MASTER FINAL STATUS SURVEY PLAN

New York District
Formerly Utilized Sites Remedial Action Program
Maywood Superfund Site

Prepared by:
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for:
US Army Corps of Engineers - Kansas City District
Formerly Utilized Sites Remedial Action Program
Contract No. DACW41-99-D-9001

US Army Corps
of Engineers

November 2001 Revision 1

FINAL

MASTER FINAL STATUS SURVEY PLAN

FUSRAP MAYWOOD SUPERFUND SITE
MAYWOOD, NEW JERSEY

SITE-SPECIFIC ENVIRONMENTAL RESTORATION
CONTRACT NO. DACW41-99-D-9001
TASK ORDER 001
WAD 04 WBS 05

Submitted to:

Department of the Army
U.S. Army Engineer District, New York
Corps of Engineers
FUSRAP Project Office
26 Federal Plaza
New York, New York 10278

Department of the Army
U.S. Army Engineer District, Kansas City
Corps of Engineers
700 Federal Building
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NOVEMBER 2001

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REVISIONS

Revision No.	Description of Revision		Date
0	Draft for NJDEP and USEPA review.		July 2001
1	General	Incorporate NJDEP and EPA comments on Master Final Status Survey Plan and property specific addenda (C-1).	November 29, 2001
	General	Incorporate NJDEP Comment/Response Matrix as Appendix B.	
	General	Include omitted tables in Appendix A.	
	Section 2.4.3	Modified statement on performing scans over pooled or saturated areas of water. Permit the scan of these areas when the MDC are re-evaluated to ensure elevated measurement comparison criteria are met.	
	Section 2.6.1	Closed quotation mark.	
	Section 3.4.2	In step 4 of performing the WRS test added text to read, "if there are t less than (<) the decision level (L_c) values..."	
	Section 4.4.1	Clarified decision errors for Class 3 as α=0.05 and β=0.10.	
	Section 5.5.2	Deleted reference to offsite data processing specialist.	
	Section 5.3	Provided for instances when GPS function is not available. In these instances, walkover data will be manually recorded.	
	Section 6.2.1	Changed calibration requirements from a facility with the appropriate NRC or agreement state license with NIST traceable standards to an upper tier ANSI standard.	
	Section A2.5	Revised exposure rate ratio units from 2700cpm uR/hr to 2700cpm/uR/hr.	

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ADDENDA

ACRONYMS AND ABBREVIATIONS

ARAR	Applicable or Relevant and Appropriate Requirement
cm^2	centimeters squared
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
cpm	counts per minute
DCGL or $DCGL_W$	Derived Concentration Guideline
DOE	U.S. Department of Energy
DQA	Data Quality Assessment
dpm	disintegrations per minute
DQO	Data Quality Objective
EMC	Elevated Measurements Comparison
EPA	U.S. Environmental Protection Agency
FSS	Final status survey
FUSRAP	Formerly Utilized Sites Remedial Action Program
g	gram
GGM	General Gas Mantel
GM	Geiger Mueller
hr	hour
HSA	Historical Site Assessment
HVAC	Heating Ventilation and Air Conditioning
LBGR	Lower Bound of the Gray Region
L_c	Critical level
L_d	Lower limit of detection
m^2	meters squared
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MCW	Maywood Chemical Works
MDC	Minimum Detectable Concentration
mrem	millirem
NIST	National Institute of Standards and Technology
NJDEP	New Jersey Department of Environmental Protection
NRC	U.S. Nuclear Regulatory Commission
pCi	picocurie
PDI	Pre-Design Investigation
QA	Quality Assurance
QC	Quality Control

RCRA	Resource Conservation and Recovery Act
RESRAD-BUILD	Department of Energy Computer Code; RESidual RADioactivity for Buildings
RI	Remedial Investigation
ROC	Radionuclides of Concern
SOR	Sum of the Ratios
μR	microRoentgen
USACE	U.S. Army Corps of Engineers
WRS	Wilcoxon Rank Sum (statistical test)
yr	year

1.0 INTRODUCTION

This plan documents the approach for implementing final status surveys (FSS) at the Formerly Utilized Site Remedial Action Program (FUSRAP) Maywood Superfund Site (the Site). The Master FSS Plan follows an approach that is consistent with the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM).

1.1 BACKGROUND

The Site includes the Maywood Interim Storage Site (MISS), the adjacent Stepan Company property (formerly Maywood Chemical Works, or MCW), and other vicinity properties, including numerous residential, commercial, federal, state, and municipal properties. A detailed remedial investigation (RI) to evaluate the nature and extent of radiological and chemical contamination at the Site was conducted in 1992. The RI included radiological surveys and environmental sampling and analysis. The history of the Site and the results of the RI are documented in the *Remedial Investigation Report for the Maywood Site* prepared by Bechtel National, Inc for the Department of Energy (DOE 1992). The RI identifies thorium-232 (Th-232), radium-226 (Ra-226), and natural uranium (U_{nat}) as the radioactive contaminants of concern in soil at the Site.

A total of 88 properties were identified for cleanup based on the RI and risk assessment findings. Cleanup of these properties is being approached in two phases. Phase I involved 64 properties (including all residential and municipal properties) that were remediated by the DOE or USACE. Phase II involves the remaining 24 commercial and governmental properties.

1.2 SCOPE

This Master FSS Plan addresses the Phase II properties. Cleanup activities at the Phase II properties will be accomplished in accordance with the Master Construction Work Plan. The objective of this plan is to provide a consistent approach for planning, performing, and assessing site soils through final status surveys in order to demonstrate compliance with established dose and risk-based release criteria.

2.0 DATA QUALITY OBJECTIVES

Data Quality Objectives (DQOs) are qualitative and quantitative statements that establish a systematic procedure for defining the criteria by which data collection design is satisfied in order to make determinations regarding remediated properties. The DQOs at Maywood include:

- Clarifying the project problem;
- Defining the data necessary for achieving the end use decisions;
- Determining the appropriate method of data collection; and
- Specifying the level of decision errors acceptable for establishing the quantity and quality of data needed to support the project decisions.

The overall Quality Assurance (QA) objective for this project is to develop and implement procedures for obtaining and evaluating data that meet the DQOs to ensure or confirm that the required remediation is accomplished. Specifically, radionuclide data will be generated to demonstrate that the properties have achieved the remediation criteria. QA procedures are established to ensure field measurements, sampling methods, and analytical data provide information that is comparable and representative of actual field conditions, and that the data generated are technically defensible.

To determine the project DQOs, a series of planning steps are used, as specified in the EPA Guidance for Data Quality Objective Process QA/G-4 to identify the data needed to support project decisions and develop a data collection program. The process is intended to be iterative, optimizing data collection to meet the applicable decision criteria. The seven steps, as applied to the Maywood Site, are detailed in the following sections.

2.1 STATE THE PROBLEM

Various properties in Maywood have, or have a potential for, elevated levels of radioactive material from processes involving chemical separation of monazite ores that took place prior to 1959. ROCs include Th-232, Ra-226, and natural uranium.

This FSS will be used to demonstrate that the residual radionuclide concentrations following remediation comply with concentration and exposure based criteria per the decision documents. The objective of FSS activities is to obtain data of sufficient quality and quantity to support an evaluation of the criteria for the properties. Compliance will be satisfied using guidance found in MARSSIM (EPA, 2000). Compliance will be demonstrated using:

- Soil samples
- Gamma surveys
- Dose calculations

The ultimate decision regarding site disposition will rest with the USACE and EPA decision makers.

2.2 IDENTIFY THE DECISION

Survey and sampling data will be evaluated with respect to the following in order to demonstrate compliance:

- Following remedial activities, do ROC concentrations at properties of the Maywood Site exceed natural background concentrations by more than the release criteria?

2.3 IDENTIFY INPUTS TO THE DECISION

Decisions will be based on the data received from a combination of survey and sampling events including, but not limited to: field surveys and laboratory analytical results. The objective of the survey and sampling activities are to identify the concentrations of residual radioactive material in the survey units. This information will allow determination of whether or not a survey unit is likely to be suitable for release. The average soil concentrations will be evaluated to verify that the radiological DCGLs are met.

2.4 DEFINE THE STUDY BOUNDARIES

2.4.1 Data Population

The data population of interest for the properties is the concentration of ROCs and their associated comparison to the release criteria in surface and subsurface soils. A separate data population of concern is the activity concentration of ROCs in the designated background reference area.

2.4.2 Spatial and Temporal Boundaries

The information will be subdivided geographically by survey units. The spatial boundaries of the project are horizontally limited to land areas located in the property boundaries. The vertical study area extends from the land surface to the depth of up to 5 meters below ground surface, depending on the specific previous contamination events at the properties. The study period begins with acceptance of this document by the USACE and EPA decision makers and runs throughout the duration of the Maywood Site property remediation action.

