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Overview of Draft Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual

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ABSTRACT

This paper provides an overview of the draft Multi-Agency Radiation Survey and Assessment of Materials and Equipment (MARSAME) Manual. NUREG-1761, Radiological Surveys for

Controlling Release of Solid Materials, was the first attempt to provide guidance for surveying materials and equipment (M&E). From this starting point, the MARSSIM workgroup is developing MARSAME as a supplement to the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM). MARSSIM and MARSAME are joint publications from EPA, NRC, DOE and DoD addressing the conduct of final status surveys for residual radioactivity. MARSAME provides guidance for the design, implementation, assessment, and documentation of technically-defensible surveys to determine whether there is a need to initiate, maintain, remove or transfer radiological controls on specific M&E. An overview of the proposed MARSAME graded approach is discussed including initial assessment of M&E, inputs to the decision rule, survey design, survey implementation, and survey results assessment.

INTRODUCTION

Large quantities of materials and equipment (M&E) potentially affected by radioactivity are present throughout the United States. The potential for residual radioactivity can come from use of source, byproduct, and special nuclear materials as well as naturally occurring radioactive material (NORM), naturally occurring and accelerator-produced radioactive materials (NARM) and technologically enhanced naturally occurring radioactive material (TENORM). This M&E may be commercial, research, education, or defense related. The M&E might be:

- used or stored at sites and facilities licensed to handle radioactivity,
- commercial products purposely containing radionuclides (e.g., smoke detectors),
- commercial products incidentally containing radionuclides (e.g., phosphate fertilizers), or
- associated with NARM and TENORM.

The owners of M&E potentially affected by radioactivity need to determine acceptable disposition options for M&E currently under their control. Industries or facilities sensitive to the presence of radioactivity need to evaluate the acceptability of M&E coming under their control. Regulatory agencies need to distinguish items in general commerce that are inherently radioactive from illicit trafficking of radioactive M&E.

During the 1990's, there was a concerted effort to improve the planning, implementation, evaluation, and documentation of building surface and surface soil final radiological surveys for demonstrating compliance with standards. This effort included the preparation of NUREG-1505 [1] and NUREG-1507 [2] by the NRC and culminated in 1997 with the issuance of the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) [3]. MARSSIM was a joint effort by DOD, DOE, EPA, and NRC to develop a multi-agency approach for planning, performing, and assessing the ability of surveys to meet dose- or risk-based standards while at the same time encouraging effective use of resources. MARSSIM provided recommendations for developing appropriate final status survey designs using the DQO Process to ensure survey results were of sufficient quality and quantity to support a final decision. NUREG-1505, NUREG-1507, and MARSSIM replaced the previous approach for such surveys contained in NUREG/CR-5849 [4].

The Multi-Agency Radiation Survey and Assessment of Materials and Equipment (MARSAME)

is a supplement to MARSSIM. Like MARSSIM, MARSAME is a joint effort by the Department of Defense (DOD), Department of Energy (DOE), Environmental Protection Agency (EPA), and Nuclear Regulatory Commission (NRC) and as such the document is designated NUREG-1575, Sup. 1; EPA-402-R-06-002; and DOE/EH-707. MARSAME also incorporates information for measuring radioactivity from the Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP) [5]. The supplement provides information on surveys where radiological control of M&E could be initiated, maintained, removed, or transferred (i.e., an M&E disposition) to another responsible party. In addition, MARSAME discusses the need for a graded approach to surveying M&E.

MARSAME provides technical information on approaches for planning, implementing, assessing, and documenting surveys to determine proper disposition of M&E. Release (including clearance) and interdiction are types of disposition options in MARSAME. Examples of M&E include metals, concrete, tools, equipment, piping, conduit, furniture, and dispersible bulk materials such as trash, rubble, roofing materials, and sludge. Liquids, gases, and solids stored in containers (e.g., drums of liquid, pressurized gas cylinders, containerized soil) are also included in the scope of this document.

