(English translation by Masa Takubo at http://kakujoho.net/ with assistance from Aileen Mioko Smith and Youichi Nishiyama
The original Japanese version is here:
http://www.asahi-net.or.jp/~pn8r-fjsk/saiakusinario.pdf)

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Rough Description of Scenario(s) for Unexpected Situation(s) Occurring at the Fukushima Daiichi Nuclear Power Plant

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Objective

It cannot be said that there is no possibility that new events will occur resulting in unexpected situation(s) at the Fukushima Daiichi Nuclear Power Plant, where the accident conditions continue.
This document describes an outline of such unexpected situation(s).

Structure of the document

- New events assumed
- Measures to prevent each of these events and measures to prevent a chain of events
- Unexpected situation(s): a chain of events
- Radii for emergency measures
- Soil contamination
- Sea contamination

New events assumed

Facilities for event occurrence

	Unit 1	Unit 2	Unit 3	Unit 4	Common Pool	Unit 5	Unit 6
Reactor	○	○	○	----	----	○	○
Spent Fuel Pool	○	○	○	○	○	○	○

Contents of events

○Reactor

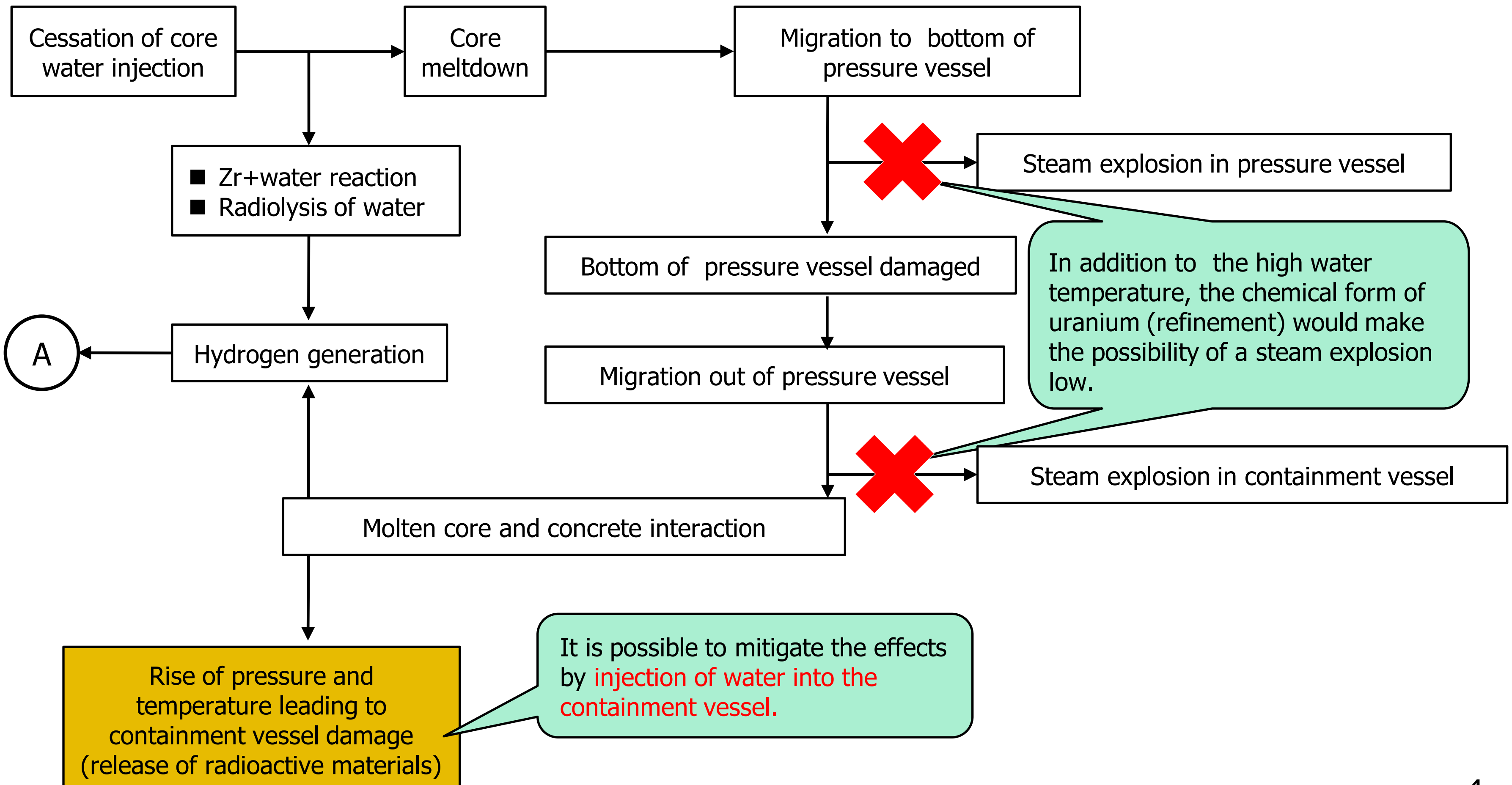
- Core damage leading to occurrence of steam explosion resulting in release of radioactive materials
- Hydrogen explosion leading to loss of cooling function resulting in overheat damage
- Loss of cooling function leading to overheat/overpressure damage

