

ELECTRONIC ATTACHMENT

SUMMARY OF THE MAIN OUTCOMES OF MEETINGS WITH THE JAPANESE RESEARCH COMMUNITY

Developments since the 2013 UNSCEAR report on the levels and effects of radiation exposure due to the nuclear accident following the great east-Japan earthquake and tsunami

A 2017 white paper to guide the Scientific Committee's future programme of work

Notes

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I. INTRODUCTION

1. The objectives of the meetings with the Japanese research community were:
 - (a) To exchange information on gaps and uncertainties in assessments of the health and environmental impacts of radiation exposure due to the accident at the Fukushima Daiichi Nuclear Power Station (FDNPS) and how further research could improve the quality and robustness of the assessments;
 - (b) To exchange information on the objectives, scope, content, status and envisaged outcomes of major Japanese research projects/programmes and determine the extent to which they address the research needs identified in the 2013 report;
 - (c) To better inform the Committee when making judgements on if, and if so when, it may be appropriate to update its 2013 report;
 - (d) To establish mechanisms to enable effective dialogue and exchange of information between the Committee and the Japanese research community.

2. Two meetings were held in Japan in the period 13 to 17 November 2016. The first was held in Tokyo to discuss projects/programmes being carried out or funded at a national level; the second was held in Fukushima City for those projects/programmes being carried out largely under the auspices of the Fukushima Prefecture. Members of the Expert Group and the Japanese Working Group attended both meetings, together with lead researchers for each project/programme and representatives of a number of organizations that had commissioned/funded the research. The main outcomes of these meetings are summarized below.

II. ATMOSPHERIC SOURCE TERM AND SUBSEQUENT DISPERSION AND DEPOSITION

3. The 2013 report had provided estimates of the atmospheric source term due to the accident and the subsequent dispersion and deposition. There are significant uncertainties for the source term, both in the temporal patterns of the releases and for the estimates of radionuclide concentrations—in air and from deposition—derived from the atmospheric transport and dispersion models (ATDM). There are also uncertainties in the understanding of the chemical form of the radioiodine released during the accident.

4. After the FDNPS accident, various ministries/agencies of the Japanese Government have supported several major research projects/programmes. A “Comprehensive Study to Assess Radiation Doses to Residents from the Fukushima NPP Accident” (subsequently referred to as the “Comprehensive Study”) is being undertaken with support from the Japanese Ministry of Environment (MOE) for the assessment of radiation doses to residents from the FDNPS accident. The MOE is also supporting a project concerned with radiation exposure and risk from suspended particulate matter. A project on levels of radioactive material in air is being funded by the Japanese Ministry of Education, Culture, Sport, Science and Technology (MEXT) and by the Nuclear Regulatory Agency (NRA). The MEXT, NRA and MOE are also funding a project on levels of radioactive material in soil, the ocean and non-human biota, together with the mitigation of radioactive material in the environment.

5. Within the Comprehensive Study, the Nuclear Science and Engineering Centre at the Japan Atomic Energy Agency (JAEA) is implementing a new meteorological model with enhanced data assimilation to provide improved ATDM simulations. It addresses the uncertainties in the source term and modelling by using improved ATDM results, actual measurement data on radionuclides in the environment and an updated source term. This includes improved estimates of ^{131}I and other radionuclides in soil (derived from detailed analysis of ^{129}I in soil) and air (using air samples collected at the time of the atmospheric releases). The updated source term is based on a new deposition scheme and updated monitoring data. A database combining the ATDM outputs, the reactor inventory and the post-accident environmental measurements has been established to facilitate the optimization of the ATDM simulations and to improve the estimates of radionuclides in the plume following the accident.