2.4.3 Constraints on Data Collection

Appropriate constraints will be placed on data collection to ensure high quality data is collected. All samples will be taken in accordance with the methodology identified in this Master FSS plan, as well as applicable Maywood project standard operating procedures (SOPs) contained in the Chemical Data Quality Management Plan (CDQMP) (USACE, 2000). Prudent sample collection scheduling will be employed to ensure that surface samples are not taken in Class 2 or Class 3 survey units until Class 1 remedial excavations have been sampled and achieved their release criteria, thus minimizing the potential for cross contamination. In addition, scan minimal detectable concentrations will be evaluated on a case by case basis in areas such as over pooled water or water-saturated soil, to ensure elevated measurement comparison criteria are met.

2.5 DEVELOP A DECISION RULE

2.5.1 Parameter of Interest

Parameters of interest are the mean, median, and standard deviation of data collected during the study. Nonparametric statistical tests (as discussed in Section 3.4) will be utilized to determine whether or not the level of residual activity uniformly distributed throughout the survey unit exceeds the $DCGL_W$. Since these methods are based on ranks, the results are generally expressed in terms of the median. In some cases, the mean may exceed the median. For this reason, the arithmetic mean of the survey unit data will also be compared to the $DCGL_W$ as a first step in the interpretation of the data. By using a graded approach to data testing as discussed below, decisions will be made according to the decision rule stated at the end of this discussion.

2.5.2 Scale of Decision Making

Decisions are made on two fundamental scales, the survey unit and smaller localized areas of elevated activity. Localized areas of elevated radiation levels are evaluated on an ongoing basis throughout the field effort. In cases where clear indications of elevated measurements are observed, decisions on remediation, survey unit subdivision, etc., may be taken as appropriate. On a larger scale, and as a final determination, data will be evaluated on a survey-unit specific basis. Survey unit boundaries will be established according to the methodology discussed in Section 4.2. For localized surface soil areas with radioactive concentrations above the $DCGL_W$, an elevated measurement comparison (EMC) will be performed (Section 3.4.2).

2.5.3 Action Level

Decisions on a survey unit's acceptability are based on a comparison of the measured residual radioactivity concentrations in survey units and the background, subject to applicable statistical analyses specified in MARSSIM. The USACE has established the Release Criteria (Residual Radioactivity Limits) that will be utilized (See Section 3.1).

2.5.4 Decision Inputs

Scanning and analytical results (soil gamma and alpha spectroscopy) will be used to evaluate the effectiveness of remedial activities. Results will be compared to soil cleanup criteria discussed in Section 3.1 and summarized in Table 1. Determination of whether or not ROC concentrations at properties of the Maywood Site exceed background concentrations by more than the release criteria following remedial activities will be made using all collected data and a strict statistical methodology (discussed in detail in Section 3.4). If the survey unit does not meet the DCGLs, further investigation is warranted. This application of decision rules (Section 4.5) or investigation levels may prompt; additional samples, further remediation, or reclassification of the survey unit. If the survey unit meets the DCGLs, no further remediation will be required.

2.6 DEFINE ACCEPTABLE LIMITS ON DECISION ERRORS

The decisions necessary to determine compliance with the soil cleanup criteria are based on precise statistical statements called hypotheses. These hypotheses will be tested using data from a survey unit. The state that is presumed to exist is expressed as the null hypothesis (H_0). For a given Null Hypothesis, there is a specified Alternative Hypothesis (H_a) that is an expression of what is believed to be the state of reality if the null hypothesis is not true.

2.6.1 Null and Alternative Hypotheses

The hypotheses selected for the FSS are as follows:

> Null Hypothesis (H_0):
> The median concentration in the survey unit exceeds the median concentration in the reference area by more than the $DCGL_W$.

Versus:

> Alternative Hypothesis (H_a):
> The median concentration in the survey unit does not exceed the median concentration in the reference area by more than the $DCGL_W$.

These hypotheses were chosen because the burden of proof is on the Null Hypothesis. Therefore, the survey unit will not be released until proven to meet the cleanup criteria. The measured median concentration in the survey unit must be less than the $DCGL_W$ in order to pass.

These hypotheses also were chosen because contamination below the $DCGL_W$ is measurable. Releasing a survey unit that requires additional remediation is an unacceptable alternative.

Statistically based decisions will be utilized for evaluating the release criteria. Statistical acceptability decisions, however, are always subject to error. Two possible error types are associated with such decisions. These are discussed below and summarized in Table 4.

The first type of decision error, called a Type I error, occurs when the null hypothesis (H_o) is rejected when it is actually true. A Type I error is sometimes called a 'false positive'. The probability of a Type I error is usually denoted by α. This error could result in higher potential doses to future site occupants than prescribed by the dose-based criterion. Therefore, for the purposes of this study, the maximum Type I error rate will be set to 0.05.

The second type of decision error, called a Type II error, occurs when the null hypothesis is not rejected when it is actually false. A Type II error is sometimes called a 'false negative'. The probability of a Type II error is usually denoted by β. The power of a statistical test is defined as the probability of rejecting the null hypothesis when it is false. It is numerically equal to $1\text{-}\beta$. Consequences of Type II errors include unnecessary remediation expense and project delays. For Class 1 and 2 survey unit evaluations, the maximum Type II error rate will be β=0.05. For Class 3 survey unit evaluations, the maximum Type II error rate will be β=0.10.

2.6.2 Relative Shift

The lower boundary of the gray region (LBGR) and the target values for α and β are selected during the DQO process. For FSS planning purposes at the Maywood Site properties, the LBGR is set to one half the $DCGL_W$. The width of the gray region (DCGL - LBGR), is a parameter that is central to WRS test. This parameter also is referred to as the shift, Δ. The absolute size of the shift is actually of less importance than the relative shift Δ/σ, where σ is an estimate of the standard deviation of the measured values in the survey unit. This estimate of σ includes both the real spatial variability in the quantity being measured and the precision of the chosen measurement system. The relative shift, Δ/σ, is an expression of the resolution of the measurements in terms of measurement uncertainty. The value of the relative shift is used to calculate the number of samples required to demonstrate that a survey unit has met the applicable release criteria.

2.7 OPTIMIZE THE DESIGN

The variability of data will have an effect on the sampling design. If necessary, the sample frequency and the analytical procedures will undergo changes to optimize the design. Changes will occur concurrently for several steps with the DQO process. The design options, such as sample collection design, sample size, and analytical procedures will be evaluated based on cost and the ability to meet the DQOs. The number of measurement and sample locations are addressed in Section 4.4.1. This FSS design follows the framework for design outlined in Sections 4 and 5 of MARSSIM (EPA, 2000).

3.0 FINAL STATUS SURVEY CRITERIA

The purpose of this section is to describe the technical approach to FSS that will be implemented at the Maywood Site properties. Site-specific soil cleanup criteria must be met before the Maywood Site properties may be released for unrestricted use. Federal guidance listed below provide acceptable methodology to demonstrate compliance with project goals:

- Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM, EPA 2000); and
- NUREG-1505, A Nonparametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys (NRC 1998).

A major component of a survey design is the efficient use of sampling at distinct locations combined with scanning to accurately determine the final status of a survey unit. The statistical procedures described in this section are used to establish the number of samples taken at distinct locations needed to determine if the median concentration in the survey unit exceeds the regulatory limit, with a specified degree of precision. Thus, these statistical procedures are essential in the planning and design of the FSS and the analysis and interpretation of the resulting data.

The survey and sampling approach for Maywood Site properties described below encompass both sampling at discrete points and scanning of the excavation. In this manner, both the average concentration and elevated areas of residual radioactive material exceeding the cleanup criteria are addressed.

The following sections describe the MARSSIM process.

3.1 RELEASE CRITERIA (RESIDUAL RADIOACTIVITY LIMITS)

The objective of FSS activities is to obtain data of sufficient quality and quantity to support an evaluation of the criteria for the properties. The USACE must adequately demonstrate that the average radiological residual concentrations in the soil do not exceed the DCGLs in order to release the site. The DCGLs are based on acceptable dose equivalent limits and are the soil cleanup criteria.

The Maywood Site cleanup criteria for residential and commercial properties are summarized in Table 1. Remediating the site to these levels eliminates the risk of exceeding the CERCLA risk range of 10^{-6} to 10^{-4} (EPA, 1997) and applicable or relevant and appropriate requirement (ARAR) dose limitations.

The soil cleanup criteria for residential soils is an average concentration of 5 pCi/g of Ra-226 and Th-232 combined and an average concentration of 100 pCi/g total uranium, above background, regardless of depth.