○Spent Fuel Pool

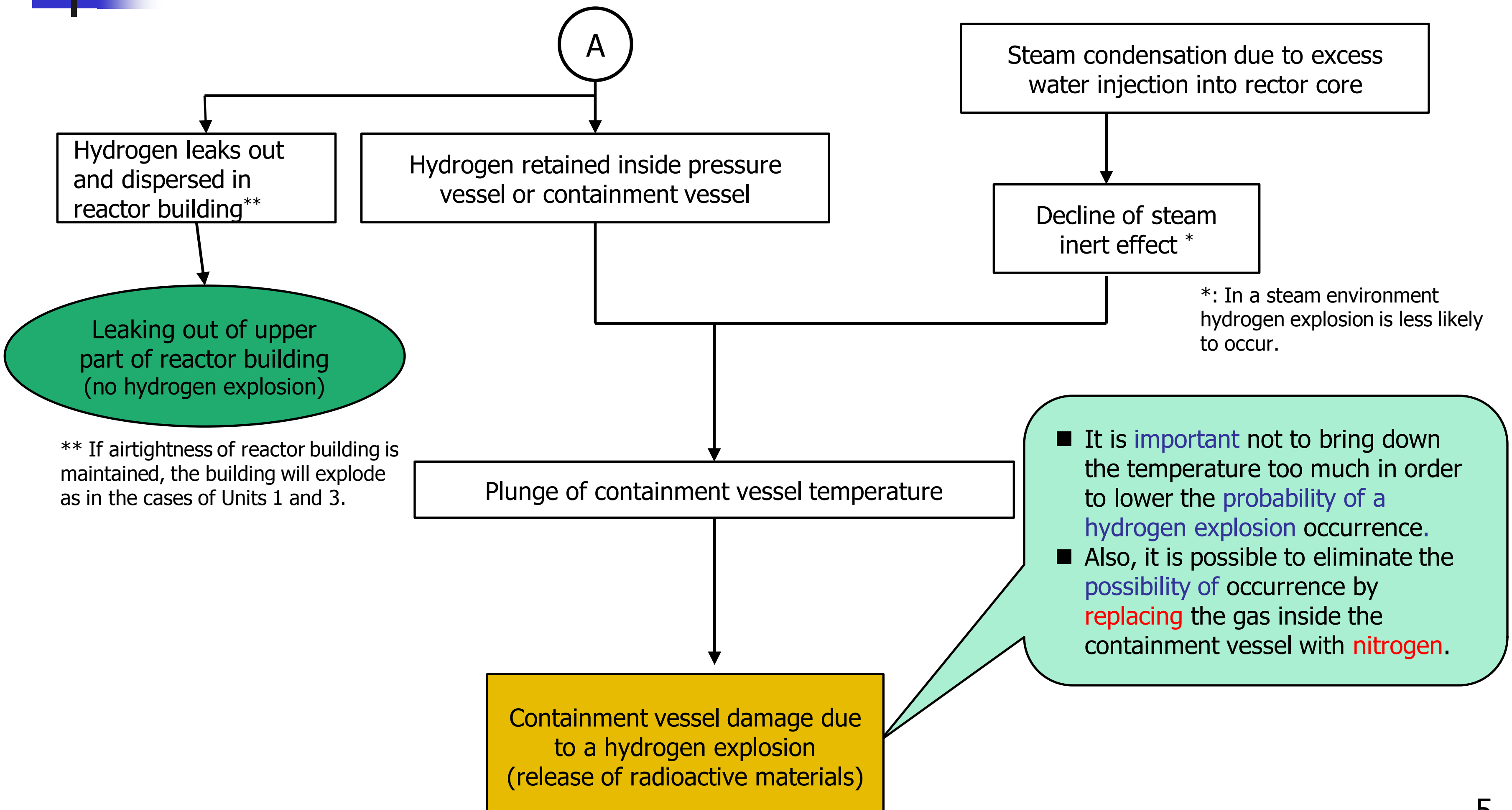
- Start of release of "gap radioactivity"*1 caused by insufficient cooling
- Process where, after the meltdown, the molten core concrete interaction causes the concrete floor to collapse and thus corium*2 falls to a lower level.