Radionuclides or radioactivity on workers or members of the public are outside the scope of the supplement. Liquid and gaseous effluent releases, and real property (e.g., fixed buildings and structures, surface and subsurface in situ soil) are also outside the scope of MARSAME.

The purpose of the supplement is to provide information for the design and implementation of technically-defensible surveys for disposition of M&E. MARSAME provides information on selecting and properly applying disposition survey strategies and selecting measurement methods. The data quality objectives (DQO) process is used for selecting the best disposition survey design based on the selected disposition option, action level, description of the M&E (e.g., size, accessibility, component materials), and description of the radioactivity (e.g., radionuclides, types of radiation, surficial versus volumetric activity). Detailed information on the DQO Process can be found in EPA QA/G-4 [6], MARSSIM Appendix D, and MARLAP Appendix B. The supplement describes a number of different approaches for performing technically-defensible disposition surveys and provides information for optimizing survey designs. However, MARSAME does not represent the only acceptable approach to radiologically evaluate M&E. MARSAME describes a graded approach that the signatory agencies find acceptable and useful for most situations. The signatory agencies recognize that alternative approaches or modification of the MARSAME procedures may be appropriate or necessary for some situations. Nothing in MARSAME should be construed to prohibit the use of other appropriate procedures.

Disposition surveys may be performed as a single event or as part of a routine process. Single event disposition surveys are usually performed once in association with a specific project. Surveying a backhoe at the completion of a decommissioning project is one example of a single event disposition survey. Routine process disposition surveys are usually associated with ongoing tasks where similar surveys are performed repeatedly. One example of a routine process disposition survey would be a radiological survey of tools prior to removal from a controlled area at a nuclear facility. Both single event and routine process types of surveys are

included in the scope of MARSAME.

MARSAME assumes the user has some historical knowledge of the M&E being investigated. The historical information is gathered during the Initial Assessment (IA) to determine acceptable disposition options. The characteristics, history of prior use, and inherent radioactivity of the M&E are important when determining the appropriate disposition options. The historical information is termed "process knowledge." The role of process knowledge is important in providing information on the nature and amount of radioactivity that might be expected on, or incorporated in, the M&E being investigated. If no historical information is available, information on the current status of the M&E can be determined using preliminary surveys (i.e., scoping, characterization, remedial action support) prior to designing a disposition survey.

The recommendations in MARSAME may be applied to a broad range of regulations, including dose-, risk-, or radionuclide concentration-based regulations. The translation of a regulatory dose or risk limit to a corresponding concentration level is not addressed in MARSAME. The terms dose, risk, and dose- or risk-based regulation are used throughout the supplement, but these terms are not intended to limit the applicability of this supplement. MARSAME can be applied to activity concentrations (e.g., Bq/m^2) without associated dose or risk values. MARSAME does not address the regulatory status of the M&E (e.g., NRC exempted or excluded materials).

Understanding Key MARSAME Terminology

In order to understand the information in MARSAME, the user should first become familiar with the scope, the terminology, and the concepts in the supplement. As a supplement to MARSSIM, MARSAME uses terms generally consistent with MARSSIM. Some additional terms were developed for MARSAME, while other commonly used terms were adopted from other sources.

The terms *impacted*, *non-impacted*, and *graded approach* are defined in MARSSIM. These terms are used consistently in MARSSIM and MARSAME. Unlike MARSSIM which applies to land, structures, or buildings, MARSAME applies to M&E. The action taken may initiate, maintain, remove, or transfer radiological controls associated with the M&E. The decision to take action may be largely based on the results of a radiological survey designed to evaluate the disposition of the M&E, either through release or interdiction. Therefore, the terms *release criterion*, *derived concentration guideline level (DCGL)*, and *final status survey* used in MARSSIM are replaced by the more generic terms *disposition criterion*, *action level*, and *disposition survey*, respectively, in MARSAME.

