



Generic Overview of the Status of Characterization Surveys & Guidance for Decommissioning

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Workshop on Radiological Characterization for Decommissioning

Nuclear Energy Agency/OECD/WPDD

April 17 -19, 2012

Studsvik, Sweden

Presentation Topics

- **NRC Requirements for Decommissioning & Survey**
- **Decommissioning Processes: Role of Characterization & Survey**
- **Characterization Survey Types & Decommissioning Groups**
- **Characterization Surveys Guidance — status & update**
- **Key Characterization Survey Issues**
- **Needs & Anticipated Future Development**

NRC Decommissioning Safety & Survey Requirements

- 10 CFR Part 20, Subpart E – Radiological Criteria for License Termination.
- Total Effective Dose Equivalent (TEDE) ≤ 0.25 mSv/a and As Low As is Reasonably Achievable (ALARA); Average member of the critical group; All pathways. Period of performance - 1000 years
- **The requirements for final status surveys** are contained in 10 CFR 20.1501(a). Each licensee shall make or cause to be made, surveys that:
 - (1) May be necessary for the licensee to **comply with the regulations** in this part; and
 - (2) are reasonable under the circumstances **to evaluate: (i) the magnitude and extent of radiation levels; and (ii) concentrations or quantities of radioactive materials; and (iii) The potential radiological hazards.**
- 10CFR Parts 50.75, 50.82, 51.53, and 51.95
Reporting and Record keeping for **decommissioning planning; Termination of the License; Post-construction environmental report,** and Post-construction EIS

General Decommissioning Process

Power Reactor Facilities

Materials/Fuel Cycle Facilities

Before Cleanup

- Licensee ceases operations and notifies NRC
- Licensee submits decommissioning plan (DP) to NRC for review
- NRC reviews and approves plan, if it is acceptable

During Cleanup

- Licensee conducts cleanup work
- NRC conducts inspections

After Cleanup

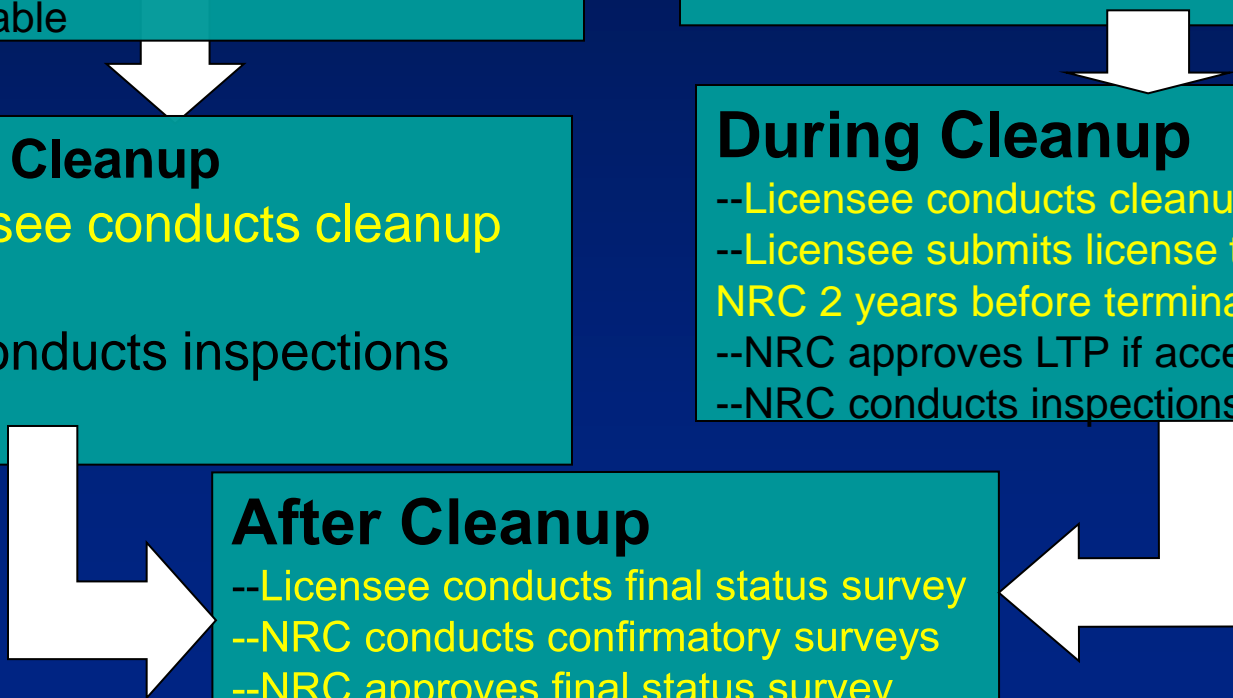
- Licensee conducts final status survey
- NRC conducts confirmatory surveys
- NRC approves final status survey report and terminates license

