



Off-site post-accident recovery after the Fukushima Daiichi accident: challenges and solutions

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Outline

- Remediation
- Remediation after the Fukushima accident
- Estimation of doses
- Setting derived reference levels
- Waste generation and management
- Summary

IAEA Report on

**Decommissioning and
Remediation after a
Nuclear Accident**

International Experts Meeting
28 January–1 February 2013, Vienna, Austria



IAEA
International Atomic Energy Agency
Atoms for Peace

NE/NEFW/2013
ORIGINAL: English

Final Report

**The Follow-up IAEA
International Mission on
Remediation of Large
Contaminated Areas Off-Site the
Fukushima Daiichi Nuclear
Power Plant**

Tokyo and Fukushima Prefecture, Japan

14 – 21 October 2013

What is remediation

IAEA Safety Glossary:

“.. any measures that may be carried out to reduce the radiation exposure from existing contamination of land areas through actions applied to the contamination itself (the source) or to the exposure pathways to humans”.

World Health Organization defines health as

- “... a state of physical, mental and social well-being”.

Remediation and recovery objectives

- Reduction of dose
- A return to normal life and livelihoods



Principles For Remediation

- **Justification** for undertaking remediation
- **Optimisation** of protection through application of remedial actions
- **Limitation** of radiation doses
- Providing appropriate protection of both **humans and the environment**
- **Targeting** use of resources efficiently
- Ensuring open and transparent **communication** with stakeholders

Remediation Strategy

- Sets out the means for achieving the principles and requirements set out in the national policy
- Normally established by the relevant remediation implementer or by government

