated surface samples containing characterized amounts of anthropogenic and naturally occurring alpha, beta and gamma emitting radionuclides.

Since the 1960s the Isotope Hydrology Laboratory of the International Atomic Energy Agency has conducted international ^{3}H analysis proficiency tests (TRIC, Tritium Inter-Comparison), primarily aimed towards high-precision users in the hydrological and groundwater sciences. Therefore, the participating laboratories receive water samples with a very low tritium level – 0 to 10 Tritium Units (TU) – that resemble samples targeted in hydrology and environmental monitoring. Samples containing higher levels of TU – 40 to 1000 TU – are also included. These proficiency tests provide an independent assessment of the quality of tritium data generated by laboratories.

A confidential individual evaluation report is provided to each laboratory participating in each IAEA PT.

The IAEA is encouraging as many laboratories as possible, that are participating in the ILCs for the corroboration of source and environmental monitoring, including TEPCO, relevant authorities in Japan and ALMERA laboratories, to also consider participation in these PTs. This enables the IAEA to assess and assure that the results reported in the ILCs have been performed by laboratories adhering to Good Laboratory Practice and using methods which are fit-for-purpose and subject to adequate quality controls.

Corroboration Timeline

Planning for the corroboration has been focussed relative to 2023, when discharges of ALPS treated water are due to begin. The results of the source monitoring ILCs and the review of related sampling

[14] Further details on the TERC PTs can be found on the webpage "Proficiency Test and Interlaboratory Comparison Exercises (iaea.org)" : https://nucleus.iaea.org/sites/ReferenceMaterials/SitePages/Home.aspx

and analytical methods will be completed in advance of the commencement of discharge. Similarly, sampling for the first ILC for corroboration of environmental monitoring which is corroborating baseline monitoring will have been performed in advance of the commencement of discharges. Sampling for the second ILC for corroboration of environmental monitoring will take place after the discharges have begun.

TABLE II-2: SAMPLING PLAN FOR THE ILCs FOR CORROBORATION OF ENVIRONMENTAL MONITORING

Sample type	**Nuclides**	**Locations**[15]	**Detection limits**[16]	**Note**
Seawater	^{3}H, ^{60}Co, ^{90}Sr, ^{106}Ru, ^{125}Sb, ^{129}I, ^{134}Cs, ^{137}Cs	E-S15: close to the coast at 1.5 km SW of discharge point, boundary of area where common fishery rights are set (Ministry of the Environment, MOE)	^{3}H: 0.1 Bq/L ^{134}Cs, ^{137}Cs, ^{90}Sr: 1×10^{-3} Bq/L ^{106}Ru: 1.2 Bq/L ^{125}Sb: 0.5 Bq/L ^{60}Co: 0.3 Bq/L ^{129}I: 1×10^{-2} Bq/L	Five sampling locations covering distances from very near and approximately 10 km, 30 km and 50 km from the discharge point.
	^{3}H	T-0-1A: 220 m north of discharge point (TEPCO)	0.1 Bq/L	
		T-3: close to the coast at 11.5 km south of discharge point (TEPCO)	0.1 Bq/L	
		M-E1: at 30 km east of discharge point (NRA)	0.1 Bq/L	
		M-E3: at 50 km east of discharge point (NRA)	0.1 Bq/L	
Marine sediment	Gamma-emitting radionuclides (^{60}Co, ^{106}Ru, ^{125}Sb, ^{134}Cs, ^{137}Cs)	T-1: close to the coast at 1 km west of discharge point (TEPCO)	1 Bq/kg dry weight (^{134}Cs, ^{137}Cs)	Two sampling locations, one from nearby and one from within 10 km of the discharge point
		T-S4: close to the coast at 3.2 km east of discharge point (TEPCO)		
Marine biota	^{3}H(OBT), ^{3}H(FWT)	E-S15: close to the coast at 1.5 km SW of discharge point, boundary of area where common fishery rights are set (MOE)	OBT: 0.5 Bq/L FWT: 0.1 Bq/L	Three sampling locations, one nearby and two at more than 10km from discharge point (^{14}C is monitored only at one location close to the
		T-S2, T-S7 (TEPCO)		

[15] The codes refer to sampling locations as defined in the CRMP. The organization listed in parentheses is assigned responsibility in the CRMP for monitoring for each location. The sampling locations are mapped in Figures II-2, II-3 and II-4.

[16] The approximate activity concentration to which laboratories should have the capability to analyse, generally as defined in the CRMP.

Sample type	Nuclides	Locations[15]	Detection limits[16]	Note
	^{14}C	E-S15 (MOE)	2 Bq/kg fresh weight	discharge point). One or two species will be sampled from each location depending on availability.
Seaweed	^{129}I	One sampling location within 10km south of FDNPS where it is feasible to collect samples MOE)	0.1 Bq/kg fresh weight	Three sampling locations within 10km from discharge point. One species will be sampled from each location.
		Two sampling locations within 10km north and south of FDNPS where it is feasible to collect samples (TEPCO)		
Fisheries products	^{3}H(OBT), ^{3}H(FWT), ^{14}C	Six edible species from local fish markets (Fisheries Agency of Japan, FAJ)	OBT and FWT: :0.5 – 1.0 Bq/L ^{14}C: 0.3 Bq/kg fresh weight	