Before Cleanup

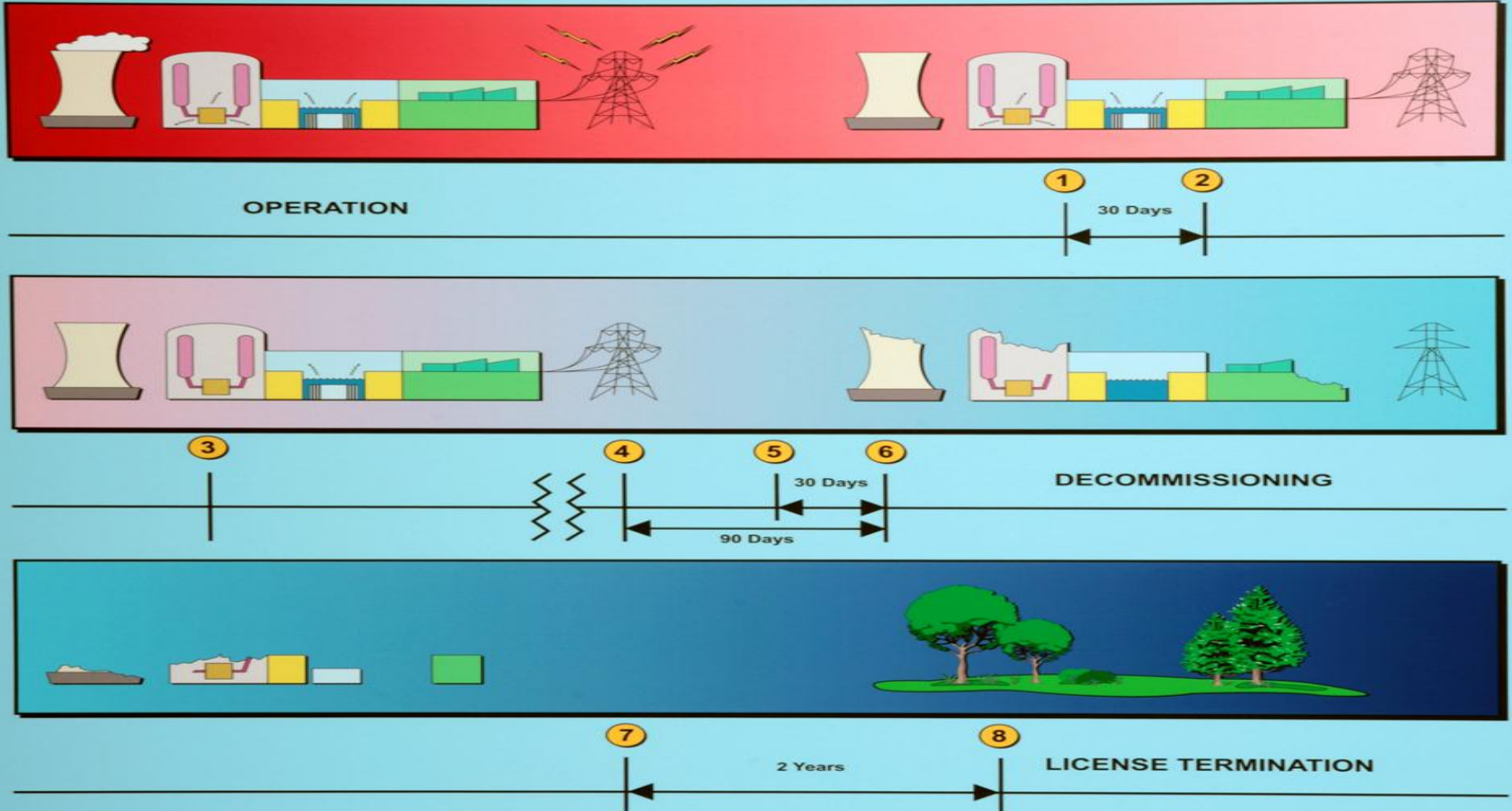
- Licensee ceases operations and notifies NRC
- Licensee submits post-shutdown decommissioning activities report to NRC for information
- Licensee waits 90 days before starting any major decommissioning activities

During Cleanup

- Licensee conducts cleanup activities
- Licensee submits license termination plan to NRC 2 years before termination
- NRC approves LTP if acceptable
- NRC conducts inspections



Decommissioning of Nuclear Power Reactors



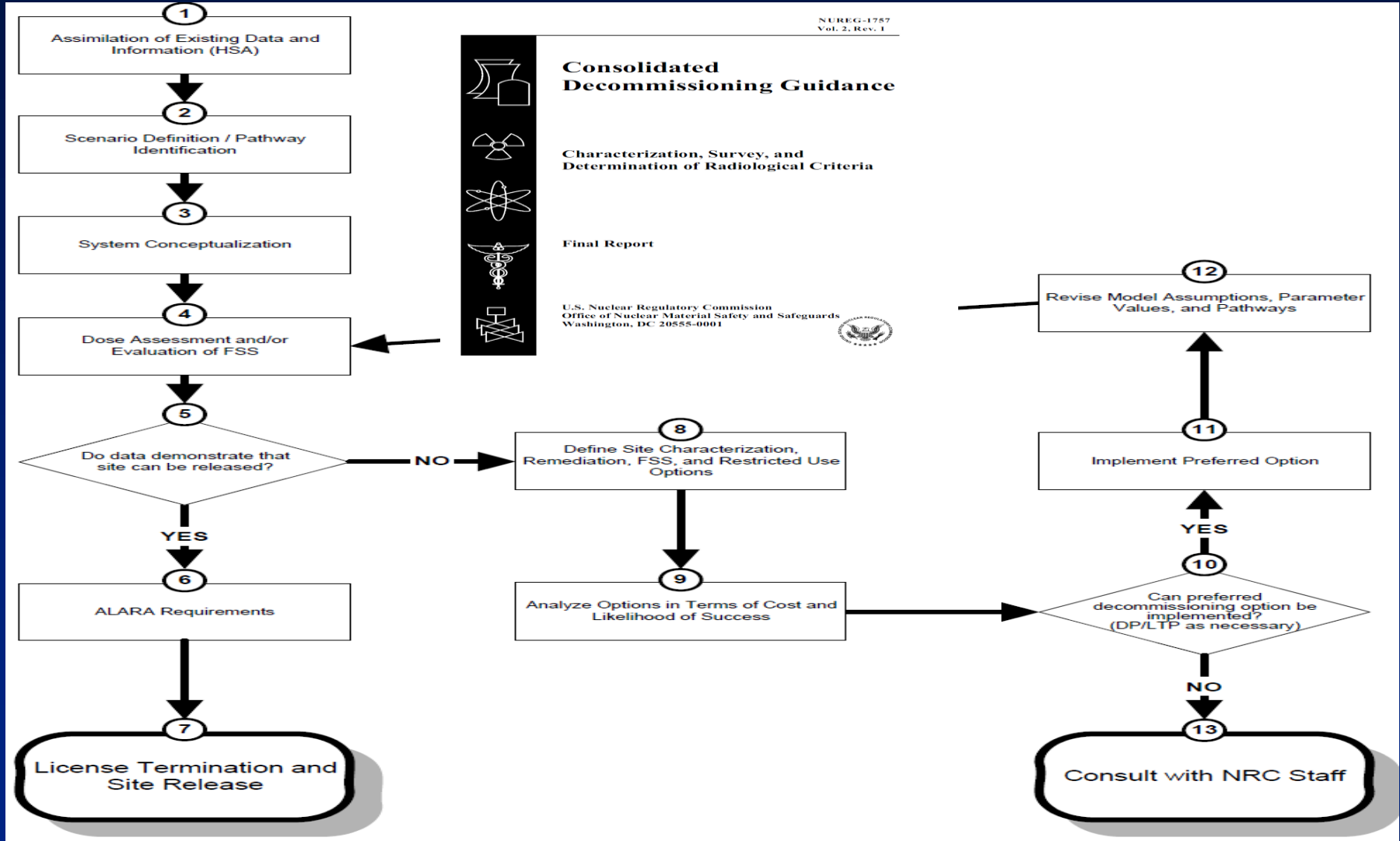
- 1 Permanent Cessation of Operations
- 2 Certification of Permanent Cessation of Operation
- 3 Certification of Permanent Fuel Removal (Variable)
- 4 Post Shutdown Decommissioning Activity Report (PSDAR) Submittal
- 5 Public Meeting 30 Days
- 6 Major Decommissioning Activities/Preparation for Storage or Dismantlement
- 7 License Termination Plan Submitted
- 8 License Termination