The soil cleanup criteria for commercial surface soils (to a depth of 15 cm) is an average concentration of 5 pCi/g of Ra-226 and Th-232 combined and an average concentration of 100 pCi/g of total uranium, above background. The soil cleanup criteria for commercial subsurface soils (below a depth of 15cm) is an average concentration of 15 pCi/g of Ra-226 and Th-232 combined and an average concentration of 100 pCi/g of total uranium, above naturally occurring background.

For the Maywood Site properties, with potential multiple contaminants, it may be possible to measure just a few of the contaminants and still demonstrate compliance for all of the contaminants present with surrogate measurements. For example, the isotopes that comprise natural uranium are uranium-234 (U-234), uranium-235 (U-235), and uranium-238 (U-238), and are represented by 0.489, 0.022, and 0.489 activity fractions, respectively. Therefore, for a 100 pCi/g total uranium cleanup criteria, a nuclide-specific cleanup criteria for U-238 of 49 pCi/g will be used to demonstrate compliance with the total uranium cleanup criteria (note that some documents round this value to 50). In addition, actinium-228

(Ac-228) is often used as a surrogate quantifier of Th-232 using gamma spectroscopy, with the assumption that the two are in equilibrium.

3.2 BACKGROUND REFERENCE AREA AND DATA

A background reference area is a geographical area from which representative samples of background conditions are selected for comparison with samples collected in specific survey units at the remediated site (NRC, 1998). The background reference area has similar physical, chemical, radiological, and biological characteristics to the site being remediated, but is not contaminated by site activities (NRC, 1998). The distribution of background measurements in the reference area should be similar to the distribution of measurements in the survey unit.

The current background values for radiological constituents are presented in Table 2. These values reflect samples taken at non-impacted locations. A separate background study is also being performed at non-impacted Saddle River Park. The background (reference area) data will be revised when this study is completed (USACE, 2001).

The radioisotope activity values obtained from these investigations will be adjusted using DCGLs, compared to the survey unit, and used to determine if the site cleanup criteria were met. Therefore, the background sample analysis will be done to meet the FSS DQOs and Quality Assurance as discussed in the Background Study Work Plan (USACE, 2001).

3.3 SURVEY UNIT CLASSIFICATION

As discussed in MARSSIM, site areas being final status surveyed should be classified according to their potential for residual radioactivity. The classification process is discussed in detail in MARSSIM Sections 2.2, 4.4, 5.5.2, and 5.5.3, and is defined in the glossary (EPA, 2000). Each Maywood Site property has been classified as impacted.

3.3.1 Non-Impacted

Non-impacted areas are those areas identified through knowledge of site history or previous survey information where there is no reasonable possibility (extremely low probability) for residual radioactive contamination.

3.3.2 Impacted

According to MARSSIM, impacted areas have a potential for radioactive contamination (based on historical data) or contain known radioactive contamination (based on past or preliminary radiological surveillance). This includes areas where:

- Radioactive materials were used and stored;
- Records of spills, discharges, or other unusual occurrences resulting in the spread of contamination; and
- Radioactive material was buried or disposed.

Areas immediately surrounding or adjacent to these locations are included in this classification due to the potential for the inadvertent spread of contamination. Areas with the potential for residual contamination (impacted areas) are further divided into one of three groups, as defined by MARSSIM.

For the purposes of this Master FSS design, each of the 24 remaining Phase II properties is considered impacted. The following schema will be utilized to further classify specific survey units within each property:

Class 1

Class 1 areas will include areas that have, or had prior to remediation, a potential for radioactive contamination or known contamination that exceed the $DCGL_W$. For the purposes of the Master FSS, areas that meet the following criteria will be considered as requiring a Class 1 FSS:

- Property areas previously subjected to remedial actions; or
- Areas with previously identified contamination above the $DCGL_W$; or
- Excavated areas (including the area between the toe of the slope of the excavation).

Class 2

Class 2 areas will include all areas that have a potential for radioactive contamination or known contamination, but are not expected to exceed the $DCGL_W$. For the purposes of the Master FSS, areas that meet the following criteria will be considered as requiring a Class 2 FSS:

- Areas with previously identified contamination at a factor of 2 times above the background (e.g. >3.4 pCi/g based on current background information for Th-232 + Ra-226); or
- Areas with the potential for contamination from migrated fill material or contamination that has been carried by the Lodi Brook into the property.

Class 3

Impacted areas that are not expected to contain any residual radioactivity, or are expected to contain levels of residual radioactivity at a small fraction of the $DCGL_W$, based on site operating history and previous radiological surveys. Examples of areas that might be classified as Class 3 include areas around Class 1(with appropriate data from characterization) or Class 2 areas and areas with very low potential for residual contamination but insufficient information to justify a non-impacted classification.

The suggested maximum survey unit size for the variously classified areas are given in Table 3. These areas are suggested because they give a reasonable sampling density. However, the size and shape of a particular survey unit may be adjusted to conform to the existing features of the particular property survey unit area.

3.4 STATISTICAL CONSIDERATIONS

This section introduces several terms and concepts associated with the statistical compliance verification methods implemented at the Maywood Site properties.

A sufficient number of samples determined in accordance with Section 4.4.1 will be obtained from each survey unit. These samples will be analyzed for the radionuclides of concern. The activities of these radionuclides will be compared to their respective DCGLs. The WRS test will be applied to the data if necessary to test the null hypothesis identified in Section 2.6.1.

3.4.1 Type I and Type II Errors

As discussed in Section 2.6.1, there are two types of decision errors that can be made when performing the statistical tests described in this document; Type I error and Type II error. These designations are used to describe the relationship of errors to the Null and Alternative Hypothesis (Table 4).

The standard deviation of the results of the remedial surveys for Class 1 excavated areas and the standard deviation of the Preliminary Design Investigation (PDI) sample results will be used for Class 2 and Class 3 areas. The standard deviations will be adjusted by a factor of 1.5 times to ensure that sufficient statistical power exists for the tests. Using this assumed standard deviation, a relative shift will be determined and the calculations in Section 4.4.1 will be used to identify the number of samples that need to be taken from each survey unit.

After the samples are analyzed, the actual standard deviation of each survey unit will be used to recalculate the relative shift and verify that enough samples were taken for the data set. If it is determined that an insufficient number of samples were taken, additional samples will be taken from that survey unit as required.

The locations of the samples within each survey unit will be determined based on the area being surveyed. Final status sampling is described in depth in Section 4.4.

3.4.2 Statistical Tests

The WRS test discussed in this section will be used to compare each survey unit with the reference area. This test was chosen because contamination is present in the background at the Maywood Site.

The comparison of measurements from a reference area to the survey unit is made using the WRS test (MARSSIM). The WRS test is effective when residual radioactivity is uniformly present throughout a survey unit (i.e., the sample distribution is symmetrical). The test is designed to detect whether or not activity exceeds the $DCGL_W$.

The Null Hypothesis is assumed to be true unless the statistical test indicates that it should be rejected in favor of the alternative. It is assumed that any difference between the reference area and survey unit concentration distributions is due to a shift in the survey unit concentrations to higher values (i.e. due to the presence of residual radioactivity in addition to background that exceeds cleanup criteria). Survey units may meet the release criteria even though some measurements may be greater than some reference area measurements. Also, survey unit measurements may exceed some reference area measurements by more than the $DCGL_W$. The result of the hypothesis test determines whether or not the survey unit as a whole meets the release criterion.

Two underlying assumptions of the WRS test are:

- Samples from the reference area and survey unit are independent, identically distributed random samples; and
- Each measurement is independent of every other measurement, regardless of the set of samples from which it came.

If all of the sample results are less than the $DCGL_W$ then no WRS statistical evaluation is required.

Performing the Wilcoxon Rank Sum Test

The WRS test is applied as outlined in the following six steps by MARSSIM:

Step 1

Obtain the adjusted reference area measurements, Z_i, by adding the $DCGL_W$ to each reference area measurement, X_i. $Z_i = X_i + DCGL_W$.

Step 2

The *m* adjusted reference sample measurements, Z_I, from the reference area and the *n* sample measurements, Y_I, from the survey unit are pooled and ranked in order of increasing size from 1 to N, where $N = m + n$.

Step 3

If several measurements are tied (i.e., have the same value), they are all assigned the average rank of that group of tied measurements.

Step 4

If there are *t* less than (<) the decision level (L_c) values, they are all given the average of the ranks from 1 to *t*. Therefore, they are all assigned the rank $t(t+1)/2t = (t+1)/2$, which is the average of the first *t* integers. If there is more than one detection limit, all observations below the largest detection limit should be treated as < values.

Step 5

Sum the ranks of the adjusted measurements from the reference area, W_r. Note that since the sum of the first N integers is N(N+1)/2, one can equivalently sum the ranks of the measurements from the survey unit, W_s, and compute $W_r = N(N+1)/2 - W_s$.