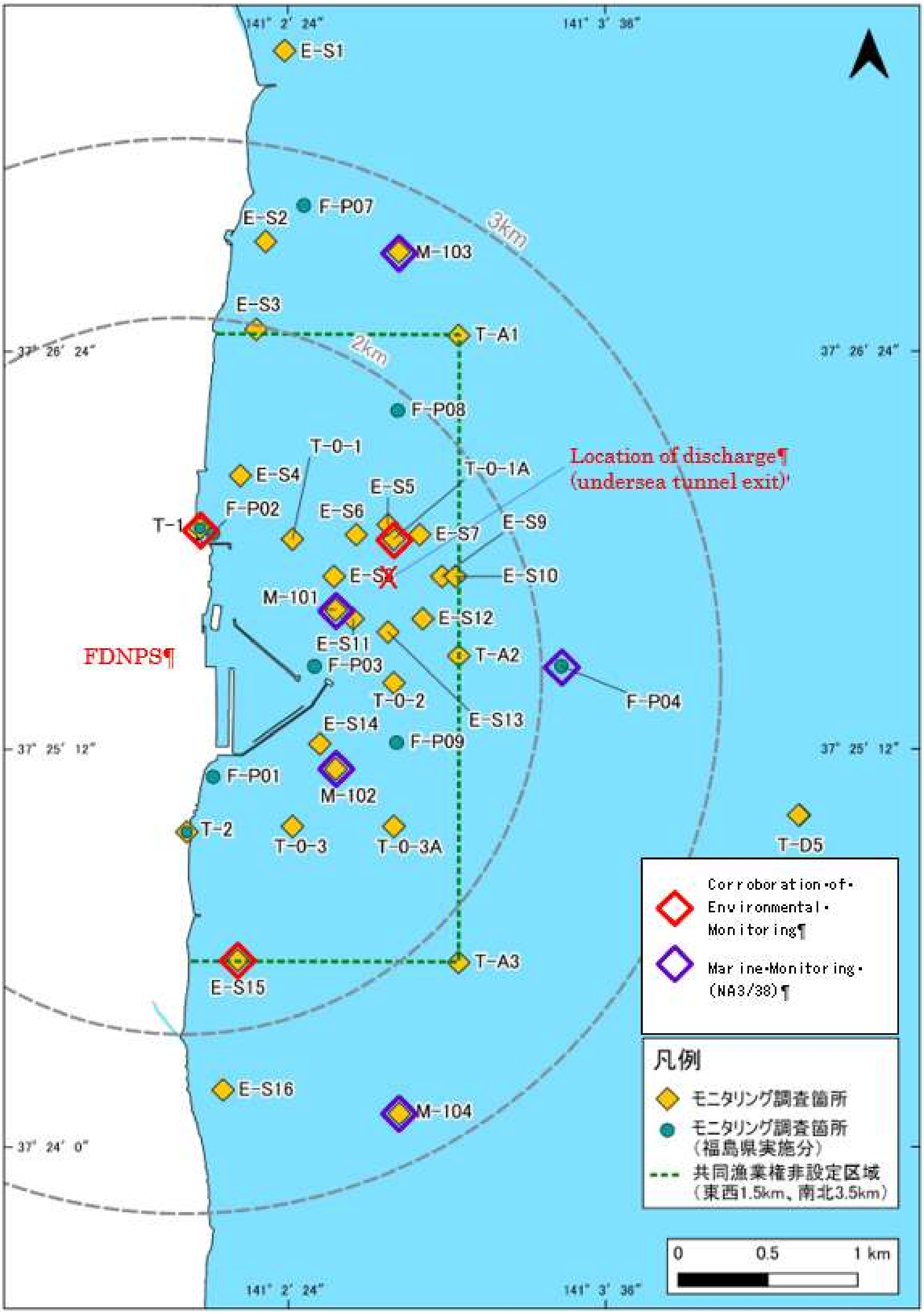

Fig II-2: Sampling locations (seawater, sediment and marine biota) for the ILCs for corroboration of environmental monitoring – nearshore sea area (Source: NRA, Radiation Monitoring Division)

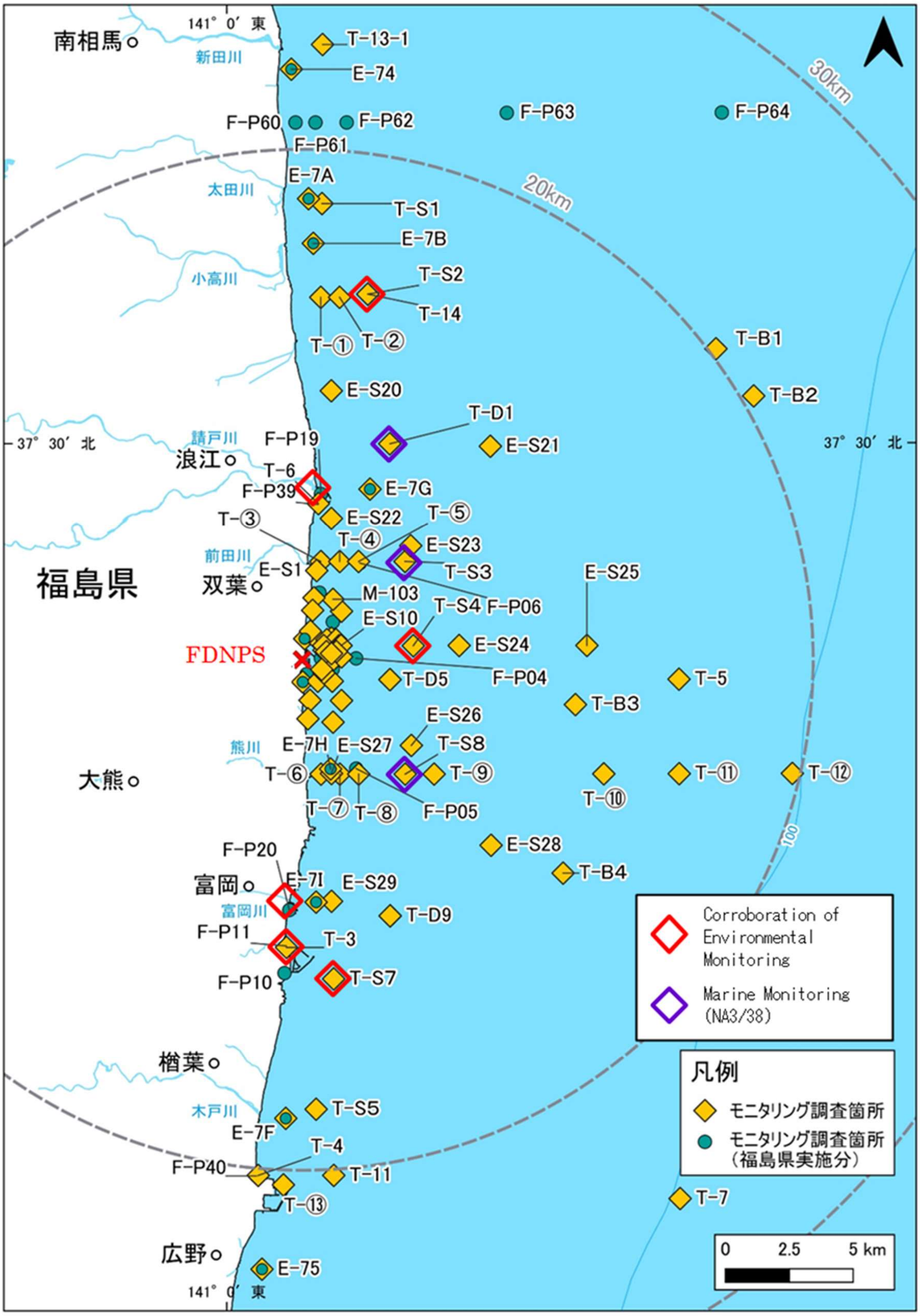

Fig II-3: Sampling locations (seawater, sediment and marine biota) for the ILCs for corroboration of environmental monitoring – coastal sea area (Source: NRA, Radiation Monitoring Division)