Material Facilities Decommissioning Process

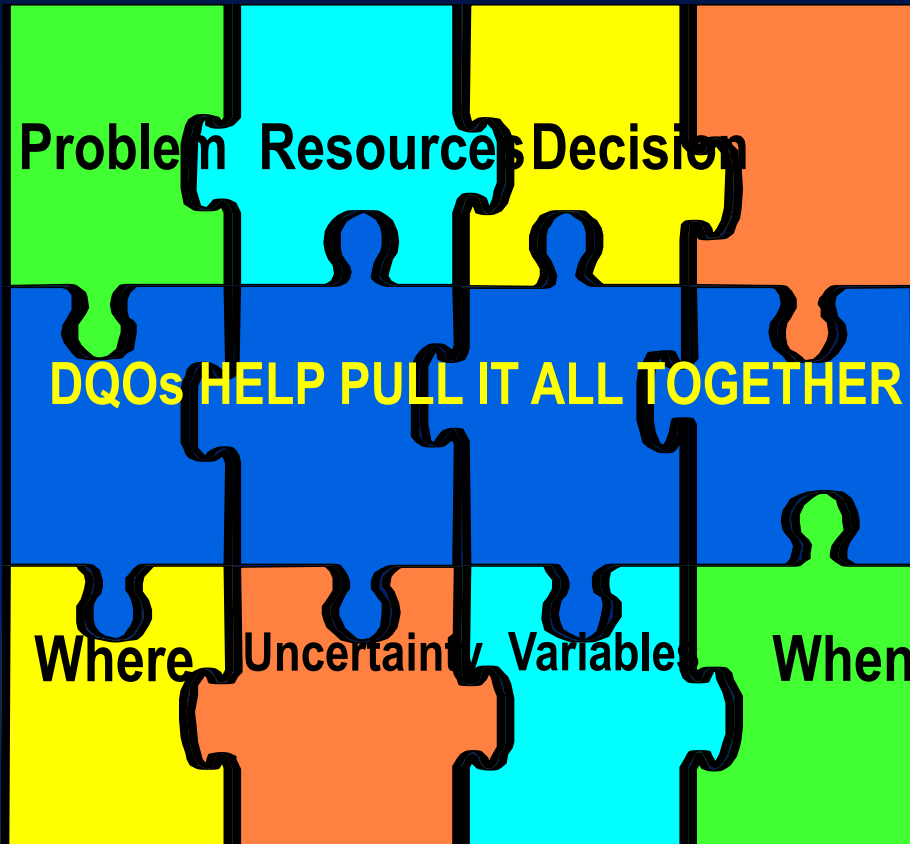
- Licensee notifies NRC within 60 days of permanently ceasing licensed activities
- Licensee submits **decommissioning plan (DP)** within 12 months
- NRC Reviews DP
- NRC offers the public opportunity to request hearing
- NRC approves DP by amending license
- Licensee performs **site decontamination/decommissioning**
- NRC conducts regulatory oversight during decommissioning (inspection, license amendment, **in-process surveys**, etc)
- Licensee **performs final radiological surveys and submits Final Status Survey Report (FSSR)** demonstrating compliance with **DCGLs**
- NRC performs **confirmatory survey**
- NRC terminate license

The Decommissioning Processes – Decision Framework & Characterization

DCGLs & Surveys (NURG-1757 V2)







It has been demonstrated that the DQO Process greatly strengthens the planning process by *improving planning efficiency, promoting defensibility of data, and saving resources*





1. STATE THE PROBLEM

Clear description of the problem for a specific project.

2. IDENTIFY THE DECISION

Decision that will be needed to address the problem.

3. IDENTIFY INPUTS TO THE DECISION

Information that will be needed to make the decision.

4. DEFINE THE STUDY BOUNDARIES

Description of statistical population for which the decision will be made.

5. DEVELOP A DECISION RULE

How parameter of interest and action level will be used to make a decision.

6. SPECIFY LIMITS ON DECISION ERRORS

Acceptable probability of making an incorrect decision.

7. OPTIMIZE DESIGN FOR OBTAINING DATA

Optimal probability of making an correct decision.