Disposition is the future use, fate, or final location for something (e.g., recycle, reuse, disposal). Disposition options range from release to interdiction:

- *Release* - A reduction in the level of radiological control, or a transfer of control to another party. Examples of release include clearance (i.e., unrestricted release of materials and equipment to the public sector), recycle, reuse, disposal as waste, or transfer of control of radioactive M&E from one authorized user to another.
- *Interdiction* - The authoritative refusal to approve or assent to an action. Examples of

interdiction include identification of uncontrolled radioactive material that results in the initiation of radiological controls, or decision not to accept control of M&E. The goal of an interdiction survey is often to detect radioactivity that should be controlled.

Categorization is the act of determining whether M&E are impacted or non-impacted. This is a departure from MARSSIM where this decision was referred to as classification. This change was made to emphasize the difference between the decision of whether a survey is needed (i.e., impacted or non-impacted) and the determination of the appropriate level of survey effort (i.e., classification).

Classification is the act or result of separating impacted M&E or survey units into one of three designated classes: Class 1, Class 2, or Class 3. Classification is the process of determining the appropriate level of survey effort based on estimates of activity levels and comparison to action levels, where the activity estimates are provided by historical information, process knowledge, and preliminary surveys.

Measurable radioactivity is radioactivity that can be quantified using known or predicted relationships developed from historical information, process knowledge or preliminary measurements as long as the relationships are developed, verified, and validated as specified in the DQOs and measurement quality objectives (MQOs). Measurability is of primary importance in MARSAME.

Surficial radioactive material is radioactive material distributed on any of the surfaces of a solid object. Surficial radioactive material may be *removable* (by non-destructive means such as casual contact, wiping, brushing, or washing) or *fixed*. Surfaces may either be accessible or difficult-to-measure. Changes to the surface (e.g., paint, dirt, oxidation) may affect the measurability and the physical condition of surficial radioactive material.

Survey unit for M&E is the specific lot, amount, or piece of equipment on which measurements are made to support a disposition decision concerning the same specific lot, amount, or piece of equipment. The survey unit defines the spatial boundaries for the disposition decision and a separate decision is made for each survey unit, similar to MARSSIM. The survey unit boundaries also define the population for the parameter of interest.

Volumetric radioactive material is radioactive material that is distributed throughout or within the material or equipment being measured, as opposed to a surficial distribution. Volumetric radioactive material may be homogeneously (e.g., uniformly activated metal) or heterogeneously (e.g., activated reinforced concrete) distributed throughout the M&E. Volumetric radioactive material may be distributed throughout the M&E being measured or distributed in layers. Layers of volumetric radioactive material may start at the surface (e.g., porous surfaces penetrated by radioactive material) or under a layer of other material (e.g., activated rebar inside a concrete wall). By definition all radioactive liquids and gases in containers and all bulk quantities of radioactive material when measured as a whole are volumetric radioactive material.
The concept of whether radioactivity is measurable is the major factor in demonstrating compliance with an action level. MARSAME does not provide an exact definition for the transition between surficial and volumetric radioactive material. Rather, the assumptions used to

quantify the radioactivity need to be clearly defined and identified so they can be compared to the DQOs and MQOs. Individual action levels may specify applicability to surficial or volumetric radioactivity. In these cases, the definition of surficial and volumetric radioactivity should be specified as part of the definition of the action level.

Accessible area is an area that can be reached or where measurements can be readily performed. In many cases M&E must be physically accessible to perform a measurement. However, radioactivity may be measurable even if M&E are not physically accessible (e.g., energetic gamma rays may be quantified even after passing through a layer of shielding).

Difficult-to-measure radioactivity is radioactivity that is not measurable until the M&E to be surveyed is prepared. Preparation of M&E may be relatively simple (e.g., cleaning) or more complicated (e.g., disassembly or complete destruction). Given sufficient resources, all radioactivity can be made measurable; however, it is recognized that increased survey costs can outweigh the benefit of some dispositions.

Initial Assessment (IA) is an investigation to collect existing information describing M&E and is similar to the Historical Site Assessment (HSA) described in MARSSIM. The IA provides initial categorization of M&E as impacted or non-impacted. In addition to the HSA activities described in MARSSIM, the IA may lead to grouping or segregating M&E with similar characteristics as well as designing and implementing preliminary surveys. The IA also identifies the expected disposition of the M&E (e.g., clearance, radiological control, recycle, reuse, disposal). The results of the IA provide most, if not all, information needed to design a disposition survey for impacted M&E. A graded approach is used to determine the level of effort applied during the IA.

