Field Survey Techniques to be Used for the PRR-1

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Why field survey?

- To
  - ✓identify location
  - ✓measure and
  - ✓give extent of
    - Residual activity (contamination)
    - Radiation exposure levels

Outline of Presentation

- Graded approach & survey locations
- General considerations for field surveys
- Survey planning & design
- Instrumentation
- Survey types and measurements
- Records and documentation
- Safe work methods statement

Graded Approach for Field Surveys

- The type of field surveys that will be conducted in a particular area will depend on the category where that area belongs
  - Category 1 – Low likelihood of contamination
  - Category 2 – Some likelihood of contamination
  - Category 3 – High likelihood of contamination
  - Category 4 – Known to be contaminated
  - Category 5 – Highly radioactive

Flow diagram for field surveys

- Classify areas by contamination potential
- Determine survey locations
- Clear & provide access to surfaces
- Prepare reference drawings
- Establish reference grid system
- Select instrumentation
- Determine possible hazards & take precautions
- Conduct surface scans

Flow diagram for field surveys

- Perform direct measurements: exposure rate, $\alpha/\beta/\gamma$ activity
- Perform removable activity measurement
- Perform special/additional direct measurements: furnishings, fixtures, ducts, pipes, cracks
- Evaluate results relative to guideline values & limits
- Document results

Category 1

Diesel Fuel Tank (RG-9)

Raw Water tank (RG-10)

Category 2

Cooling Tower (RG-11)

Truck Entrance (RB-3)

Category 3

Retention Tank (E0-3a)

Category 4

Transfer Pump (E0-4b)

Beam tubes (RP-6)

Category 5

Co-60 source (RB-4c)

Co-60 source holder (RB-4h)

Field survey aspects

I. General considerations
II. Survey planning & design
III. Instrumentation and personnel
IV. Survey types and measurements
V. Records and documentation
VI. Safe work methods statement

I. General considerations

- Survey plans & procedures
  - ✓Survey plan: survey objectives, design, general approach to measurements
  - ✓Survey techniques in detailed procedures
  - ✓Personnel training

I. General considerations

- Records/documentation
  - ✓adequate, legible, unambiguous, signed, dated
  - ✓Should enable independent evaluation of site status
  - ✓Survey data recorded in standardized forms, logbook, database
  - ✓Protected from damage or loss

I. General considerations

- Contamination controls
  - ✓Minimize possibility of personnel contamination
  - ✓Prevent cross-contamination of samples
  - ✓Prevent contamination of instruments
  - ✓Monitoring of protective clothing & good personal hygiene

II. Survey planning & design

- ✓ Identify radionuclides, their pathways, contaminated media & types of measurements
- ✓ Choose instrumentation based on detection limits as compared to regulatory limits
- ✓ Establish number of personnel, type of expertise, necessary training levels required to conduct measurement
- ✓ Determine site characteristics and the survey design and measurements needed

CONSIDER!

✓Radionuclides & limits
✓Instrumentation
✓Personnel
✓Survey design & measurements

Inventory of radionuclides

Radio-nuclide	Half-Life	Decay Mode	Analytical Technique	Production Mode	Likely Locations	Single-Nuclide Clearance Level (Bq/g)
H-3	12.32 y	β-	liquid scintillation	neutron activation	concrete	100
C-14	5.7×10^3 y	β-	liquid scintillation	neutron activation	thermal column graphite, bioshield concrete	1
Na-22	2.6 y	β+, γ	gamma spectrometry	neutron activation	bioshield concrete, ion-exchange resin	0.1
Cl-36	3.01×10^5 y	β-	liquid scintillation	neutron activation	bioshield concrete, stainless steel and aluminum core parts, ion-exchange resin	1

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Inventory of radionuclides

Radio-nuclide	Half-Life	Decay Mode	Analytical Technique	Production Mode	Likely Locations	Single-Nuclide Clearance Level (Bq/g)
Ar-39	269 y	β-	liquid scintillation	neutron activation	bioshield concrete and rebars, stainless steel core parts	
Ca-41	1.02×10^5 y	EC, weak x-rays	liquid scintillation	neutron activation	bioshield concrete, ion-exchange resin	
Fe-55	2.737 y	EC, weak x-rays	x-ray spectrometry, or correlation with Co-60	neutron activation	stainless steel core parts, bioshield rebars, ion-exchange resin	1000
Co-60	5.27 y	β-, γ	gamma spectrometry	neutron activation	stainless steel core parts, bioshield rebars, ion-exchange resin	0.1