NUREG 1757 Decommissioning Groups – Surveys & Site Investigation Process

Groups	Simple			Complex			
	1 - 3	4	5	6	7		
	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7
Dose Assessment Method	N/A	Screening criteria (Section 5.1, Appendix H)		Site-specific assessment (Section 5.2, Appendices I and M)		Site-specific assessment (Section 5.3, Appendices I and M)	Site-specific assessment (Section 5.4, Appendices I and M)
Dose Assessment for Partial Site Release	No	Yes, for licensees electing partial site releases (Appendices K and L)					
Site Characterization	No	Yes (Section 4.2, Appendix E)			Yes (Section 4.2, Appendices E, F, and G)		
Remedial Action Support Surveys	No	Yes, if remediation is required (Section 4.3, Appendix E)					
Final Status Survey (FSS)	No	Yes (Sections 4.4 and 4.5, Appendices A, B, D, and E)		Yes (Sections 4.4 and 4.5, Appendices A, D, and E)			
Complex Survey Situations (Not Addressed in MARSSIM)	No			Yes (Section 4.6, Appendix G)			
Ground Water Characterization	No			Yes, surface water only (Appendix F)	Yes (Appendix F)		
ALARA Analysis	No	Yes, good housekeeping only (Section 6.2)		Yes (Chapter 6, Appendix N)			

Types of Surveys

- Background & Historical Assessment Survey
- Preliminary Survey
 - Scoping Survey
 - Characterization Survey
- Remedial Action Support Surveys
- Final Status Surveys
- Confirmatory Surveys
- Physical/Chemical Characterization needed to support Conceptual models, radionuclide transport, and Dose Analysis to Derive DCGLs

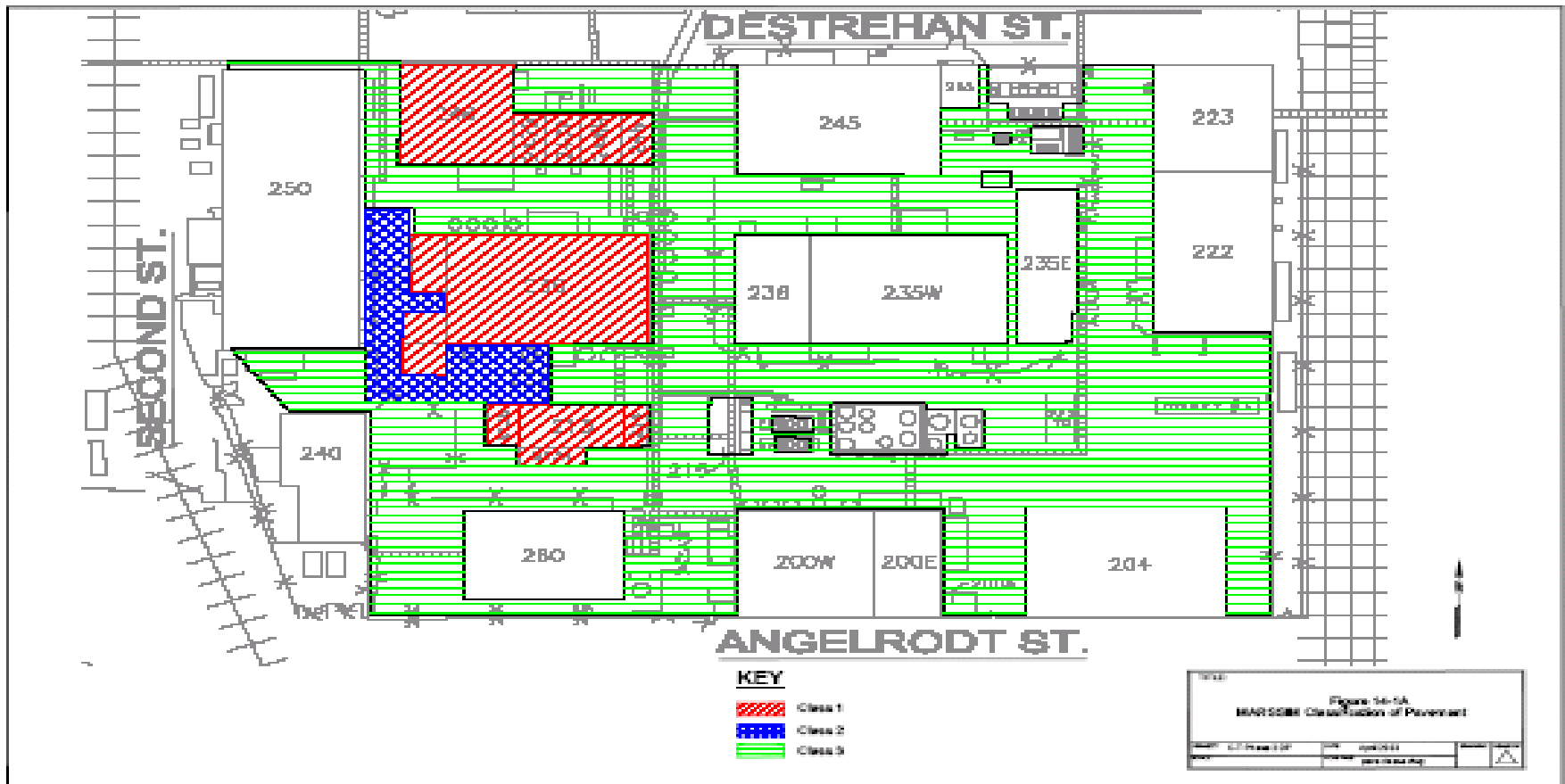
Evaluation of Historical Site Assessment Data

- Decisions following assessment of HSA data:
 - site is impacted - further investigation needed; scoping and characterization surveys required for area classifications
 - site is non-impacted - extremely low probability of residual radioactivity; site release possible
- Surface Soil
- Subsurface Soil
- Buildings/Structures
- Groundwater