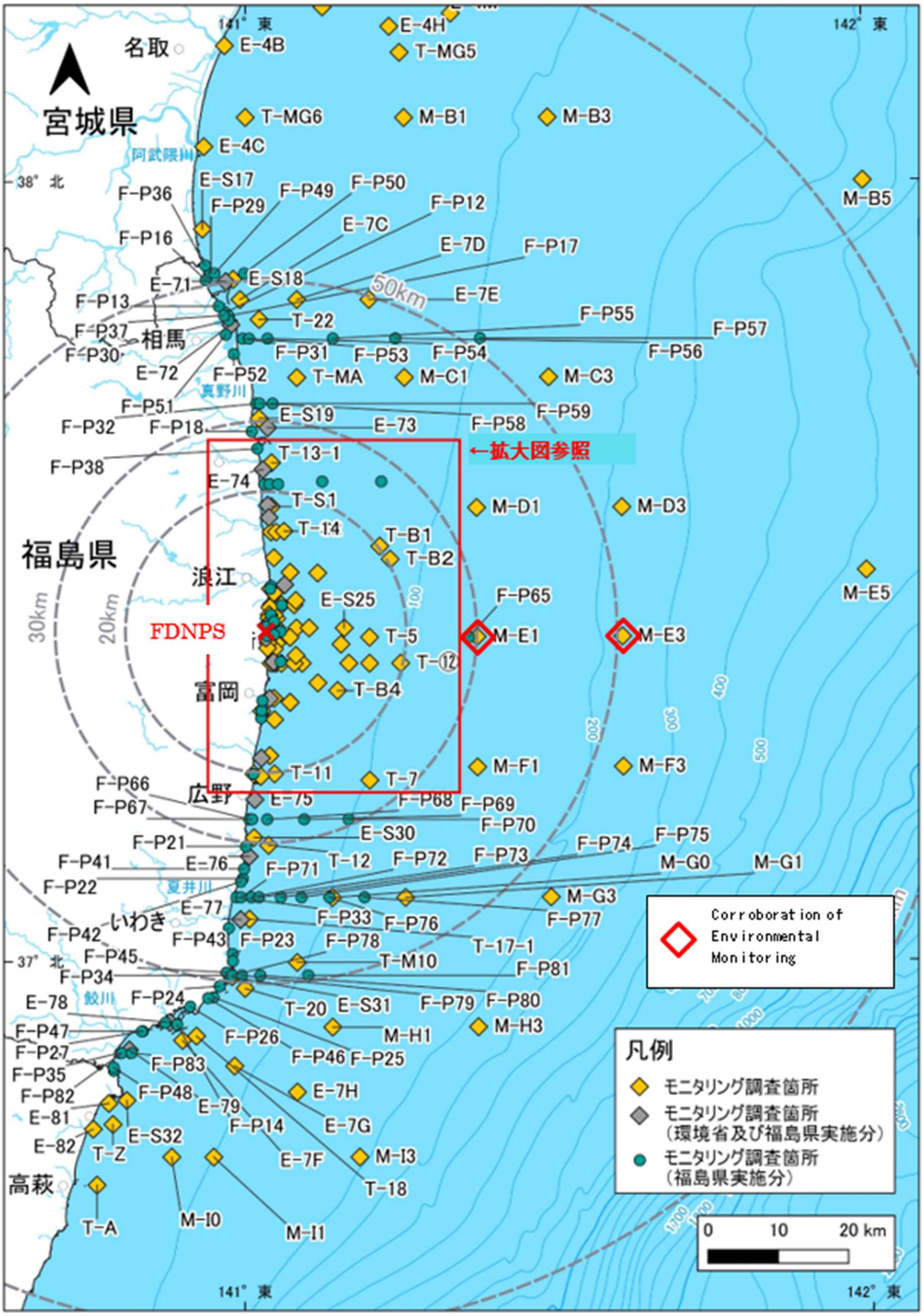

Fig II-4: Sampling locations (seawater) for the ILCs for corroboration of environmental monitoring – offshore sea area (Source: NRA, Radiation Monitoring Division)

II.B. Participating IAEA Laboratories[17]

IAEA Marine Environment Laboratories, Radiometrics Laboratory

The Radiometrics Laboratory (RML) in Monaco fosters expertise in marine radioactivity measurement, monitoring and assessment and in the application of radiotracers for marine pollution, climate change and oceanographic studies. RML operates specialised radiochemistry laboratories and an underground counting facility for the analysis of low levels of radionuclides in marine and atmospheric samples and environmental forensics applications. The laboratory maintains an open access marine radioactivity data portal (MARIS) and assists Member States to prepare for nuclear and radiological incidents or emergencies that could impact the marine environment. By supporting data quality in Member States for analyses of radionuclides in seawater, sediment and marine biota, including through production of reference materials according to an accredited quality system and PTs and ILCs, RML contributes to the credibility of monitoring and research results.

Terrestrial Environmental Radiochemistry

The Terrestrial Environmental Radiochemistry (TERC) laboratory in Seibersdorf (Austria) assists Member States in assuring the quality of performed analytical work by supporting respective , laboratories active in the fields of environmental radioactivity, stable isotope and trace element analysis. TERC provides technical support to Member State laboratories by providing suitable reference materials for calibration and quality control, by organising PTs to facilitate checks of analytical quality, by providing thoroughly tested and published analytical methods, and by training laboratories in their setup and operation.

Isotope Hydrology Laboratory

The Isotope Hydrology Laboratory (IHL) in Vienna provides analytical services, training, and expert technical advice to Member States to develop their own analytical facilities and to help ensure the quality of isotope measurements conducted in their laboratories. The IHL houses state-of-the-art analytical equipment for the collection and measurement of stable and radiogenic isotopes and noble gases from water and hydrological samples and provides analytical support to the IAEA's Water Resource Programme's global hydrology monitoring networks, including the global network of isotopes in precipitation (GNIP), and the global network of isotopes in rivers (GNIR). Isotopic data produced by the IHL are included in the GNIP and GNIR databases, data which are made available cost-free to Member States via the internet.

Analyses Undertaken by Each Laboratory

For each ILC and radionuclide, the IAEA laboratories will submit a single measurement result for comparison with the results of TEPCO and the other participating laboratories. Analyses will be undertaken in the three environmental laboratories for both corroboration of source and environmental monitoring. By undertaking independent confirmatory analyses, using distinct analytical methods where possible, the laboratories will work together to ensure that the submitted results have been thoroughly checked. This approach facilitates maximum confidence in the results reported by the IAEA.

[17] In addition to the IAEA Laboratories, the IAEA is coordinating the ALMERA laboratories as described in Section II.A.

II.C. Evaluation and Reporting of Results

For the corroboration of source and environmental monitoring, the IAEA will compile and evaluate the results reported by all ILC participants. The statistical evaluation will consist of a method for calculating a comparison reference value as a power-moderated mean of the combined results [18], which is currently being used by the International Bureau of Weights and Measures' Consultative Committee for Ionizing Radiation, Section II: Measurement of radionuclides, CCRI(II). For each sample and for each radionuclide for which results will be intercompared, a comparison reference value will be determined as a power-moderated mean of the combined results submitted by participating laboratories. Then, a relative degree of equivalence (DoE) will be calculated for each submitted result and if this is significantly different from zero, the corresponding result will be evaluated as being discrepant. The relative DoE (%) is calculated according to:

$$\text{DoE (\%)} = \frac{x_{\text{lab}} - X_{\text{ref}}}{X_{\text{ref}}} 100 \quad (1)$$

where:

x_{lab} is the individual laboratory result; and
x_{ref} is the reference value calculated as the power-moderated mean of the combined results.

The standard uncertainty of the relative DoE, u_{DoE}, was calculated according to reference [18]. If the absolute value of the relative DoE exceeds 3 times u_{DoE}, the corresponding result was evaluated as being discrepant (at a 99.7% confidence level), as the relative DoE in this case would be significantly different from zero. This shall be considered to give an 'action signal'. Likewise, if the absolute value of the relative DoE exceeds 2 times u_{DoE}, this shall be considered to give a 'warning signal'. A standard approach, according to ISO 13528:2022, is that a single "action signal", or "warning signals" in two successive ILCs, shall be taken as evidence that an anomaly has occurred that requires investigation.

The precision of each result reported will also be assessed to ensure that the analytical methods selected by each laboratory are fit for purpose and that uncertainties have not been artificially inflated. The precision of analytical results varies quite broadly depending on the techniques employed, the radionuclide levels and the sample matrix. However, the measurement uncertainties reported by any participating laboratory should not be excessive when compared to those for the same sample and radionuclides submitted by other laboratories. A precision check will be undertaken by comparing each result reported to a multiple of a characteristic uncertainty of a typical measurement, a parameter calculated as part of the determination of the power-moderated mean. For example, a reported uncertainty of greater than five times the characteristic uncertainty of a typical measurement would be deemed statistically irrelevant.