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- ✓Survey design & measurements

Inventory of radionuclides

Radio-nuclide	Half-Life	Decay Mode	Analytical Technique	Production Mode	Likely Locations	Single-Nuclide Clearance Level (Bq/g)
Ni-59	7.6×10^5 y	EC, weak x-rays	x-ray spectrometry, or correlation with Co-60	neutron activation	stainless steel core parts, ion-exchange resin	100
Ni-63	100 y	β-	liquid scintillation, or correlation with Co-60	neutron activation	stainless steel core parts, ion-exchange resin	100
Sr-90	28.9 y	β-	beta spectroscopy	fission product	ion-exchange resin	1
Nb-94	2.03×10^4 y	β-, γ	gamma spectrometry	neutron activation	stainless steel core parts	0.1
Mo-93	4.0×10^3 y	EC	x-ray spectrometry of daughter products	neutron activation	stainless steel core parts	10
Tc-99	2.111×10^5 y	β-	beta counting	fission product	ion-exchange resin	1

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Inventory of radionuclides

Radio-nuclide	Half-Life	Decay Mode	Analytical Technique	Production Mode	Likely Locations	Single-Nuclide Clearance Level (Bq/g)
Ru-106	373.59 d	β-	gamma spectrometry (of daughter Rh-106)	fission product	ion-exchange resin	0.1
I-129	1.57×10^7 y	β-	x-ray or gamma spectrometry or correlation with Cs-137	fission product	ion-exchange resin	0.01
Cs-134	2.0652 y	EC, β-, γ	gamma spectrometry	neutron activation, fission product	bioshield concrete, ion-exchange resin	0.1
Cs-137	30.03 y	β-, γ	gamma spectrometry	fission product	ion-exchange resin	0.1
Ba-133	10.5 y	EC, γ	gamma spectrometry	neutron activation	barytes concrete (might not be present in the PRR-1)	

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Inventory of radionuclides

Radio-nuclide	Half-Life	Decay Mode	Analytical Technique	Production Mode	Likely Locations	Single-Nuclide Clearance Level (Bq/g)
Eu-152	13.506 y	EC, β-, γ	gamma spectrometry, beta counting	neutron activation	bioshield concrete, ion-exchange resin	0.1
Eu-154	8.59 y	β-, γ	gamma spectrometry, beta counting	neutron activation	bioshield concrete, ion-exchange resin	0.1
Eu-155	4.753 y	β-, γ	gamma spectrometry, beta counting	neutron activation	bioshield concrete, ion-exchange resin	1
Ho-166m	1.2×10^3 y	β-, γ	gamma spectrometry	neutron activation	bioshield concrete, thermal column graphite	
U-235	7.04×10^8 y	α	alpha spectrometry	fuel component	ion-exchange resin	
U-238	4.468×10^9 y	α	alpha spectrometry	fuel component	ion-exchange resin	
Pu-239	2.411×10^4 y	α	alpha spectrometry	fuel irradiation	ion-exchange resin	0.1

CONSIDER!

✓Radionuclides & limits
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III. Instrumentation

Identify radionuclides of concern

↓

Identify associated radiation

↓

Type of measurement: Exposure rate, contamination, surface activity?

↓

Select & obtain instruments (backup)

↓

Calculate detection sensitivities required & of that of the instrument (efficiency, response time..)

↓

Calibrate

↓

Proceed with field survey

CONSIDER!

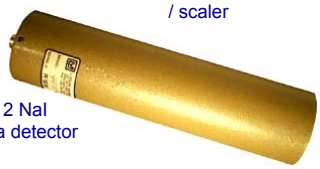
- ✓Radionuclides & limits
- ✓Instrumentation
- ✓Personnel
- ✓Survey design & measurements

III. Instrumentation

Scintillation
alpha detector

ratermeter
/ scaler

Low beta/gamma
gas proportional detector



2 x 2 NaI
gamma detector

CONSIDER!

