JAEA Activities towards Environmental Restoration of FUKUSHIMA

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Headquarters of Fukushima Partnership Operations

JAPAN ATOMIC ENERGY AGENCY

JAEA activities for environment restoration

(1) Assessment of radiological contamination situation
- Support to government's mapping and monitoring
- Detailed investigation with Autonomous Unmanned Helicopter and Plastic Scintillation Fibers

(2) Development of decontamination measures for public facilities such as schools and parks

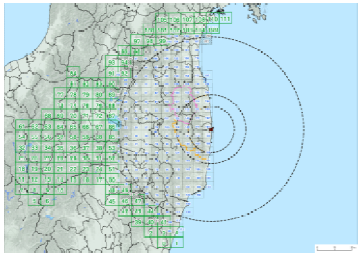
(3) Demonstration of decontamination measures for residential areas
- Areas including "specific spots recommended for evacuation" (2 sites) → Areas including "deliberate evacuation area" & "restricted area" (12 sites)
- Monitoring → Planning based on Simulation → Decontamination → Monitoring

(4) Communication activities to provide reliable information on environment contamination to Fukushima citizens

(1) Assessment of radiological contamination situation

- Detailed measurements and mapping of ground surface deposition density distribution of radionuclides
- Wide area radiation dose-rate distribution measurement and mapping using monitoring vehicles.

Source term for predictive models of future radioactive spread

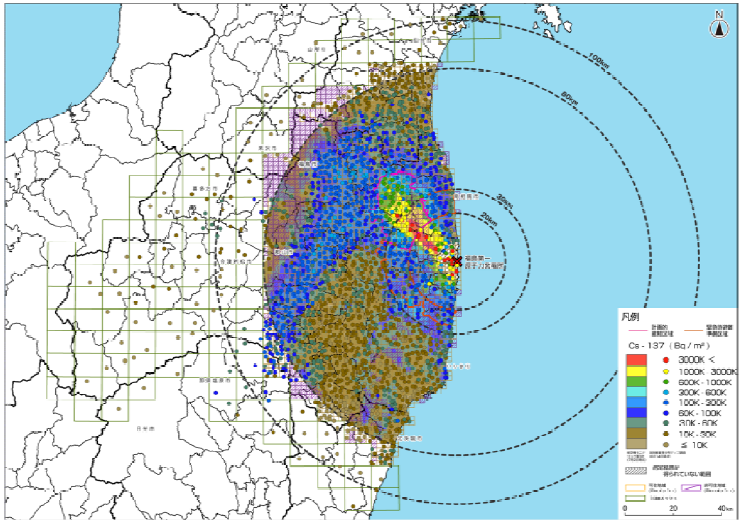


Variable mesh size:
- 2km near NPP
- 10km in distant locations

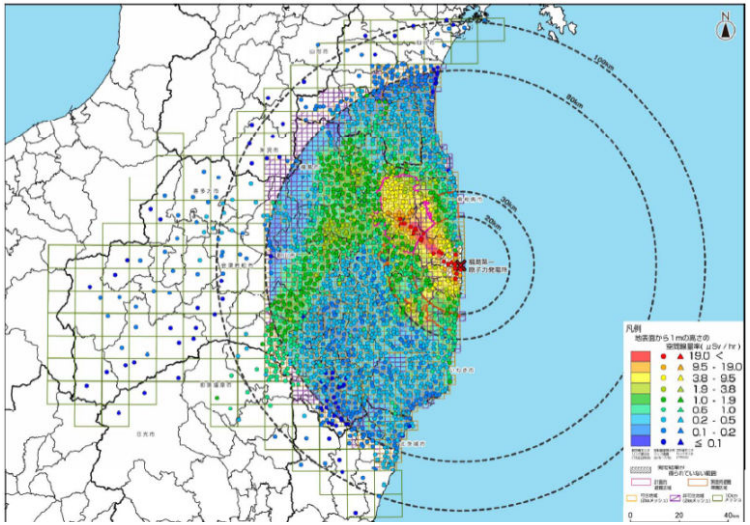
Quantitative radionuclide analysis with Ge-detector.

Survey vehicles are used for measurements of the dose-rate distribution over a large area.

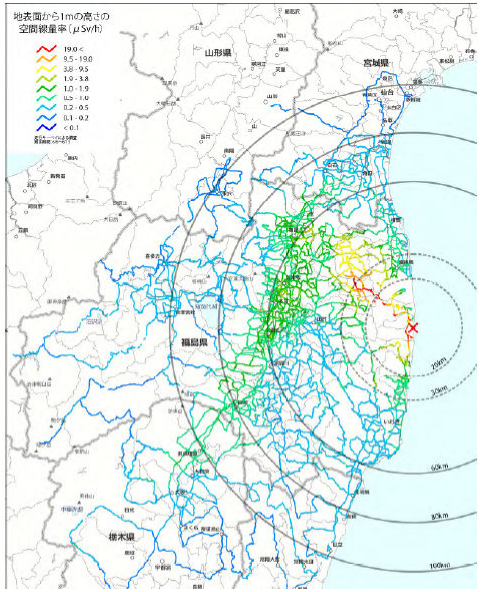
Detailed dose rate distribution map made by correcting measurements according to surroundings circumstances, etc.



