Radiation Protection issues on Preparedness and Response for a Severe Nuclear Accident : Experiences of the Fukushima Accident

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ICRP Committee 4

Evolution from ICRP 60 to ICRP 103

ICRP 60 (1991), ICRP 63 (1992)

- Recommends values for the **Averted** dose for **Single** protective measure where intervention is almost always justified.

ICRP 103 (2007), 109 (2009), 111 (2010)

- No more distinction between **practices** and **interventions**. The two concepts are replaced by three generic exposure situations.
- Recommends an upper value of the **Projected** dose (Reference Level) received via **All** pathways below which optimization is applied.

IAEA BSS (1996)

- Recommends values for Generic Intervention Level and Action Level

IAEA GSG-2 (2012), New BSS

- Generic criteria
- Operational Intervention level (OIL)

ICRP Task Group 84

- Initial Lessons Learned from the NPP Accident in Japan vis-à-vis the ICRP System of Radiological Protection

Emergency response system in Japan

- After TMI accident, “Emergency Preparedness Guide for nuclear power plants” by NSC in 1980 specified technical criteria such as EPZ, intervention levels
- Impact of Chernobyl accident in 1986 in Japan on ER system not so significant (differences between reactor types were emphasized)
- Tokaimura criticality accident in 1999 addressed several weaknesses such as prompt initial actions, collaboration of national and local governments and the clarification of licensee’s responsibilities.

- “Act on Special Measures Concerning Nuclear Emergency Preparedness” enacted in December 1999.

Emergency response system in Japan
- Decision making to initiate off-site protective actions relies heavily on computer-based prediction system

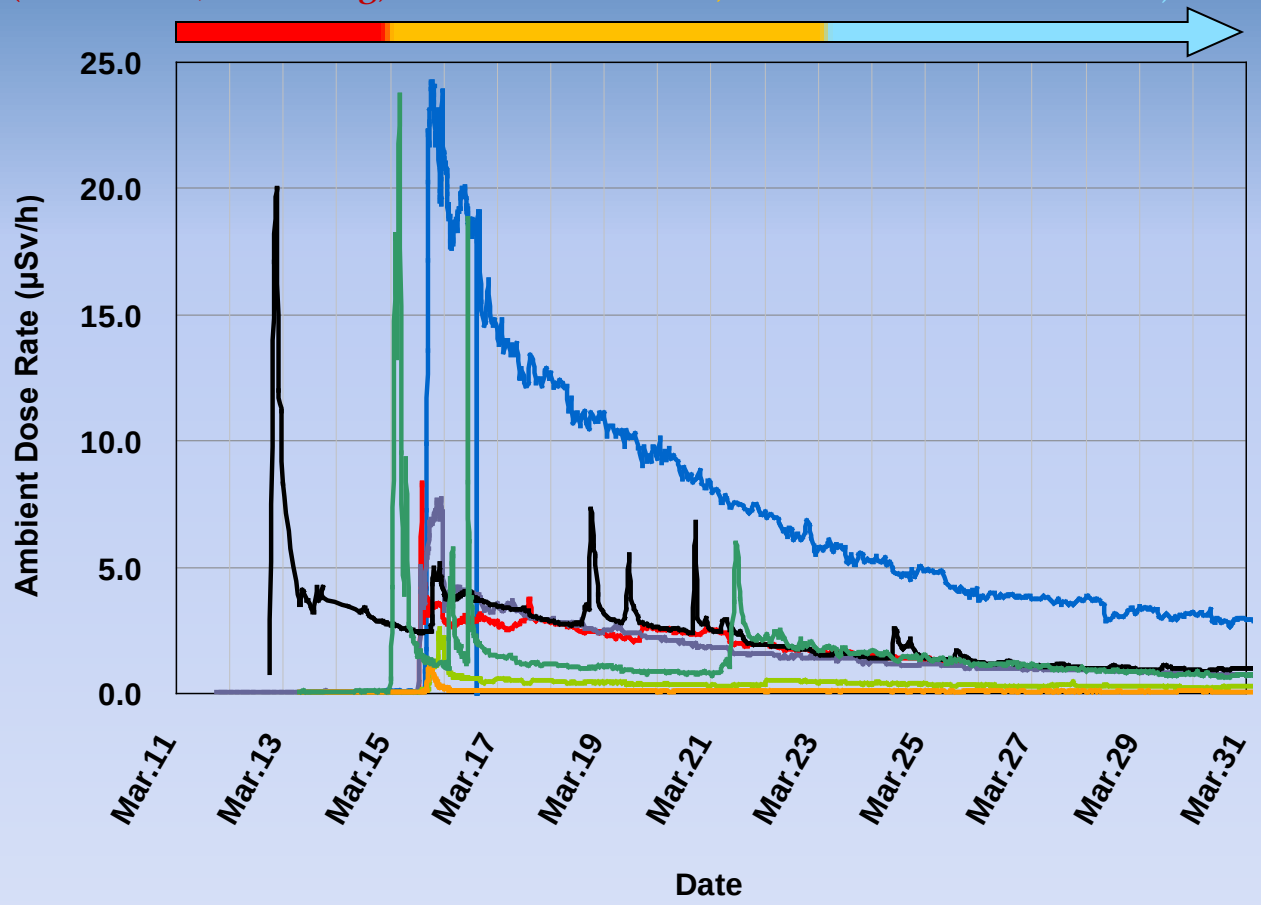
NSC “Emergency Preparedness Guide”
- Criteria for long term protective actions such as temporary relocation and termination criteria are not prepared