- ✓Radionuclides & limits
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- ✓Personnel
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Instrumentation

Additional survey meters
NE Portable Dose Rate Meters
Neutron Detectors, TLD

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Instrumentation

Instrument / Model	Detector	Radiation detected	Measurement
Ludlum 44-92	140 cm^2 Xenon Gas Proportional Detector	Low-level beta/gamma	Surface scanning for contamination
Ludlum 43-65	50 cm^2 alpha scintillator	Alpha radiation	Surface scanning for contamination
Ludlum 44-10	2"x2" NaI scintillator	High energy gamma	Gamma scanning
Radiagem 2000	100 cm^2 alpha scintillator, GM pancake, 2"x2" NaI scintillator	Alpha, beta, gamma	Dose rate survey, surface scanning for contamination
Inspector 1000	2"x2" NaI scintillator, GM detector	Alpha radiation	Gamma identification and scanning
Automess 6112 t eletector	Extendible GM probe	Beta/gamma radiation	High dose rate radiation
NE PCM 5	50 cm^2 alpha/beta scintillator	Alpha, beta	Surface scanning for contamination
70L/min portable air sampler		Airborne particulates	Airborne contamination

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Calibration standards

Planar calibration standard: 100mm × 100mm
1kBq

- C-14
- Cs-137
- Cl-36
- Sr-90/Yt-90
- Th-230

CONSIDER!

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Instrument Sensitivity & Efficiency

- ✓ Efficiency (for different radionuclides)
- ✓ Minimum detectable concentrations (MDC)
- ✓ Critical limit
- ✓ Detection limit

CONSIDER!

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Personnel

- ✓ Radiation protection personnel – 5
- ✓ Reactor operations personnel – 3
- ✓ Varying expertise in radiation monitoring
- ✓ Training on use of instruments and survey plan

CONSIDER!

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Personnel

- ✓ Team responsibilities
  - ✓ Team leader
  - ✓ Instrumentation specialist
  - ✓ Map maker
  - ✓ Health physicist & safety officer
  - ✓ Documentation specialist
  - ✓ Surveyor

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IV. Survey design & measurements

a. Reference site selection for background measurements
b. Grid system & reference drawings
c. Types of measurements
d. Data recording & documentation
e. Safe work methods statement

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Background Measurements

Reference site selection

- comparison of level of residual radionuclides on site with background level off-site (control)
- Establish representative nature of a reference area
- Surface activity measurements on building surfaces, exposure rate, radionuclides present/concentrations

CONSIDER!

✓Radionuclides & limits
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Grid system & reference drawings

2.1.8.1 Category 1 Locations

W0-1 (Storage Rm.)	W0-2 (Stairwell)
W1-6 (Stairwell)	W1-7 (Operating Rm.)
W1-10 (Clean Rm.)	W1-11 (Contam. Rm.)
W2-1 (Vent. Eqpt. Rm.)	W2-6 (Hallway)
W2-9 (Storage Rm.)	
RG-7 (Large Powerhse.)	RG-8 (Small Powerhse.)
RG-12 (Utility House)	

2.1.8.2 Category 2 Locations

RB-3 (Truck Entr. Ramp)	RB-7 (Wall Surfaces)
E0-9 (Storage Rm.)	E0-10 (Office)
E0-13 (Toilet)	E0-14 (Stairwell)
E1-2 (Hallway)	E1-3 (Office)
E1-7 (Shaft)	E2-2 (Visitor's Gallery)
W1-1 (Transfer Rm.)	W1-2 (Transfer Corridor)
W1-5 (Hot Cell 2)	

2.1.8.3 Category 3 Locations and Items

RB-1 (Floor)	RB-2 (Alcove)
RB-4b (Sml. Prt. Demin.)	RB-4j (Racks and Tanks)
RB-8 (Storage Holes)	RB-13 (Fuel Sto. Racks)
RP-7 (Ext. Surfaces Pool)	RP-8 (Pool Platform)
E0-1 (Decay Tank Rm.)	E0-1a (Decay Tank)
E0-3 (Reten.Tank Rm.)	E0-3a (Retention Tank)

2.1.8.4 Category 4 Locations and Items

RB-10c (Neutron Dets.)	RB-12 (SNIF)
RP-1 (Int. H.P. Section)	RP-2 (Int. I.P. Section)
RP-5 (Thermal Column)	RP-6 (Beam Tubes)
E0-4a (Suspect Tank)	E0-4b (Transfer Pump)
E0-20 (Isotopes Sto. Rm.)	