The results of the ILCs will be reported in stand-alone reports which will include a compilation of the data reported by each laboratory, the results of the statistical evaluation in graphical and tabular format and subsequent conclusions. These reports will be organized using a standard template for technical reports used by the IAEA and will also include a general overview to aid in the public's understanding and interpretation of the results.

Prior to publication, the results will be shared with all participating laboratories to ensure that their reported results have been compiled accurately. Any discrepancies (significantly different results) identified by the statistical evaluation will be first carefully verified and then investigated using all available information including relevant details from the review of sampling and analytical methods, the results of relevant PTs, and relevant information released by TEPCO and other Japanese authorities. Relevant laboratories will also be consulted. This information will be used to provide context and to aid interpretation of the root cause of the differences. If it is concluded that the discrepancy is real this will be published with accompanying explanation and analysis of implications and consequences.

II.D. Summary of Progress (August 2021 – November 2022)

Corroboration activities that have been completed or are in progress during the period August 2021 to November 2022 are elaborated in this section.

Laboratory Preparatory Meeting

In February 2022, an IAEA team travelled to FDNPS and Tokyo to hold meetings with technical staff, visit the FDNPS site and discuss the key components of the IAEA's planned activities for corroboration of source and environmental monitoring related to discharges of ALPS treated water. During this series of meetings, the IAEA observed the analytical facilities at FDNPS and had access to key scientific staff at TEPCO. As a result, the IAEA team made significant progress in gathering information, identifying key technical contacts, defining preparations needed for sampling water from the tanks, discussing sampling and analysis methods used by Japan with laboratory staff, outlining plans for a review of relevant sampling and analytical procedures and initiated a request for related documentation and records.

Test Samples for Corroboration of Source Monitoring

During the first review mission to TEPCO/METI held in February 2022, IAEA staff were on-site at FDNPS to witness the collection of initial 'test samples' of ALPS treated water. Test samples are used to conduct preliminary analyses for verification of methods and to assess any changes or refinements which may be required regarding the instructions for laboratories participating in the ILCs being used to undertake the corroboration of source monitoring. Results of analyses of these initial samples will not be intercompared but are being used by the IAEA to determine the physical and chemical properties of the ALPS treated water. The samples for each IAEA laboratory are comprised of 25.3 L of ALPS treated water sampled from the K4-B tanks at FDNPS (prior to dilution with seawater). These tanks are being re-utilized as a measurement and confirmation facility within the discharge facility that is currently under construction.

For 14 days prior to the collection of the samples, TEPCO had performed a circulation and agitation experiment to verify the adequacy of plans for the homogenisation of samples in the measurement and confirmation facility once construction will have been completed. The results of this experiment were subsequently released by TEPCO [20].

ALPS treated water in this tank group was separated into sample sets of 5 x 5 L collected in plastic cubitainers and of 3 x 100 mL collected in amber glass bottles and were not acidified or filtered when collected. The test samples were received by TERC in Seibersdorf, Austria in June 2022. The samples were forwarded to the Monaco and Vienna laboratories in July 2022, after all necessary radiation protection checks had been performed.

More details on the analyses of these test samples undertaken by the IAEA laboratories are provided in the subsection 'Preparations by the IAEA Laboratories'.

First ILC for Corroboration of Source Monitoring

During the first review mission to the NRA held in March 2022, IAEA staff were on-site at FDNPS to witness the collection of samples of ALPS treated water from the K4-B tanks. This batch of samples will be used to conduct the first full scope ILC to corroborate source monitoring, according to the design described in section II.A.

Sampling was undertaken as described for the test samples above. The experimental equipment for circulation and agitation to ensure homogeneity was run again by TEPCO for 14 days prior to the collection of samples. Instructions for the first ILC were sent to all participating laboratories between March and July 2022. The samples were received by the IAEA laboratories in Monaco and Austria and by the participating ALMERA laboratories between August and October 2022.

The laboratories participating in the first ILC are the following:

- IAEA laboratories: RML, TERC, IHL;
- TEPCO laboratories, Japan;
- Institut de Radioprotection et de Sûreté Nucléaire (IRSN), France;
- Korea Institute of Nuclear Safety (KINS);
- Los Alamos National Laboratory (LANL), USA;
- Labor Spiez, Switzerland.

The reference date for decay correction of activity concentrations is the sampling date, 24 March 2022.

The laboratories have been requested to submit results in early 2023.

Second and Third ILCs for Corroboration of Source Monitoring

In October 2022, the IAEA witnessed the collection of two additional batches of samples of ALPS treated water. These samples are being used in the second and third ILCs to support the corroboration of source monitoring.

The samples were collected from the G4S-B10 and the G4S-C8 tanks. In contrast to the samples collected for the first ILC for the corroboration of source monitoring, these are standard tanks for storage of ALPS treated water and not interconnected or subject to circulation and agitation. To ensure inter-sample homogeneity in each case, ALPS treated water was first transferred to a 300 L plastic tank, then to a second 300 L plastic tank and, finally, back to the first 300 L plastic tank. Sample containers (3 L) were then filled and prepared for shipping to each participating laboratory. The sample volume was smaller for the second and third ILCs as robustness testing will not be carried out for these samples, having already been completed for the earlier samples.

As well as TEPCO and the IAEA laboratories, the ALMERA laboratory Korea Institute of Nuclear Safety (KINS) will participate in these ILCs. The IAEA's samples were received by TERC in November 2022. KINS also received its samples in in November 2022. This timing will allow for results to be received, evaluated and reported prior to the start of the discharge of ALPS treated water in 2023.

The reference date for decay correction of activity concentrations is the sampling date, 19 Octoer2022.

The laboratories have been requested to submit results in early 2023.

Sampling for Corroboration of Environmental Monitoring

In November 2022 the IAEA participated in a sampling mission in Japan to collect environmental samples (e.g., seawater, marine sediment, fish, seaweed) for the first ILC to corroborate environmental monitoring related to discharges of ALPS treated water. These samples were collected jointly with experts from Japan according to methods mirroring existing sampling practices utilized by the IAEA for ILCs organized within the project NA3/38 (Marine Monitoring: Confidence Building and Data Quality Assurance) over the past nine years.

Participating laboratories will be instructed to submit results according to a similar protocol to that described above for the first ILC for corroboration of source monitoring above. Following evaluation of all data submitted, the results of the ILC will be made available by the IAEA by mid-2023. The results of future monitoring of environmental samples will be compared against the baseline to assess any measurable impacts from the future discharges of ALPS treated water.

Preparations by the IAEA Laboratories

Throughout 2021, the IAEA laboratories performed an assessment of the capabilities, capacity and resources needed to successfully achieve the objectives of the corroboration of source and environmental monitoring related to discharges of ALPS treated water at FDNPS within the defined timeline for the project. This resulted in the identification of specialised equipment, skilled personnel and dedicated facilities to undertake the required analysis activities following international best practice.

Additional equipment for both sample preparation and analysis was procured to ensure that the capacity needed to analyse the large range of identified radionuclides within the defined timeline was available.