Step 6

Compare W_r with the critical value given in MARSSIM Table I.4, Critical Values for the WRS Test, for the appropriate values of *n*, *m*, and α. If W_r is greater than the tabulated value, reject the Null Hypothesis that the survey unit exceeds the release criterion. The standard deviation of the sample set is then calculated to establish the relative shift of the test. The relative shift is used to investigate whether or not the survey unit has the proper number of samples (See Section 2.6.2 and Section 4.4.1)

Elevated Measurement Comparison

An EMC will be performed on localized surface soil areas and the bottom surface of excavated areas with radioactive concentrations above the $DCGL_W$. For subsurface residual radioactivity, there is no adjustment to the grid spacing for the elevated measurement comparison because scanning is not applicable (NRC, 2000). The EMC will only be performed for surface (i.e. 0-15 cm below ground surface, or below the bottom surface of excavated areas) soil sample locations in Class 1 survey units.

Any surface areas with radioactive concentrations above the $DCGL_W$ that are easily removable will be excavated prior to continuing the FSS of a survey unit. USACE will be notified of any areas where an EMC will be performed.

A surface area EMC is performed by comparing an area of elevated residual radioactivity against the $DCGL_{EMC}$. If a measurement exceeding the $DCGL_W$ is confirmed, the size of the area of elevated activity, A, and the median concentration, C_A, within it will be determined by sampling the area of elevated contamination. Using the area factor, F_A, for the area, A, C_A will not exceed (F_A) * ($DCGL_W$). A table of F_A values is presented as Table 5. The most restrictive value of F_A, Th-232, will be used for Class 1 survey units.

A calculation will be made after the EMC has been completed. The calculation will ensure that the total activity in the survey unit is within release criterion established for the FSS. For the calculation, the average concentration in the elevated area and the average concentration in the entire survey unit (δ) is used. The survey unit fails if the calculation results are greater than one, resulting in further excavation of the survey unit. The calculation follows:

$$\frac{\delta}{DCGL_W} + \frac{(average\_concentration\_in\_elevated\_area - \delta)}{(area\_factor\_for\_elevated\_area)(DCGL_W)} < 1$$

4.0 MASTER FINAL STATUS SURVEY DESIGN

This plan is prepared as a master FSS plan. The purpose of this plan is to identify standard DQOs, assumptions, technical approaches, and methodologies. Although specific decisions will be formulated on a property-by-property evaluation, a number of concepts will be applied on a consistent basis. These include establishing reference coordinate systems, survey unit identification, scanning surveys, discrete sampling, and application of the decision rules. These are discussed in generic detail below. For each property, a property-specific evaluation will be performed and documented as an addendum to this Master FSS. Survey and construction schedules are unique to each property and will be presented in the property-specific evaluation, e.g., portions of a final status survey such as subsurface sampling may be performed prior to excavation with surface sampling performed post excavation activities. In each property, the FSS design will be consistent with this Master FSS. Properties that significantly deviate from the FSS design, such as the class designation of an area or a reduction or increase in the number of samples by 25%, should require further regulatory discussion. A summary of the integrated survey design is presented in Table 7.

4.1 ESTABLISH SURVEY REFERENCE COORDINATE SYSTEM

To facilitate both survey measurements and data analysis, a survey reference coordinate system will be developed and installed early in the survey process. All coordinates will be referenced to the state plane coordinate system. At a minimum, the corners of survey units will be identified and clearly marked. Additionally, to facilitate the walkover survey process, intermediate markings may be installed to mark the start and end points of planned survey lines. Use of a Global Positioning System (GPS) reduces the need for marking small grid intervals.

4.2 IDENTIFY SURVEY UNITS

As defined in MARSSIM, a survey unit is a physical area consisting of structures or land areas of specified size and shape for which a separate decision will be made as to whether or not that area exceeds the release criterion. As a result, the survey unit is the primary entity for demonstrating compliance with the release criterion.

To facilitate survey design and ensure that the number of survey data points for a specific site are relatively uniformly distributed among areas of similar contamination potential, the site is divided into survey units that share a common history or other characteristics, or are naturally distinguishable from other portions of the site.

A survey unit should not include areas that have different classifications. Therefore, the classification schema discussed in Section 3.3 will be considered when identifying survey units. In addition, survey units should be limited in size based on classification, modeling assumptions, and site-specific conditions. The suggested areas for survey units are listed in Table 3.

For the purposes of this Master FSS Plan, Class 1 survey units should be contiguous areas; Class 2 and Class 3 survey units need not be contiguous areas. In addition, special considerations may be necessary for survey units with land areas less than 100 m^2. In this case, the number of data points obtained from the statistical tests is unnecessarily large and not appropriate for smaller survey unit areas. Instead, the level of survey effort should be determined collectively based on nearby similarly classified survey units. The determination of these areas will be based on judgment and will be specifically discussed in each property-specific FSS plan.

4.3 SCANNING SURVEY

MARSSIM suggests that scan surveys for Class 1 survey units be performed to cover 100% of the accessible areas in each survey unit. Class 2 survey unit scans can be performed over 10% of the accessible area. The purpose of the gamma/beta scan survey is to identify areas of elevated radioactivity.

For the purposes of this Master FSS design scan surveys will be performed to cover 100% of all accessible areas in each survey unit classified as Class 1, Class 2, or Class 3. The instrumentation and minimum detectable concentration for these scan surveys are discussed in detail in Section 5.3.

4.4 DISCRETE SAMPLES

The results of the FSS determine if residual radiological concentrations are present in soil at levels that meet the radiological soil cleanup goals presented in Table 1. Discrete sampling is performed to determine the radiological parameters needed to apply the statistical tests identified in this Master FSS design. The radiological parameters are measured in picoCuries per gram (pCi/g) on a dry weight basis. Laboratory analysis by gamma spectroscopy will assume U-234 in equilibrium with U-238 and Th-232 in equilibrium with Ac-228. If allowed sufficient time for ingrowth, Ra-226 will be assumed in equilibrium with Bi-214, or an ingrowth correction factor will be determined and applied.

4.4.1 Frequency of Discrete Samples

The WRS statistical test will be used to determine whether portions of the Site are considered to be suitably free of residual radioactivity. The minimum number of systematic measurement locations required in each survey unit for the WRS statistical test is determined using the following equation from Section 5.5.2.2 of MARSSIM. It relies on P_r, the probability that a random measurement from the survey unit exceeds a random measurement from the background reference area by less than the DCGL when the survey unit median is equal to the LBGR above background (based on the relative shift from Section 2.6.2.

$$\frac{N}{2} = \frac{1}{2} x \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{3(P_r - 0.5)^2}$$

Where:

$N/2$ = the minimum # of measurement locations per survey unit or reference area

$Z_{1-\alpha}$ = the percentile represented by the decision error α (Type I)

$Z_{1-\beta}$ = the percentile represented by the decision error β (Type II)

P_r = the probability that a random measurement from the survey unit exceeds a random measurement from the background reference area by less than the cleanup criterion when the survey unit median is equal to the ‘Lower Boundary of the Gray Region’, assumed to be ½ the value of the cleanup criterion, above background

Section 2.6.1 establishes the acceptable decision errors for Class 1 and Class 2 as α=0.05 and β=0.05, and for Class 3 as α=0.05 and β=0.10. Based on these acceptable decision errors, $Z_{1-\alpha} = Z_{1-\beta}$ = 1.645 (from

Table 5.2 in MARSSIM). Using the relative shift for each property, a specific P_r will be obtained from Table 5.1 in MARSSIM. Thus, using the above equation, the minimum number of measurement locations in the survey unit will be calculated. MARSSIM suggests that additional measurements and/or samples be collected (MARSSIM recommends 20% additional) to protect against the possibility of lost or unusable data. As such, a minimum number of measurement locations will be determined for each survey unit. After analytical results are received, the number of samples will be recalculated using statistics derived from the survey unit analysis. Additional samples may be taken as necessary.

4.4.2 Scan Minimum Detectable Concentration Considerations

For surface areas, a dose area factor may also be used to evaluate the magnitude by which the concentration within a small area of elevated activity can exceed the $DCGL_W$ while maintaining compliance with the release criterion. The following formula is listed in Section 5.5.2.4 of MARSSIM for determining the necessary scan sensitivity when incorporating the area factor:

Scan MDC (required) = ($DCGL_W$) x (Area Factor)

If the actual scan MDC is less than the required scan MDC, additional discrete samples are not required to ensure that the dose-based criterion is satisfied. For the purposes of this Master FSS, scan MDCs are estimated in Appendix A and are found to be less than the required scan MDCs.