Map of density distribution of sesium-137



Dose-rate measurement at each mesh elements

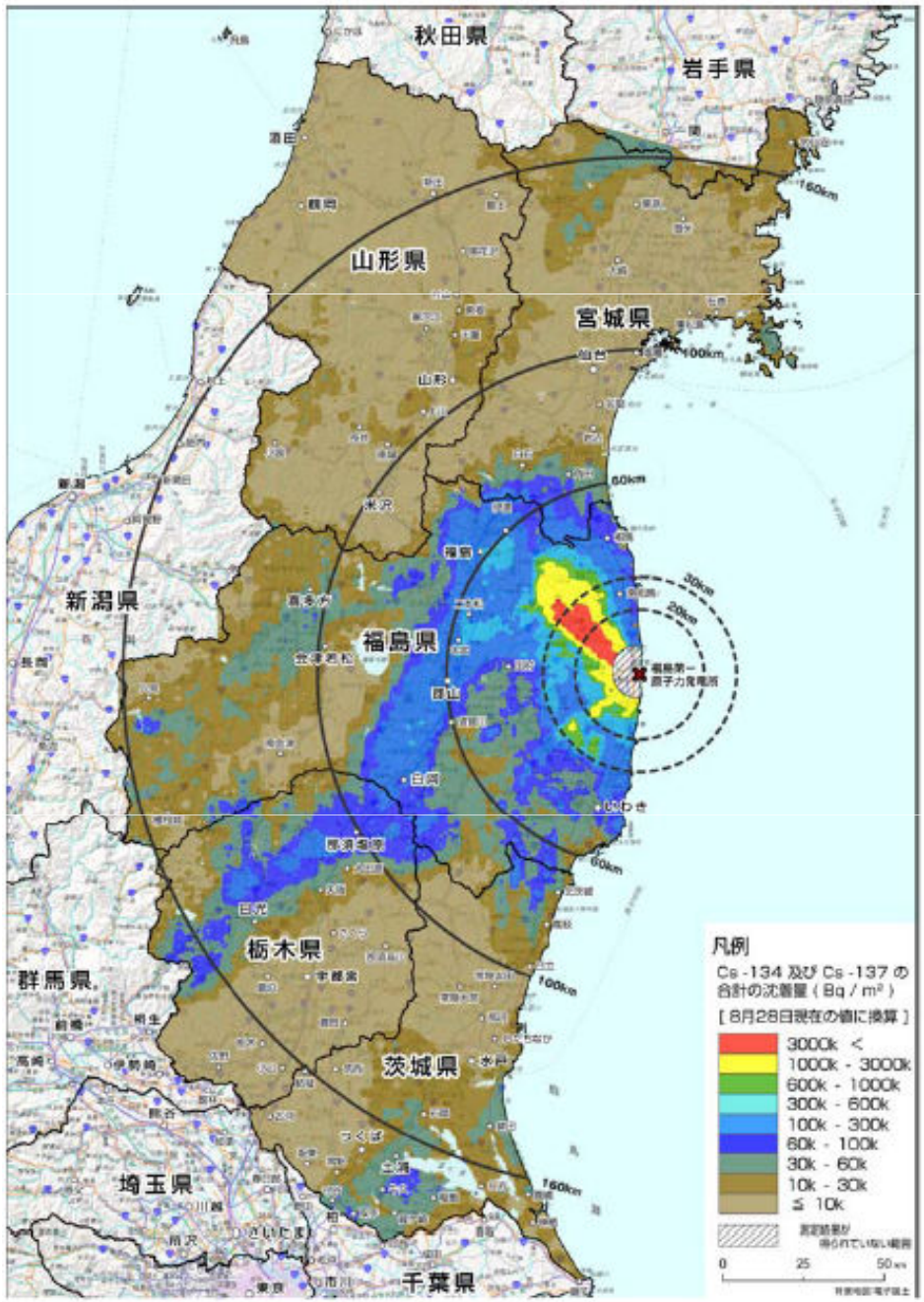


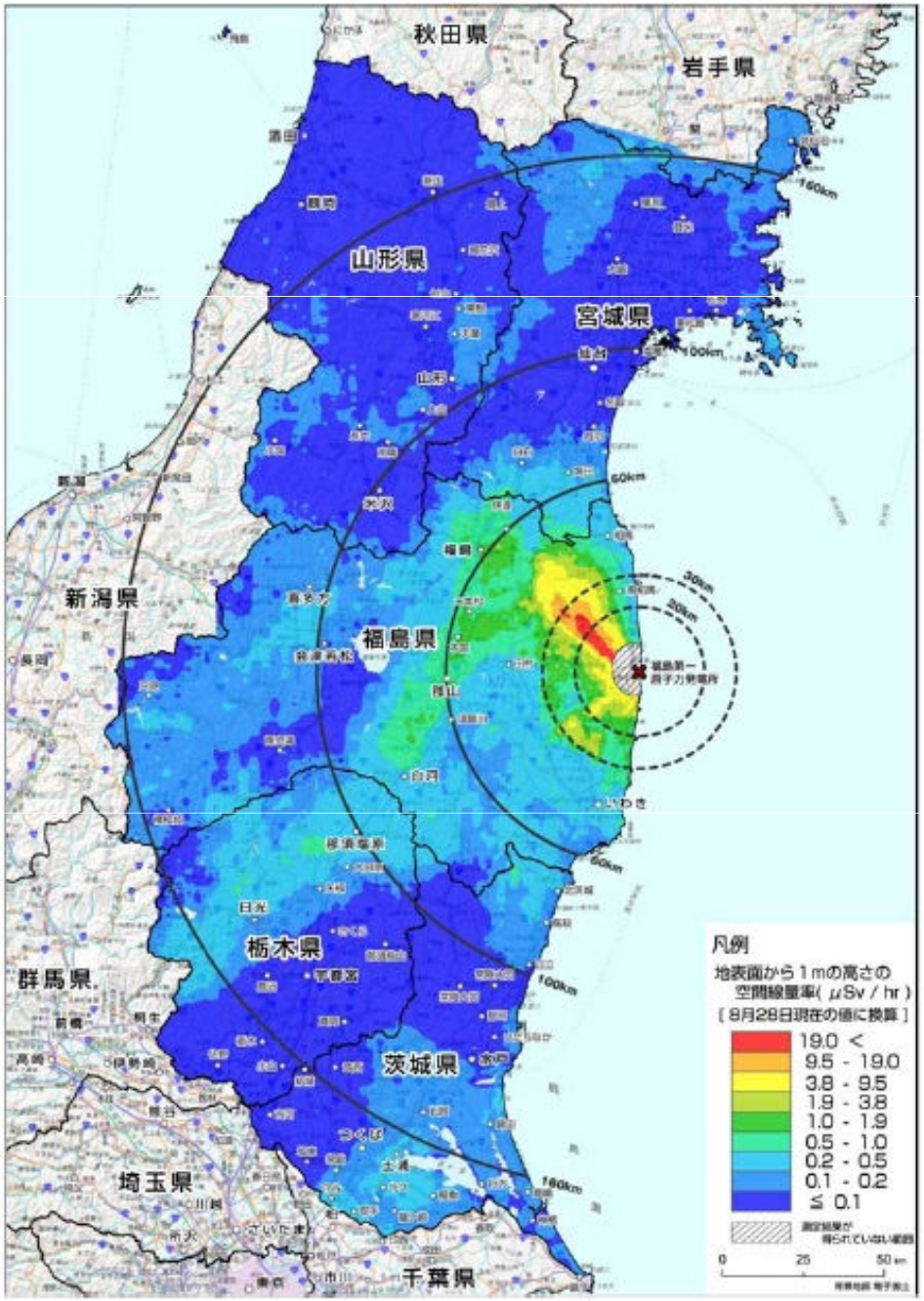
Measurement using survey vehicles

Maps of radiation dose-rate distribution

Aircraft radiation monitoring around Fukushima NPP1

(measured by JAEA and NSTC)





Monitoring system using an Autonomous Unmanned Helicopter (AUH)

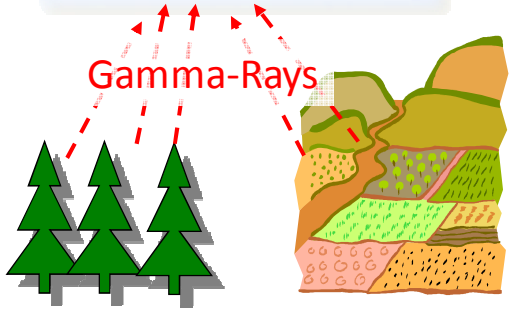
Monitoring system using AUH

The AUH and the detector (below)

Grand station

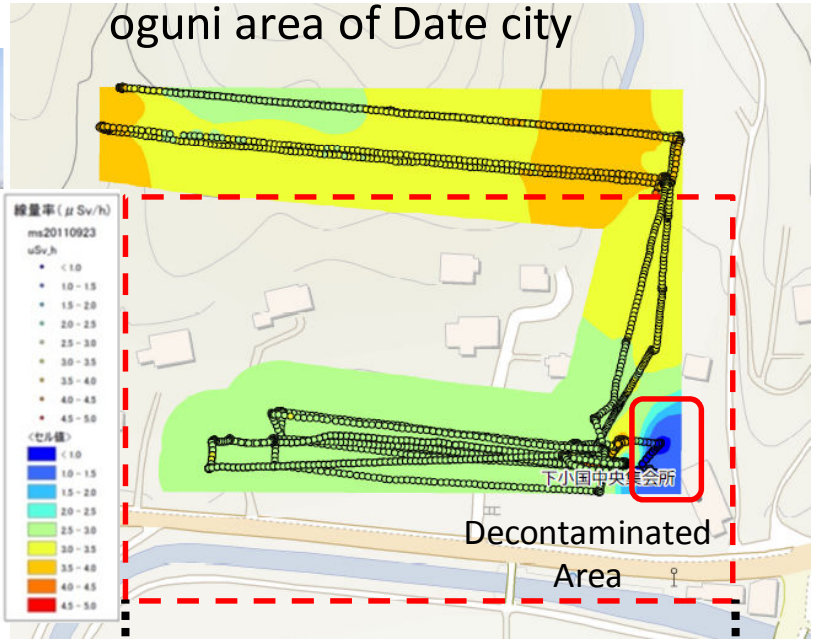
Air dose rate (1 m high) can be measured from an altitude of 30 m

Monitoring above rice paddy/forest

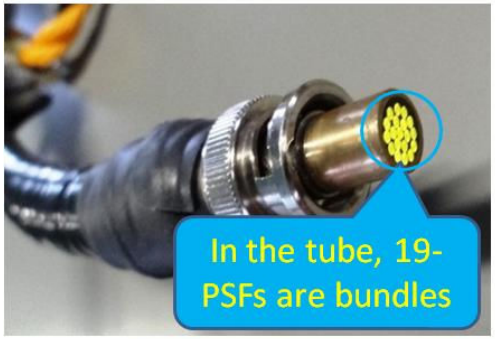


Monitoring above Shimo oguni area of Date city

Monitoring results for Shimo oguni area of Date city



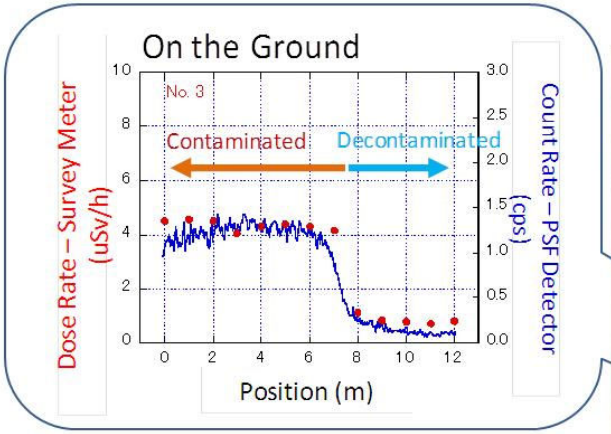
Measurement of radiation distribution by Plastic Scintillation Fibers (PSFs)