All three IAEA laboratories have many years' experience in the handling and analysis of samples containing radionuclides at environmental levels. Preparation for the receipt of ALPS treated water samples containing higher activities of radionuclides, in particular ^{3}H, presented a challenge. Focus was given to ensuring the safe handling of samples containing elevated activity concentrations (i.e., above environmental levels) in the laboratories' low-level environmental facilities. This required deployment of additional instruments for screening as well as quantitative analysis. Practical guidance and recommendations on operational radiation protection aspects related to the safe handling of ALPS treated water samples, in particular tritium contamination, were also developed. General principles of radiation protection to prevent acute exposures, to ensure that regulatory limits are not exceeded and to keep exposures are as low as reasonably achievable are followed.

A large proportion of the activities to date have been the development and validation of fit-for-purpose radioanalytical methods. It has been important to procure the appropriate consumables for this including certified radioactive standard solutions for quality assurance and control. It was also necessary to recruit skilled analysts on a temporary basis to support this workload, while continuing to deliver on the existing programmatic activities and obligations of each laboratory.

In advance of the planned series of ILCs to corroborate source monitoring, an examination of potential sources of variability in ALPS treated water sampling, temporary storage and transport methods was undertaken. The robustness or ruggedness of an analytical process is a measure of its capacity to remain unaffected by small, but deliberate variations in method parameters and provides an indication of its reliability during normal usage. It also encompasses the integrity of the sample material, specifically that any changes induced by temporary storage or shipping should not adversely affect the results of analysis. Robustness testing is an ISO17025 requirement for the development of analytical procedures, including sampling. The robustness testing of ALPS treated water sampling and transport is being carried out on the test samples collected in February 2022 using the method described in references [27, 28]. The process involves varying degrees of filtration, acidification and refrigerated storage time of the samples. A report of this testing was provided to all laboratories participating in ILCs for the corroboration of source monitoring in November 2022.

Proficiency Testing

IAEA proficiency testing in 2022 for laboratories analysing for levels of radionuclides included well-characterised synthetic samples replicating source and environmental samples, with activity concentrations, sample matrices and radionuclides relevant to the ALPS corroboration. All laboratories planning to contribute results to the ALPS corroboration – TEPCO, ALMERA laboratories and other Japanese laboratories involved in environmental monitoring under the CRMP –have been encouraged to participate in these PTs.

TERC organized the IAEA-TERC-2022-01/02 Proficiency Test, which includes four water samples containing radionuclides consistent with those required to be analysed for the corroboration of source and environmental monitoring related to ALPS treated water including ^{3}H, ^{60}Co, ^{90}Sr, ^{134}Cs, ^{137}Cs, ^{241}Am and gross α and β. RML and all ALMERA laboratories involved in the ILCs are participating in this PT. The deadline for reporting results was 30 September 2022. The results submitted by participating laboratories were analysed by the IAEA in October 2022 and an individual evaluation report will be sent to each laboratory by early 2023. The results of the PT will provide additional quality assurance to complement the ILC results.

RML organised the IAEA-RML-2022-01 Proficiency Test for determination of radionuclides in seawater. This PT is comprised of a single 5 L seawater sample spiked with known amounts of ^{3}H , ^{90}Sr, ^{134}Cs, ^{137}Cs and an 'Undisclosed Gamma Emitter'. Samples were shipped to participating laboratories in July 2022 and the results will be available in January 2023. As in previous years, around 100 laboratories worldwide are participating, with approximately 25 of these from Japan.

The Tritium Inter-Comparison (TRIC) was also organized by IHL in 2022. Water samples containing higher (40 – 1000 TU, 4.7 – 118 Bq/L) and lower (<10 TU, 1.18 Bq/L) activities of ^{3}H were distributed to participating laboratories in March 2022. The deadline for participating laboratories to report results was August 2022 and these are in the process of being evaluated. RML and TERC are participating in TRIC, through the analysis of samples containing higher activities, in order to demonstrate competence.

II.E. Anticipated Future Activities (December 2022 and Beyond)

Review of Sampling and Analysis Methods

For the review of TEPCO's laboratories, desk reviews will initially be undertaken by the IAEA of (a) the generic Japanese methods recommended by the NRA [29] for measurements of radionuclide levels in environmental samples and (b) procedures based on these that are used by TEPCO for both source and environmental monitoring purposes. The IAEA team will assess the appropriateness of each method, including – for analytical methods – an evaluation of required detection limits and uncertainties. Then on-site observation by the IAEA team of the implementation of these methods will take place. The team will initially examine relevant documentation and data for a representative number of samples that have been collected and analysed for source and environmental monitoring. The IAEA team will then observe the laboratories, staff, and processes to gain a better understanding and knowledge of laboratory activities. This will also provide confirmation of the approach taken regarding quality for source and environmental monitoring activities. Lastly, the IAEA team will engage with scientists and technical staff in these laboratories to verify and elaborate on the information gathered throughout the review.

The main objective is to provide background information to help interpret any significant differences, if any, in TEPCO's measurement results compared to those of the IAEA's laboratories and those of the ALMERA laboratories participating in the ILCs.

As the corroboration progresses, the IAEA will also gather information on the methods used for environmental monitoring at other relevant laboratories in Japan.

Corroboration Activities After the Start of Discharges of ALPS Treated Water

After the discharges of ALPS treated water begin, the IAEA will continue its corroboration activities as one of the main elements of its ongoing review and monitoring efforts. However, the precise sample types, frequency of sampling, and frequency of ILCs have yet to be determined. These details will be clarified based on the results of the sampling and analysis activities performed before the discharges of ALPS treated water start and insights gained from TEPCO's initial operation of the discharge process. It is anticipated that sampling missions will continue on an annual basis, including for corroboration of both source (i.e., ALPS treated water) and environmental monitoring. The laboratories participating in the ongoing sampling activities will also be encouraged to participate in future proficiency tests which are organized by the IAEA on a yearly basis. Follow-ups to reviews of sampling and analysis methods of TEPCO's laboratories may be conducted on an ad hoc basis, driven by any significant changes to the operation or oversight of the ALPS discharge process.

As new information and operational insights become available, certain aspects of the corroboration as described in this report may be changed. The corroboration has been designed to be flexible, to incorporate additional information when available, and to consider opportunities for innovation and improvement as they arise. The following items could result in changes to the plan:

- Ongoing monitoring results, unexpected discharges, or events.
- Changes in ALPS operations.
- Other factors considered relevant by IAEA.

A regular review of all aspects of the corroboration is also envisaged to ensure the work keeps abreast of periodic reviews and evolution of the monitoring programmes being corroborated and any changes made to the discharge authorization by the NRA on the basis of its own regular review as required by RS-G-1.8 paras 5.9 – 5.10. Details of the plan will be reviewed at regular intervals by the Task Force.

It is also noted that more frequent and detailed environmental measurements may be needed in the early stages of operation (GSG-9 para 5. 8). If this early monitoring is subsequently scaled back, then corroboration activities could also be reduced.

III. Part III

III.A. Corroboration Concept for Occupational Radiation Protection Data

According to the requirements of GSR Part 3 [8], the responsibility for the protection of workers against occupational exposure resides with employers, registrants and licensees who shall ensure that protection and safety is optimized and that the dose limits for occupational exposure are not exceeded. Furthermore, appropriate arrangements shall be made with authorized or approved dosimetry service providers that operate under a quality management system for assessment and recording of the occupational exposure of workers. For workers who usually work in controlled areas, or who occasionally work in controlled areas and may receive a significant dose from occupational exposure, individual monitoring shall be undertaken where appropriate, adequate, and feasible. For workers who regularly work in supervised areas or who enter controlled areas only occasionally, the occupational exposure shall be assessed on the basis of the results of workplace monitoring or individual monitoring, as appropriate. Employers shall ensure that workers who could be subject to exposure due to contamination are identified, and arrangements are made to assess intakes of radionuclides and the committed effective doses.