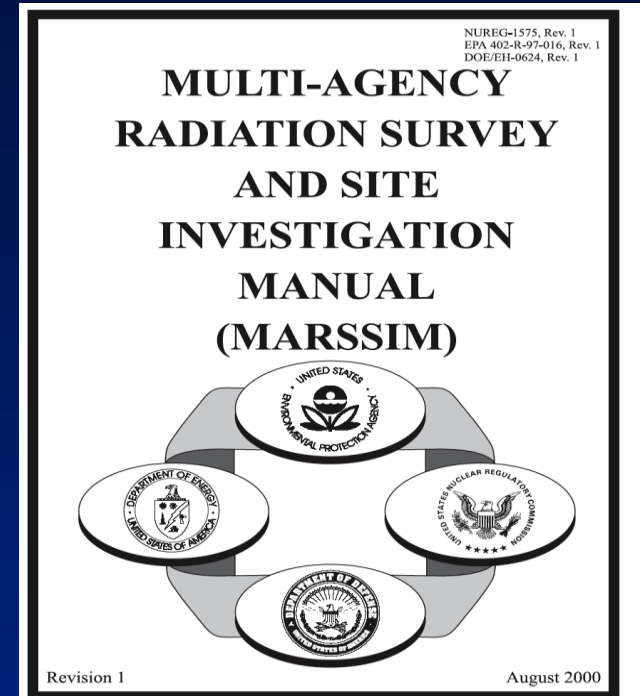
HSA Summary

- Site diagram showing preliminary classification of areas: impacted (Class 1, 2, or 3) and non-impacted



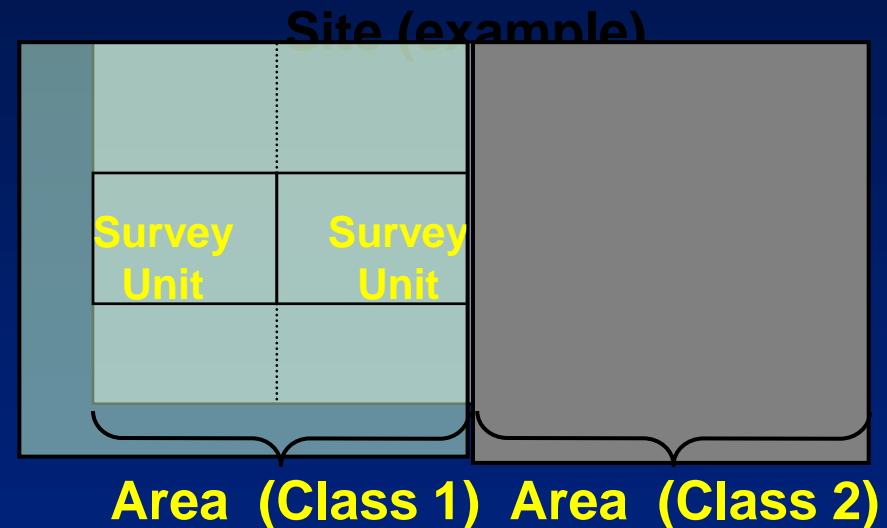
Characterization Survey Guidance & Status - MARSSIM

- **Multi-Agency Radiation Survey and Site Investigation Manual**
- **Nationally consistent approach**
 - Design Final Status Surveys
 - Evaluation of Collected Data
- **Surface Contamination**
 - Soil
 - Building Surface
- **MARSSIM survey may not be necessary**
 - Appendix B of MARSSIM
 - Appendix B of NUREG-1757
- **Computer-Based Data Acquisition Systems**
 - Scans
 - Complete characterization of the property



MARSSIM Basic Approach

- Statistical tests are used to plan and evaluate Final Status Survey data.
 - Wilcoxon Rank Sum (contaminants in background)
 - Sign Test (contaminants **not** in background)
- Null Hypothesis: Residual radioactivity exceeds the release criteria
- Survey design relies on DQOs to set acceptable decision errors.