Radiological situation and corresponding protective actions

Precautionary urgent protective actions (evacuation, sheltering)

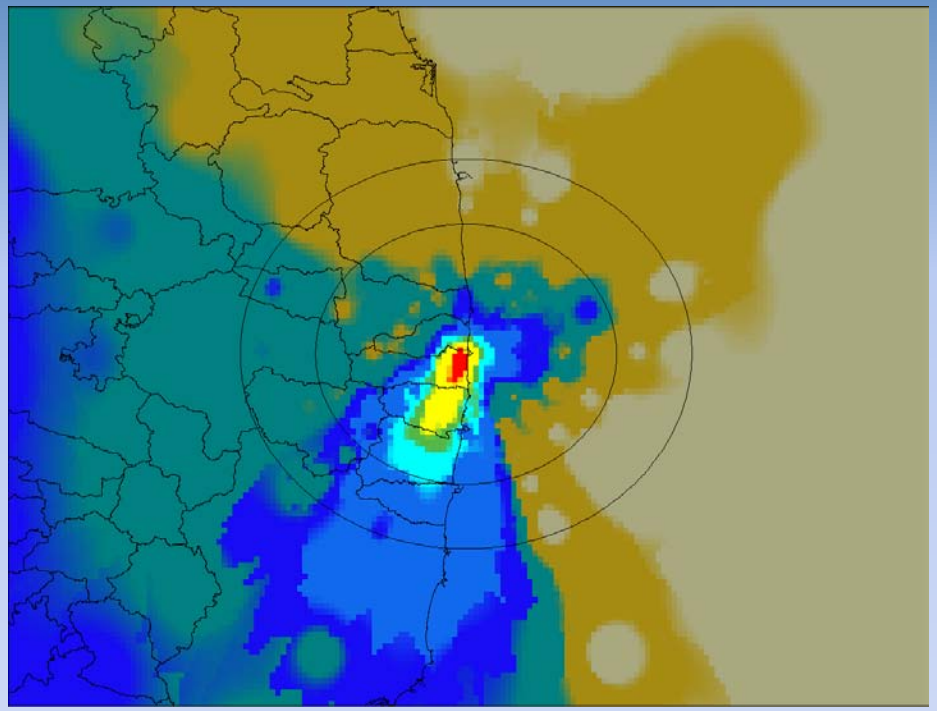
Urgent protective actions (foodstuff and water restrictions)

Early protective actions (preparation for temporary relocation)