An individual monitoring programme is designed to assess radiation doses to workers arising from exposure due to external sources of radiation and from exposure due to intakes of radionuclides. Consequently, there are three distinct elements that the IAEA's corroboration must focus on, as illustrated in Figure III.1:

1. Corroboration of relevant Japanese individual monitoring services (IMS) capabilities for monitoring and assessing external exposure;
2. Corroboration of relevant Japanese IMS capabilities for monitoring and assessing internal exposure; and
3. Review of analytical methods in external and internal dosimetry used by the relevant Japanese IMS.

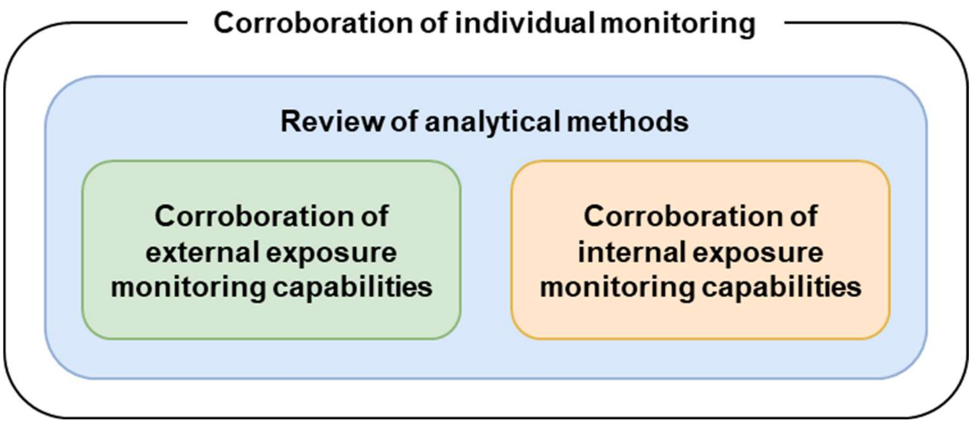

Figure III.1. Schematic overview of the corroboration of individual monitoring.

The IAEA will address all three elements mentioned above, considering the overall schedule and progress by TEPCO as they prepare to discharge ALPS-treated water in 2023.

First, the IAEA will corroborate the capabilities of IMS used by TEPCO for the assessment of occupational exposure of workers <u>from external sources of radiation</u>. An interlaboratory comparison (ILC) will be the principle means of accomplishing this corroboration, which will focus on TEPCO's monitoring programme for assessing the occupational exposure of workers involved in handling ALPS-treated water. Personal dosimetry systems with integrated passive detectors will be provided by and evaluated at the IAEA Radiation Safety Technical Services Laboratory (RSTSL) and relevant Japanese

IMS. Irradiation of dosimeters will be carried out in two phases for whole-body and extremity dosimeters, respectively, at primary or secondary standards dosimetry laboratories. The IAEA will also conduct a review of analytical methods relevant to external dosimetry used by the relevant Japanese IMS. The results of this review will contribute to ensuring the validity of the data generated as part of the above-mentioned ILC.

Second, the IAEA will corroborate the capabilities of IMS used by TEPCO for the assessment of occupational exposure of workers due to intake of radionuclides. An ILC will be the principle means of accomplishing this corroboration for in-vitro and in-vivo radiobioassay and will focus on TEPCO's capabilities to detect radionuclide activities in urine reference samples and in phantoms emulating the human body. In the first phase, urine reference samples will be prepared by accredited laboratories and distributed for comparative analysis at the IAEA RSTSL and relevant Japanese IMS. In a second phase, a solid, leak-proof sliced bottle mannequin absorption (BOMAB) phantom containing exempt laminated planar radionuclide sources inserted between layers of polyethylene will be measured at body counters in Fukushima Daiichi and at IAEA Headquarters in a round-robin test. The IAEA will also conduct a review of analytical methods relevant to internal dosimetry used by the relevant Japanese IMS. The results of this review will contribute to ensuring the validity of the data generated as part of the above-mentioned ILC.

The use of ILCs, including a review of analytical methods, will provide for an independent demonstration of the reliability and robustness of the IMS involved.

The proposed ILCs serve the following purposes:

- Evaluation of the performance of laboratories for specific tests or measurements and monitoring;
- Identification of inconsistencies in results between laboratories;
- Establishment of the effectiveness and comparability of test or measurement methods;
- Provision of additional confidence to interested parties; and
- Validation of uncertainties.

Monitoring and Assessment of External Exposure

The corroboration of the capabilities of relevant Japanese IMS used by TEPCO for assessing external exposure will utilize dosimetry systems with integrating passive detectors to determine the personal dose equivalent, $H_p(d)$, at a depth d in the body. The ILC will be organized in two phases. In the first phase, the performance of whole-body dosimeters and extremity dosimeters capable of measuring $H_p(10)$ and $H_p(0.07)$ will be compared. In the second phase the response of eye-lens dosimeters in terms of $H_p(0.07)$ and/or $H_p(3)$ will be analysed. The dosimeters will be irradiated at primary or secondary standards dosimetry laboratories according to the requirements of ISO 4037-1:2019 [10] and IEC 62387:2020 [21]. Electron and photon qualities, doses and angles of incidence will be selected to emulate the field exposure conditions and allow for an investigation of accuracy, linearity of response and reproducibility (Tables III.1 and III.2).

Table III.1. Photon reference irradiations for ILC of whole-body dosimeter performance.

Radiation quality	Average energy (keV)	Type of phantom	Angle of incidence	$H_p(10)$ (mSv)
N-40	33	ISO slab phantom	0°	3
N-40	33	ISO slab phantom	H +60°	3
N-100	84	ISO slab phantom	0°	3
N-300	248	ISO slab phantom	0°	3
S-Cs	662	ISO slab phantom	0°	0.3
S-Cs	662	ISO slab phantom	0°	1
S-Cs	662	ISO slab phantom	0°	3
S-Cs	662	ISO slab phantom	0°	10
S-Cs	662	ISO slab phantom	H +60°	3

Table III.2. Electron reference irradiations for ILC of extremity dosimeter performance.

Radiation quality	Average energy (MeV)	Type of phantom	Angle of incidence	$H_p(10)$ (mSv)
^{85}Kr	0.24	ISO rod phantom	0°	3
$^{90}Sr/^{90}Y$	0.80	ISO rod phantom	0°	1
$^{90}Sr/^{90}Y$	0.80	ISO rod phantom	0°	3
$^{90}Sr/^{90}Y$	0.80	ISO rod phantom	0°	10
$^{90}Sr/^{90}Y$	0.80	ISO rod phantom	H +45°	3

To obtain clear reference values in terms of personal dose equivalent, irradiations will be carried out on the following phantoms:

- Slab phantom of outer dimensions 30 cm × 30 cm × 15 cm with polymethyl methacrylate (PMMA) walls (front wall 2.5 mm thick, other walls 10 mm thick) filled with water to approximate the human torso for irradiation of whole-body dosimeters;
- Rod phantom composed of a PMMA cylinder of 19 mm diameter and 300 mm length to approximate a finger for irradiation of extremity dosimeters; and/or
- Cylinder phantom composed of a water-filled hollow cylinder of 200 mm diameter and 200 mm length with 5 mm-thick PMMA walls to approximate the head for irradiation of eye-lens dosimeters.