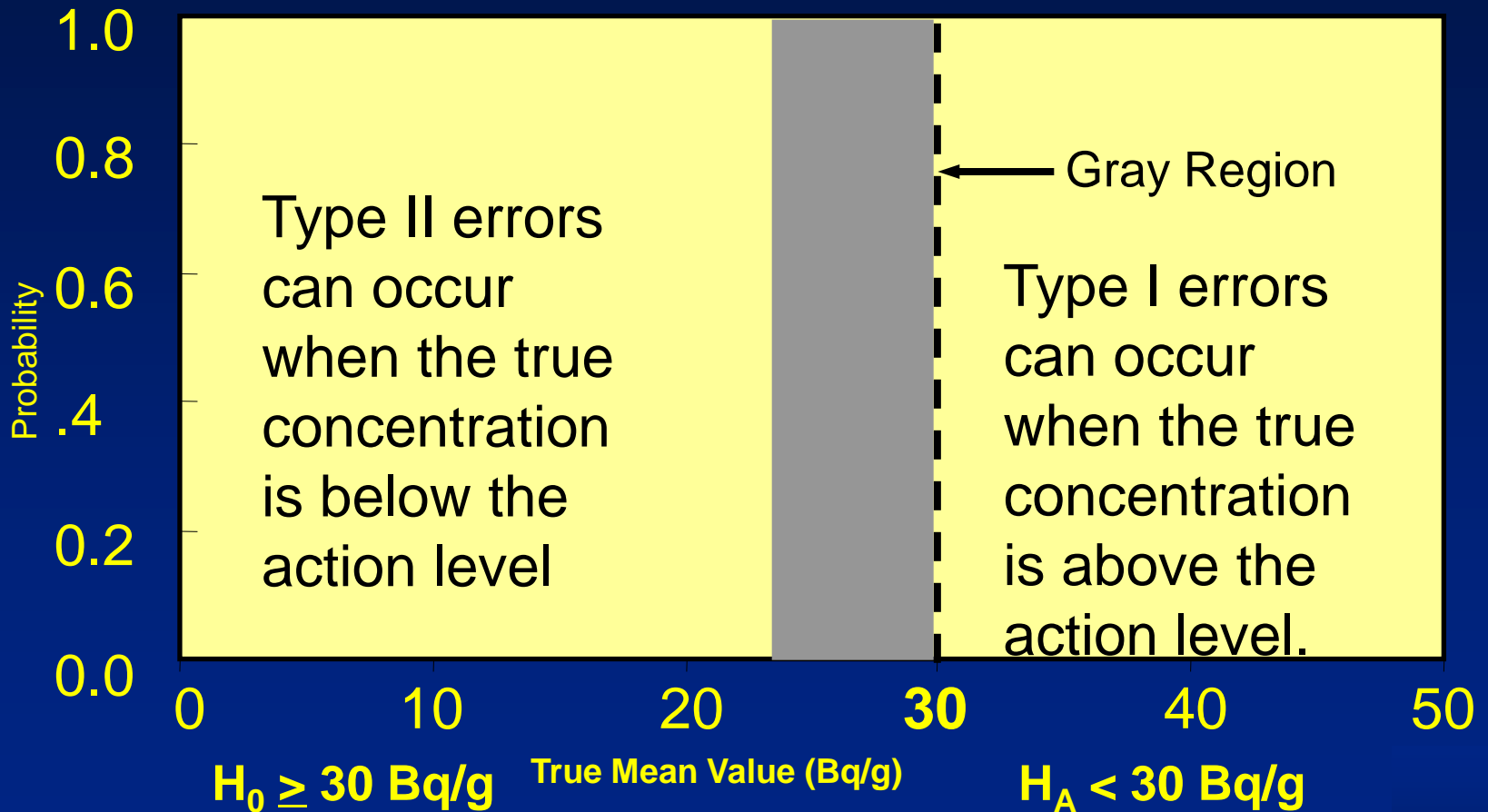


Statistical Test

- **Conducting a statistical test appropriately requires some thoughtful decisions:**
 - What statistic to use
 - What sample size to employ
 - What alpha and beta to specify, and
 - What criteria to establish for rejection the null hypothesis.

Hypothesis Testing

- **Null Hypothesis (H_0): Residual radioactivity exceeds the release criteria.**
 - H_0 is the baseline condition, assumed to be true in the absence of strong evidence to the contrary
- **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)**



To determine the number of survey unit measurements required to meet the DQOs, the relative shift must be calculated. This requires the use of the DCGL as follows:

$$\begin{aligned} \text{Relative shift} &= \frac{\Delta}{\sigma} \\ &= \frac{DCGL - LBGR}{\sigma} \end{aligned}$$

Decision Errors

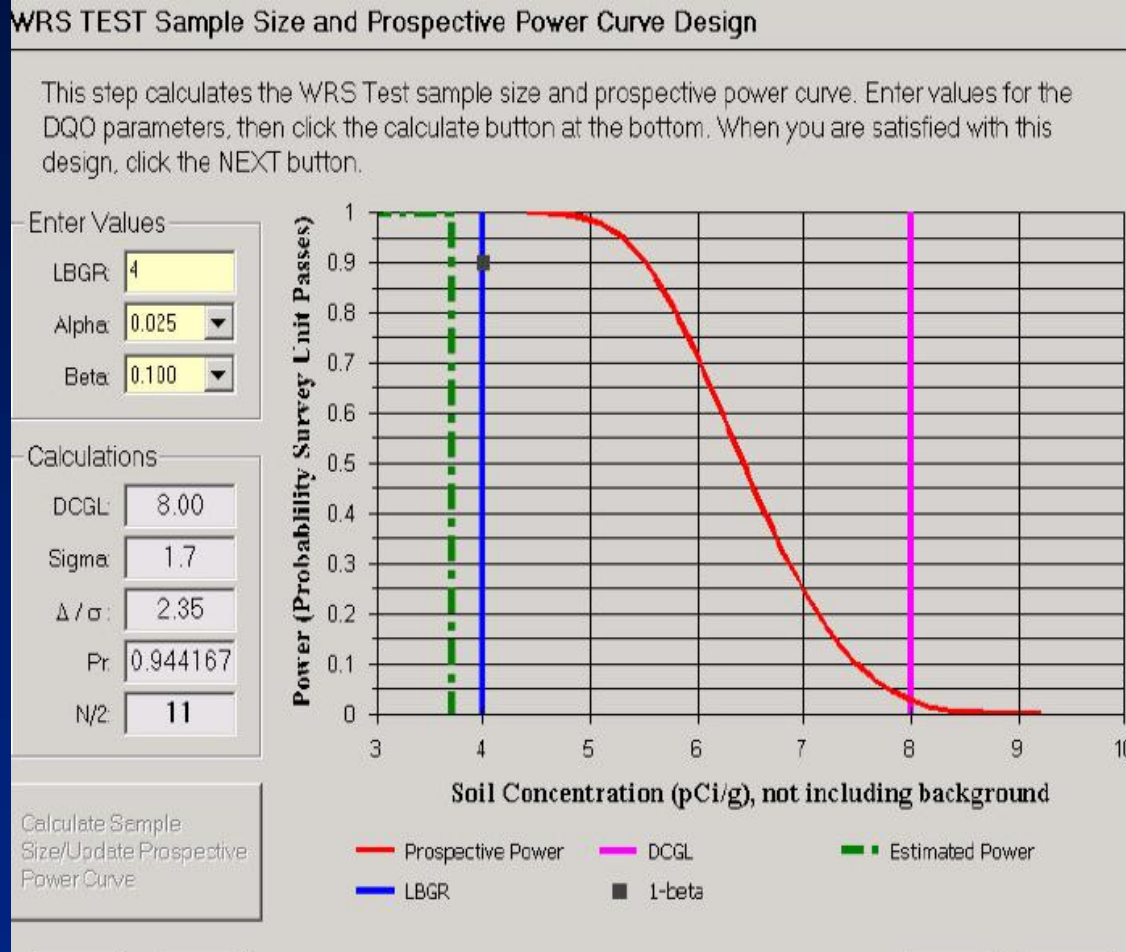
Decision	True State	Consequences
Deciding a survey unit is clean...	...when it actually isn't (H_0).	Type I α
Deciding a survey unit isn't clean...	...when it actually is (H_A).	Type II β



- Software to facilitate designing final status radiological surveys.
- prospective power curves - determining what level of confidence the user is willing to accept for a particular number of measurements or samples for a survey unit.
- After performing the final status survey, use to assesses the data for comparison to the release criteria.