Sentinel measurement is a biased measurement performed at a key location to provide information specific to the objectives of the IA. Sentinel measurements cannot be used as the only source of information to support a decision that M&E are non-impacted. The objective of performing sentinel measurements as part of the IA is to gather additional information to support a decision regarding further action, verify assumptions based on process knowledge, provide additional support to a finding of impacted or non-impacted for M&E, and to distinguish illicit or inadvertent transport of radioactive materials from items in general commerce that are inherently radioactive (e.g., fertilizers, phosphates, sand-blasting grit).

OVERVIEW OF MARSAME PROCESS

The Data Life Cycle is the foundation for the design, implementation, and assessment of surveys for disposition of M&E in MARSAME. However, before commencing survey planning the user must select an appropriate disposition option. Multiple disposition options may exist. Consider all of the various disposition options and develop the most appropriate option for a given situation. Survey designs may then be planned using the DQO Process, which is often iterative. The DQO Process iterations may take place at different times during the disposition process, for example during the IA or during the disposition survey. The different survey designs are compared and the most resource-effective design that meets the survey objectives is selected for implementation. Following implementation of the selected survey design, the results are

evaluated using Data Quality Assessment (DQA). A technically defensible decision regarding disposition of the M&E can then be made.

Whenever practical, MARSAME recommends designing disposition surveys where one hundred percent of the M&E are measurable. This means that all radioactivity associated with the M&E has been measured and quantified (e.g., 100% scan with conventional instruments, measurement with a box counter, or measurement using in situ gamma spectroscopy), a known or accepted relationship was used to estimate concentrations for difficult-to-measure radionuclides using surrogate measurements, or that a known or accepted relationship allows quantification of radioactivity in areas that were not measured. MARSAME employs the use of a graded approach to determine if a 100% measurable survey is practical and to ensure that a sensible, commensurate balance is achieved between resource expenditures and risk reduction.

MARSAME uses the Data Life Cycle to design disposition surveys and each chapter in MARSAME provides information for specific steps in the process. The Data Life Cycle consists of four phases (planning, implementation, assessment, and decision-making). A brief description of each of the phases and how they apply to the disposition survey design process is provided in the following sections. Figure 1 illustrates how the Data Life Cycle is applied to disposition surveys.