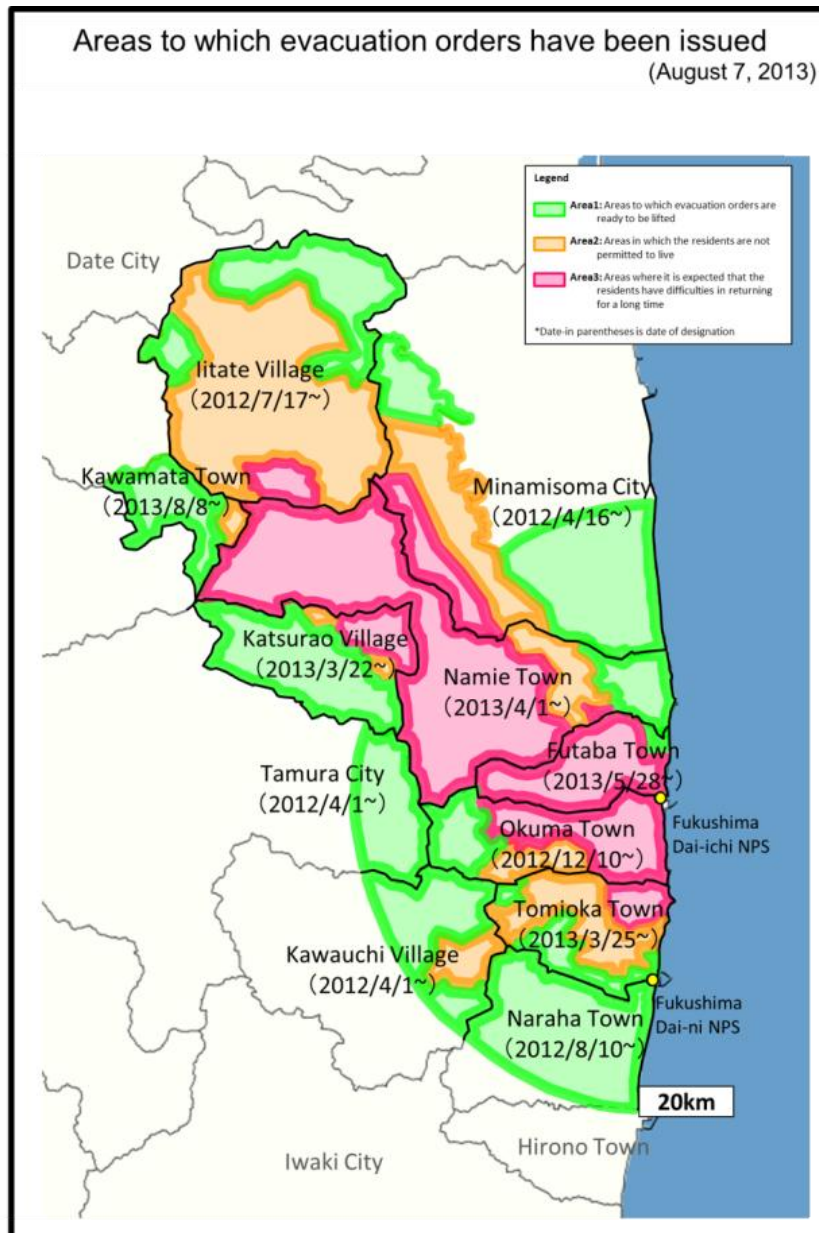


Remediation After The Fukushima Accident

- Strategy applied in Japan includes the ICRP and IAEA dose criterion [reference level of annual additional effective dose 1-20 mSv]
- stepwise and rapid reduction in total doses in residential areas and farmland
- Long term goal - additional annual effective dose shall be 1 mSv or less
- Most of the dose from external dose pathways from 2012 onwards



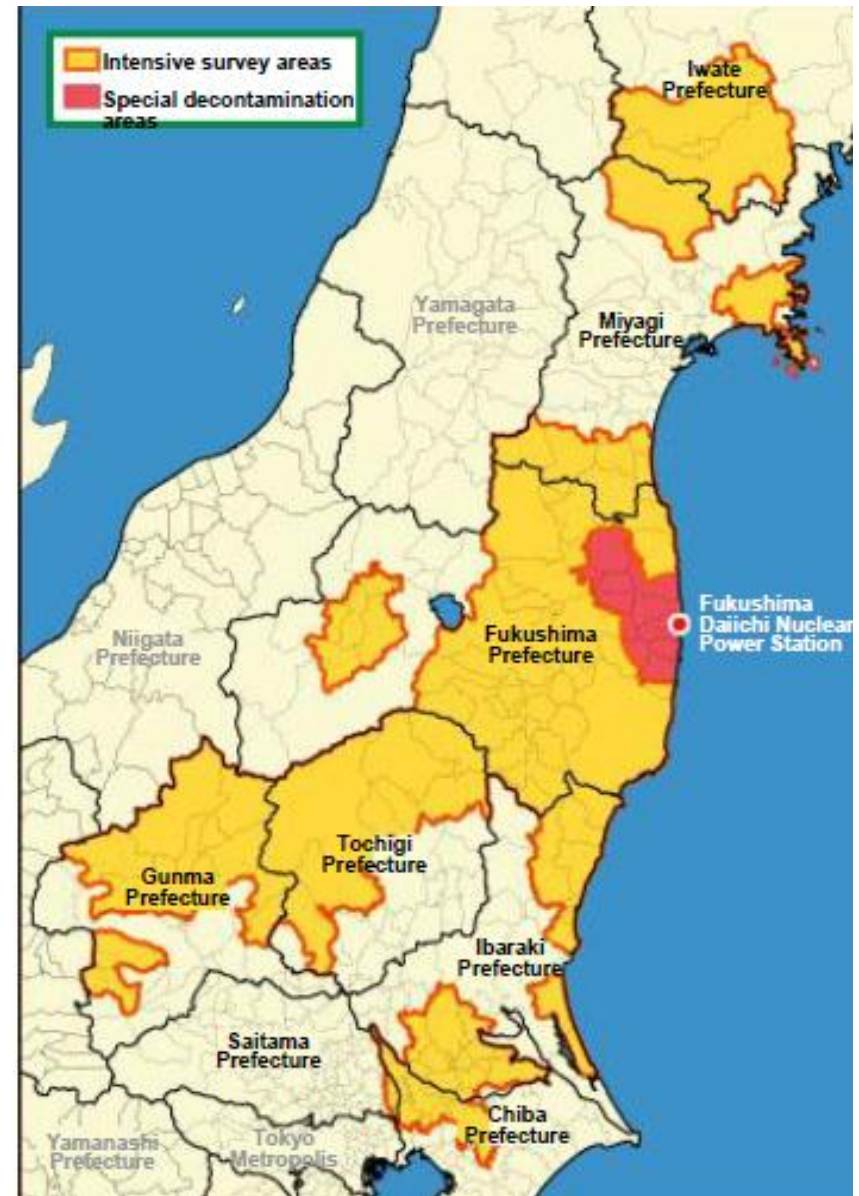
Special Decontamination Area (SDA)