6. Within the study funded by MEXT, the Fukushima Environmental Safety Centre at JAEA is leading a study aimed at characterizing and mapping the ground deposition around FDNPS, based on the results of large scale environmental monitoring programmes, combined with investigations of radionuclide migration in the environment. Use is being made of the extensive measurements of air kerma rates from the monitoring at fixed locations and from the surveys using measurement systems that are hand-carried, car-borne and transported on rotary wing aircraft (drones and helicopter). Data on radionuclide deposition on the ground, from the analysis of soil samples and studies of ^{137}Cs depth profiles in soil, have been used to produce

detailed maps that show the temporal and spatial variations of the ground deposition. Data from the atomic mass spectrometry measurements of ^{129}I in soil samples provide improved maps of ^{131}I deposition. Information on the ratios of ground deposition of ^{134}Cs to ^{137}Cs has been used to estimate the contribution from each reactor unit to the ground deposition at different locations around FDNPS. Measurements of temporal decreases in air kerma rates by handheld and car-borne monitors have been used to estimate air kerma rates into the future. These environmental monitoring data have been compiled in a database and the air kerma rates have been combined with information on individual patterns of behaviour to estimate potential doses from external exposure for individual evacuees returning to their homes.

III. RADIONUCLIDE RELEASES, DISPERSION AND DEPOSITION IN THE OCEAN

7. The 2013 report had provided estimates of the radionuclide releases, dispersion and deposition in the ocean from the FDNPS accident. There is large variability in the published estimates for releases and discharges to the ocean and further research is needed to improve the estimates of the magnitude of the releases and the understanding of the dispersion in the Pacific Ocean of radionuclides from the accident.

8. The Nuclear Science and Engineering Centre at JAEA is undertaking studies to quantify the magnitude of releases of radioactive water from FDNPS to the ocean. Levels of ^{137}Cs are being monitored in seawater close to FDNPS and in the surrounding coastal area. A seabed coating inside the port of FDNPS and a sea-facing impermeable wall have significantly reduced the leakage rate of radiocaesium from the port, but measurements show that some leakage continues. Data are available on the inventories and fluxes to the ocean up to the year 2014 and further studies and monitoring will allow the forecast of levels into the future.

IV. TRANSFER OF RADIONUCLIDES IN THE TERRESTRIAL ENVIRONMENT

9. The estimation of ingestion doses to the public beyond the first year in the 2013 report had been based on the use of the FARMLAND model [B1] using very conservative assumptions. At the time of the assessment there had been limited data on concentration ratios and transfer factors for rice, fish, crops, animals and other foodstuffs in Japan, and values for European conditions had generally been used in the model. There is a need for data on the values of these model parameters for Japanese conditions to improve the assessment of doses to the public and to quantify the impact of remediation on these doses.

10. The Fukushima Environmental Safety Centre at JAEA is undertaking several relevant studies: one is assessing the migration of radionuclides in the terrestrial environment; the Fukushima Mapping Project, carried out in collaboration with a number of universities and institutes, is looking at the mechanisms of radiocaesium migration in various environmental media, mainly in the Abukuma river basin, where the lead is being taken by Tsukuba University; and the F-Trace Project aims to study the behaviour of radiocaesium in the forests affected by the FDNPS accident and to evaluate its transport through river systems to the ocean.

11. The Institute of Environmental Radioactivity (IER) at Fukushima University is undertaking six projects associated with the FDNPS accident, covering radionuclide transport in the terrestrial and aquatic environments, the physio-chemical forms of radionuclides, long-term behaviour of radionuclides in the marine environment, the long-term behaviour of radionuclides

in ecosystems, and the development of tools for simulation of radionuclide dynamics and for the measurement of radionuclides. One study at IER on radionuclides in the aquatic environment is investigating the wash-off of radiocaesium from the river catchments of Fukushima Prefecture, the vertical migration and distribution of radiocaesium in soils, the removal of ^{137}Cs from water, and the monitoring of ^{137}Cs in soil and bottom sediments in lakes and rivers.

12. Further studies at IER are aimed at modelling radionuclides in the aquatic environment, including the modelling of pathways for transport of radionuclides in rivers and reservoirs affected by the accident, and the application of hydrological dispersion models in an analysis of decontamination.

V. DOSES TO THE PUBLIC

13. The aim of the assessments carried out for the 2013 report had been to make realistic estimates of doses to the public from the FDNPS accident, based on the data and information then available. The priorities for research to improve the assessment of doses to the public had included: the further measurement of dose rates due to external exposure to deposited material in various environments, together with studies to forecast and track changes over time and quantify the impact of environmental remediation programmes; better characterization of distributions of doses to the public, including the variability between individuals and uncertainties; and the use of improved models with parameters specific to Japan.