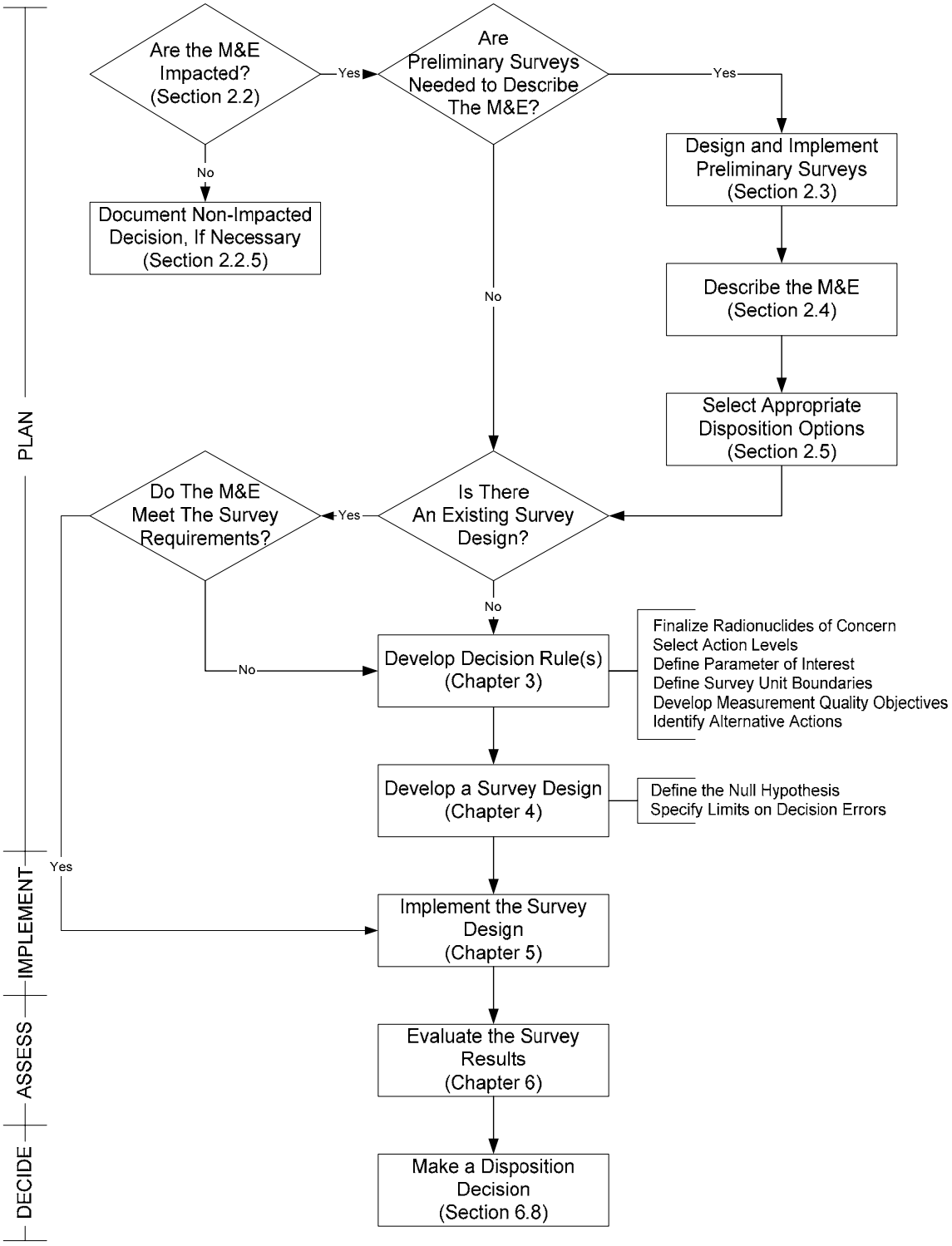

Figure 1. The Data Life Cycle applied to MARSAME disposition surveys (chapter and section numbers from draft manual)

Planning Phase

The planning phase is where the survey design is developed and documented using the DQO Process. The survey design documents the decision rule as well as the number, type, and location of measurements required to support the disposition decision. Soliciting input from regulatory agencies early in the planning phase helps ensure the disposition survey results will meet regulatory needs.

MARSAME processes begin with the IA and its historical evaluation of the M&E being investigated. This IA usually combines a review of process knowledge and historical records with a visual inspection of the M&E. The results of the IA are used to develop a conceptual model describing the physical characteristics of the M&E and providing information on the radioactivity potentially associated with the M&E. The physical description of the M&E should include information on the size, shape, complexity (e.g., can it be broken down or combined with other M&E), accessibility (e.g., can the surveyor physically access areas of concern to perform measurements), and inherent value (i.e., resources associated with reuse, recycle, repair, remediation, replacement, and disposal). Information on radioactivity should include the radionuclides of potential concern, the expected levels of radioactivity, the distribution of radioactivity (e.g., uniform or not), and the location of the radioactivity (i.e., surface or volume).

The IA may also include limited data collection in the form of sentinel measurements. The results of sentinel measurements can be used as the basis to reject assumptions based on process knowledge. However, sentinel measurements alone cannot be used to justify the categorization of M&E as non-impacted.

There are two decisions associated with the IA. The first decision, called categorization, is whether or not the M&E are impacted. Non-impacted M&E do not require additional investigation, but may require documentation of the non-impacted decision. The second decision is to select an appropriate disposition option for impacted M&E at the end of the IA to provide direction for designing a disposition survey. Additional information may be required before a disposition survey can be designed. Preliminary surveys (e.g., scoping, characterization, and remedial action support surveys) may be performed as part of the IA to collect this additional information.