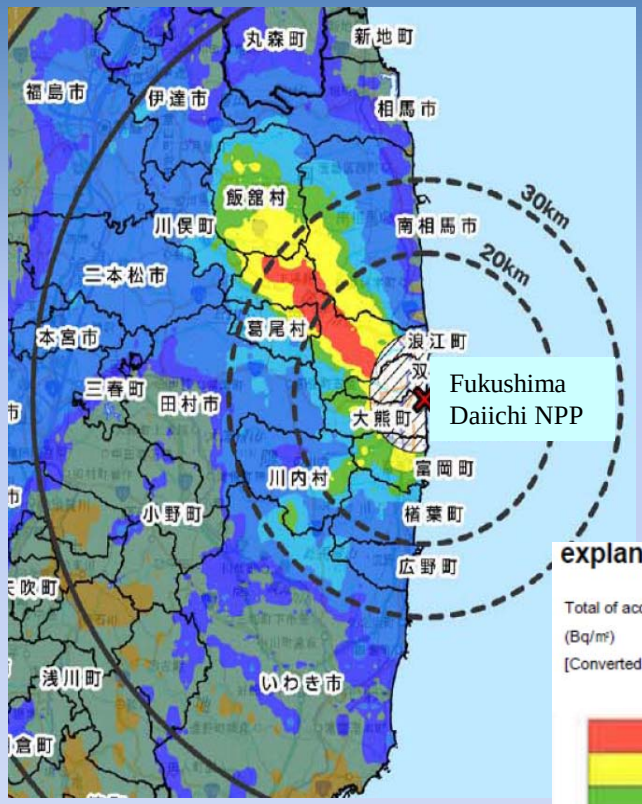


Cs-137 contamination by models and monitoring data

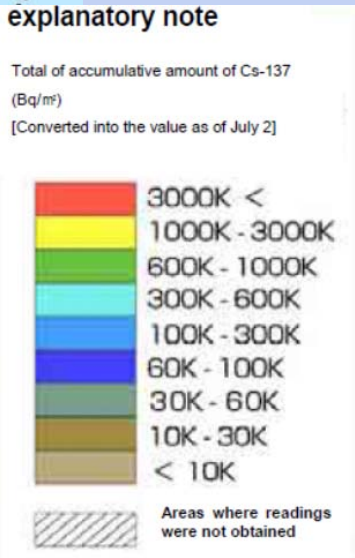
Unit 1, 2 and 3 release combined



Level 3 PSA calculation with MELCOR source term



airborne monitoring



Strategy of precautionary urgent protective action

- In emergency exercises, recommendations of taking urgent protective action are made based on **real-time dose predictions** by computer-based prediction system (ERSS, SPEEDI) with intervention levels.
- In the Fukushima case, Government implemented evacuation and sheltering based on **plant conditions**.

ICRP 109 (**§** 9)

- To implement urgent protective actions, there is no time to undertake detailed exposure assessments in real time. It is therefore necessary to determine, in advance, a set of internally consistent criteria for taking such actions, and, based on these criteria, to derive appropriate **"triggers"** for initiating them in the event of an emergency.

