Comparison of Final Status Survey Design Using MARSSIM Approach and the Former NUREG/CR-5849 Guidance at a Power Reactor Facility

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Introduction

- Final status surveys using guidance in NUREG/CR-5849
- Implementing MARSSIM at power reactor facility
  - Class 2 survey unit
  - Class 1 survey unit (using RESRAD-BUILD to obtain DCGL and area factors)

Final Status Survey using NUREG/CR-5849

- Site divided into affected and unaffected survey units
- Sample size for each survey unit simply depends on survey unit classification:

  1 measurement per 1 m^2 for affected survey units, 30 measurements for unaffected
- Student's t test performed once survey unit data are collected - requires data normality

Final Status Survey using MARSSIM

- Null hypothesis (H_0): Residual radioactivity **exceeds** the release criteria
- Decision errors occur when H_0 is rejected when it is true (Type I), or when H_0 is accepted when it is false (Type II)
- Sample size depends on many variables: DCGL, LBGR, decision errors, variability of contaminant (σ)

Final Status Survey Design at FSV - Example Survey Units

- Level 7 Turbine Deck - survey unit included floor, lower walls, and equipment surfaces
- "Suspect affected" classification - similar to Class 1 in MARSSIM
- Direct measurements of surface activity were generally collected on a 1 m x 1 m grid, for a total of **573** measurements using a gas proportional detector

Final Status Survey Design at FSV - Example (cont.)

- Site-specific guideline considering radionuclide mix was 4,000 dpm/100 cm^2
- Survey unit summary results:
  – mean = 82 dpm/100 cm^2
  – standard deviation = 238 dpm/100 cm^2
  – max value = 676 dpm/100 cm^2
  – upper 95% confidence level = 98 dpm/100 cm^2
- Survey unit easily satisfies release criteria

Implementing MARSSIM at FSV- Class 2 Example

- Level 7 Turbine Deck survey unit would likely be Class 2:
  – some positive contamination, but no contamination exceeds $DCGL_W$
  – only 1 survey unit because approximate floor area (400 m^2) is less than 1,000 m^2
- WRS test used for gross measurements of surface activity, also may consider Sign test

Implementing MARSSIM at FSV- Class 2 Example (cont.)

- Select decision errors:

  Type I = 0.05; Type II = 0.05

- Calculate the relative shift—ratio of Δ/σ

  ($\Delta = DCGL_W$ - LBGR)

  – $DCGL_W$ = 4,000 dpm/100 cm^2

  – LBGR is initially set at 50% of $DCGL_W$

- Standard deviation in this survey unit: 238 dpm/100 cm^2

Implementing MARSSIM at FSV- Class 2 Example (cont.)

- Relative shift = (4,000 - 2,000)/238 = 8.4
  - Take advantage of big relative shift by moving LBGR closer to $DCGL_W$ (set LBGR = 3,600)
  - Relative shift = (4,000 - 3,600)/238 = 1.68
- Table 5.3 in MARSSIM provides WRS test sample sizes: **16** direct measurements required in this Class 2 survey unit

Implementing MARSSIM at FSV- Class 1 Example

- Level 10 Reactor Building - survey unit included floor, lower walls, and equipment surfaces; about 390 m^2 total surface area
- "Suspect affected" classification
- Direct measurements of surface activity were generally collected on a 1 m x 1 m grid, for a total of **474** measurements using a gas proportional detector

Implementing MARSSIM at FSV- Class 1 Example (cont.)

- Site specific guideline considering radionuclide mix was 4,000 dpm/100 cm^2
- Survey unit summary results:
  - mean = 105 dpm/100 cm^2
  - standard deviation = 416 dpm/100 cm^2
  - max value = 2,422 dpm/100 cm^2
  - upper 95% confidence level: 136 dpm/100 cm^2
- Survey unit easily satisfies release criteria

Implementing MARSSIM at FSV- Class 1 Example (cont.)

- Level 10 Reactor Building survey unit may be Class 1:
  - significant contamination identified during characterization survey
  - only 1 survey unit because approximate floor area is less than 100 m^2
- Class 1 survey units may need additional measurements due to potential for hot spots

Implementing MARSSIM at FSV- RESRAD-BUILD

- Calculate $DCGL_W$ based on 25 mrem/y; also need area factors and scan MDC
- Source term identified at FSV:
  - Fe-55 74.2%
  - H-3 10.9%
  - Co-60 8.6%
  - C-14 1.0%

Implementing MARSSIM at FSV- RESRAD-BUILD (cont.)

- Input source term at the fractional amounts that each radionuclide is present
- $DCGL_W$ for mixture is 60,370 dpm/100 cm^2
- This may be confirmed by entering each radionuclide separately, calculating its DCGL, and then the gross activity DCGL:

$$Gross\ Activity\ DCGL = \frac{1}{f_1/DCGL_1 + f_2/DCGL_2 + \ldots + f_n/DCGL_n}$$

Implementing MARSSIM at FSV- RESRAD-BUILD (cont.)

- **Area factors** determined from same modeling parameters used to generate DCGLs, only size of contaminated area is changed:

$1\ m^2$	$2\ m^2$	$4\ m^2$	$10\ m^2$	$16\ m^2$	$36\ m^2$
10.7	5.9	3.4	1.9	1.5	1

Implementing MARSSIM at FSV- Scan MDC

- Gas proportional detector (126 cm^2) used; determine weighted efficiency:

Nuclide	Fraction	Eff	Weighted Eff
Fe-55	0.742	0	0
H-3	0.109	0	0
Co-60	0.086	0.21	0.018
C-14	0.01	0.05	5E-4

total efficiency = 0.02

Implementing MARSSIM at FSV- Scan MDC (cont.)

- $DCGL_W$ for mixture (60,370 dpm/100 cm^2) using 2% eff is comparable to 4,000 dpm/100 cm^2 using 21% eff (in terms of net counts, DCGL is 1520 cpm vs. 1060 cpm)
- Determine scan MDC
  - based on selected parameters, scan MDC is 25,900 dpm/100 cm^2

Implementing MARSSIM at FSV- Sample Size

- Because the scan MDC is less than the $DCGL_W$, no additional samples are needed above that required by WRS test
- Standard deviation in survey unit corrected for weighted efficiency: 4,500 dpm/100 cm^2
- Relative shift:(60,370 - 52,000)/4,500 = 1.9
- MARSSIM provides WRS test sample size: **13** direct meas for this Class 1 survey unit

Summary

- The MARSSIM survey design implemented at reactor D&D sites may greatly reduce sample sizes, however….

  these potential savings come at the expense of increased planning and design resources
- MARSSIM surveys for alpha contamination may not exhibit same savings