*1 Radioactive materials (such as noble gases) trapped in the gap between the fuel and cladding
*2 Mixture of molten fuel, molten cladding, concrete, etc.

Steam explosion and overheat damage



Hydrogen explosion



Measures to prevent a chain of events and their effect (1)

Measures that can be effective if taken in advance to prevent a newly occurring event from creating a chain of events affecting Units 1-4

	Measures that can be effective if taken in advance
At Reactor	• Prompt recovery of reactor core cooling function ✓ Recovery of heat sink (such as makeup sea water pumps) ✓ Diversification of water injection methods • Switching to fresh water injection and securing water sources*1 • Drainage and treatment of injected and contaminated sea water
At spent fuel pool	• Switching to fresh water injection and securing water sources*1 • Securing access for workers (including measures for reducing radiation exposures) and installation of water injection equipment that can be controlled remotely*2 • redundancy of water injection methods

*1: Necessary quantity of water injection: Unit 1 Reactor: 4tons/h approx.
Unit 2 Reactor: 6tons/h approx.
Unit 3 Reactor: 6tons/h approx. Total for the reactors: 16 tons/h=384 tons/day
Units 1-4 pools: total 160 tons/day (actual record) **Grand total: 560 tons/day(approx.) or more**

*2:If the unexpected situation is caused by a hydrogen explosion, the reactor core will be exposed to the atmosphere and the onsite radiation dosage condition will be very severe (1Sv/hr), and dropping water by helicopters will be nearly impossible. "Kirin" [giraffe: long armed concrete pumping vehicle] needs to be placed at each reactor site in preparation for unexpected situation(s). (Cooperation of Ministry of Defense and Fire and Disaster Management Agency necessary).

As the last resort, for a case where progress of events cannot be stopped, even if the abovementioned measures are taken, “shielding by mixture of sand and water” will be the most effective (necessary quantity: 1100 tons/reactor).

Measures to prevent a chain of events and their effect (2)

Measures to be taken in the case that workers evacuate after a new event occurs at Units 1-4, and measures that can be effective if taken in advance, to prevent that event from creating a chain of events affecting Units 5-6, are as follows:

	Measures	Effects
Measures at the time of evacuation	• Keeping water in the equipment well + opening of the gate to the pool (increase of coolant contained in the pool + cooling of the top of the containment vessel from outside) • "Open operation" of the pressure release safety valve of the reactor pressure vessel	If there is no loss of outside electricity or equipment malfunction, the integrity will be maintained. Also, even if there is loss of outside electricity or equipment malfunction, the measure of keeping water in the equipment well will make it possible to extend the period of integrity by about a half month*. *The period before the release from the spent fuel pool can be extended from about a month to about a month and half.
Measures that can be effective if taken in advance	• Multiplexing of the sea water cooling system • Putting plant monitoring under remote control of and securing of access means (securing of vehicles with shielding function, etc.)	It will become possible to detect minor equipment malfunctions and repair malfunctioning equipment.

At the Fukushima Daini Nuclear Power Plant, spillover effects can be prevented by making preparations to make it possible for operators to access the facility even under a high radiation situation.