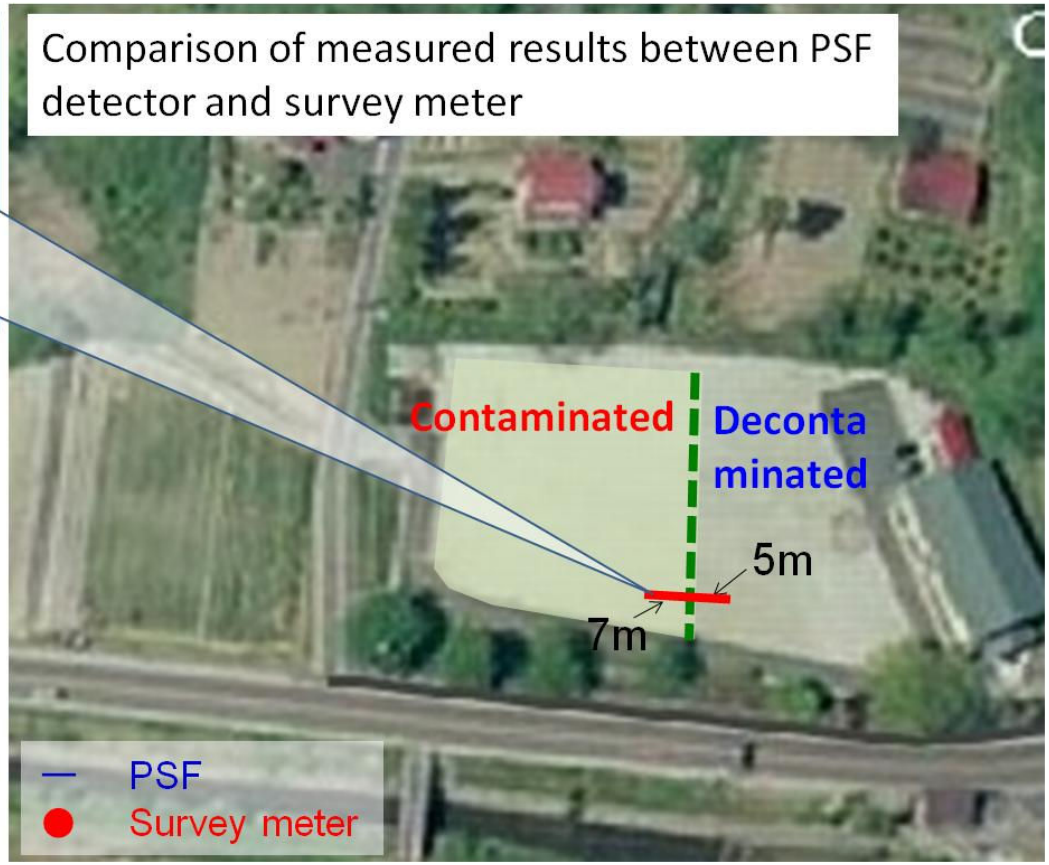


***PSF*: Optical fiber made of plastic scintillator**

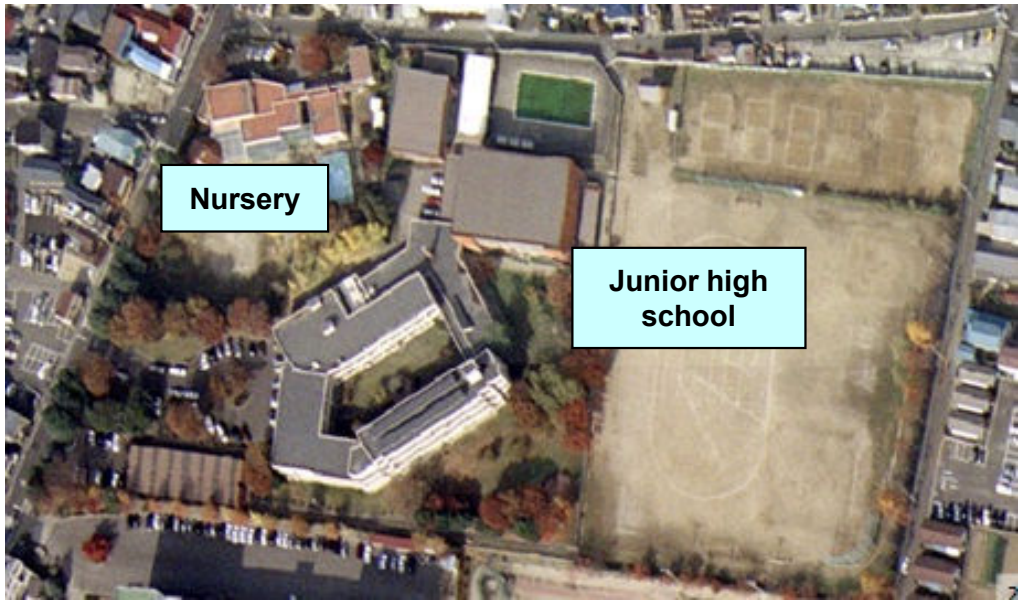
≪**Feature of the Detector**≫

- Measureable at a time in wide areas
- By using bendable nature, it can be measured along curves.
- It can be measured the contamination in the water, such as rivers and ponds.





(2)Development of decontamination measures for public facilities such as schools and parks
- National Fukushima University nursery, junior high school -



Comparison of dose rate before and after decontamination.

	Dose rate (μSv/h)		Reduction rate (%)
	Before	After	
JHS yard			
100 cm	2.5 ± 0.3	0.15 ± 0.07	94
50 cm	2.9 ± 0.3	0.16 ± 0.06	94
1 cm	3.1 ± 0.5	0.16 ± 0.06	95
JHS court			
100 cm	2.4 ± 0.2	0.11 ± 0.05	95
50 cm	2.7 ± 0.2	0.11 ± 0.06	96
1 cm	3.0 ± 0.3	0.12 ± 0.07	96
Nursery yard			
100 cm	1.9 ± 0.2	0.21 ± 0.06	89
50 cm	2.8 ± 0.2	0.22 ± 0.08	92
1 cm	3.1 ± 0.4	0.19 ± 0.09	94

School yard and Nursery yard

- Contaminated topsoil of 5 cm was removed.
- Yards were recovered with clean soil.

Trench for removed soil

- excavated in the school yards,
- with 1.5 m-deep,
- lined with impermeable sheets,
- covered by a mixture of soil removed from the trench and clean soil (50 cm),
- just a tentative countermeasure.

Dose rate (D) was measured in a 10m x 10m mesh.

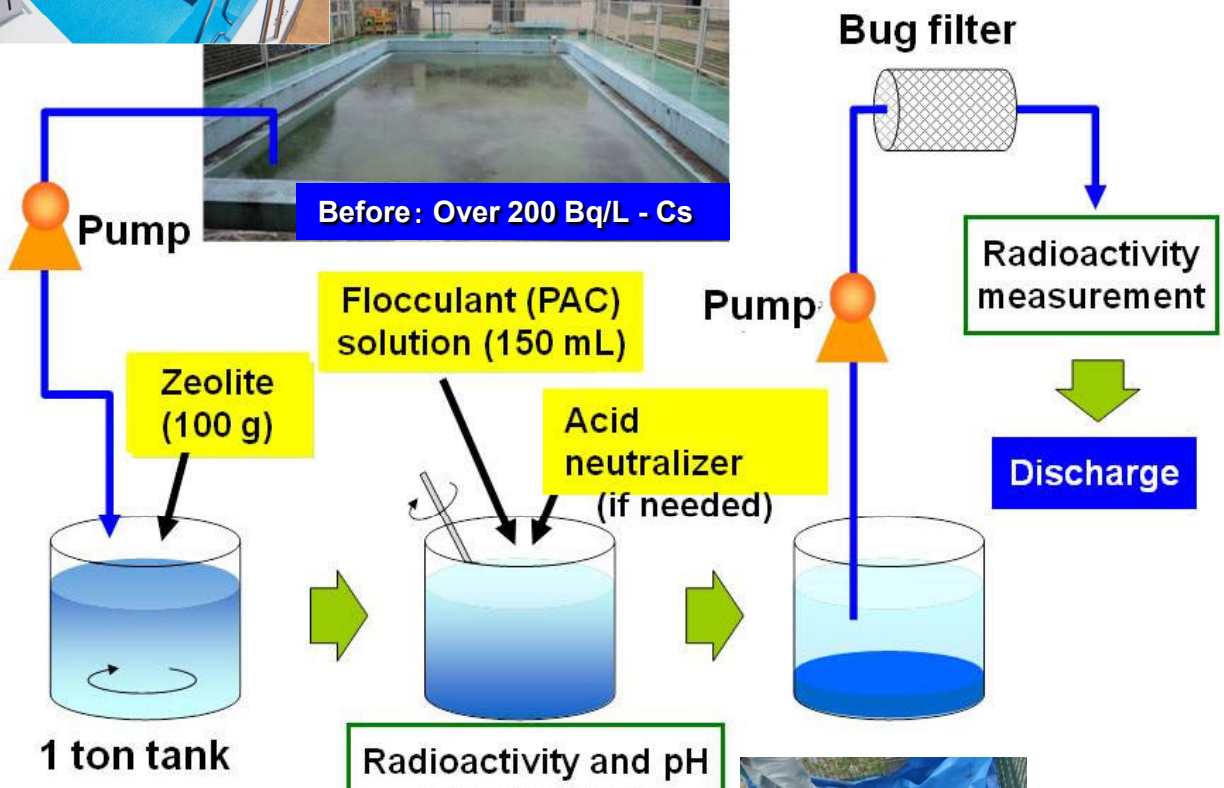
- Before decontamination;
  D(100cm)<D(50cm)<D(1cm) indicates contribution of radinuclides (RNs) on the topsoil.
- After decontamination;
  Dose rate drastically decreased.
  D(100cm)~D(50cm)~D(1cm) indicates contribution of RNs in surroundings.

The used techniques and methodology are effective.

Decontamination of Swimming Pools

- Nursery, elementary and junior high schools in Fukushima and Date area -

- Water stored in outdoor swimming pools included Cs.
- The flocculation & precipitation was applied for purification of water
- After discharge of purified water, the swimming pool was decontaminated



Flocculation & precipitation method

1) Add zeolite (100 g) and flocculant (150 ml) to pool water (1 ton).
2) Stir well and age for 15 - 30 min.
3) Flocculate zeolite adsorbing cesium with soil grains and green alga.
4) Discharge filtered water.
5) Fold sediments in jute bags in impermeable sheets, which are sandbagged for radiation shielding.

Concentration of cesium in pool water

- Before decontamination; > 200 Bq/L
- After decontamination; N.D.

Safe interim storage of sediments was attained.

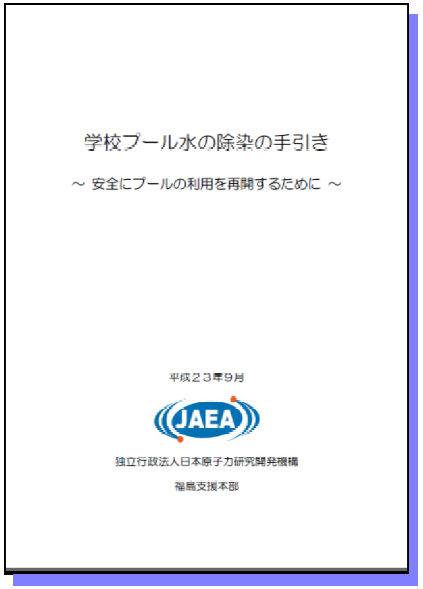
Ambient dose rate (μSv/h)

- Background : 0.7～0.9
- After putting jute bags : 13～21
- After sandbag jute bags : 1.0～1.2

The used techniques and methodology are effective.