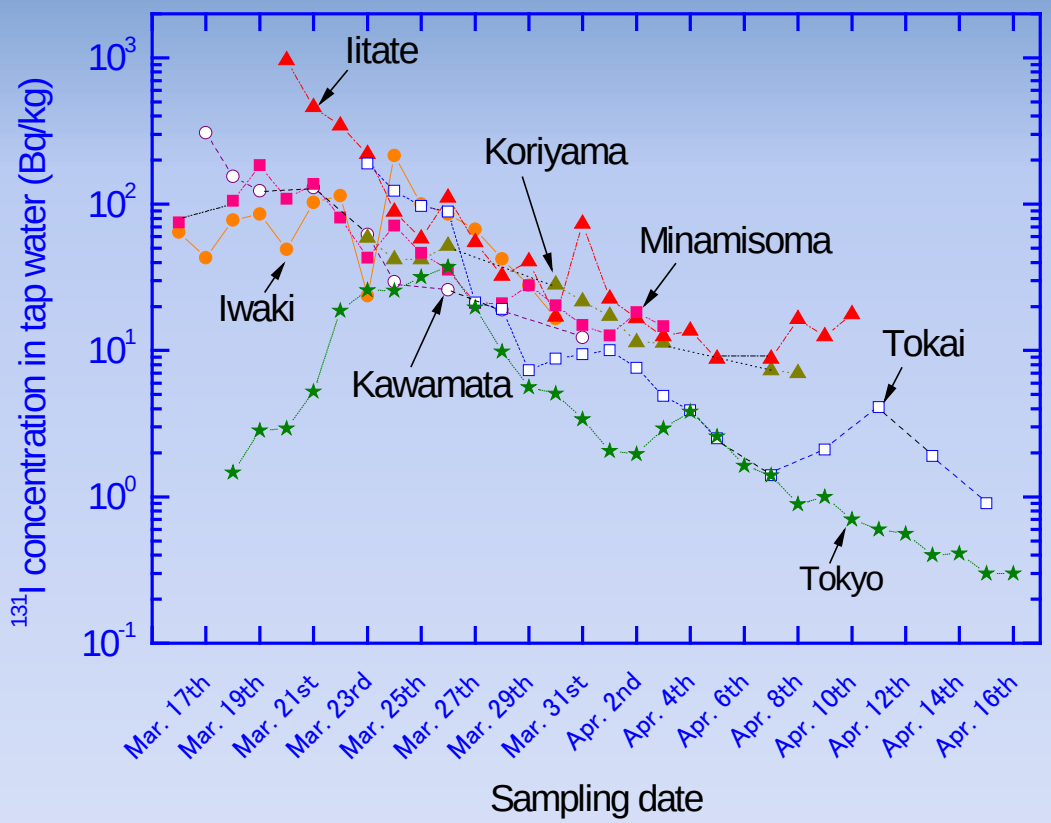
IAEA GS-R-2, GSG-2

- Precautionary urgent protective actions are taken on the basis of **conditions at the facility** to prevent severe deterministic health
- GSG-2 provides **emergency classification system** and examples of EAL (Emergency Action Level)

Protective actions for drinking water

- Actions against water supply (MHLW, 3/19)
  - To refrain from drinking water (I: 300 Bq/kg, Cs: 200 Bq/kg)
  - Use the tap water for domestic use (Iitate: 3/21 - 4/1)
- Actions for infants' ingestion of tap water
  - To refrain from giving infants formula milk dissolved by tap water (100 Bq/kg) (Fukushima, Ibaraki, Chiba, Tokyo, Tochigi, 3/21 – 4/1, 5)

Concentration of ^{131}I in tap water



(S. Kinase *et al.*, Trans. A. Energy Soc. Japan, 10(3) 149, 2011)

Protective actions for foodstuffs

- MHLW adopted the NSC's criteria for restrictions of distribution and/or consumption of foodstuffs as the provisional regulation values:
  - Iodine: 2000 Bq/kg for vegetables, 300 Bq/kg for Milk and dairy products
  - Cesium: 500 Bq/kg for vegetables, grains, meat, eggs, fish; 200 Bq/kg for Milk and dairy products

Foodstuffs	Location	Samp.Date	I-131(Bq/kg)	Cs-137(Bq/kg)	Restriction
Raw milk	Fukishima Kawamata	Mar 16	1190	11	F:3/21- O:3/21-4/10
Spinach	Ibaraki Takahagi	Mar 18	15020	524(Cs)	F:3/21- O:3/21-6/1
Shiitake	Fukushima Iwaki	Apr 2	3100	440	F:4/13-
Tea leaf	Kanagawa Odawara	May 11	ND	770-780(Cs)	O:6/2-
Beef	Fukushima Minamisouma	Jul 8	ND	2300(Cs)	F:7/19- O-7/28-

F:Fukushima, O: Other prefectures

Criteria for use in food and water restrictions

- Radioactivity in food and drinking water has cause significant public anxiety and also rumor effect.

Early stage

- Quick response is needed to avert ingestion dose from elevated levels of radioactivity.