The way of thinking about the accident chain

① Hydrogen explosion occurs in the reactor vessel or containment vessel of Unit 1, which has a relatively higher risk of such occurrence, and radioactive materials are released. It becomes impossible to inject water into Unit 1. This results in damage of the containment vessel.
② The dose levels increase forcing all the workers to evacuate.
③ Water injection/cooling of Units 2 and 3 becomes impossible. Water injection to the Unit 4 spent fuel pool becomes impossible.
④ The fuel in the Unit 4 spent fuel pool gets exposed leading to fuel damage and melting. Later, molten fuel concrete interaction (MFCI) occurs resulting in release of radioactive materials. (The next page shows damage progress sequence of the spent fuel pool.)
⑤ The containment vessels of Units 2 and 3 get damaged and radioactive materials are released.
⑥ Fuel in the spent fuel pools in Units 1,2, and 3 get damaged and melt. Later, MFCI occurs and radioactive materials are released.

Insufficient cooling of the spent fuel pool

Cessation of water injection → Fuel exposed → Gap radioactivity released → MFCI*1

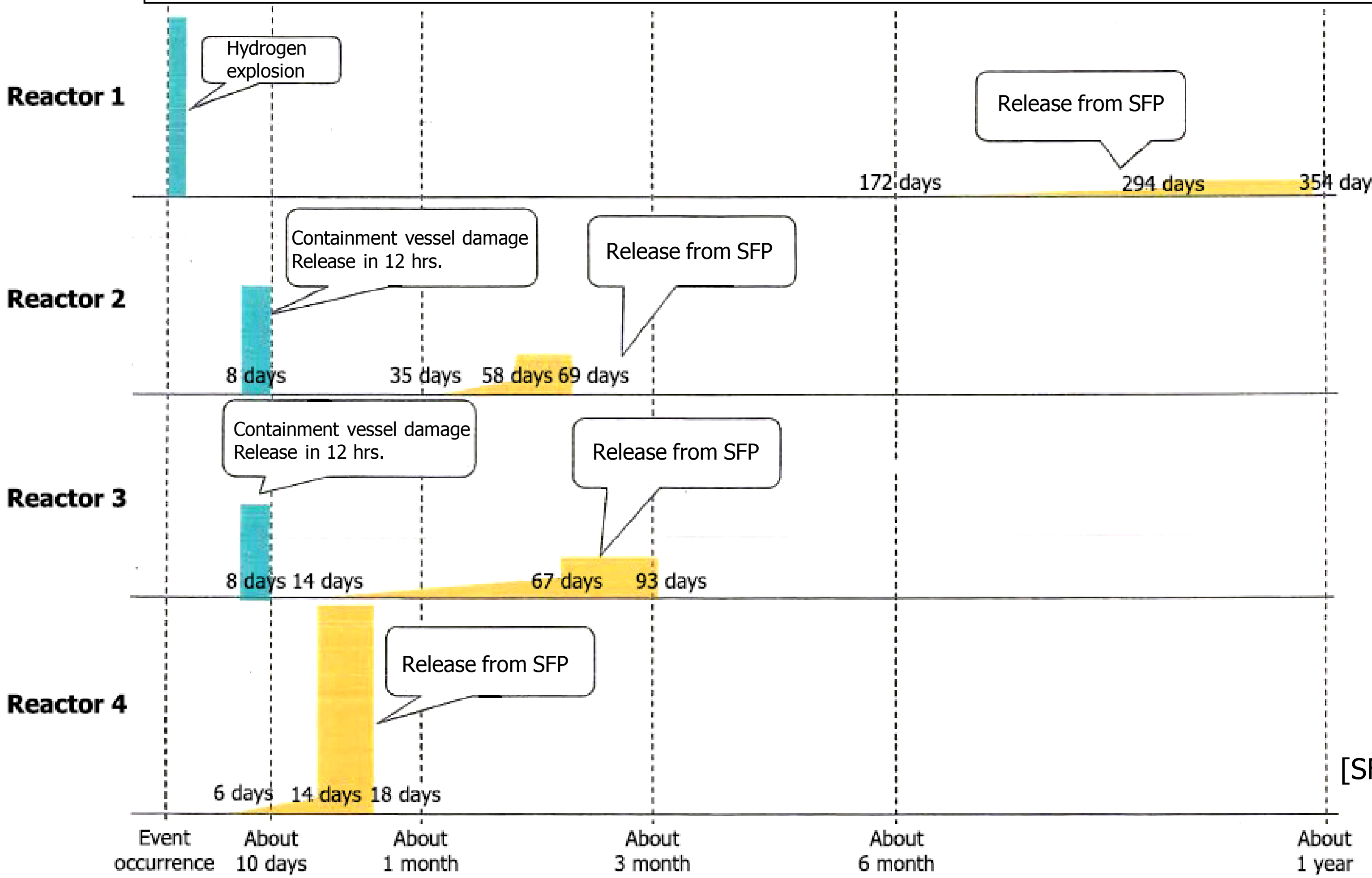
- Event progress based on the assessment by TEPCO as of the 19th. However, if a structural problem has developed in the spent fuel pool leading to water leakage, the event will progress more quickly.
  In the case of Units 3 and 4, sea water is being injected through the (permanent) cooling and filtering system of the spent fuel pool.