Handbook of Pool Water Decontamination

- Published a user-friendly handbook “Handbook for Decontamination of School Swimming Pools” based on a series of our tests
  (uploaded on JAEA website)
  http://www.jaea.go.jp/02/press1.shtml
  (in Japanese)



Handbook

- News briefing held on 17th of Sep. 2011 at Fukushima University

- Fostered a trustful relationship with school officials, municipality and local people (Fukushima and Date citizen) through dialogue and decontamination works

“Kizuna” (絆: bond) team and JAEA staff for school pool decontamination in Date city

(3) Demonstration of decontamination measures for residential areas

Demonstration of decontamination technologies;

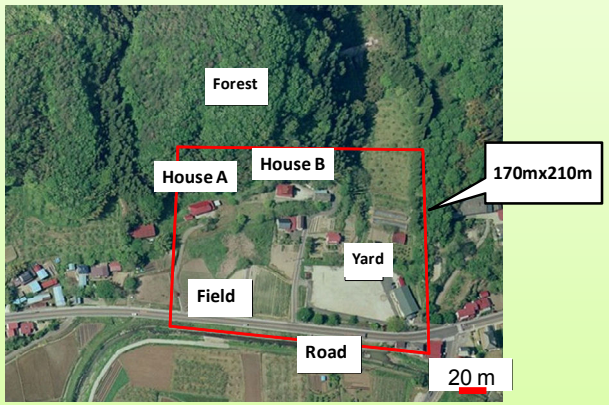
- ➢ review previous experiences,
- ➢ apply technologies to the model sites,
- ➢ evaluate efficiency, cost, generation of waste, safety, etc.
- ➢ establish “technologies catalogue”

Demonstration of decontamination methodology;

- ➢ propose brief approach and draft guideline
- ➢ extract points to be considered during decontamination at model sites
- ➢ update guideline

Demonstrations at model sites

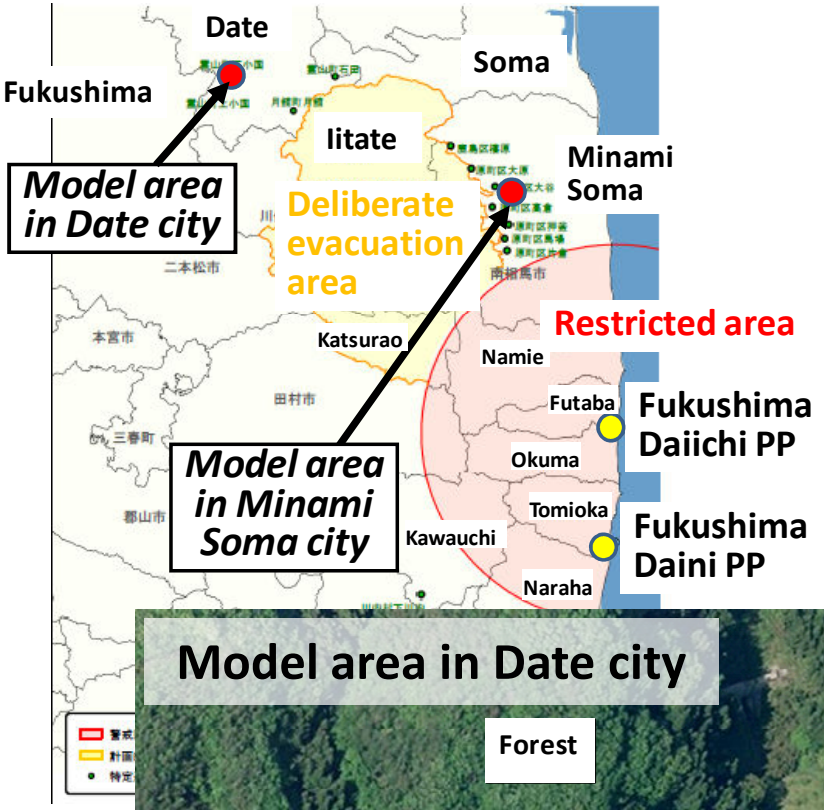
- ➢Model area1: Areas including “specific spots recommended for evacuation” (2 sites)
- ➢ Model area2: Areas including “deliberate evacuation area” & “restricted area” (12 sites)

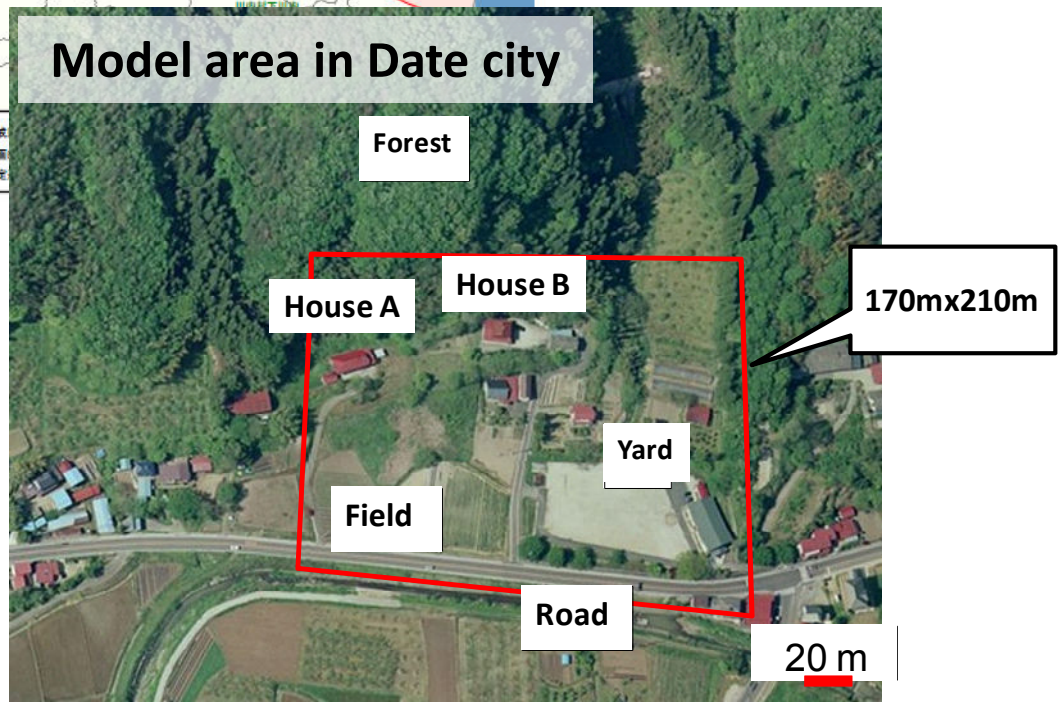


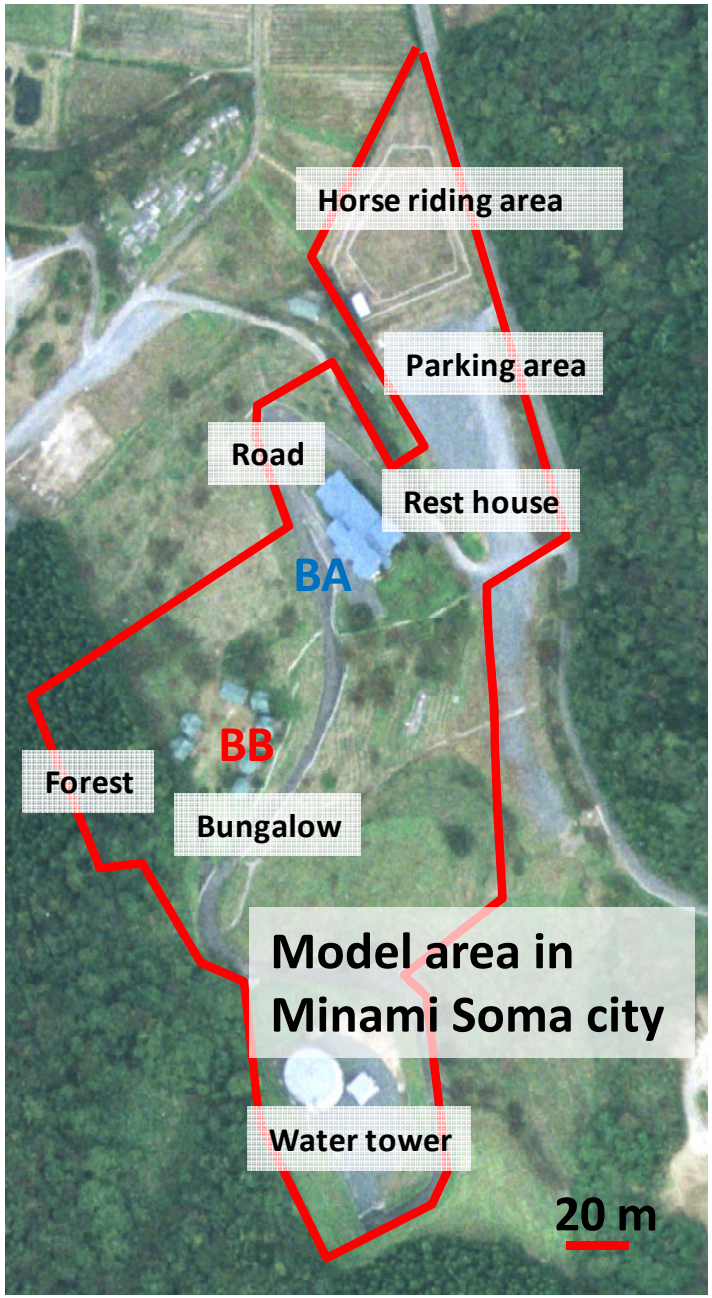
Model area1

Model area2

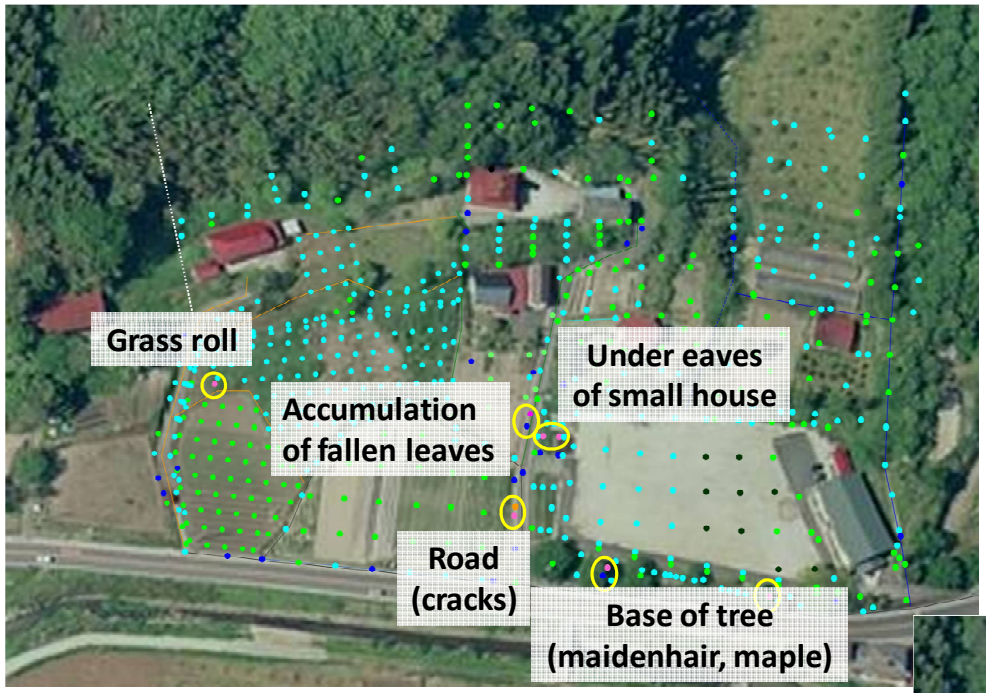
Demonstration of remediation at model area