The U.S. Nuclear Regulatory Commission (NRC) sponsored development of the COMPASS (Computerization of the MARSSIM for Planning and Assessing Site Surveys) computer code for facilitating statistical calculations in planning of final status surveys using MARSSIM and NRC guidance in support of the decommissioning license termination rule (10 CFR Part 20, Subpart E). The COMPASS code was developed by the Oak Ridge Institute for Science and Education (ORISE) - Environmental Survey and Site Assessment Program, the prime contractor used by NRC for independent verification of site decommissioning.

MARSSIM Sample Size, Type I & II Errors Power Curve



Survey design using WRS test for

processed uranium, DCGLW = 8 pCi/g

- Characterization data result in 4.8 pCi/g mean and 1.7 pCi/g std dev in survey unit;
- bkg had U-238 conc of 1.1 pCi/g (net 3.7 pCi/g in survey unit)


- Relative shift: $D/s = (8 - 4)/1.7 = 2.35$;
- Type I error = 0.025; Type II error = 0.1

NRC Subsurface Guidance

NUREG/CR 7021

The problems with adapting MARSSIM to the subsurface include:

- **Assuming no explicit knowledge is contradictory to the investigation**
- **The subsurface is difficult to access**
- **Volume (not area) is being investigated, increasing sampling requirements**
- **No comprehensive scans are possible**



U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

NUREG/CR-7021

A Subsurface Decision Model for Supporting Environmental Compliance

Manuscript Completed: December 2009
Date Published: January 2012

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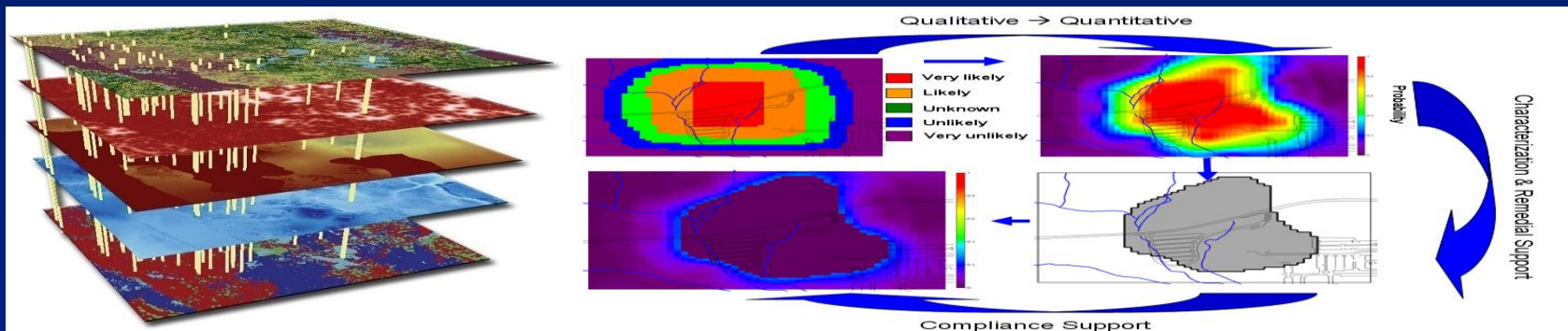
Dr. George Powers, NRC Project Manager
NRC Job Code N6232



- Assume that a decision limit is available
 - Based on a vadose to groundwater transfer (source term)
 - Based on a future excavation scenario
 - Can vary with depth
 - Can vary with spatial scale
- Make empirical use of all available information
 - Information relevant to exceedance of decision limit
 - Provides a surrogate for comprehensive scans
 - Provides a means to optimally locate boreholes
 - Everyone plays (able to use knowledge from different domains)
 - Spatial expressed in a Contamination Concern Map (CCM)
- Cradle to grave
 - Introduce CCM early
 - Evolve CCM from Historical Site Assessment to Compliance Evaluation.
 - Evolve CCM from qualitative to quantitative
 - Provide tools that facilitate empirical evolution of CCM.
 - Emphasized in EPA's Triad model.
- CCM supports compliance evaluation
 - CCM contains all information and should be best evidence for success or failure

Spatial Analysis and Decision Assistance (SADA) Code

- SADA is free software that incorporates tools from environmental assessment fields into an effective problem solving environment.
- These tools include integrated modules for visualization, geospatial analysis, statistical analysis, human health risk assessment, ecological risk assessment, cost/benefit analysis, sampling design, and decision analysis. Focus on Area of Concern Map (ACM)
- The capabilities of SADA can be used independently or collectively to address site specific concerns when characterizing a contaminated site, assessing risk, determining the location of future samples, and when designing remedial action.
- A fully functional freeware version is available on the download page of this web site: <http://www.tiem.utk.edu/~sada/index.shtml>.