CONSIDER!

- ✓Radionuclides & limits
- ✓Instrumentation
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Grid system & reference drawings

2.1.8.1 Category 1 Locations

W0-1 (Storage Rm.)	W0-2 (Stairwell)
W1-6 (Stairwell)	W1-7 (Operating Rm.)
W1-10 (Clean Rm.)	W1-11 (Contam. Rm.)
W2-1 (Vent. Eqpt. Rm.)	W2-6 (Hallway)
W2-9 (Storage Rm.)	
RG-7 (Large Powerhse.)	RG-8 (Small Powerhse.)
RG-12 (Utility House)	

2.1.8.2 Category 2 Locations

RB-3 (Truck Entr. Ramp)	RB-7 (Wall Surfaces)
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E0-13 (Toilet)	E0-14 (Stairwell)
E1-2 (Hallway)	E1-3 (Office)
E1-7 (Shaft)	E2-2 (Visitor's Gallery)
W1-1 (Transfer Rm.)	W1-2 (Transfer Corridor)
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CONSIDER!

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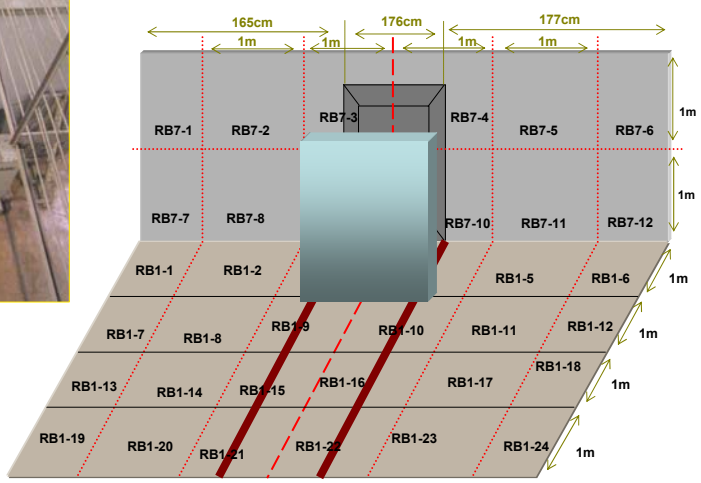
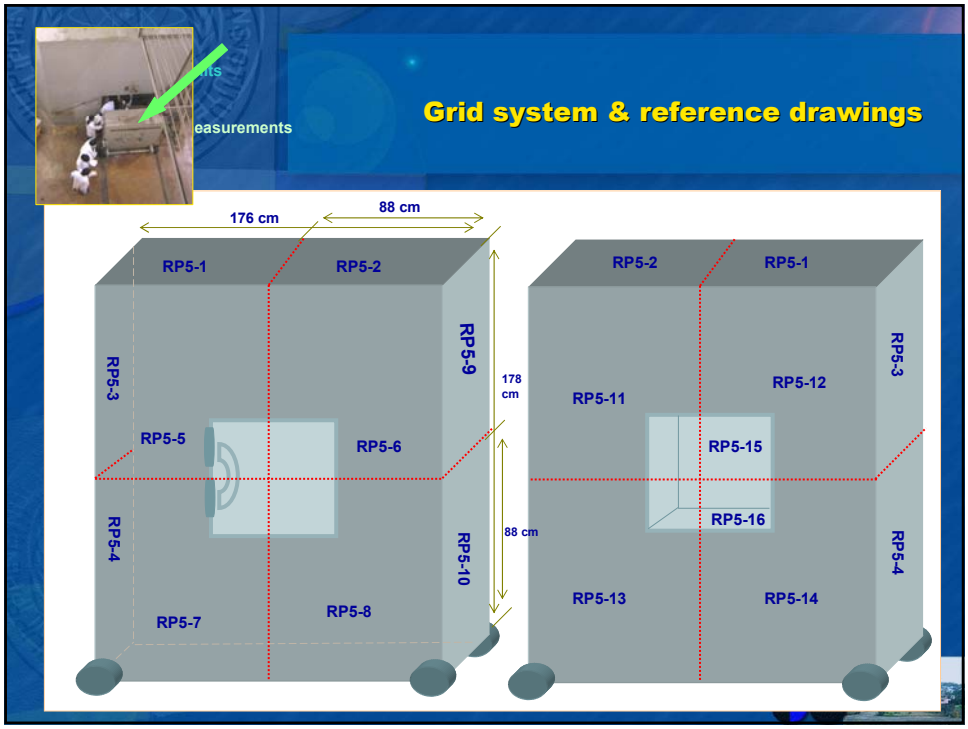
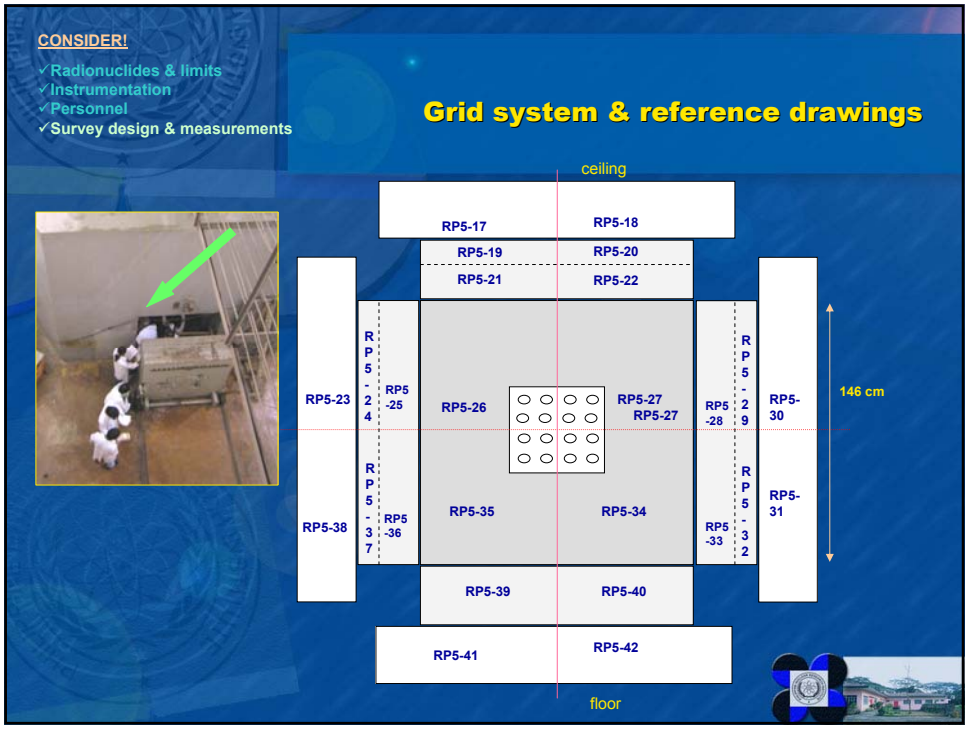
Grid system & reference drawings




easurements
Grid system & reference drawings
176 cm
88 cm
RP5-1
RP5-2
RP5-3
RP5-4
RP5-5
RP5-6
RP5-7
RP5-8
RP5-9
RP5-10
178 cm
88 cm
RP5-2
RP5-1
RP5-3
RP5-11
RP5-12
RP5-15
RP5-16
RP5-4
RP5-13
RP5-14


CONSIDER!
✓Radionuclides & limits
✓Instrumentation
✓Personnel
✓Survey design & measurements
Grid system & reference drawings
ceiling
RP5-17
RP5-18
RP5-19
RP5-20
RP5-21
RP5-22
RP5-23
RP5-24
RP5-25
RP5-26
RP5-27
RP5-27
RP5-28
RP5-29
RP5-30
RP5-31
RP5-32
RP5-33
RP5-34
RP5-35
RP5-36
RP5-37
RP5-38
RP5-39
RP5-40
RP5-41
RP5-42
146 cm
floor

CONSIDER!