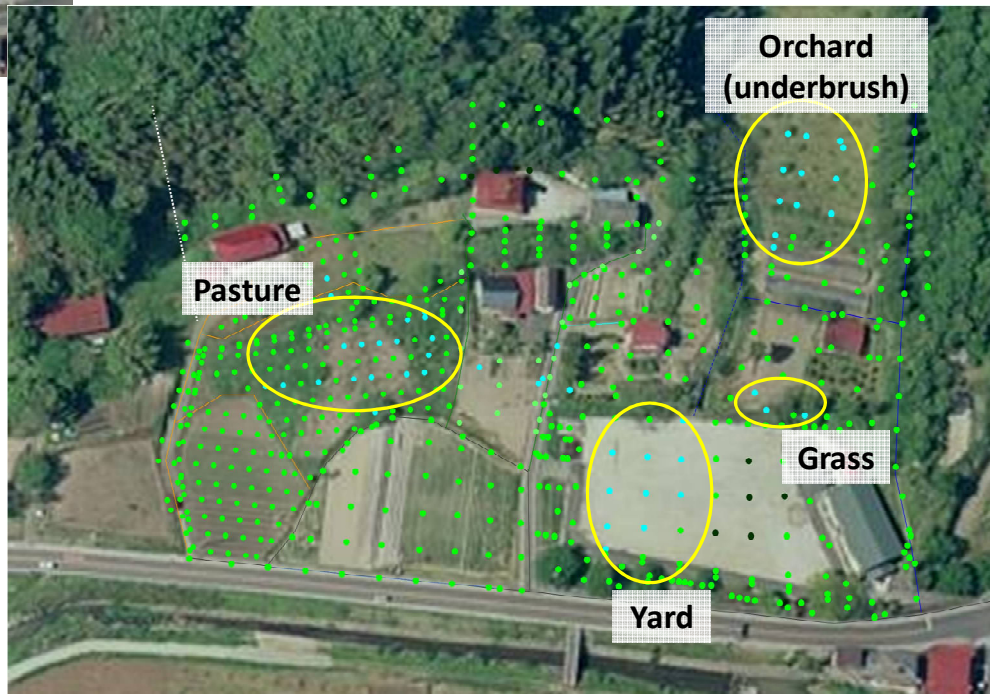
Radiation survey (whole area to be remediated)



Surface dose rate

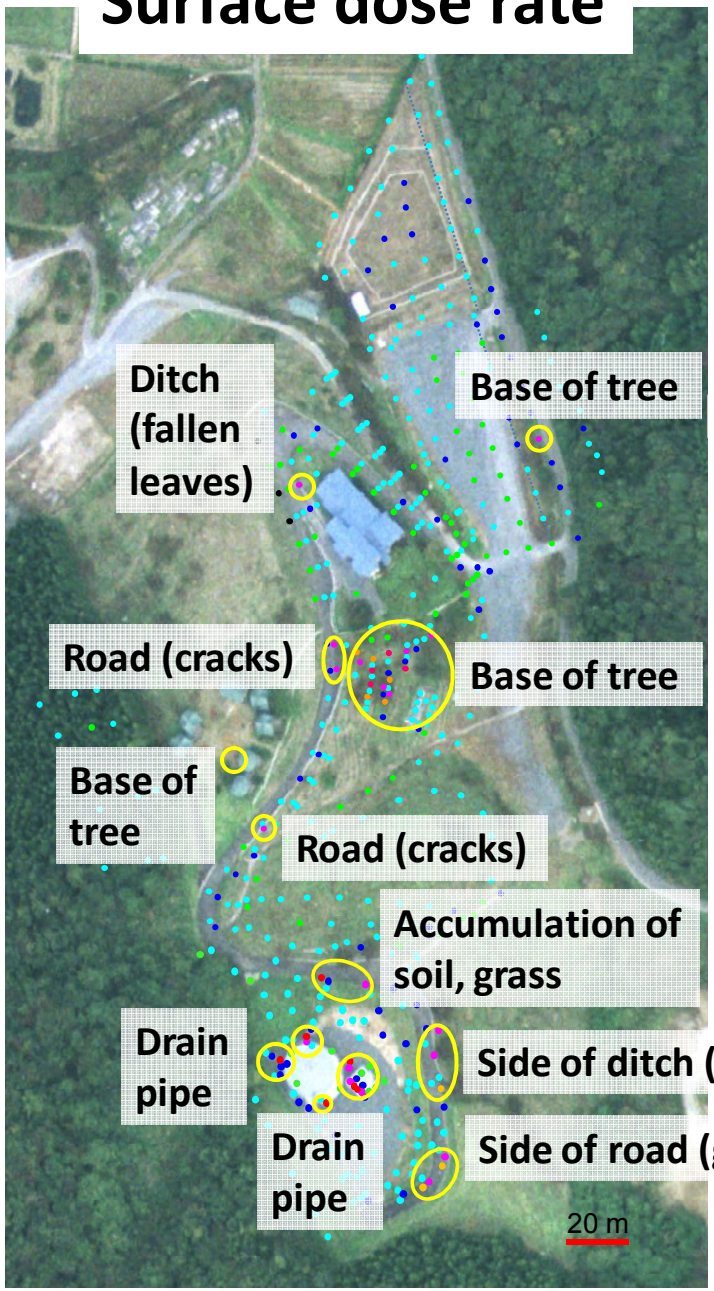
Model area in Date city

Air dose rate [1 m]

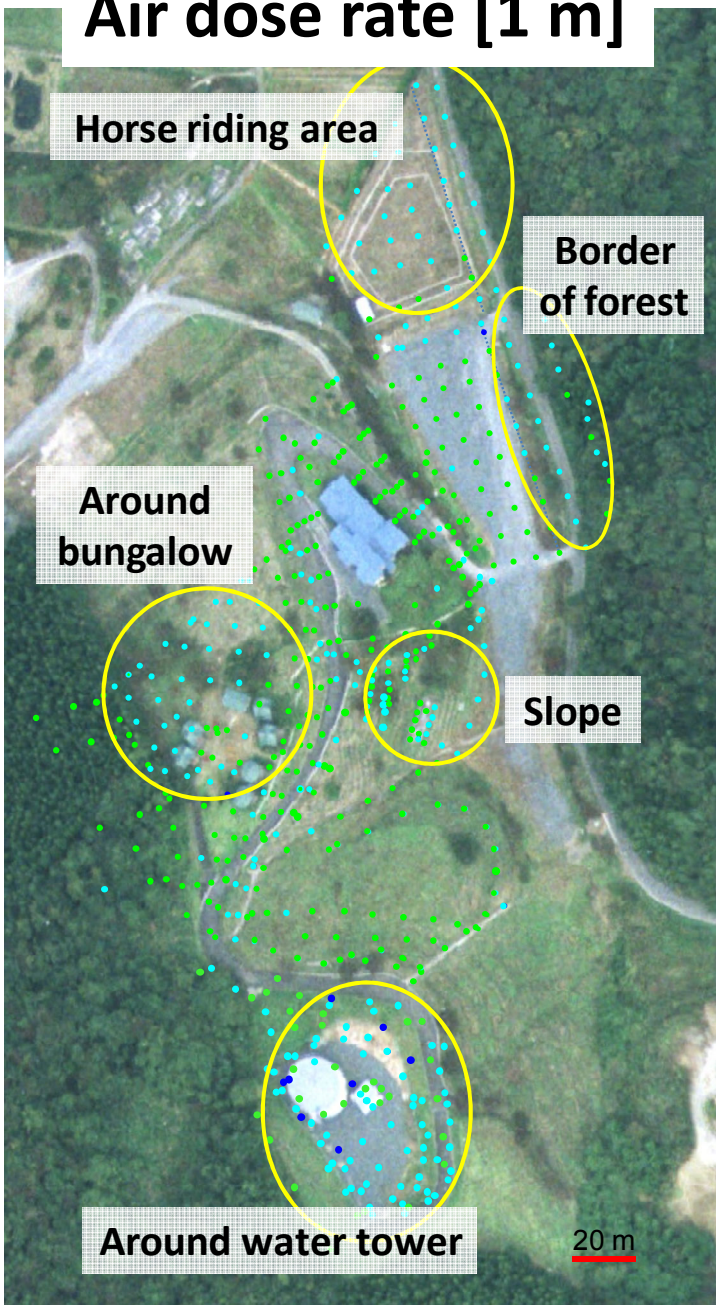


Radiation survey (whole area to be remediated)

Surface dose rate



Air dose rate [1 m]



Dose rate (μSv/h)
- ~1
- 1~3
- 3~5
- 5~10
- 10~20
- 20~30
- 30~

Model area in Minami Soma city

Overview of approach

Preliminary planning for remediation

- Select demonstration site(s)
- Establish remediation goals and targets
- Estimate remediation sub-areas and inventories of contaminants
- List potentially appropriate remedial tools & methods