After irradiation, the dosimeters will be returned to the participating IMS for readout and evaluation according to routine laboratory procedures. The services will report their results, as applicable, in terms of $H_p(10)$, $H_p(0.07)$ and/or $H_p(3)$, to the IAEA RSTSL for summary and cross-comparison. An evaluation of performance will compare the ratio of the measured to the reference dose against the acceptance criteria for relative response, R, with respect to the conventional quantity value, H_{ref}, of ISO 14146:2018 [21]:

$$0.71 \cdot \left(1 - \frac{2 \cdot H_0/1.33}{H_0/1.33 + H_{\text{ref}}}\right) \leq \text{R} \leq 1.67 \cdot \left(1 + \frac{H_0}{4 \cdot H_0 + H_{\text{ref}}}\right) \quad (2)$$

wherein the lower dose limit to be tested, H_0, is chosen as 0.1 mSv for whole-body and 1 mSv for extremity dosimeters. The workflow is illustrated in Figure III.2.

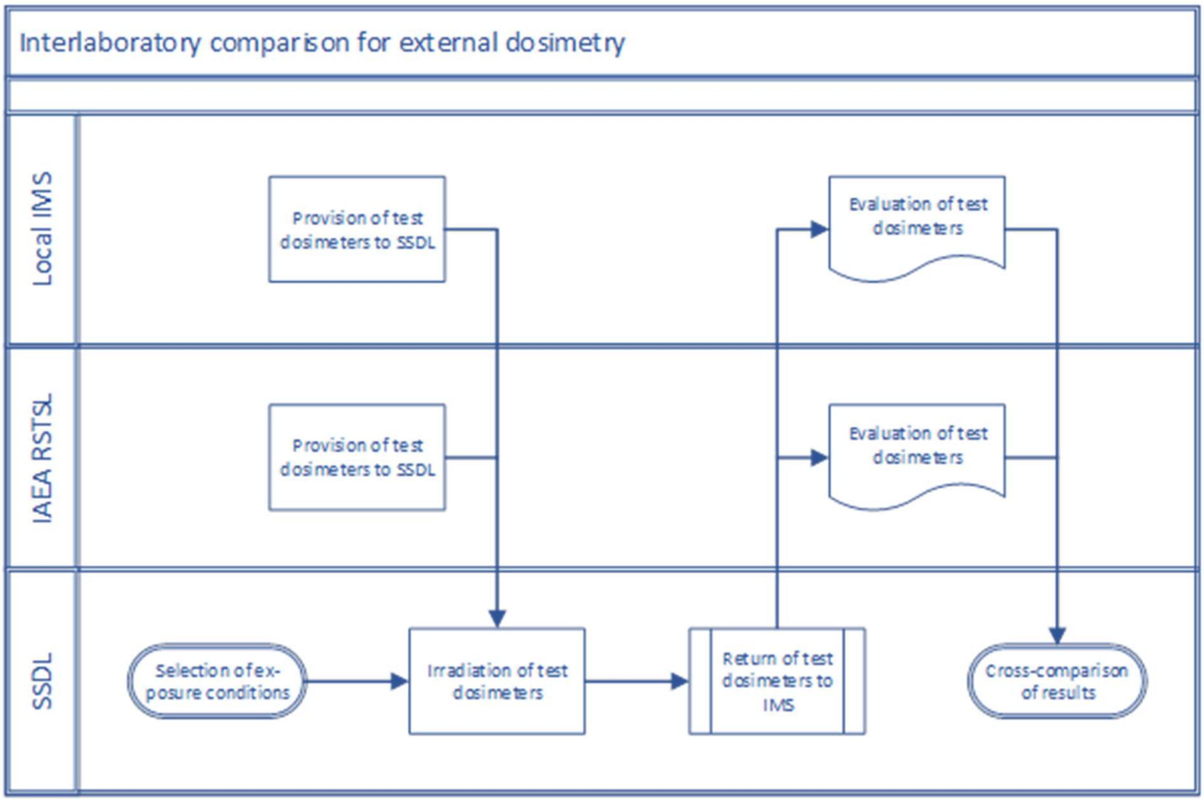

Figure III.2. Schematic workflow of the interlaboratory comparison for external dosimetry.

Monitoring and Assessment of Internal Exposure

The IAEA's corroboration of capabilities of IMS for assessing internal exposure will utilize both in-vitro radiobioassay and in-vivo monitoring. For in-vitro radiobioassay of excreta, aliquots of urine spiked with tritiated water (HTO) or ^{90}Sr will be prepared by dilution from certified reference materials and be provided for analysis according to routine laboratory procedures to the IMSs involved. Activity concentrations in the reference samples will be less than 10 kBq L^{-1} for ^{3}H and less than 20 Bq L^{-1} for ^{90}Sr. Depending on the radionuclide, the sample volume will range between 50 mL and 500 mL. The selection of radionuclides is aimed at mimicking the most likely and significant potential source of internal dose by workers on site. (Table III.3).

Table III.3. Reference urine samples for ILC of in-vitro monitoring performance.

Radionuclide	Activity concentration (Bq L^{-1})	Sample volume (mL)
^{3}H (HTO)	5E+02	100
^{3}H (HTO)	8E+02	100
^{3}H (HTO)	8E+03	100
^{3}H (HTO)	Blank	100
^{90}Sr	3E+00	500
^{90}Sr	6E+00	500
^{90}Sr	Blank	500