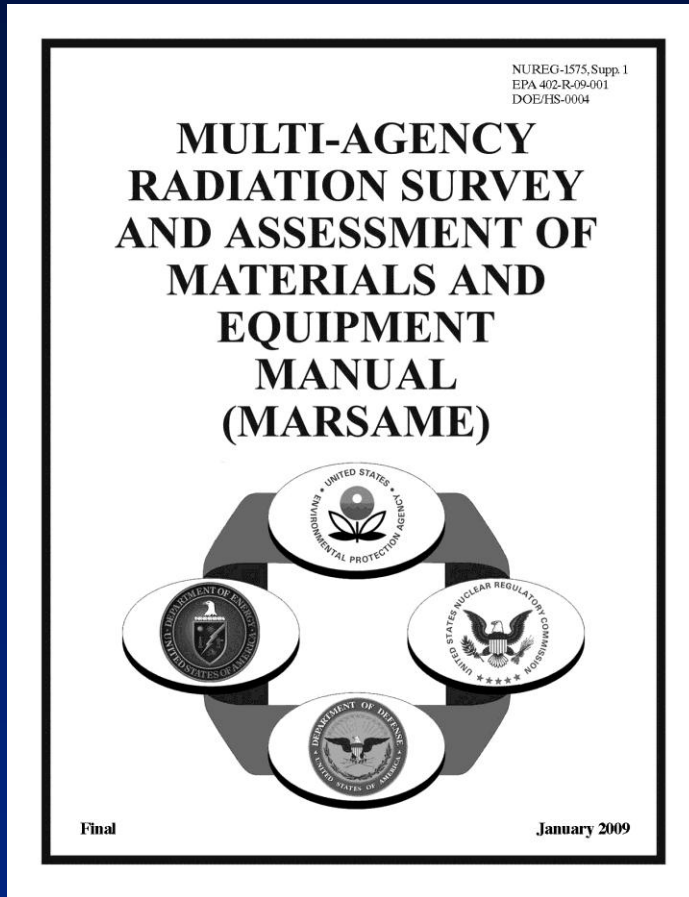


MARSAME

NUREG-1575, Supp. 1

EPA 402-R-09-001

DOE/HS-0004



- MARSAME is a supplement to MARSSIM providing information on planning, conducting, evaluating, and documenting radiological disposition surveys for the assessment of materials and equipment.

Materials and Equipment (M&E) or *non-real property*:

- **Tools, heavy equipment, furniture, etc.**
- **Scrap metal, concrete, etc.**
- **Bulk materials, rubble**
- **Containers**



- Design and Conduct Preliminary Surveys
- Describe the M&E
- Disposition Survey Design
 - Develop Survey Statistics
 - Develop an Operational Decision Rule
 - Classify M&E - Classes 1, 2, and 3
 - Select and Optimize Survey Type
 - Scan-only, In situ, or MARSSIM-type
 - Document survey design

MARSAME Survey Types

- Prepare M&E for survey
- Segregate M&E as necessary
- Set Measurement Quality Objectives (MQOs)
 - Determine Measurement Uncertainty
 - Determine Measurement Detectability
 - Determine Measurement Quantifiability
- Select Measurement Technique and Instrumentation
- Perform the Survey
 - segregation is to separate M&E based on the estimated total measurement uncertainty, ease of handling, and disposition options. Segregation is based on physical and radiological attributes.



MARSSIM TYPE SURVEY



MARSAME Survey Areas

- Class 1 Scan-Only Surveys - Measure 100%
- Class 2 Scan-Only Surveys – $>10\% < 100$
- Class 3 Scan-Only Surveys - Measure $\leq 10\%$



- Scanning percentage based on classification
 - Class 1 – 100%
 - Class 2 – 10% – 100% (uniform coverage)
 - Class 3 - $\leq 10\%$ (professional judgment)

NRC Decommissioning Issues & Challenges

- **Prevention of Legacy Sites**
 - Legacy sites – complex sites difficult to decommission for a variety of financial, technical, or programmatic reasons
 - Draft rulemaking to revise financial assurance requirements and 10 CFR 20.1406
 - Requirements to detect and minimize contamination
 - Requirements for prompt remedial action to limit migration
- **Decommissioning Lessons Learned Applicable to design and operation stages:**
 - Adequate characterization of the subsurface;
 - Plant designs should minimize use of embedded pipes
 - Keeping records of:
 - Spills & contamination
 - As-built drawings and modifications of structures and equipment
 - Decommissioning cost estimate
 - Records of originally licensed area, acquisition of property, and partial site release

Guidance Updates

- MARSSIM Revision
- SUBSURFACE - (MARSAS) ?
- DOSE MODELING – (MARMOD) ?
- SOFTWARE UPDATE DEVELOPMENT
- INPUT PARAMETERS

Lessons Learned from Regulatory Reviews of Survey Plans

Attributes a Survey Plan Should Include

- Reliance on applicable guidance documents
 - MARSSIM
 - NUREG-1505 (statistics report); NUREG-1507 (instrument selection report)
 - EPA QA/G-4, EPA QA/G-9, ANSI/ASQC-E4 (data quality reports)

Common Survey Issues

- Avoidance of common mistakes
- Insufficient explanation of quality control procedures, data quality assessment, release criteria and action levels
- Survey procedures are not provided or incomplete
- Improper instrument selection for site conditions
- Inadequate technical basis for survey unit classification
- Misapplication of release criteria (DCGL)

Key to Decommissioning Success:

- **Early and frequent consultations between NRC and licensee throughout the decommissioning process,**
- **Communication during licensee development (e.g.; DCGLs) and NRC review of decommissioning-related documents,**
- **Open and regular communication to discuss changes to decommissioning schedule and activities, challenges, etc.,**
- **Flexibility and transparency in regulatory implementation emphasizing on safety and environmental protection,**
- **Realistic approach in selection of scenarios (e.g., based on foreseen land use) and parameters,**
- **Risk-Informed Performance-Based approaches.**

More Information

- **Decommissioning Web Page -** <http://www.nrc.gov/what-we-do/regulatory/decommissioning.html>
 - **Sites; regulations and guidance; process; public involvement; key program documents; International aspects; FAQs; Lessons Learned**
- **NRC's Regulations -** <http://www.nrc.gov/reading-rm/doc-collections/cfr/>