✓Radionuclides & limits
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Survey Measurements

- Gross area radiation survey
- Air sampling
- Gamma and beta scanning for surface contamination
- Gamma and beta dose rate survey
- Gamma identification
- Gamma, beta and alpha scanning for surface contamination
- Surface dose rate for contaminated surfaces
- Swipe sampling for removable contamination

CONSIDER!

✓Radionuclides & limits
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V. Recording & documentation

- ✓ Survey map
- ✓ Contamination survey worksheet
- ✓ Dose rate survey worksheet
- ✓ Air sampling record worksheet

CONSIDER!

- ✓Radionuclides & limits
- ✓Instrumentation
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Recording & documentation

Contamination survey worksheet

CONTAMINATION SURVEY DATA SHEET

Performed by: _____ Date: _____

Contamination Monitor: _____ Model: _____ SN: _____

Team leader signature

Item Monitored: _____ equipmen _____ area
_____ object _____ other

Specify nature: _____

Location	Reading (cps)			Swipe sample
	α	β+γ	γ	
Background				

CONSIDER!

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Recording & documentation

Dose rate survey worksheet

GAMMA AMBIENT DOSE RATE RECORD

Performed by: _____ Date: _____

Instrument Type: _____ Model: _____ SN: _____

Background re _____ **Location:** _____

Location	Description	Ambient dose rate (uSv/hr)		Remarks
		Waist level or 1m away from source	Ground level or at contact	

_____

Team leader signature

CONSIDER!

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Recording & documentation

Air sampling record

AIR SAMPLING RECORD

Performed by: _____ Sampling Date & Time: _____

Sampling Location: _____ Filter Type: _____

Instrument Type: _____ Model: _____ SN: _____

Start Time: _____

Flow Rate: _____

End Time: _____

Average dose rate while sampling (u Instrument Type: _____

Waist level (1m above	Ground level

Model: _____

SN: _____

In-situ measurements of filters

Background Reading: _____ Filter Reading: _____

Contamination Monitor: _____ Model: _____ SN: _____

VI. Hazards Evaluation (non-radiological)

Category 1	Category 2	Category 3	Category 4	Category 5
✓ Dusts ✓ Confined spaces ✓ mechanical injuries ✓ heights ✓ electrical hazards	✓Dusts ✓ Confined spaces ✓ mechanical injuries ✓ heights ✓ fall & trip hazards ✓electrical hazards	✓Dusts ✓ Confined spaces ✓ mechanical injuries ✓ heights ✓ fall & trip hazards ✓electrical hazards	✓Dusts ✓ Confined spaces ✓ mechanical injuries ✓ heights ✓ fall & trip hazards ✓ poorly lit working areas ✓ Bump hazards	✓Dusts ✓ Confined spaces ✓ mechanical injuries ✓ heights ✓ fall & trip hazards ✓ poorly lit working areas ✓ Bump hazards ✓ ventilation

VI. Hazards Evaluation (radiological)

Category 1	Category 2	Category 3	Category 4	Category 5
✓ presence of unknown radionuclides possible ✓ contamination possible	✓presence of unknown radionuclides possible ✓ contamination levels uncertain	✓presence of unknown radionuclides ✓ contamination levels, location & dose rates uncertain	✓Presence of known & unknown radionuclides ✓ spatial distribution & migration of contamination levels ✓ gamma exposure rates uncertain	✓Presence of known & unknown radionuclides ✓spatial distribution of contamination levels and activation products ✓ high gamma exposure rates

VI. Safety measures (radiological)

Category 1	Category 2	Category 3	Category 4	Category 5
✓ dosimeters (TLD) ✓Dust masks as applicable	✓dosimeters (TLD) ✓Dust masks ✓Gloves & cover shoes as applicable	✓dosimeters (TLD, EPD) ✓Dust masks ✓Gloves & cover shoes as applicable	✓ dosimeters (TLD, EPD) ✓Dust masks ✓Gloves & cover shoes as applicable	✓ dosimeters (TLD, EPD) ✓Full PPE ✓Appropriate shielding ✓Setting of dose constraints ✓Use of teletectors

Needs / assistance / concerns

- A more systematic map-making scheme
- Additional instruments (backup)
- Availability of team members
- Data management
- Other unforseen matters..