	Unit 1	Unit 2	Unit 3	Unit 4	common	Unit 5	Unit 6
Start of the gap radioactivity release (days)*2	172	35	14[3]*4	6	46	21	27
Start of MFCI (days)*3	294	58	67 [56]*4	14	72	34	44
Cessation of MFCI (days)	354	69	93[82]*4	18	85	40	52

*1: Molten fuel concrete interaction
*2: The start of the release of radioactivity is assumed to be the time when the pool water level drops to the top of the spent fuel.
*3: The start of MFCI is assumed to be the time when the pool water level drops to the bottom of the spent fuel.
*4: Since white smoke (thought to be steam) appeared three days after the accident, it can be assumed that the water level went down quicker than expected due to some reason. Therefore, the assessment has been made subtracting the 11 days worth of acceleration.

Release sequence

Case where all the work becomes impossible due to Unit 1 hydrogen explosion



[SFP: spent fuel pool]

Result of the assessment of radiation dose

Radius of the area (from the power plant) where the dose exceeds the guideline dose in an assumed event

Guideline dose	Hydrogen explosion	Containment vessel damage	Spent fuel pool (Unit 4)	
			One-reactor-core equivalent	Two-reactor-core equivalent
10 mSv (sheltering)	15 km	10 km	50 km	70 km
50 mSv (evacuation)	7 km	6 km	15 km	18 km
100 mSv	5 km	4 km	9 km	10 km

The radiation dose is the total effective dose during the first seven days of the external dose from the radioactive plume, the external dose from the deposits on the ground, and the internal dose due to inhalation.

The zone where relocation was called for and the zone where voluntary relocation was allowed due to soil contamination, instituted during the Chernobyl accident (1)

The radius of the area where the surface contamination concentration of Cs-137 exceeds the guideline*
(*The guideline figure is for the Chernobyl accident)

The guideline for Cs-137 surface contamination concentration	One-reactor-core equivalent	Two-reactor-core equivalent
1480 kBq/m^2 (compulsory relocation)	110 km	170 km
555 kBq/m^2 (voluntary relocation)	200 km	250 km

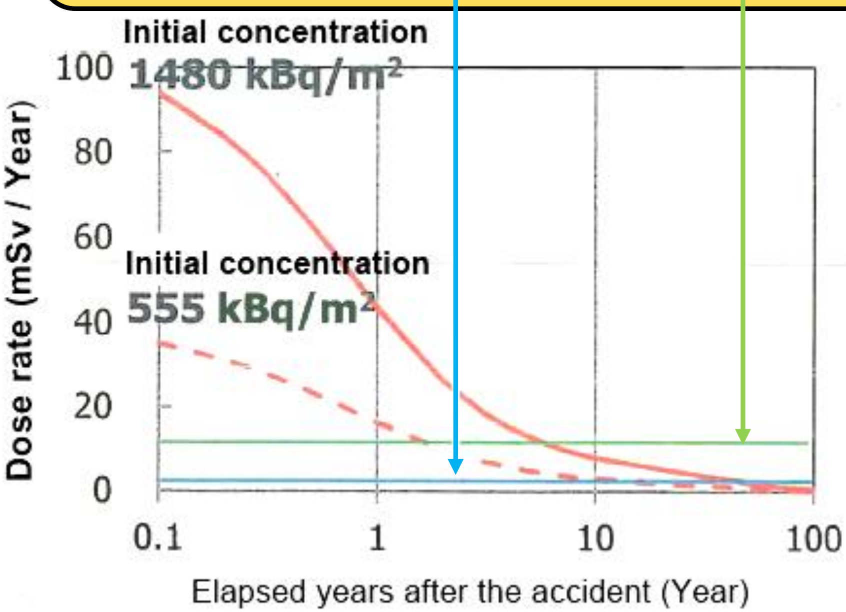
The zone where relocation was called for and the zone where voluntary relocation was allowed due to soil contamination, instituted during the Chernobyl accident (2)