For single event surveys, the IA should focus on collecting the information necessary to develop a technically-defensible disposition survey design. Information necessary to design a disposition survey includes a description of the M&E and the radioactivity potentially associated with the M&E. The results of the IA are carried forward and used to develop the survey design, which is usually documented in a project-specific work plan.

For routine process surveys, the IA should lead to an existing survey design from a standard operating procedure (SOP), if applicable, or develop a new survey design for documentation in an SOP. The SOP should clearly state the assumptions used to develop the survey design, along with a description of the M&E and radioactivity that are covered by the SOP. The selection process is based on evaluating the M&E to determine if the survey design in a specific SOP is applicable. Documentation of individual survey results may not be required as long as there are

records showing that the SOP was approved, the instruments were working properly, and the personnel performing the survey were properly trained. Development of SOPs is usually accomplished using the same processes as those used to develop single event surveys. There may be regulatory or site-specific guidance that specifies documentation requirements for SOPs. Information on developing SOPs can be found in EPA QA/G-6 [7].

Following the IA, it is necessary to develop a decision rule for the disposition of M&E being investigated. The decision rule is an "if...then..." statement consisting of three parts: action level(s), parameter of interest, and alternative actions. An example of a decision rule might be "If the average surficial activity concentration is less than a level specified by the regulator, then the M&E can be cleared, otherwise the M&E are not cleared." The parameter of interest is closely related to the description of the M&E, the description of the radioactivity, and the survey unit boundaries. The action level reflects the selection of a disposition option. The selected disposition option defines two alternative actions. A decision rule should be developed for each decision to be made concerning the M&E. For example, if the action level is stated in terms of total activity, generally only one decision rule is required. If, on the other hand, the action level provides limits for fixed, removable, and maximum levels of radioactivity, e.g., DOE Order 5400.5, Figure IV-1 [8], then a decision rule is required to evaluate each action level. The measurement performance requirements, or MQOs, are also evaluated when developing a decision rule to ensure that an acceptable measurement technique is available to support the proposed survey design.

Once the decision rule(s) have been established, a survey design is developed. The survey design specifies the number and quality of measurements required to support a disposition decision recorded in the decision rule. MARSAME recommends that a graded approach be applied to the disposition of M&E. Non-impacted M&E are removed from further consideration early in the process through categorization. Impacted M&E are classified based on the level of residual radioactivity so that a higher level of scrutiny can be applied to M&E with the highest potential for residual radioactivity. Finally, MARSAME includes practical considerations such as inherent value of the M&E and handling the M&E when evaluating options for disposition. The combination of these considerations results in a graded approach where an appropriate level of survey effort is applied to M&E to minimize the impacts of any decision errors. The survey design, definitions of decision errors, and burden of proof are determined by the selection of a null hypothesis.

The survey design should be documented in a quality document (e.g., QA Survey Plan, SOP) that has been reviewed and accepted by the appropriate authority (e.g., technical expert, management, or regulator). Survey designs that are often repeated may be documented in SOPs along with supporting records on instrument performance and personnel training. Other types of disposition surveys are usually documented in a project-specific work plan and survey results are presented in a disposition survey report. If the selected survey design is not technically or economically practical, the planning team can investigate additional disposition options if necessary.

Implementation Phase

To ensure flexibility and encourage the use of optimal measurement techniques for a specific project, MARSAME does not provide detailed information on specific implementation techniques. However, detailed descriptions of several measurement techniques are provided. These descriptions serve as a template for information required to evaluate different measurement techniques. It is important to remember that the survey design is usually linked to a specific option for disposition of the M&E.

During implementation, the descriptions of measurement techniques are compared to the MQOs defined during survey planning. A measurement method (i.e., combination of a measurement technique with an instrument) is selected based on its ability to meet the MQOs. The number and type of measurements specified in the documented survey design are performed at the locations specified in the survey design. If a measurement method is specified in the survey design, that method should generally be used during implementation. If the specified measurement method cannot be performed (e.g., the instrument is unavailable or the measurement method does not meet the MQOs), another measurement method should be selected based on the MQOs. The selection of the replacement measurement method should be documented in the survey design and survey report.