- previously restricted areas
- deliberate evacuation areas
- additional annual effective dose for individuals anticipated >20 mSv during the first year
- National government

Intensive Contamination Survey Area (ICSA)

- additional annual effective dose between 1 -20 mSv estimated in some parts of the municipality
- areas where air dose rate > $0.23 \mu\text{Sv/h}$ designated “Decontamination Implementation Areas”.
- Municipalities

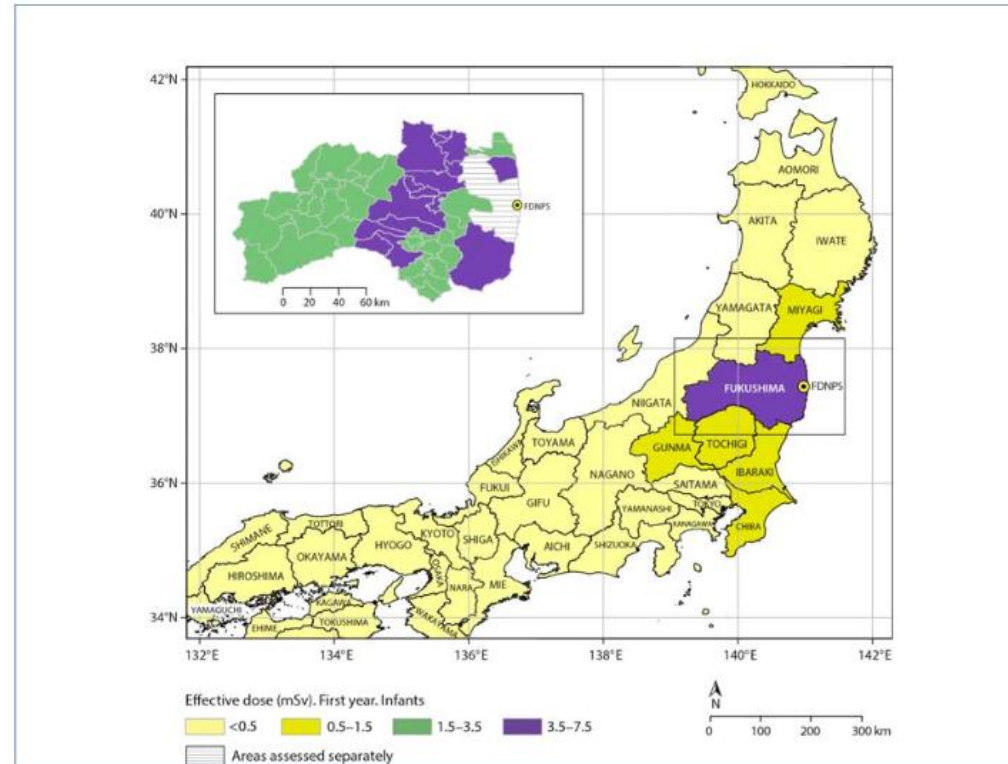


Estimation Of Doses

- Estimation of additional annual effective dose to individuals used to define the designated areas for remediation were deliberately conservative and based on the concept of the critical group
- an air dose rate of $0.23 \mu\text{Sv/h}$ assumed to correspond to an additional annual effective dose of 1 mSv.