4.4.3 Location of Surface Samples

Surface samples (0-15 cm below ground surface) will be taken in all impacted survey units based on the number of samples required (Section 4.4.1). A systematic grid will be utilized to identify survey unit sample locations for Class 1 and Class 2 surface samples. The use of a systematic grid allows conclusions to be drawn about the size of any potential areas of elevated activity based on the area between measurement locations, while the random starting point of the grid provides an unbiased method for determining measurement locations for the statistical tests. Random measurement patterns are used for Class 3 survey units to ensure that the measurement locations meet the requirements of the statistical tests.

For systematic sampling, a triangular grid will be established for each survey unit based on its area. The grid spacing for each survey unit will be determined using the following equation (Equation 5-7 from MARSSIM):

$$L = \sqrt{\frac{A}{0.866(N)}}$$

Where:

L = triangular grid spacing for survey unit (m)
A = area of survey unit (m^2)
N = number of sample locations

A random start point will be generated and systematic sample locations will be marked in a triangular grid spacing calculated using the equation above. A random number generator will be used to identify a coordinate location (e.g., N5060, E10060). The value of L will be rounded down to the nearest whole number. After L is determined, a row of points is identified parallel to the X-axis, at intervals of L. A second row of points will then be developed parallel to the initial row at a distance 0.866*L from the first row. Sampling locations along the second row are midway (on the X-axis) between the points on the first row. This process will be repeated to determine the sampling locations in each grid. Grids are presumed in a single flat plane, continuing with a suitable number of sample locations. If the sample spacing does not result in sufficient number of locations required, additional sampling will be determined randomly (through the use of random number generator).

4.4.4 Location of Subsurface Samples

Subsurface sampling will be performed to assess the extent and location of any residual radioactivity in the survey units. For Class 2 survey units, subsurface sampling will be performed at the sample locations identified in Section 4.4.3 (i.e. in the same location as surface samples). For Class 1 survey units, subsurface sampling will only be performed at those locations where remedial excavation was not performed. This is based on the fact that excavated areas (within the 'toe of the slopes of the excavation') will be surveyed as a surface area. Therefore, non-excavated areas in Class 1 survey units may have residual radioactivity that will need to be assessed with subsurface sampling. Class 3 subsurface sampling will not be conducted unless determined by professional judgment to be appropriate in the property specific FSS plan.

The sampling methodology for subsurface samples is discussed in detail in Section 5.4.2.

4.5 APPLY DECISION RULES USING STATISTICAL TESTS

4.5.1 Field Measurements of Survey Unit Dimensions

For each property, the survey unit sizes will be adjusted to fit suggested maximum survey unit sizes (Table 3) where possible. Site aspects may require survey unit sizes slightly larger than these suggested sizes. Such instances will be discussed in the property-specific FSS plans.

4.5.2 Gamma Walkover Survey in Survey Units

A biased soil sample will be collected at the location where the highest gamma walkover datum point is observed. If areas exceeding three standard deviations above the average are observed (i.e., a Z-score ≥ 3.0), additional measurements and soil samples may be collected at the discretion of the project manager.

4.5.3 Sample Results: WRS Statistical Test

If all sample results for the survey unit have associated concentrations that are less than the release criteria, the survey unit is deemed radiologically appropriate for release. If any of the sample results for the survey unit exceed an appropriate release criteria (Table 1), perform the WRS test. If W_r, the sum of the adjusted reference area ranks from the WRS test, is greater than the applicable critical value, then the mean value for residual radioactivity in the survey unit is less than the $DCGL_W$ to the specified confidence level. In this case, the null hypothesis is rejected and the survey unit is deemed to be appropriate for release, assuming all EMC are addressed. If W_r is less than the critical value, the null hypothesis is accepted and the survey unit is not considered to meet the release criteria and further remediation may be evaluated.

5.0 FINAL STATUS SURVEY METHODOLOGY

5.1 SAFETY

During implementation of the FSS, safety and health protection will be ensured through the implementation of the Maywood Site Safety and Health Program (USACE, 1999b).

5.2 DEVELOP PROPERTY-SPECIFIC FSS DESIGN

Prior to performing a FSS in a Maywood Site property, the following information will be developed and captured as an addendum to this Master FSS plan:

- A computer-aided-design (CAD) drawing will be prepared showing the property boundaries and layout.
- The remedial design excavation limit lines.
- The preliminary design investigation identified contamination limit lines.
- An indication of sample locations that exhibit Th-232+Ra-226 radioactive concentrations greater than 2x above background radioactive concentrations.
- The depth of this maximum Th-232+Ra-226 radioactive concentration.
- The depth of the deepest sample that exhibits Th-232+Ra-226 radioactive concentrations greater than 2x above background radioactive concentrations.
- The number and initially assumed layout of each type of MARSSIM classified survey units (i.e. Class 1, Class 2, and/or Class 3) for the property. Note that these survey unit classifications and layout may be adjusted later based on field measurement results.
- Property-specific information that may effect the FSS design (e.g. location of historical burial areas, Lodi Brook lines, or other historical site assessment information).
- Survey schedule.

5.3 SCANNING SURVEY METHODOLOGY

Gamma walkover scan (GWS) surveys will be performed to cover 100% of Class 1, 2, and 3 survey units. Scan surveys will be performed using a 3” x 3” Sodium Iodide (NaI) detector coupled with a rate-meter/scalers that is configured to output directly to a Global Positioning System (GPS) unit.

MARSSIM Section 6.7.2.1 describes the methodology used to calculate the Scan Minimum Detectable Concentrations (MDCs) for land areas that are delineated in MARSSIM Table 6.7. Appendix A to this document presents detailed instrument sensitivity calculations. The scan MDC for a 3-in x 3-in sodium iodide detector based on site-specific geometry and shield factors are presented in Table 6. The MDCs are based on a scan speed of 0.5 meters per second and a minimum contaminated area 56 cm in diameter and 15 cm in thickness.

The gross gamma walkover scan survey in this plan was designed using these parameters. The basic method for performing a gamma walkover survey is to walk along a path while moving the sodium iodide detector from side to side. A 1-meter path length will be used to perform the survey. The side-to-side motion of the detector must be 0.5 meters per second to meet the design criteria. Therefore, each detector pass will take 2 seconds (i.e. 1m / 0.5 m/s).

The GPS will provide high quality, precision geospatial positioning data to support data verification, and remediation. The rate-meter/scalars used for this work plan will be configured to output directly to the GPS unit. The GPS unit will perform data logging functions. There may be instances where GPS data may not be available, such as alongside buildings and in areas excavations. In these instances, walkover data will be manually recorded.

5.4 SAMPLING METHODOLOGY

5.4.1 Surface Samples

Surface samples for the FSS will be taken using a stainless steel trowel at a depth of 15 centimeters in accordance with procedures contained within the site CDQMP (USACE, 2000). The sample will placed into stainless steel bowl and be thoroughly mixed. The homogenized soil will then be placed in a suitable container. The sample containers will be transferred to the laboratory for gamma and alpha spectroscopy analyses.

5.4.2 Subsurface Samples

As discussed in Section 4.4.4, for Class 2 survey units, subsurface sampling will be performed at the sample locations identified in Section 4.4.3 (i.e. in the same location as surface samples). For Class 1 survey units, subsurface sampling will only be performed at those locations where remedial excavation was not performed. Subsurface samples will be obtained in accordance with procedures referenced in the site CDQMP.

Continuous soil core geoprobes (or similar technology) will be utilized to sample subsurface soils. Soil cores will be drilled to the point below ground surface that coincides with the deepest location where contamination had been identified during characterization surveys for that survey unit or where there is the potential for contamination, based on historical data and assumptions. Soil cores will be extended to a depth of at least one-foot beyond the deepest excavation elevation, where possible. Downhole gamma logging will be performed using a sodium-iodide gamma detector. Readings will be obtained every foot below ground surface.

A minimum of two samples will be obtained at each subsurface sampling location. These will consist of one sample at the depth where the maximum gross gamma measurement is observed. And one sample at the deepest elevation of excavation in other portions of the property or one foot beyond the apparent fill depth based on whichever is encountered first, i.e., the highest elevation. Additional subsurface soil samples may be collected at the discretion of the project manager. The sample containers will be transferred to the laboratory for analyses.

5.5 DATA PROCESSING

5.5.1 Field Records

Project data will be recorded and controlled in accordance with SOP SW-MWD-507, *Field Notebook Content and Control*.

5.5.2 Electronic Data

Electronic data collected during the day will be backed-up at the end of the same day in the field (e.g. to tape or zip drive) and before processing or editing. This is an archive of the raw data and, once created, shall not be altered. More than one day’s data may go on a single tape or zip disk. Field computer(s) used to store GPS data will be backed up weekly. Raw archived data will be stored in a different location from weekly backups. The time and data that data files are transmitted will be recorded in the data logbook. File names will be verified by comparison with field notes and corrected if necessary, following approval by the project manager.