Radiation survey before remediation

- Detailed surface dose survey of the entire area
- Radiochemical assessment of relevant samples at appropriate locations
- Simple model assessment of inhabitant exposure

Establish remediation plan

- Integrate planning and site characterization data to develop improved site model
- Assess effectiveness of potential approaches to remediation for sub-areas on the basis of dose reduction, cost and safety
- Evaluate inventory of removed contaminants and interim storage and waste management requirements (conditioning, packaging, transportation, …)
- Rank options and establish remediation plan (time schedule, remediation goals, uncertainty management processes, etc.)
- Workers safety

Apply remedial measures

- Stepwise implementation with monitoring procedures to check effectiveness of all remedial action
- Development of a complete inventory of all resultant materials in interim storage

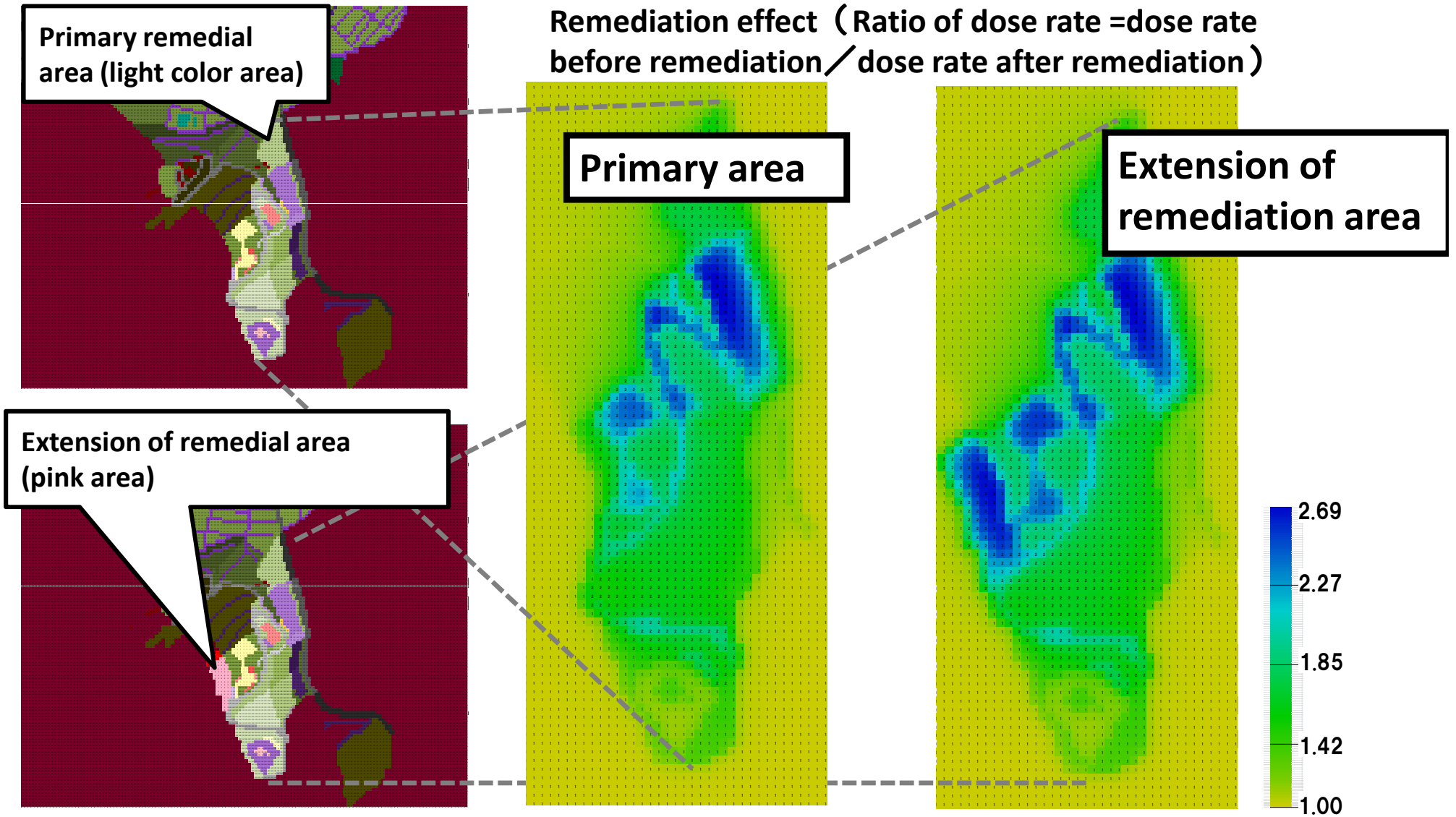
Evaluate effectiveness of remedial measures

- Radiation survey after remediation, with associated sampling and analysis as required
- Examine remediation effectiveness in terms of radiation dose to critical groups
- Assess waste inventory, conditioning/packaging/transportation effectiveness and management options
- Record experience (including staff feedback)

Review effectiveness & establish Remediation Guidelines

Estimation of dose rate reduction due to extension of remedial area

Model area in Minami Soma city



Remediation planning to select appropriate remedial areas before remedial actions using a calculation tool to estimate dose rate reduction due to extension of remedial area

Basic approach to establishing a remediation plan

- **Remedial measures**
  - Use well-tried, easy and practical measures
  - Ensure amounts of removed contaminants as low as practically achievable
  - Restrict use of water to the extent possible to avoid secondary contamination
  - Take measures to reduce environmental impact of remediation, if needed

- **Procedures**
  - Optimize remedial actions using a calculation tool to estimate dose rate reduction due to alternative approaches
  - Generally implement remediation from higher to lower ground to reduce the risk of re-contamination
  - An example of remedial actions for different target contaminants; Remediation of forest; restricted to a few meters - tens meters from the edge of the forest
  - In all cases, continuous radiation monitoring during actions to assess effectiveness and develop inventories of resultant waste

Remediation plan

Model area in Minami Soma city

STEP 1

Principal remediation methods for water tower
- Roof and drain pipe : Removal of dust (man power), wash and wipe (man power)
- Field : Removal of fallen leaves and grass (man power), Removal of topsoil and soil dressing/compaction (man power, machine)

STEP 2

Principal remediation methods for forest and grass field
- Fallen leaves : Removal of leaves (man power)
- Grass : Removal of grass (man power, machine)
- Tall tree : Trim
- Topsoil : Removal of topsoil (man power, machine), Soil dressing/compaction (machine)

STEP 3

Principal remediation methods for bungalow
- Roof and drain pipe : Removal of dust (man power), wash and wipe (man power)
- Field : Removal of fallen leaves and grass (man power), Removal of topsoil and soil dressing (man power, machine)

STEP 4

Principal remediation methods for grass field
- Fallen leaves : Removal of leaves (man power)
- Grass : Removal of grass (man power, machine)
- Tall tree : Trim
- Topsoil : Removal of topsoil (man power, machine), Soil dressing/compaction (machine)

STEP 5

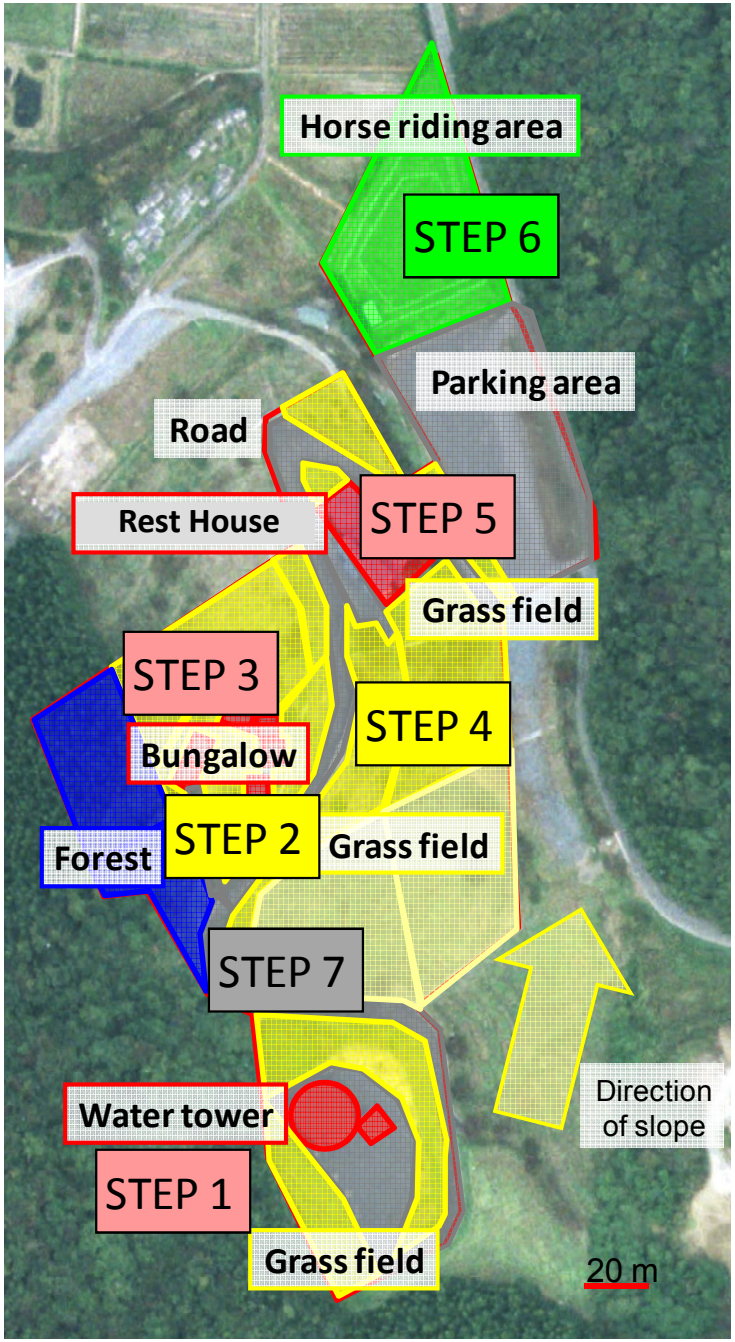
Principal remediation methods for training house
- Roof and drain pipe : Removal of dust (man power), wash and wipe (man power)
- Field : Removal of fallen leaves and grass (man power), Removal of topsoil and soil dressing (man power, machine)