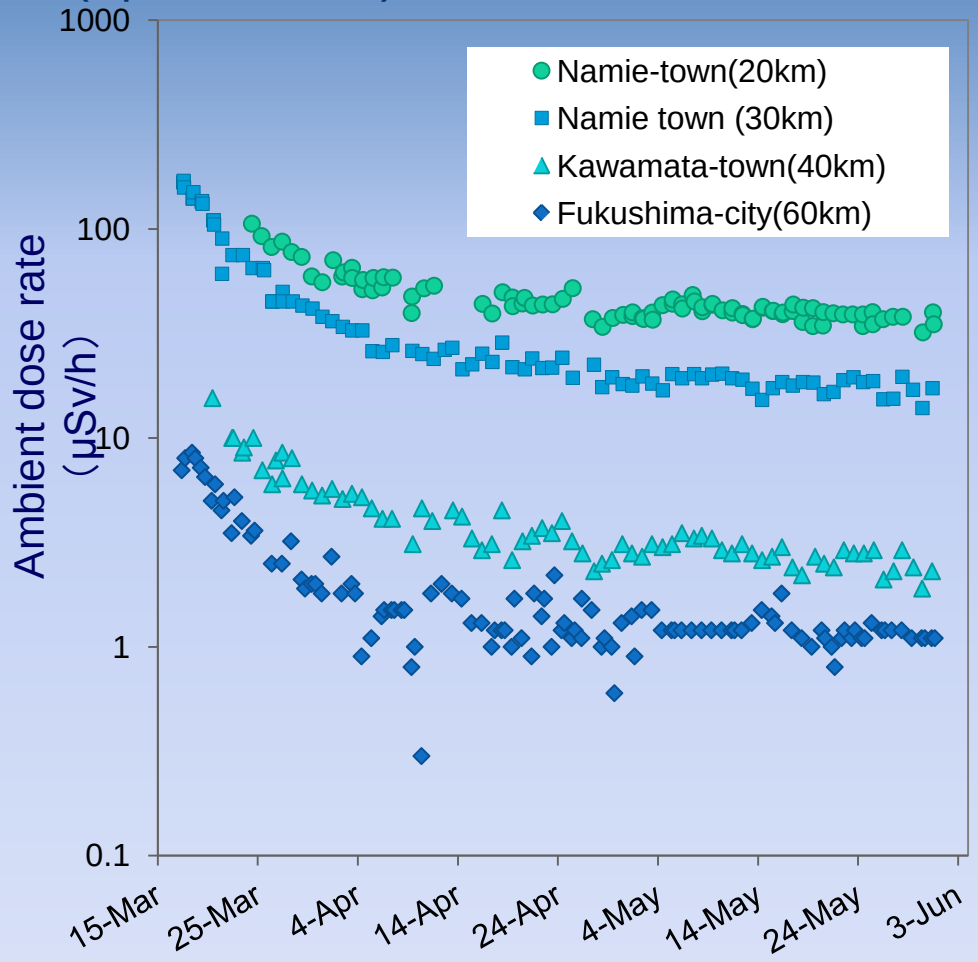
  ⟹ OILs for gamma dose from contaminated surface (GSG-2)

Intermediate and longer term stage

- Criteria for foodstuff restrictions should be considered in the process of **optimization for the whole protection strategy**.
  - Radiological and nutritional impact
  - Reference level and contribution of ingestion dose to the total dose
  - Realistic estimates based on dietary habits and market dilution
  - Harmonization to internationally agreed standards for trade

Additional urgent protective actions

- NSC applied the concept of optimization of protection below reference levels in Emergency Exposure Situation and Existing Exposure Situation for the first time (April 10, 2011).



Transition from emergency to existing situation

Deliberate Evacuation Area (Emergency exposure situation)

- The residents in this area, where annual cumulative dose after the onset of the accident would potentially reach 20mSv, are to be advised to evacuate.
- A level of 20 mSv was selected with consideration of ALARA in the dose band of 20 to 100mSv.