5.5.3 Post Processing

Post-processing specialists will convert daily GWS/GPS data to state plane coordinates, as necessary, and review the data for errors to fluctuations/interferences in the GPS signal. Post-processing specialists will be able to determine qualitatively, by density of recorded GPS positions, rapid or increased velocity of the surveyor performing the GWS, which could have an adverse effect on the predicted scan MDC. Post-processing specialists will inform the project manager of any identified deficiencies and will make corrections as directed. All conversions, errors, corrections, and/or adjustments to project data shall be documented in the data logbook.

6.0 QUALITY ASSURANCE / QUALITY CONTROL (QA/QC)

6.1 PROJECT QA / QC

Activities associated with this Master FSS plan shall be performed in accordance with written procedures and/or protocols in order to ensure consistent, repeatable results. Topics covered in project procedures and protocols may include proper use of instrumentation, QC requirements, equipment limitation, etc.

For all activities associated with the Maywood Site remediation, the project QA/QC procedures shall apply including the Maywood CDQMP (USACE, 2000).

In addition, specific QA/QC requirements are listed below.

6.2 FIELD INSTRUMENTATION REQUIREMENTS

The project manager is responsible for determining the instrumentation required to complete the requirements of this work plan. Only instrumentation approved by the project manager will be used to collect radiological data. The project manager is responsible for ensuring individuals are appropriately trained to use project instrumentation and other equipment, and that instrumentation meets the required detection sensitivities. Instrumentation shall be operated in accordance with either a written procedure or manufacturer's manual, as determined by the project manager. The procedures and/or manual will provide guidance to field personnel on the proper use and limitations of the instrument.

6.2.1 Calibration

Current calibration/maintenance records kept on site for review and inspection for all instruments used during the survey in accordance with the site CDQMP (USACE, 2000).

The records will include, at a minimum, the following:
Name of the equipment

- Equipment identification (model and serial number)
- Manufacturer
- Data of Calibration
- Calibration Due Date

Instrumentation must and will be maintained and calibrated to manufacturer's specifications to ensure that required traceability, sensitivity, accuracy and precision of the equipment/instruments are maintained. Instruments will be maintained and calibrated in accordance with ANSI N323.

6.2.2 Source and Background Checks

Prior to and after daily use, instruments will be QC checked by comparing the instrument's response to a designated gamma radiation source and to ambient background. Prior to the commencement of field operations, a site reference location will be selected for the performance of these checks. QC source checks will consist of one-minute integrated counts with the designated source position in a reproducible geometry, performed at the designated location. Background checks will be performed in an identical fashion with the source removed. The results of the background and QC checks will be recorded in a field logbook. Prior to the start of initial surveys, this procedure will be repeated at least five times to establish average instrument response.

Instrument response to the designated QC check source will be plotted on control charts and evaluated against the average established at the start of the field activities. A performance criterion of +/– 2 sigma of this average will be used as an investigation action level. A performance criterion of +/– 3 sigma of this average will be used as a failure level requiring corrective action. The project manager will investigate results exceeding this criterion and will make appropriate corrections to instrument readings if response is deviated by factors beyond personnel control, such as large humidity or temperature changes. The project manager has authority to decide whether or not the instrument is acceptable to use or must be removed from service.

Instrument response to ambient background will be used to establish a mean background response for each instrument, to monitor gross fluctuations in background activity (e.g., from changes in barometric pressure and other, non-contaminant related causes), and to evaluate detector response. The background measurements are made solely for the purpose of normalizing each day's survey results and eliminating bias introduced by natural fluctuations in site radiological conditions, if necessary.

During QC checks, instruments used to obtain radiological data should be inspected for physical damage, current calibration and erroneous readings in accordance with applicable protocols. The individual performing these tasks shall document the results in accordance with the associated instrument protocol. Instrumentation that does not meet the specified requirements of calibration, inspection, or response check will be removed from operation. If the instrument fails the QC response check, any data obtained to that point, but after the last successful QC check will be considered invalid due to faulty instrumentation.

6.2.3 GPS Requirements

Daily Field Checks

A reference location will be established for the GPS system. At the start of the field effort, when average sodium iodide source and ambient background response is established, the average easting and northing GPS position data will be used to establish the average response of the GPS system. During subsequent routine checks, GPS position data will be compared to the established averages and recorded in the field logbook. Measurements differing by more than one meter from this average will be investigated and corrective actions will be implemented, if possible.

Quality Control of the Field Survey

Data quality control will be accomplished with mapping control points, viewing plotted survey data, and keeping detailed field notes. Mapping control points (a discrete point at a known location such as in the corner of a base map) will ensure that the area surveyed will overlay with existing maps. Gamma surveys, when plotted, should exhibit the same configuration as shown in annotated field sketches and field notes.

6.3 SOIL SAMPLING

6.3.1 NJ Approved Laboratory

All samples will be analyzed for radionuclide concentration (picoCuries per gram; pCi/g). All analyses will be performed by a New Jersey Bureau of Environmental Radiation approved laboratory and in accordance with the CDQMP (USACE, 2000). The approved laboratory shall analyze method blanks, matrix spike samples, laboratory control samples and replicates at the minimum frequencies in accordance with the CDQMP (USACE, 2000).

6.3.2 Confirmatory Analysis Samples

Sampling will be conducted in a manner to provide the number of field QC samples required by the CDQMP (USACE, 2000). Additionally, 10% of FSS samples will be sent to an off-site NJ certified laboratory for confirmation.

6.3.3 Data Validation

Data validation will be performed on 100% of FSS analytical results in accordance with the CDQMP (USACE, 2000).

7.0 REFERENCES

(DOE, 1992) Remedial Investigation Report For the Maywood Site, DOE/OR/21949-337, prepared for the U.S. Department of Energy (Oak Ridge Operations) by Bechtel National, Inc., Oak Ridge, TN, December.

(FFA, 1990) Federal Facilities Agreement, Administrative Docket Number II CERCLA-FAA-00101, transmitted by memorandum, Wing to La Grone, September, 27, 1990.

(NJDEP, 2000) *New Jersey Department of Environmental Protection Field Sampling Procedures Manual, Chapter 12*, State of New Jersey, dated August, 2000.

(NRC, 1981) Nuclear Regulatory Commission. *Inspection Report #40-8610/80-01*; February 1981.

(NRC, 1997) NUREG-1507, *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions*, U.S. Nuclear Regulatory Commission, pre published draft, dated December, 1997.

(NRC, 1998) NUREG-1505, Rev.1, *A Nonparametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys*, U.S. Nuclear Regulatory Commission, dated June 1998.

(NRC, 1999) *Supplemental Information on the Implementation of the Final Rule on Radiological Criteria for License Termination*, Federal Register, Volume 64, Number 234, Tuesday, December 7, 1999, 68396-68396.

(EPA, 1997) *Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination*, OSWER No. 9200.4-18, dated August 1997.

(EPA, 2000) EPA 402-R-97-016, Rev. 1,
Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), U.S. Environmental Protection Agency, dated August 2000.

(NRC, 2000) NUREG-1727, *NMSS Decommissioning Standard Review Plan*, U.S. Nuclear Regulatory Commission, dated September 2000.

(USACE, 1999a) Maywood Environmental Remediation Contract, Contract No. DAC41-99-D9001, March 1999.

(USACE, 1999b) Site Safety and Health Plan, FUSRAP Maywood Superfund Site, prepared for USACE by Stone & Webster, Inc., August 1999.

(USACE, 2000) Chemical Data Quality Management Plan, FUSRAP Maywood Superfund Site, prepared for USACE by Stone & Webster, Inc., February 2000.

(USACE, 2001) Background Study Investigation, FUSRAP Maywood Superfund Site, prepared for USACE by Stone & Webster, Inc., 2001.

SECTION 8

EXHIBITS AND TABLES

Exhibit 1
Standard Operating Procedures

SOP No. SW-MWD-101-0, Surveying, Stone & Webster, Incorporated.

SOP No. SW-MWD-108-0, Global Positioning System (GPS) Survey, Stone & Webster, Incorporated.

SOP No. SW-MWD-112-0, Control of Sealed Sources, Stone & Webster, Incorporated.

SOP No. SW-MWD-307-0, Surface and Shallow Subsurface Soil Sampling, Stone & Webster, Incorporated.

SOP No. SW-MWD-308-0, Soil Borings and Sampling, Stone & Webster, Incorporated.

SOP No. SW-MWD-407-0, Data Logger, Stone & Webster Incorporated.