Estimation Of Doses

- ICRP /IAEA quantitatively defined the representative person as a virtual person receiving an average dose from the upper 10% of the population dose distribution
- large areas of land (especially ICSA) designated for remediation where average additional annual effective doses are < 1 mSv from 2012



Total effective doses (mSv) to infants in first year UNSCEAR 2014

Challenge - Solution

- Reference levels often set in emergency phase
- Large uncertainty when initially estimating doses and insufficient site-specific info



HIGHLY CONSERVATIVE

- Develop models for the estimation of internal and external dose using country-specific data as part of emergency preparedness.
- Derivation of reference levels such as air dose rates before an accident

Setting Derived Reference Levels

- Many factors affect effective dose received -
**RADIONUCLIDE, ENVIRONMENT, LAND USE,
LIVING HABITS** – and are site specific
- Derived reference levels are a practical
solution which should be site-specific and
transparently derived



Identifying Key Pathways

Measurement and characterisation

- In post accident phase BOTH deposition density and environmental characteristics important
- Most key exposure routes and areas giving higher doses will be identified quickly BUT not all

➡ LOSS OF TRUST



Preparedness

Availability / use of measurement devices critical for implementing policy and strategy



Koshiabura



Steep
forested
catchments

Identify
radioecologically
sensitive pathways /
regions BEFORE an
accident

Identifying, evaluating, implementing Remediation

Remedial measures need to be considered for:

- Effectiveness
 - Feasibility
- Practicality
 - Costs
 - Wastes
- Side effects
- Social aspects
- Experience



TEMPLATE

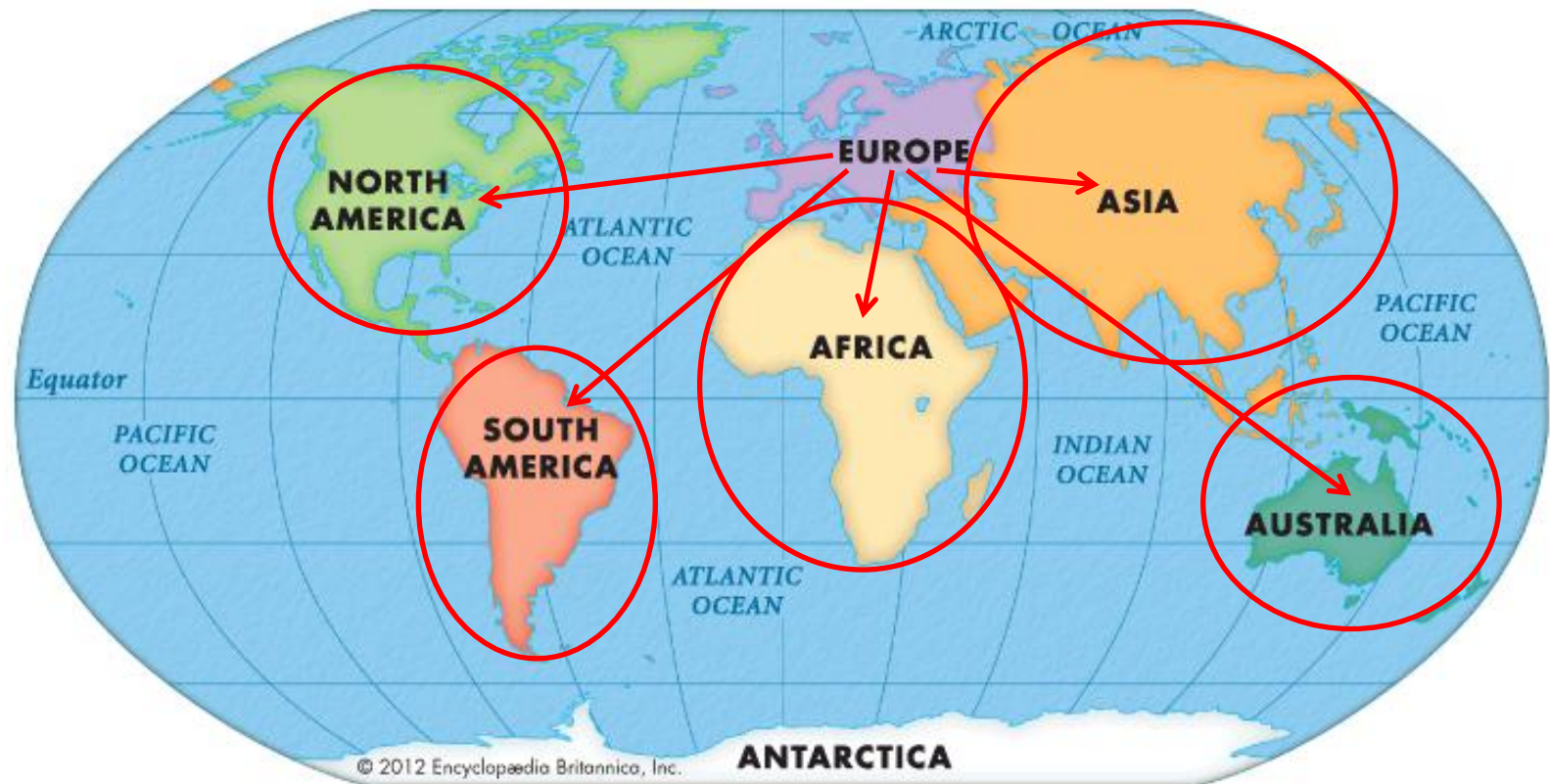
Name of measure	
Objective	Specifying the aims of the action, e.g., reassurance, dose reduction
Other Benefits	Secondary objectives e.g. social implications
Countermeasure description	Short description of what the countermeasure is.
Target	On or to what target do you apply this countermeasure?
Targeted radionuclides	Caesium, strontium, mixed deposit, Plutonium, Americium
Scale of application	Large? Small? Generally applicable?
Contamination pathway	root uptake, contaminated feed/standing water, re-suspension, plant- animal, irrigation
Exposure pathway	Ingestion? Inhalation? External?
Time of application	Time after deposition (<i>early – up to 6 weeks, medium – up to 2 years, late – more than two years</i>), season, need for repetition