STEP 6

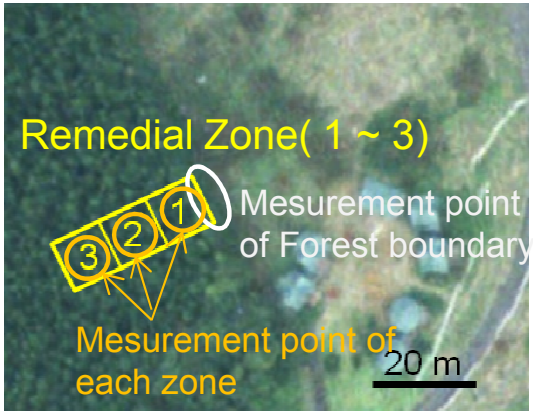
Principal remediation methods for horse riding area and parking area
- Fallen leaves : Removal of leaves (man power)
- Grass : Removal of grass (man power, machine)
- Tall tree : Trim
- Topsoil : Removal of topsoil (man power, machine), Soil dressing/compaction (machine)

STEP 7

Principal remediation method for roads
- Pave road : blast (machine)

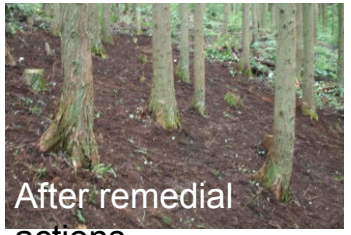


Trial of remedial actions for forest



Bird's-eye view of Trial Area

The trial area is divided into 3 zones. Dimension of the zones are 10m wide and 10m length, respectively.



- Following remedial items were examined in every remedial zone.
  1) weeding, 2) removal of fallen leaves, 3) removal of leaf mold.
- Finally, branches up to 4m height were cut off from the trees on forest boundary.
- Surface (at 1cm height) and ambient (at 1m height) dose rates were measured in the remedial zone and at forest boundary after carrying out every remedial item.

Dose rates after remedial items in each zone

(μSv/h)

	Before remediation		remedial items					
			weeding		removal of fallen leaves		removal of leaf mold	
	surface	ambient	surface	ambient	surface	ambient	surface	ambient
Zone 1	3.4	2.5	3.5	2.5	2.8	2.5	1.6	1.8
Zone 2	3.3	2.7	3.2	2.5	2.4	2.3	1.7	1.7
Zone 3	3.1	2.5	3.2	2.4	2.5	2.2	1.6	1.4

After removal of leaf mold, surface and ambient dose rates were decreased 50% and from 30% to 40% lower than the condition before remediation, respectively.

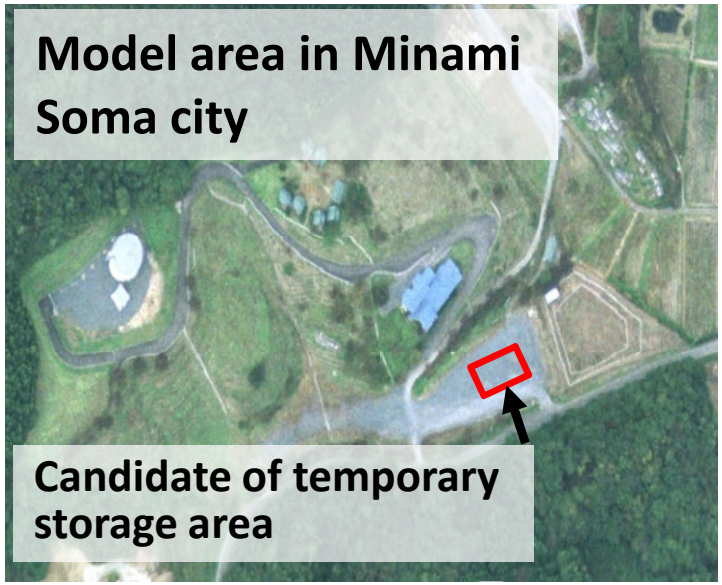
Ambient dose rates at forest boundary after remedial actions of every zone and cutting off branches

(μSv/h)

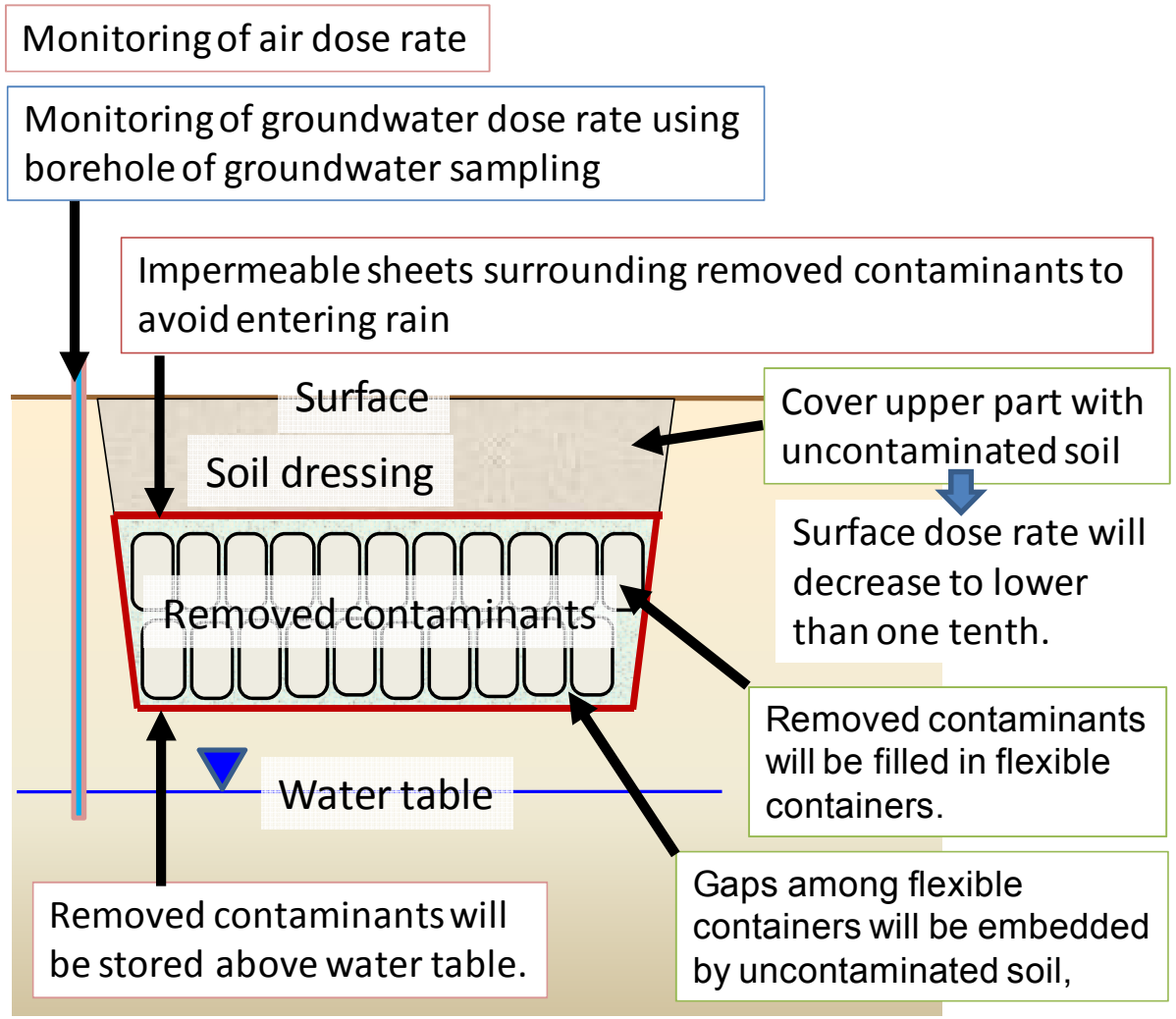
	before remediation	after zone 1	after zone 2	after zone 3	cutting off branches
forest boundary	2.4	2.2	2.3	2.4	2.1

Dose rates were not significantly decreased because of influence of contaminated materials around the trial area

Plan of temporary storage trench for removed contaminants



Temporary storage methods will change depending on radioactivity of removed contaminants and style of land utilization.