14. Estimates of radiation doses to residents from the FDNPS accident are being made as part of the Comprehensive Study. Account is being taken of uncertainties in the source term and atmospheric dispersion modelling by using improved ATDM results, actual measurements of radionuclides in the environment and information on individual behaviour following the accident. Improved estimates of ^{131}I and other radionuclides in soil and air, derived from detailed analysis of ^{129}I in soil and air samples collected at the time of the atmospheric releases, are being made. Estimates of doses to residents of Fukushima Prefecture from internal exposure in the early phase of the accident are also being made. A gamma spectroscopic analysis of data from the body surface screening measurements carried out on evacuees and residents during March 2011 has been used to improve estimates of doses due to inhalation at different locations. In a study of doses from ingestion of food and water, information on individual behaviour and ATDM results were combined to estimate doses to the public from intake of tap water following the accident.

15. The National Institute for Quantum and Radiological Science and Technology – National Institute for Radiological Science (QST-NIRS) is carrying out studies to estimate doses to residents of Fukushima Prefecture from internal exposure in the early phase of the accident. Doses to the thyroid have previously been estimated from the limited number of direct thyroid measurements and from whole body measurements. Published information on the individual evacuation behaviour of the residents and maps of radionuclide concentrations in air from recent ATDM modelling have been used to enhance the previous approach and provide better estimates of the thyroid doses for evacuees. In addition, a two-year study is proposed to develop parameters for rate of uptake into the thyroid and for thyroid volumes more specific to Japanese people.

16. The Fukushima Prefecture Government has established the Fukushima Health Management Survey (FHMS), which is implemented through Fukushima Medical University (FMU), local Governments and commissioned institutes. One part of the FHMS is the “Basic Survey”, which aims to provide dose estimates for the approximately 2 million residents in Fukushima Prefecture. The FMU is responsible for the estimation of the external dose for the

first four months after the accident for residents in all Fukushima Prefecture municipalities. These estimations are derived from information on individual behaviour from the Basic Survey questionnaire, combined with data for dose rates as a function of time and location. Dose estimates from external exposure have been carried out for most of the residents participating in the survey, using behavioural data from the questionnaire. Updated results of these analyses are provided regularly to an oversight committee and are published online. Survey participants are provided with their own individual dose assessment. A method has been developed to estimate doses to those who have not responded to the survey.

VI. DOSES TO WORKERS

17. For the assessment of doses to workers involved in the accident, priorities for research identified in the 2013 report had included: the quantification of uncertainties in reported doses to workers (arising from differences in the individual worker histories, the time varying levels of radionuclides and dose rates where the workers worked and rested, the use of protective measures and the use of shared personal dosimeters); and the estimation of doses to the lens of the eye for workers involved in the on-site mitigation strategies.

18. A dose reconstruction study initiated by the Ministry of Health, Labour and Welfare (MHLW) is underway as part of the worker epidemiological study organized by the Radiation Effects Research Foundation (RERF) to provide improved estimates of doses to workers due to both internal and external exposure. A project is underway to re-evaluate doses to the thyroid of the most heavily exposed workers by computational simulation based on voxel phantoms and Magnetic Resonance Imaging measurement. A probabilistic assessment of uncertainties in the doses to workers arising from uncertainties in the intake scenarios is underway. Future studies include the creation of a database of information on the emergency operations and performance testing of the personal dosimeters for irradiation geometry, protective equipment and shielding effects.

VII. HEALTH EFFECTS FOR PUBLIC AND WORKERS

19. The 2013 report had included a commentary on the health implications for the public and workers arising from radiation exposure due to the accident based on the data and information then available. Priorities for research had included the continuation of the health survey in Fukushima Prefecture, the analysis and quantification of the impact of ultrasonography surveys on the apparent incidence of thyroid cancer in Fukushima Prefecture and the consideration of establishing a cohort for epidemiological study with members whose individual doses could be adequately assessed. For workers, priorities included the screening of workers for thyroid cancer and the monitoring of the more highly exposed workers for long term health effects.

20. The “Detailed Survey” in FHMS aims to assess and monitor the health and wellbeing of residents of Fukushima Prefecture. It includes a “Thyroid Ultrasound Examination”. There is public concern about thyroid cancer among children and an expectation for ultrasound examinations. Mass screening programmes carry the possibility of over-diagnosis and standard protocols were developed to minimize screening effects. The full scale survey programme started in 2014 and is now in its third round of examinations.