Quality control (QC) data are collected and analyzed during implementation to provide an estimate of the uncertainty associated with the survey results. QC measurements are technical activities performed to measure the attributes and performance of a survey. A well-designed QC program increases efficiency and provides for early detection of problems. This can save time and money by averting rework and enables the user to make decisions more expeditiously [9].

Assessment Phase

The assessment phase begins with verification and validation of the survey results. Data verification is used to ensure the requirements documented in the survey design were implemented as prescribed. Data validation ensures the results of the data collection activities support the objectives of the survey (i.e., DQOs), or permit a determination that these objectives should be modified (MARSSIM Section 9.3 and MARSSIM Appendix N).

DQA determines if the collected data are of the right type, quality, and quantity to support their intended use. DQA helps complete the Data Life Cycle by providing the assessment needed to determine that the planning objectives are achieved. DQA is described in detail in EPA QA/G-9R [10], MARSSIM Section 8.2, and MARSSIM Appendix E.

The preliminary data review is performed to learn about the structure of the data (e.g., identifying patterns, relationships, or potential anomalies). Graphical techniques are used to help visualize the data. Calculation of basic statistical quantities is used to help describe the distribution of data.

The survey data are evaluated using a statistical test. A test statistic is calculated and compared to a critical value. The critical value divides the potential values of the test statistic into two

regions. The critical region includes values for the test statistic where the null hypothesis is rejected. The null hypothesis is not rejected for values of the test statistic outside the critical region.

Decision-Making Phase

Following the assessment phase, a decision is made regarding the disposition of the M&E. The decision rule defines the final decision. The statistical test or data comparison determines whether the parameter of interest exceeds the action level. Based on the outcome, a decision can be made regarding the alternative actions. If multiple decision rules are defined for a single disposition survey (e.g., a MARSSIM-type survey where the average activity is evaluated using a statistical test and small areas of elevated activity are evaluated using the elevated measurement comparison) any one decision that the action level has been exceeded should result in additional investigation.

Case Studies and Additional Information

Case studies are provided to illustrate implementation of specific concepts found throughout MARSAME. The case studies cover a range of material, equipment, radionuclides, and disposition options. In addition, MARSAME contains several appendices to provide additional information on specific topics including:

- Copies of statistical tables needed to implement the information in MARSAME
- Sources of environmental radiation such as natural background and fallout
- Potential radionuclides grouped by industry or type of facility
- Information on specific measurement systems unique to disposition surveys
- Potential sources of action levels applicable to decisions regarding disposition of M&E

SIMILARITIES AND DIFFERENCES BETWEEN MARSSIM AND MARSAME

The MARSAME supplement expands the scope of MARSSIM methods and processes to provide technical information supporting the disposition decision for M&E, specifically the design and implementation of disposition surveys, to ensure the disposition decision is technically-defensible and optimized for efficiency. MARSSIM addressed the disposition of real property (e.g., buildings and land) where the only disposition options were unrestricted release, restricted release, or maintaining radiological controls. MARSAME addresses the disposition of non-real property (e.g., M&E) and includes additional options for future use including recycle or disposal as radioactive waste. Increasing radiological controls and interdiction are also included as potential disposition options. While several, or all, disposition alternatives may be acceptable for a specific project, optimizing the disposition survey design based on the selected disposition alternative is described in MARSAME.

MARSAME as a supplement to MARSSIM expands the scope of technically sound measurement processes and methods to include M&E. Table I summarizes the major similarities between MARSSIM and MARSAME, which result from application of a graded approach to support a technically-defensible decision regarding disposition. Table II summarizes the major

differences between MARSSIM and MARSAME, which result in part from the change from real to non-real property.