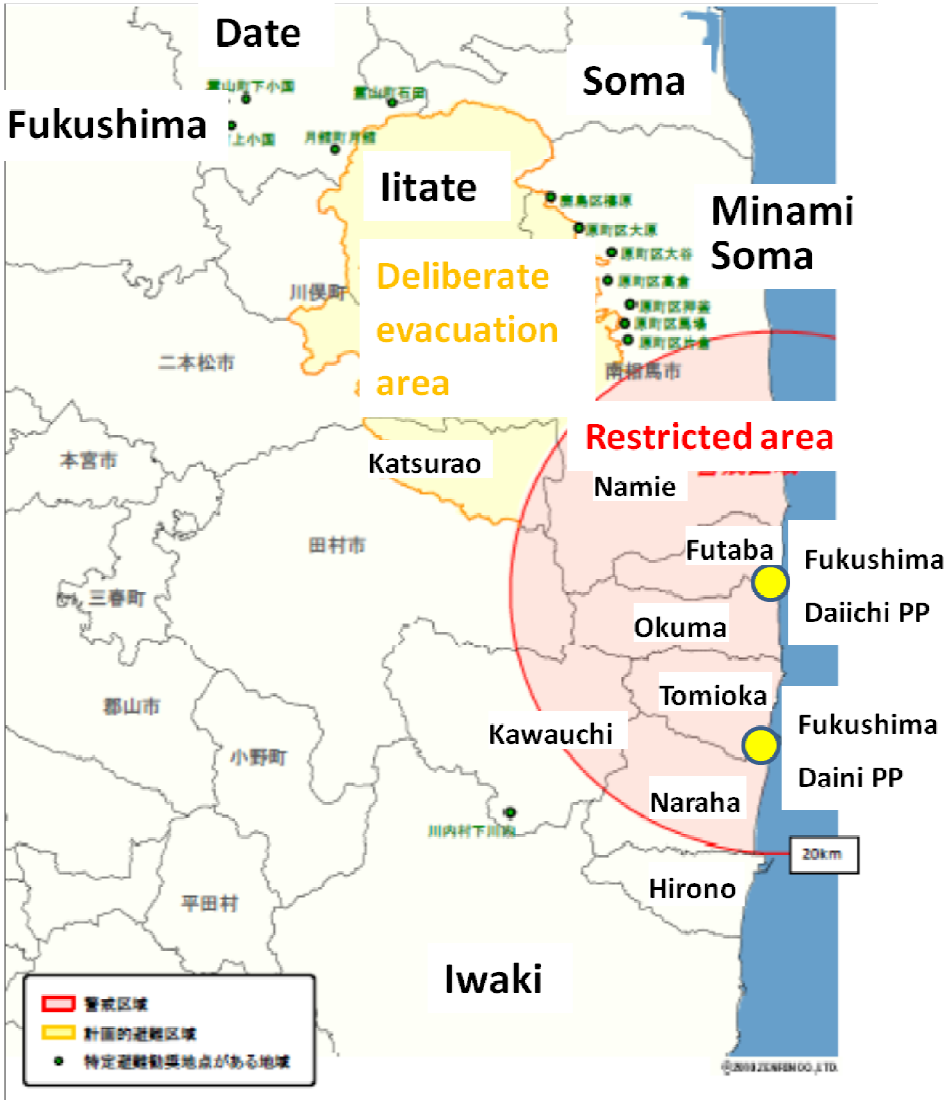


Research project for decontamination technologies

- Consigned project by Cabinet Office -

Demonstration of area decontamination

- **Decontamination at model areas in Restricted / Deliberate evacuation areas**
  - ・12 cities/towns/villages in the areas are related;
    Group A: Minami Soma, Namie, Iitate, Kawamata
    Group B: Tamura, Futaba, Tomioka, Katsurao
    Group C: Ohkuma, Naraha, Kawauchi, Hirono
- **Each group includes areas with;**
  - ・various components to be decontaminated: forests, fields, residences, buildings, roads
  - ・various dose rate level; high (> 100 mSv/y), intermediate (20 – 100 mSv/y), low (5 – 20 mSv/y)
- **Competition to select appropriate companies**
- **Evaluation of efficiency, generation of wastes, cost, safety, etc.**



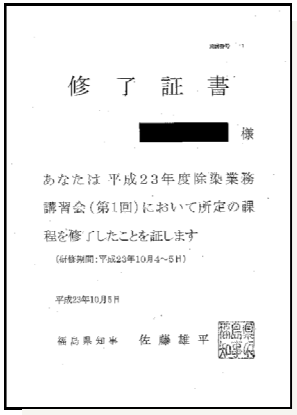
Demonstration of technologies

- **Competition of decontamination technologies**
  - ・select around 15 technologies on the appropriate level and applicable to decontamination
- **Demonstration at the site(s)**
- **Evaluation of efficiency, generation of wastes, cost, safety, etc.**

(4) Communication activities to provide reliable information on environment contamination to Fukushima citizens

Dispatch of supervisors to training sessions focusing on "certified decontamination workers/operators"

- Fukushima prefecture holds official training sessions on decontamination works with a view to ensuring safety and enhancing the skills of workers / operators engaging in decontamination works. JAEA dispatches its experts to the sessions as supervisors.
- Participants completed the session are certified by the governor of Fukushima.
- 3000 workers / operators (equivalent to half of constructors in Fukushima) anticipated by the end of FY2012.



修 了 証 書

[redacted] 様

あなたは 平成２３年度除染業務講習会（第１回）において所定の課程を修了したことを証します

（研修期間：平成23年10月4～5日）

平成23年10月5日

福島県知事 佐藤雄平

Completion certificate

Schedule of training sessions

Round	Schedule (2011)	Place
1	Oct. 4, 5	Koriyama-city
2	Oct. 11, 12	Koriyama-city
3	Oct. 20, 21	Nihonmatsu-city
4	Oct. 26, 27	Fukushima-city
5	Nov. 1, 2	Koriyama-city
6	Nov. 9, 10	Iwaki-city
7	Nov. 16, 17	Koriyama-city
8	Nov. 30, Dec. 1	Aizu-Wakamatsu-city
9	Dec. 7, 8	Minamisoma-city
10	Dec. 14, 15	Koriyama-city

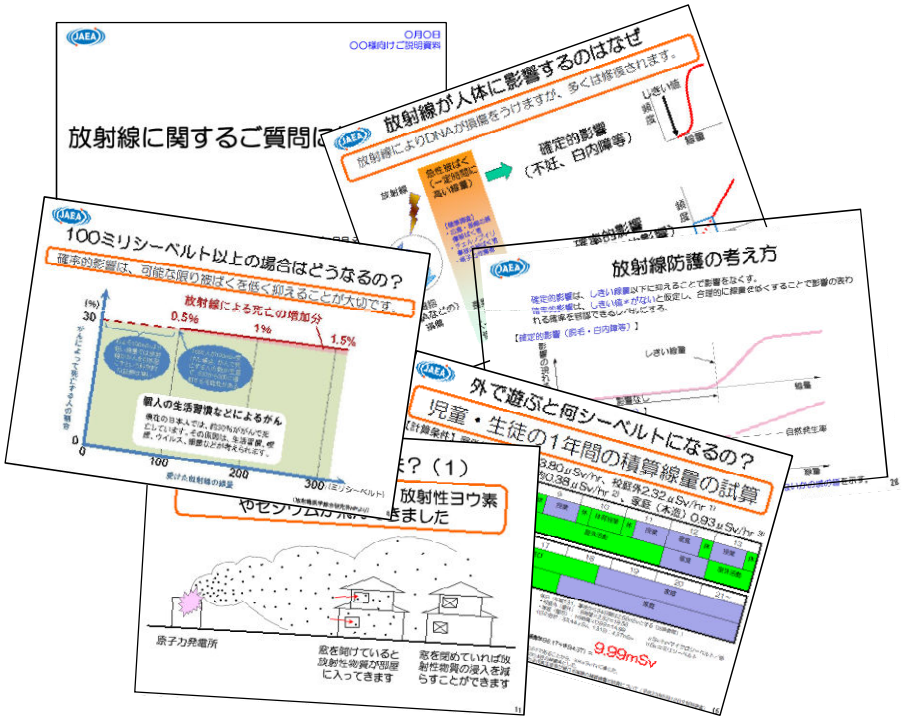
Curriculum of training session

Day 1	Opening	1. Overview of the accident	2. Fundamental of radiation	Lunch	3. Radiation safety management	4. Decontamination method	
Day 2	5. Safety management during decontamination works		6. Radiation effects on human health	Lunch	7. Demonstration and practice	8. Exam.	Closing

Question-and-answer session concerning radiation

This communication activity started in July

- Researchers are sent to Fukushima prefecture schools (from kindergartens to junior high schools) at their request
- After briefings concerning radiation, researchers answer questions from both parents and teachers.
- As of Oct. 14th, 83 sessions were held.
  A total of 115 sessions will be held by coming January.



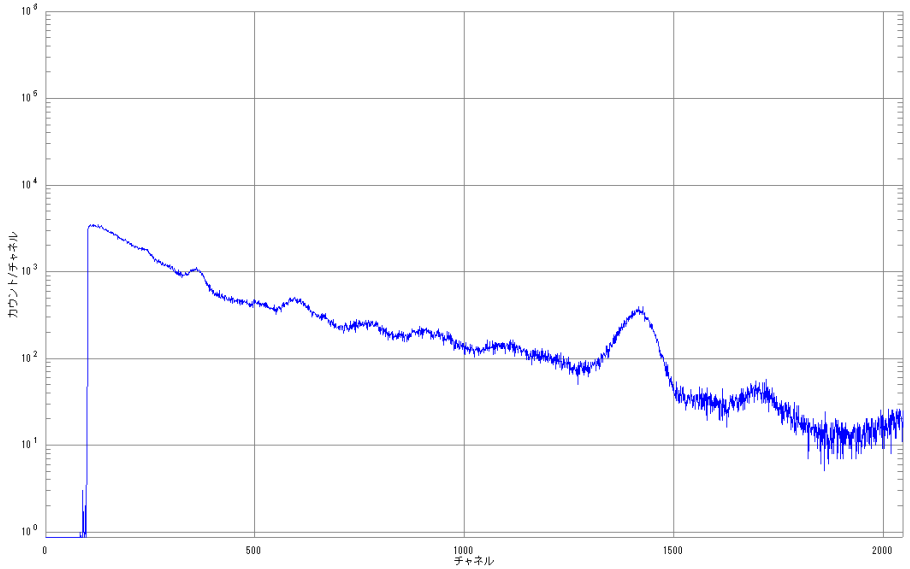
Briefing materials

WBC measurement for Fukushima pref. residents

Following Fukushima pref. request, JAEA receives residents of the ten towns (Namie, Iitate, Kawamata, Hirono, Naraha, Futaba, Okuma, Tomioka, Kawauchi, Katsurao) within the deliberate evacuation area and restricted area, and measures their internal exposure using the Whole Body Counter (WBC) in Tokai Laboratory.

- A total of 8,000 persons are scheduled to be measured by the end of December, 2011.
- About 100 persons are measured per day.
- As of Oct. 7th , 4,364 persons have been measured.

Measurement by Whole Body Counter



Energy spectrum measured