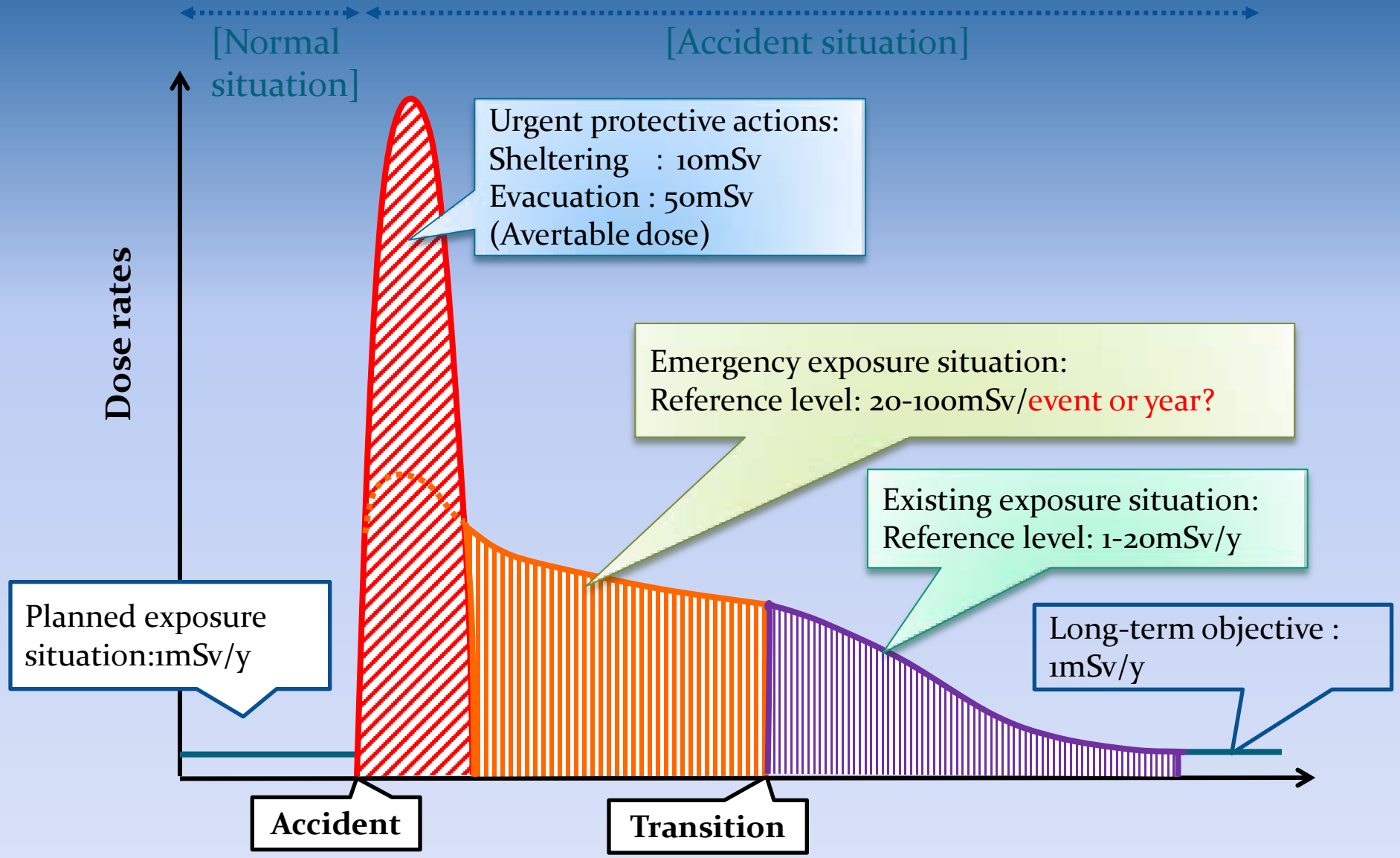
ICRP 109(§X)

- this transition may take place at different geographical locations at different times, such that some areas are managed as an emergency exposure situation whilst others are managed as an existing exposure situation.

Use of playground of schools (Existing exposure situation)

- MEXT selected 20mSv/y in the dose band of 1 to 20mSv on Aril 19.
- A level of 20mSv was selected as a starting point for optimization