SOP No. SW-MWD-504-0, Labeling, Packaging, and Shipping Environmental Samples, Stone & Webster, Incorporated.

SOP No. SW-MWD-506-0, Decontamination, Stone & Webster, Incorporated.

SOP No. SW-MWD-507-0, Field Notebook Content and Control, Stone & Webster, Incorporated.

SOP No. SW-MWD-509-0, Downhole Sodium Iodide Gamma Logging and Spectroscopy, Stone & Webster, Incorporated.

Table 1
Soil Cleanup Levels

Radionuclide	Residential Soil Cleanup Criteria (pCi/g)	Commercial Soil Cleanup Criteria (pCi/g)
Surface[1] Th-232 + Ra-226 Combined	5	5
Surface[1] Total Uranium	100	100
Subsurface[2] Th-232 + Ra-226 Combined	5	15
Subsurface[2] Total Uranium[3]	100	100

[1]Surface radionuclides are those that are found within the surface soils from 0-15 cm below ground surface. Significant surface contamination is not expected.

[2]Subsurface radionuclides are those that are found within the subsurface soils at depths greater than 15 cm below ground surface.

[3]Total Uranium limits may be based on a nuclide-specific criterion for U-238 of 49 pCi/g based on natural uranium activity fractions.

Table 2
Background Radionuclide Activity Concentration Values

Radionuclide	Background Activity Concentration (pCi/g)
Th-232 + Ra-226 Combined	1.7
Uranium-238	1.0

Note that these values will be updated based on the Reference Area Survey being performed separately (See Section 3.2 and USACE, 2001).

Table 3
Suggested Survey Unit Size

Classification of Land Area	Suggested Survey Unit Size[1]
Class 1	Up to 2,000 m^2
Class 2	2,000 to 10,000 m^2
Class 3	No limit

[1]These areas are suggested because they give a reasonable sampling density. However, the size and shape of a particular survey unit may be adjusted to conform to the existing features of the particular property survey unit area.

TABLE 4
SUMMARY OF TYPES OF DECISION ERRORS

Scenario	True Condition of Survey Unit	
Decision Based on Survey	Does Not Meet Release Criterion	Meets Release Criterion
Does Not Meet Release Criterion	Survey unit fails Correct Decision (Probability = 1-β, 0.95)	Survey unit fails Type II Error (Probability = β, 0.05 Class 1 or 2, 0.01 Class 3)
Meets Release Criterion	Survey unit passes Type I error (Probability = α, 0.05)	Survey unit passes Correct Decision (Probability = 1- α, 0.95 Class 1 or 2, 0.90 Class 3)

Table 5
Outdoor Area Factors

Nuclide	$10000m^2$	$3000m^2$	$1000m^2$	$300m^2$	$100m^2$	$30m^2$	$10m^2$	$3m^2$	$1m^2$
Ra-226	1	1	1	1.1	1.1	3	4.5	9	20
Th-232	1	1	1	1.5	1.8	2.3	3.2	6.2	12.5
U-238	1	1	1	1.3	2	6	11.1	18.3	30.6

Table 6
Estimated Scan MDCS for 3" x 3" NaI Scan

Radionuclide	Description	Estimated MDC (pCi/g)
Ra-226	Ra-226 in equilibrium with progeny	1.4
Th-232	Th-232 in equilibrium with progeny	0.95
Total Uranium	Natural Uranium in equilibrium with short-lived progeny	48.6
Total Uranium	Natural Uranium in full secular equilibrium	2.7

Refer Appendix A for a detailed explanation of factors used to calculate scanning MDCs.

Table 7
Summary of Integrated FSS Design

Survey Unit Classification		Statistical Test	Scanning	Surface Sampling	Subsurface Sampling
Impacted	Class 1	Yes	100% Coverage	Systematic	Systematic in non-excavated areas
	Class 2	Yes	100% Coverage	Systematic	Systematic
	Class 3	Yes	100% Coverage	Random	Judgmental
Non-Impacted		No	None	No	No

Refer to Section 4.0 for a detailed explanation of Master FSS design.

APPENDIX A

SCANNING MINIMUM DETECTABLE CONCENTRATIONS

A.1 INTRODUCTION

Following remedial activities, a Final Status Survey (FSS) will be performed for various properties of the Maywood Site. The final status survey is designed in accordance with the guidance of MARSSIM. The purpose of this document is to estimate gamma walkover scan sensitivities for the Radionuclides of Concern (ROCs), thorium-232 (Th-232), radium-226 (Ra-226), and uranium. The specific objective is to estimate the scan sensitivity of a gamma walkover survey performed using a 3-in by 3-in sodium iodide (NaI) scintillation detector to measure ROCs in the survey units.

A.2 ESTIMATION OF MINIMUM DETECTABLE CONCENTRATIONS (MDC)

This document utilizes the methodology and approach documented in MARSSIM (Section 6.7.2.2, Table 6.7) for a 2-in x 2-in NaI scintillation detector. MARSSIM calculations for the 2-in x 2-in detectors are based on NRC NUREG-1507, *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions* (NRC 1997). MARSSIM Table 6.7 does not provide scan MDCs for 3-in x 3-in NaI detectors; thus scan MDCs are derived using MARSSIM/NUREG-1507 methods. Factors included in this analysis are the surveyor scan efficiency, index of sensitivity, the natural background of the surveyed area, scan rate, detector to source geometry, areal extent of the potential hot spot(s), and energy and yield of gamma emissions.

The computer code Microshield was used to model the presence of a normalized 1 pCi/g of Ra-226, Th-232, total uranium and related progeny in soil with the assumption that the activity was uniformly distributed to a depth of 15 cm and spread over a disk shaped area with a diameter of 56 cm. This is consistent with the NUREG-1507 methodology and provides for a count rate to exposure ration (CPM/μR/hr) to be calculated. Activity concentrations must be entered into Microshield in units of μCi/cm^3 with consideration to the density of soil at 1.6 g/cm^3. Therefore, activity concentrations for Cs-137, total uranium with short-lived progeny, and U-235 were entered into Microshield as 1.6E-6 μCi/cm^3 with decay times sufficient to allow in-growth of progeny activities.

$$1 \text{ pCi/g} \times 1\text{E-6 } \mu\text{Ci/pCi} \times 1.6 \text{ g/cm}^3 = 1.6\text{E-6 } \mu\text{Ci/cm}^3$$

The Microshield exposure rate output is included as an attachment to this Appendix.

Two scenarios were considered for estimating the uranium scan MDC. Full secular equilibrium in the Uranium and Actinium Series and equilibrium with short-lived uranium-234, uranium-235, and uranium-238 progeny. When thorium/uranium is extracted from ore, it disrupts the equilibrium between the parent and daughter nuclides. Because some of the daughter radionuclides in both the U-235 and U-238 decay chains have large half-lives (~10^4 yr), it takes several years for the equilibrium to be reestablished. For the case where equilibrium with short lived progeny, U-235 was assumed to be in equilibrium with only Th-231, and U-238 was assumed to be in equilibrium with Th-234, and Pa-234/234m. U-234, U-235, and U-238 are assumed to exist at natural activity fractions (i.e. 0.489, 0.022, and 0.489, respectively). Therefore, isotopic uranium activity concentrations of 7.83E-7 μCi/cm^3, 3.47E-8 μCi/cm^3, and 7.83E-7 μCi/cm^3, respectively, to represent 1 pCi/g of total uranium.

When full secular equilibrium of U-235 and U-238 was used, activity concentrations of 3.47E-8 μCi/cm^3 and 7.83E-7μCi/cm^3, along with their associated progeny, to represent a total activity of 1pCi/g.

A set of tables is attached to Appendix A. The tables are based upon the NUREG-1507 methodology as applied toward a 3-in x 3-in NaI scintillation detector. Additional details and discussion describing the NUREG analysis methodology are described in that publication.

A.2.1 Fluence Rate to Exposure Rate (FRER)

The fluence rate to exposure rate (FRER) may be approximated by:

$$FRER \approx \frac{1 \mu R / hr}{(E_\gamma)(\mu_{en} / \rho)_{air}}$$

Where:

E_γ = energy of the gamma photon of concern, keV

(μ_{en}/ρ) = the mass energy absorption coefficient for air, cm^2/g

This can be represented in tabular form, as in Appendix A- Table A-1.

A.2.2 Probability of Interaction (P) Through Detector End for a Given Energy

The probability, P, of a gamma ray interaction in the NaI scintillation crystal entering through the end of the crystal is given by:

$$\Pr obability(P) = 1 - e^{-(\mu / \rho)_{NaI} (X)(\rho_{NaI})}$$

Where:

$(\mu/\rho)_{NaI}$ = the mass attenuation coefficient for NaI

X = the thickness through the end of the 3-in x 3-in NaI crystal, 7.62 cm

(ρ_{NaI}) = the density of the NaI crystal, 3.67 g/cm^3

This can be represented in tabular form, as in Appendix A- Table A-2.