Table I. Similarities Between MARSSIM and MARSAME

Parameter	MARSSIM	MARSAME
Graded Approach	Used to place greater survey effort on areas that have, or had, the highest potential for residual radioactivity.	Used to place greater survey effort on M&E that have, or had, the highest potential for residual radioactivity.
Data Quality Objectives (DQO) Process	Used to design technically defensible surveys to support decisions on disposition of real property.	Used to design technically defensible surveys to support decisions on disposition of non-real property (e.g., M&E).
Data Quality Assessment (DQA)	Used to evaluate survey results and support a decision of whether to release real property.	Used to evaluate survey results and support a disposition decision for non-real property.
Process Knowledge	Used during the Historical Site Assessment to support the determination of whether an area is impacted and provide information for designing subsequent surveys.	Used during the Initial Assessment to support the determination of whether M&E are impacted and provide information for designing subsequent surveys.
Classification	Determines the level of survey effort based on the potential amount of residual radioactivity present.	Determines the level of survey effort based on the potential amount of residual radioactivity present.
Flexibility	MARSSIM allows and encourages flexibility in the design and implementation of final status surveys for application to diverse site conditions.	MARSAME allows and encourages flexibility in the design and implementation of disposition surveys for application to diverse M&E.
Statistics	Used to develop a technically defensible survey design.	Used to develop a technically defensible survey design.
Scale of Decision Making	A separate release decision is made for every survey unit.	A separate release decision is made for every survey unit.
Inherent Radioactivity	Inherent radioactivity is site-specific and generally cannot be separated from ambient radiation.	Inherent radioactivity is specific to the M&E being investigated. Segregation of M&E based on inherent radioactivity can be used to reduce measurement variability.

Table II. Differences Between MARSSIM and MARSAME

Parameter	MARSSIM	MARSAME
Scope	Surface soil and building surface surveys (i.e., real property).	Materials and equipment (i.e., non-real property).
Disposition Options	Restricted or unrestricted release, or fail to release.	Release survey (maintain, remove, or transfer of radiological controls; clearance for reuse, recycling, or disposal), or Interdiction survey (initiation of radiological controls or decision not to accept control of M&E).
Categorization	Included as part of classification in MARSSIM.	Separates the decision to survey from determining level of survey effort.
Application of the Graded Approach	Classification and survey unit size result in varying levels of survey effort.	Multiple disposition options result in varying levels of survey effort.
Sentinel Measurements	Not described in MARSSIM.	Allows use of sentinel measurements during IA to check validity of certain process knowledge assumptions.
Documentation of Survey Designs	Assumes project-specific survey designs will be developed for individual sites.	In addition to project-specific survey design, allows SOPs for categories of M&E to provide standard approach to disposition surveys.
Preliminary Surveys	Scoping and characterization surveys regularly used to obtain information needed to design a final status survey.	Scoping and characterization surveys rarely used to obtain information needed to design a disposition survey. Historical information obtained during the IA is generally sufficient to design a disposition survey. If not, preliminary surveys may be used to provide the necessary information.

Table II Differences Between MARSSIM and MARSAME (continued)

Parameter	MARSSIM	MARSAME
Ambient Radiation	Ambient radiation is site-specific and generally cannot be separated from inherent radioactivity.	Ambient radiation is selected based on location where disposition surveys are performed, and can be separated from inherent radioactivity.
Interdiction	Not addressed in MARSSIM.	Surveys may be performed to identify uncontrolled radioactive material resulting in the initiation of radiological controls, or deciding not to accept control of M&E.
Null Hypothesis	MARSSIM recommends using the null hypothesis: 'The activity in the survey unit exceeds the action level (Scenario A).' MARSSIM allows using the null hypothesis: 'The activity in the survey unit is indistinguishable from background (Scenario B) with information from NUREG-1505 (NRC 1998a).'	User selects the appropriate null hypothesis: 'The activity in the survey unit exceeds the action level (Scenario A).' or 'The activity in the survey unit is indistinguishable from background (Scenario B).'
Scan Survey to Release	Not addressed in MARSSIM	M&E may be released based on the results of scan-only surveys provided the scan measurements meet the MQOs for the survey.

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