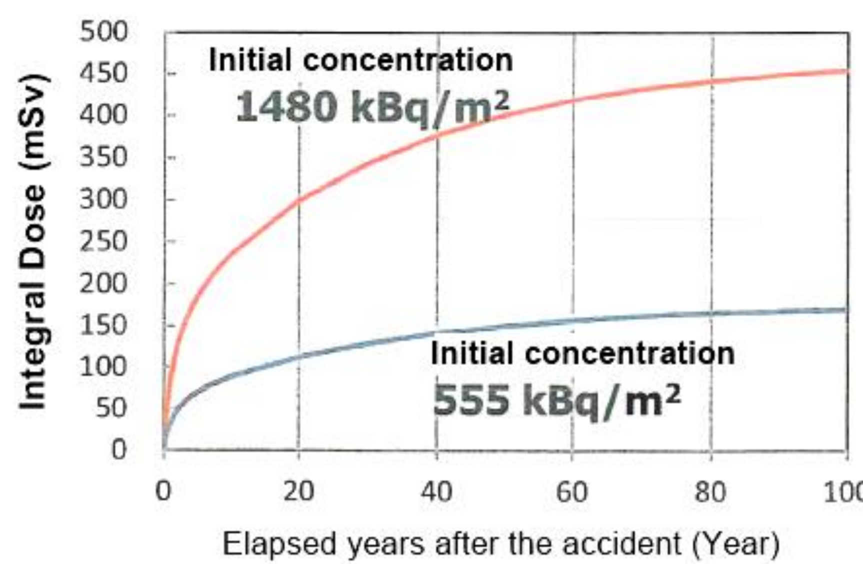
Chronological change of the dose rate (mSv/y) and of the integral dose (mSv) in the relocation zone (designated in accordance with the Cs-137 contamination concentration)

10 mSv/y - The level that is considered to be acceptable for residence by **ICRP Pub.82**

1 mSv/y - Dose limit for the general public

Meaning of the integral dose for remaining in the relocation zone:
Life time **1Sv**--Equivalent to the dose limit for workers set by **ICRP** or the level at or above which permanent relocation is almost always justified.





Evaluation of sea contamination

We estimated the concentration in seawater for a case where the radioactive materials are dispersed through the atmosphere, and deposited onto the sea, and are distributed homogeneously to a certain depth. We then estimated the internal dose in a case where marine products from organisms living there are consumed for a year.

Homogeneously distributed to 100 m depth in the sea out to a 125 km radius from the Fukushima Daiichi Nuclear Power Plant

Nuclides	Concentration in seawater (Bq/kg)	Yearly dose (mSv)
Sr-90	3.2	0.03
Cs-134	15	0.8
Cs-137	15	0.5

Concerning the dose evaluation result

(Insertion of [ ] by the translator)

- Even in a case where occurrence of hydrogen explosion leads to occurrence of additional release with the prospect of subsequent releases from the other units, based on the dose evaluation result from these events, there is no need to change the 20 km radius of the present evacuation zone.
- However, after that, following fuel damage at the Unit 4 pool, core-concrete interaction is expected to occur resulting in release of radioactive materials, and thus it is not proper to call for sheltering in the area outside that zone. At least by the 14th day, when the occurrence will turn full scale, there should be prompt evacuation within the 50-km radius which is expected to become the sheltering zone based on the dose of [the first] 7 days.
- Although sheltering will be called for, for the time being, in the 70 km radius outside that, within the 110km radius, there will be areas where relocation should be called for due to a high level of soil contamination. Also, up to a 200-km radius, there will be areas where those who want to relocate, citing the fact that the annual dose will greatly exceed the background radiation level, should be allowed to do so (depending on the acceptable dose).
- Next, in pools of other units, fuel damage will lead to core concrete interaction followed by the start of release of a large quantity of radioactive materials. As a result, there is a possibility that the zone where compulsory relocation should be called for reaches beyond the 170-km radius and that the areas where those who want to relocate, citing the fact that the annual dose will greatly exceed the background radiation level, should be allowed to do so, will reach beyond the 250km radius.
- These radii will become smaller as time proceeds, but if relying only on natural decay and weathering, it will take several decades in the abovementioned points of 170km and 250km.