21. The Detailed Survey also includes a Comprehensive Health Check to address any health issues at an early stage. It is mainly aimed at former residents of the evacuation zones. The examinations are carried out at locations within Fukushima Prefecture and at accredited locations around Japan. These studies include a longitudinal study of cardiovascular risk factors such as changes in body weight, and prevalence of hypertension, diabetes mellitus, dyslipidaemia, liver dysfunction, atrial fibrillation and increased mean body mass. The study will provide a better understanding of the health implications of the FDNPS accident for Fukushima residents.

22. A “Mental Health and Lifestyle Survey” aims to provide a better understanding of physical and mental health and lifestyle of residents of Fukushima Prefecture and a “Pregnancy and Birth Survey” aims to provide appropriate medical care and support to mothers. Measurements using Whole Body Counters and personal dosimeters are being conducted as part of the health care services, and the data will be collected in a database by FMU.

23. RERF is undertaking an epidemiological study on the health effects among the FDNPS emergency workers. The Nuclear Emergency Worker Study (NEWS) is a prospective cohort study covering the lifetime of the workers exposed in 2011. The major components of the study include a health examination, a thyroid cancer study, a cataract study, a study of psychological effects, a mortality/cancer incidence study and a radiobiological study. The radiation dose estimates include both physical and biological dose estimation methods. A network of medical institutes has been established across Japan to undertake the health examinations. Standard procedures and a quality assurance programme for the health tests have been established. NEWS will make use of the database of the National Cancer Registry System that was established on 1 January 2016. A computerized communication system will support the exchange of information for the study. Work is currently underway to recruit study participants to establish the lifetime cohort study population.

VIII. DOSES AND EFFECTS FOR NON-HUMAN BIOTA

24. The 2013 report had included an assessment of the exposures of non-human biota and associated effects as a result of the accident. Priorities for research had included further analysis of environmental effects reported in field studies to determine whether radiation exposure was an important factor.

25. The Biodiversity Policy Division in the Ministry of Environment is carrying out a number of studies of radiation effects on wild plants and animals following the accident. One study is measuring ^{134}Cs and ^{137}Cs concentrations in plant and animal samples from high and low dose rate areas around the restricted areas. A programme to record environmental changes using cameras at fixed locations is also underway.

26. The Institute of Environmental Radioactivity (IER) at Fukushima University is studying wildlife populations chronically exposed to radiation from the accident. The studies include an examination of the impacts on wildlife populations in the evacuated zone, the accurate determination of the radiation dose for free-ranging animals (such as wild boar) through the use of portable tracking and radiation measurement tools, and collaborative studies to evaluate sublethal chronic effects on wildlife at low doses.

IX. IMPLICATIONS FOR THE COMMITTEE'S FOLLOW-UP ACTIVITIES

27. Within the next two to three years (i.e. by 2020), these ongoing studies are expected to provide:

- (a) Significant improvements in estimates of the source term for releases to atmosphere (both in the temporal pattern and physico-chemical forms of the released material) and in measured and estimated levels of radionuclides in the environment (both airborne and deposited on the ground);
- (b) Improved estimates of the amounts of radionuclides released to the ocean, how they have varied with time and of their subsequent dispersion in coastal waters and more widely in the Pacific Ocean;
- (c) Enhanced understanding of the transfer of radionuclides through the terrestrial environment, enabling the development of improved models (and parameter values) that are specific to Japanese conditions;
- (d) Better estimates of the doses received by members of the public, in particular doses from internal exposure to short-lived radionuclides in the early phase of the accident, doses from external exposure and how they varied according to behaviour and location, and doses from the ingestion of foodstuffs from the second year after the accident onwards;
- (e) A better understanding of the impacts of remediation;
- (f) Improved estimates of doses to workers from internal and external exposure;
- (g) Further information on the health of residents of Fukushima Prefecture;
- (h) Further evidence to help clarify the extent to which radiation exposure as a result of the FDNPS accident has resulted in population-level effects on non-human biota.

Reference

- B1 Brown, J. and J.R. Simmonds. FARMLAND a dynamic model for the transfer of radionuclides through terrestrial foodchains. NRPB-R273. National Radiological Protection Board, Chilton, 1995.