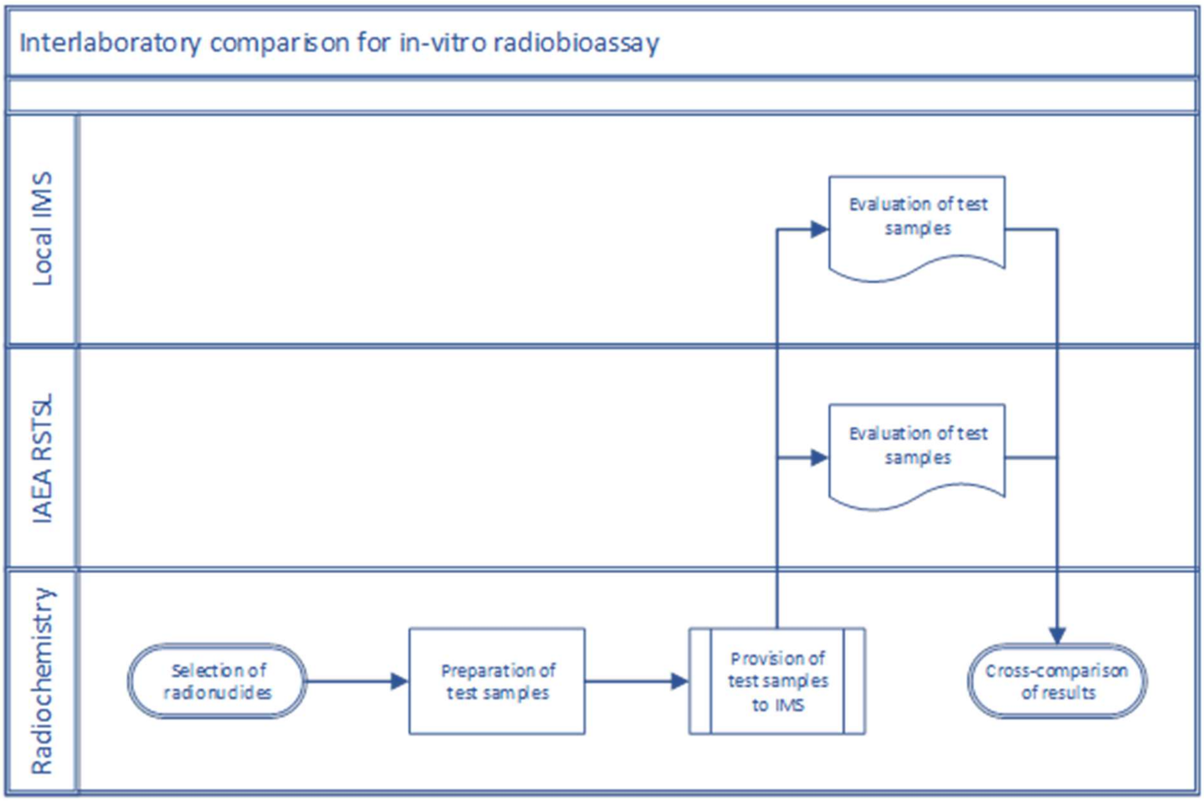

Figure III.3. Schematic workflow of the interlaboratory comparison for in-vitro radiobioassay.

The participating services will report the measured activity concentrations to the IAEA RSTSL for summary and cross-comparison. Performance evaluation will compare the trueness (relative bias, B_r), repeatability, s_{Br}, and precision (zeta score, ζ) against the acceptance criteria for radiobioassay of ISO 28218:2010 [23, 24]:

$$-0.25 < B_{\mathrm{r}} < 0.5 \quad ; \quad \left|s_{B_{\mathrm{r}}}\right| \leq 0.4 \quad ; \quad |\zeta| \leq 2 \tag{3}$$

The workflow is illustrated schematically in Figure III.3.

ILCs for in-vivo monitoring will require significantly more effort, since a solid, leak-proof sliced BOMAB phantom containing laminated planar ^{137}Cs radionuclide sources inserted between layers of polyethylene needs to be shipped in a round-robin experiment to the IMS involved. The laboratories will measure the activity and report back to the IAEA RSTSL for summary and cross-comparison. The results will be evaluated against the acceptance criteria for radiobioassay of ISO 28218:2010 [23, 24] with respect to trueness (relative bias, B_r) and precision (zeta score, ζ):

$$-0.25 < B_{\mathrm{r}} < 0.5 \quad ; \quad \left|s_{B_{\mathrm{r}}}\right| \leq 0.4 \quad ; \quad |\zeta| \leq 2 \tag{4}$$

<u>Review of Analytical Methods</u>

To evaluate the consistency of measurements and quality assurance procedures among the IMS involved, the following information will be collected prior to initiation of ILCs:

- A brief description of the analytical method and software applied for analysis of the test item, and, if applicable, reference to international standards;
- Detection limit and measurement range; and
- Uncertainty estimates and decision rule.

A review of analytical methods is necessary to demonstrate a laboratory's ability to properly maintain occupational exposure assessment capabilities, and to determine the level of agreement between laboratories. The IAEA will present a comparison of technical characteristics for both external and internal monitoring methods to enable correct interpretation of measurement results and corroboration of occupational radiation protection data.

III.B. Participating IAEA Laboratories, Evaluation, and Reporting of Results

In compliance with the requirements for safety set forth in the IAEA's internal Radiation Safety and Nuclear Security Regulations, RSTSL, in the IAEA's Division of Radiation, Transport and Waste Safety (NSRW), provides radiation protection services, including individual monitoring of workers (e.g., IAEA staff) for occupational exposure due to external and internal sources of radiation.

Since 2006, RSTSL holds accreditation to ISO/IEC 17025 [25], demonstrating the technical competence and the impartiality of the laboratory in providing valid results. In accordance with the requirements of this international ISO standard, the effectiveness of the laboratory's management system and technical operations is assessed continuously by an internationally recognized and independent accreditation body. Based on an audit conducted by certified assessors on behalf of Akkreditierung Austria, accreditation was last confirmed for a five-year period on 6 September 2021.

RSTSL will support the IAEA Review of Safety Related Aspects of Handling ALPS Treated Water at Fukushima Daiichi Nuclear Power Station by planning and implementing the corroboration of occupational radiation protection data. The laboratory will also provide individual monitoring of occupational radiation exposure of IAEA staff and Task Force members in planned exposure situations (e.g., during visits to FDNPS) to ensure compliance with the requirements of the IAEA Safety Standards and occupational radiation protection programmes.

RSTSL will use the following types of equipment to conduct the necessary analyses under this corroboration:

External monitoring:

- Whole-body radiophotoluminescence (RPL) dosimetry; and
- Thermoluminescence (TL) dosimetry for extremity and lens of the eye.

Internal monitoring:

- Urine radio bioassay using liquid scintillation counting; and
- In-vivo body activity monitoring.

RSTSL will conduct evaluations to compare the ratio of the measured dose to the reference dose against criteria for good performance [22, 23, 24, 26]. Once all the relevant activities to corroborate capabilities of IMS for assessing occupational exposure have been completed, the IAEA will issue a formal report that will include the results of the corroboration as well as information for the public on how to read and interpret the data. After the start of the treated water discharges, a first report will be issued that will reflect the results of the ILC for external dosimetry. A second report will subsequently be issued that will reflect the results of the ILC for internal dosimetry.

Additionally, when statistical data becomes available after the discharges of ALPS treated water begins, the distribution of occupational exposure of workers could be jointly compiled to confirm dose distributions assessed by the Japanese counterpart.

III.C. Anticipated Future Activities (December 2022 and Beyond)

Activities under this element of the corroboration will begin in early 2023 and will continue for approximately one to two years. The corroboration will be designed in a flexible manner to incorporate additional information when available, and to consider opportunities for innovation and improvement as they arise. Activities beyond the end of 2023 will be planned and implemented based on further discussions with TEPCO and considering the developments and lessons learned from TEPCO's operation of the ALPS discharge process.

Over the next year, the following major milestones are anticipated:

Initiate the ILC for External Dosimetry

In the first quarter of 2023, the IAEA will initiate the corroboration for external dosimetry as noted in Section III.A above. The IAEA will procure the necessary dosimeters and will identify and issue contracts to appropriate primary or secondary standards dosimetry laboratories to have dosimeters irradiated under reference conditions in support of the corroboration of external dosimetry. The irradiated dosimeters will be shipped to relevant Japanese IMS and the IAEA's RSTSL for analysis.

Analyse and Report on Results for External Dosimetry

After the relevant Japanese IMS and the participating IAEA laboratory have completed their analysis, anticipated to occur in the second quarter of 2023, the IAEA will collect and analyse the results. The IAEA will collect the results from all participating laboratories and conduct a screening to ensure that all laboratories have submitted a complete assessment package with all necessary documentation. Once the IAEA has completed its assessment, it will share the results with the Task Force. The IAEA will draft a report highlighting the results, which will be published no later than quarter three of 2023.

Initiate the ILC for Internal Dosimetry

In the second half of 2023, the IAEA will initiate the steps to conduct the corroboration for internal dosimetry, as noted in Section III.A above. The IAEA will identify vendors for the urine samples spiked with certified reference materials and will ship the urine samples and the reference phantom to TEPCO as part of the ILC. RSTSL will also conduct analyses of the spiked urine samples and the phantom throughout 2023.

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