Constraints:
•Legal constraints
•Social constraints
•Environmental constraints
•Communication constraints
Effectiveness:
•Countermeasure effectiveness
•Factors influencing effectiveness of procedure (Technical)
•Factors influencing effectiveness of procedure (social)
Feasibility:
•Required specific equipment
•Required ancillary equipment
•Required utilities and infrastructure
•Required consumables
•Required skills

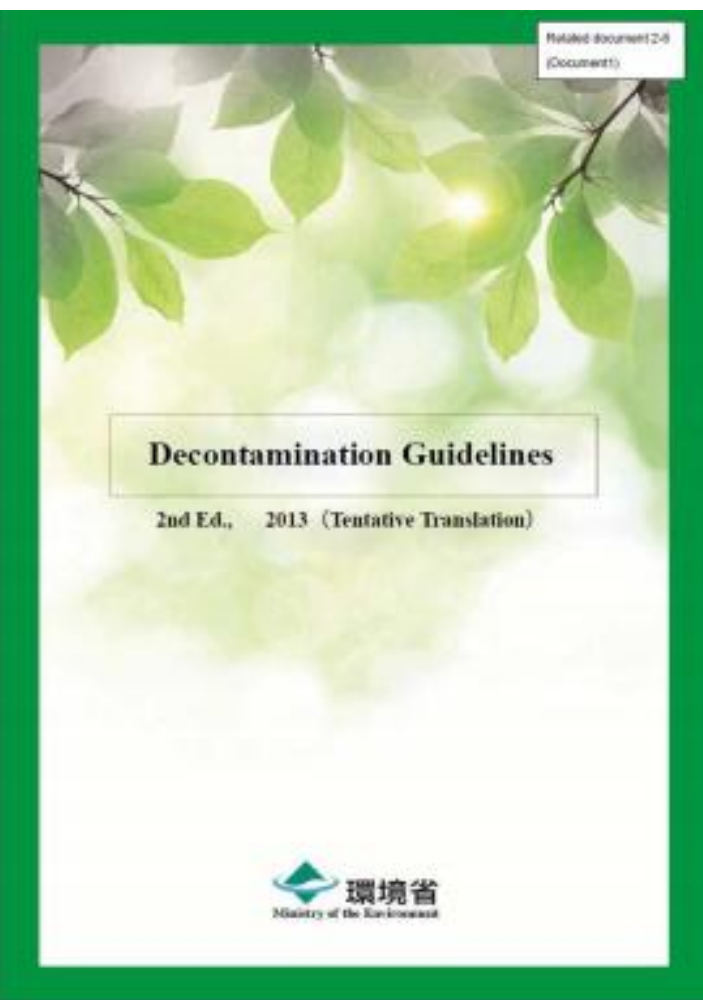
•Required safety precautions
•Other limitations
Waste:
•Amount and type
•Possible transport, treatment and storage routes.
•Factors influencing waste issues
Doses:
•Averted dose
•Factors influencing averted dose
•Additional dose
Intervention costs:
•Equipment
•Consumables
•Operator time
•Factors influencing costs