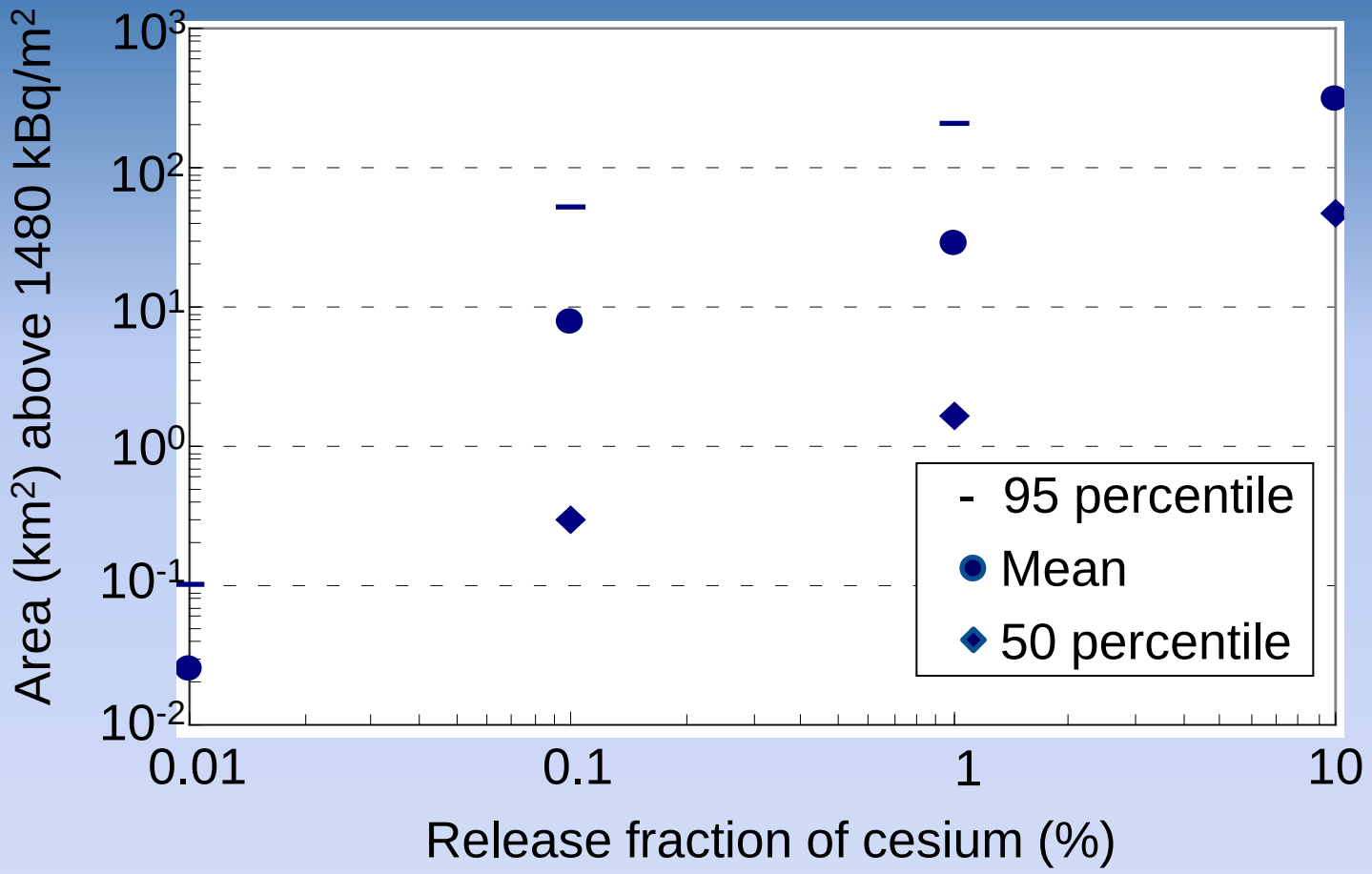
Radiological protection criteria



Preparedness for severe accident

- In December 2003, NSC issued "*Interim Report on the Discussion of **Safety Goals***" to propose qualitative and quantitative safety goals to be applied consistently to all types of nuclear activities.
  - "*The **average risk of early fatality** for members of the public in the vicinity of the site boundary of a nuclear facility due to radiation exposure from nuclear accidents should not exceed approximately one in 1000000 a year."*
  - "*The **average risk of cancer fatality** for members of the public within a certain distance from a nuclear facility due to radiation exposure from nuclear accidents should not exceed approximately one in 1000000 a year."*
- In the special committee on safety goals there has been considerable discussions about various issues such as "**collective risk", "societal risk**", "risk to individuals covered by safety goals", "comparison with the risk control goals in the air quality standards".

Land contamination



- Release of less than 0.01% of the inventory of Cs-137 in a core of about 3000 MW will be unlikely to cause long term restrictions in land use if criteria used in Chernobyl are assumed.

Potential exposure

- The committee concluded that no safety goal was developed in terms of societal risk.
  - It is difficult to quantify overall societal impact compared with human health effects
  - There was **no benchmark** of societal risk levels to be restricted.

however

- A lesson learned from the Fukushima experience is that human health effects can be protected by appropriate emergency response, but **land contamination** can not be avoided at a severe nuclear accident.
- This addresses rather the issue of nuclear safety (severe accident management), but **risk attributes** from potential exposure should be discussed to protect individuals, society and environment from the radiation protection point of view.

Lessons learned

- The revised Recommendations described in ICRP Publication 103, 109 and 111 have been very helpful and useful for taking emergency protective actions in the early stage of the Fukushima accident.

i. Arrangements should be established for taking precautionary urgent protective actions before a release on the basis of plant conditions.

ii. ICRP is suggested to make practical recommendations for control of contaminated foodstuffs and water.

iii. ICRP is suggested to clarify the intended use of the concept of dose limits, constrains and reference levels for protection of the public.

iv. ICRP is suggested to consider whether it should further elaborate the recommendations for protection from potential exposure.

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