•Communication costs
•Compensation costs
•Waste cost
•Assumptions
Cost-effectiveness:
Side-effect evaluation:
•Ethical considerations
•Environmental impact
•Agricultural impact
•Social impact
•Other side effects, pos. or neg.
Stakeholder opinion
Practical experience
Key references
Comments

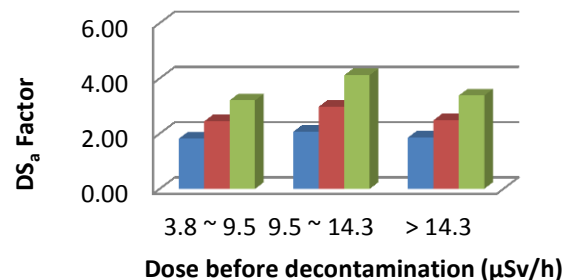
Relevance?



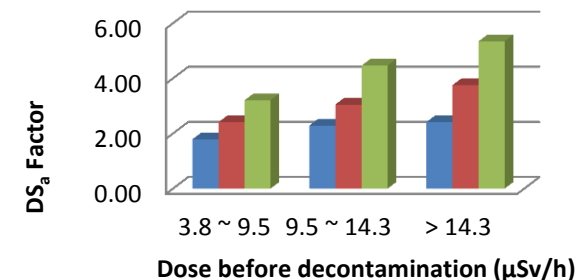
Pilot demonstration projects



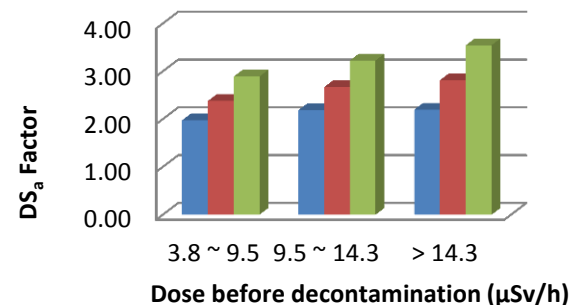
Residential Area



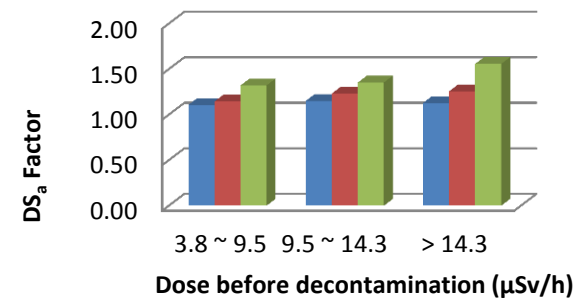
Farmland



Roads

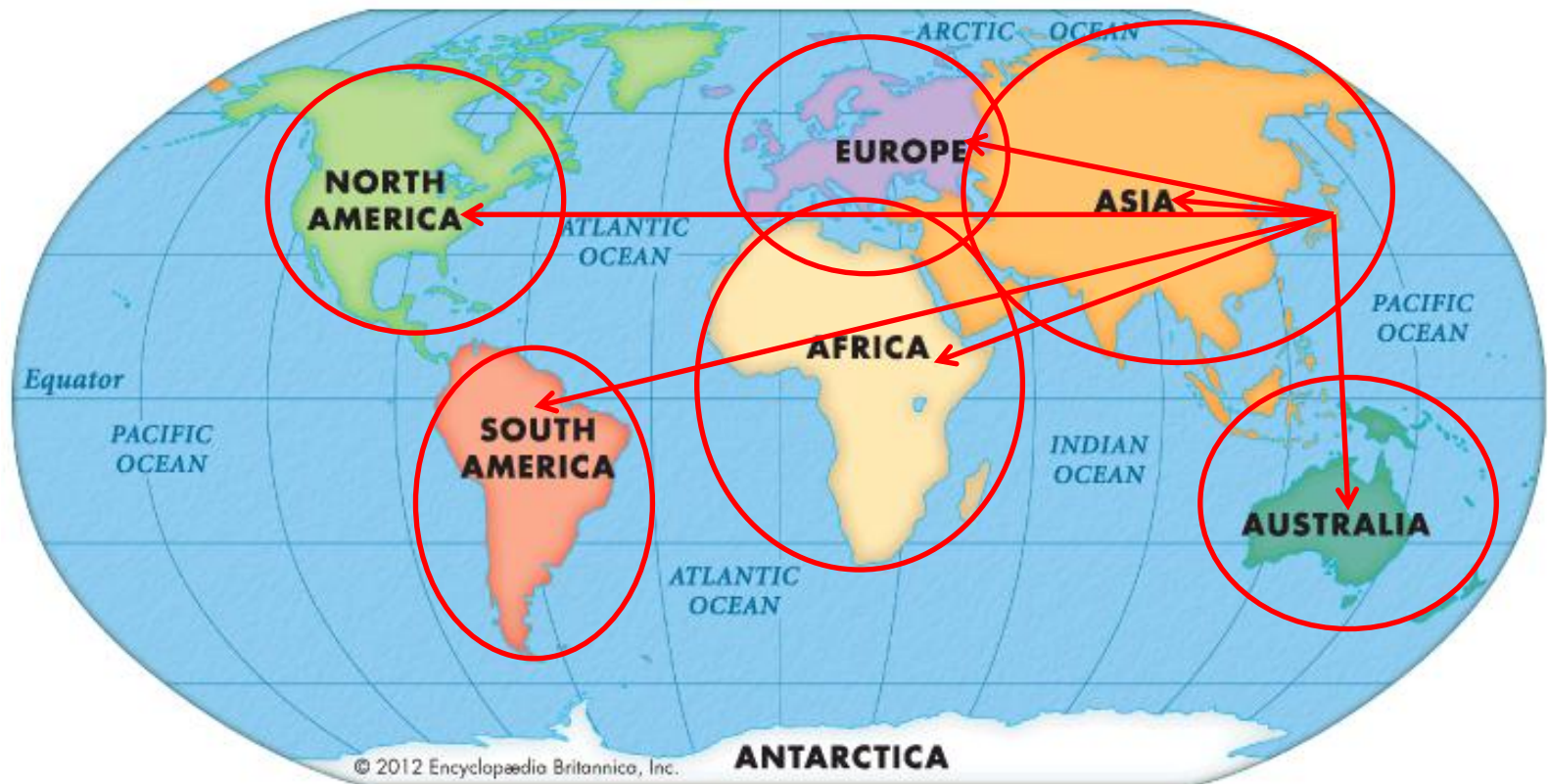


Forest



MOE Decontamination Model Evaluation Project in six SDA 3 sites

Relevance?



Waste Generation and Management

Decontamination of surfaces and topsoil



- reduces external exposure
 - High acceptability and feasibility
 - Protects economic value of residences and land
 - Well received by residents
- High logistical needs
 - Large generation of waste
 - High cost
 - Averted dose less than air dose reduction at 1 m
 - Averted dose can be small

Waste generation and management

Prior thought to regulatory, management and practical application issues relevant to waste

- Generation
- Minimisation
- Incineration
- Disposal
- Cost



Summary

- Broad objectives of remediation need to be addressed
- Site specific
- Emergency preparedness needs to include the post accident phase / remediation
- Need to retain knowledge and expertise, and promote knowledge transfer from countries with practical experience
- Revise international guidance