A.2.3 Relative Detector Response (RDR)

The Relative Detector Response (RDR) as a function of energy is determined by multiplying the relative fluence rate to exposure rate (FRER) by the probability (P) of an interaction and is given by:

$$RDR = (FRER)(P)$$

This can be represented in tabular form, as in Appendix A- Table A-3.

A.2.4 Determination of CPM per μR/hr as a Function of Energy

The equivalent FRER, P, and finally RDR may be calculated for the NaI scintillation detector at the Cesium-137 (Cs-137) energy of 662 keV. Manufacturers of this equipment typically provide an instrument response in terms of CPM and μR/hr at the Cs-137 energy. This point allows one to determine the CPM per μR/hr and ultimately activity concentration and minimum detection sensitivity level in terms of pCi/g for a specific instrument.

Based on a manufacturer's 3-in x 3-in NaI response specification (Ludlum 44-20) of 2,700 CPM/μR/hr, and using the same methodology as shown in the tables above, the FRER, P, and RDR are calculated. The mass energy absorption coefficient for air and the mass attenuation coefficient for NaI are interpolated from tables in the Radiological Health Handbook, Revised Edition January 1970, pages 139, and 140.

FRER = 0.0514

$Energy_{\gamma}$, keV = 662
$(\mu_{en}/\rho)_{air}$, cm^2/g = 0.0294

$(\mu_{en}/\rho)_{NaI}$, cm^2/g = 0.0780

P = 0.89

And Cs-137 RDR (662 keV) = 0.0456

The detector response (CPM) to another energy is based upon the ratio of the RDR at a specific energy to the known CS-137 energy RDR:

$$CPM/\mu R/hr, E_i = \frac{(CPM/\mu R/hr_{Cs-137})(RDR_{E_i})}{(RDR_{Cs-137})}$$

This can be represented in tabular form, as in Appendix A- Table A-4.

A.2.5 Minimum Detectable Count Rate

The minimum detectable count rate (MDCR) is calculated using the NUREG-1507 methodology where:

The average number of background counts in a one second interval, b_i = CPM/60

And for the Ludlum generic count rate to exposure rate ratio value of 2,700 CPM/μR/hr and 10μR/hr measured background gives:

$$B_i = (10\mu R/hr)(2{,}700\ CPM/\mu R/hr)/(60) = 450\ counts$$

The background exposure rate of 10 μR/hr is used as a conservative estimate for the property. Background exposure rates vary but are typically less than 10 μR/hr.

The MDCR is therefore calculated as:

$$MDCR = (d')(b_i)^{0.5}(60sec/1min)$$

Where d' is from Table 6.1 of NUREG-1507 and represents the rate of detections at 95% and a false positive rate of 60%, and b_i is the background counts, giving:

$$MDCR = (1.38)(450)^{0.5}(60) = 1{,}756 \text{ CPM}$$

The MDCR for the surveyor is given as:

$$MDCR_{surveyor} = MDCR / (P)^{0.5}$$

Where P is the surveyor efficiency equal to 0.5 to 0.75 as given by NUREG-1507. 0.5 was chosen as a conservative estimate and

$$MDCR_{surveyor} = 1{,}756 / (0.5)^{0.5} = 2{,}483 \text{ CPM}$$

The count rate to exposure ratio for each of the Ra-226, Th-232, total uranium and progeny gamma emissions and their contributions to the total exposure rate may be computed using the output of the Microshield runs and the count rate to exposure rate ratios from Table A-4.

A.2.6 Estimate of Ra-226 Scan MDC

The Microshield runs are summarized in Table A-5 for Ra-226. The minimum detectable exposure rate from Ra-226 and progeny is obtained from the $MDCR_{surveyor}$ divided by the Table A-5 weighted count rate to exposure rate value of 2,430 CPM/μR/hr for a 1 pCi/g normalized concentration.

$$2{,}483 \text{ CPM} / 2{,}430 \text{ CPM} /\mu R/hr = 1.02\ \mu R/hr$$

The scan MDC is then equal to the ratio of the Minimum Detectable Exposure Rate in the field to the exposure rate determined for the normalized 1 pCi/g concentration of Ra-226.

$$ScanMDC = \frac{(Normalized\_Ra_{conc})(ExposureRate_{surveyor})}{(ExposureRate_{normalized\_Ra\_conc})}$$

Scan MDC = (1 pCi/g)(1.02 μR/hr)/(.705 μR/hr) = **1.4 pCi/g**

A.2.7 Estimate of Th-232 Scan MDC

The Microshield runs are summarized in Table A-6 for Th-232. The minimum detectable exposure rate from Th-232 is obtained from the $MDCR_{surveyor}$ divided by the Table A-6 weighted count rate to exposure rate value of 2,637 CPM/μR/hr for a 1 pCi/g normalized concentration.

2,483 CPM / 2,637 CPM /μR/hr = 0.94 μR/hr

The scan MDC is then equal to the ratio of the Minimum Detectable Exposure Rate in the field to the exposure rate determined for the normalized 1 pCi/g concentration for Th-232.

$$ScanMDC = \frac{(Normalized\_Th_{conc})(ExposureRate_{surveyor})}{(ExposureRate_{normalized\_Th\_conc})}$$

Scan MDC = (1 pCi/g)(0.94 μR/hr)/(0.986 μR/hr) = **0.95 pCi/g**

A.2.8 Estimate of Total Uranium Scan MDC

The Microshield runs are summarized in Table A-7 for total uranium with short-lived progeny. The minimum detectable exposure rate from total uranium with short-lived progeny is obtained from the $MDCR_{surveyor}$ divided by the Table A-7 weighted count rate to exposure rate value of 9,643 CPM/μR/hr for a 1 pCi/g normalized concentration.

2,483 CPM / 9,643 CPM /μR/hr = 0.2575 μR/hr

The scan MDC is then equal to the ratio of the Minimum Detectable Exposure Rate in the field to the exposure rate determined for the normalized 1 pCi/g concentration for total uranium with short-lived progeny.

$$ScanMDC = \frac{(Normalized\_U_{conc})(ExposureRate_{surveyor})}{(ExposureRate_{normalized\_U\_conc})}$$

Scan MDC = (1 pCi/g)(0.2575 μR/hr)/(0.0053 μR/hr) = **48.6 pCi/g**

The Microshield runs are summarized in Table A-8 for total uranium in full secular equilibrium. The minimum detectable exposure rate from total uranium with progeny is obtained from the $MDCR_{surveyor}$ divided by the Table A-8 weighted count rate to exposure rate value of 2,613 CPM/μR/hr for a 1 pCi/g normalized concentration.

2,483 CPM / 2,613 CPM /μR/hr = 0.950 μR/hr

The scan MDC is then equal to the ratio of the Minimum Detectable Exposure Rate in the field to the exposure rate determined for the normalized 1 pCi/g concentration for total uranium in full secular equilibrium.

$$ScanMDC = \frac{(Normalized\_U_{conc})(ExposureRate_{surveyor})}{(ExposureRate_{normalized\_U\_conc})}$$

Scan MDC = (1 pCi/g)(0.950 μR/hr)/(0.354 μR/hr) = **2.7 pCi/g**

A.3 SUMMARY

Using the NUREG-1507 methodology, the calculated scan MDCs for the 3-in x 3-in NaI scintillation detector employed for this radiological survey are as follows:

Radionuclide	Scan MDC (pCi/g)
Ra-226 in equilibrium with progeny down to but excluding Pb-210 and its progeny	1.4
Th-232 in equilibrium with progeny	0.95
Natural Uranium in equilibrium with short-lived progeny	48.6
Natural Uranium in full secular equilibrium	2.7

A.4 TABLES

Table A-1
Fluence Rate to Exposure Rate

Gamma Energy (keV)	Mass Attenuation Coefficient - Air (cm^2/g)	FRER
40	0.0640	0.3906
50	0.0384	0.5208
60	0.0292	0.5708
80	0.0236	0.5297
100	0.0231	0.4329
150	0.0251	0.2656
200	0.0268	0.1866
300	0.0288	0.1157
400	0.0296	0.0845
500	0.0297	0.0673
600	0.0296	0.0563
800	0.0289	0.0433
1000	0.0280	0.0357
1500	0.0255	0.0261
2000	0.0234	0.0214
3000	0.0205	0.0163

Table A-2
Probability (P) of Interaction Through Detector End

Gamma Energy (keV)	Mass Attenuation Coefficient - NaI (cm^2/g)	P
40	19.3000	1.00
50	10.7000	1.00
60	6.6200	1.00
80	3.1200	1.00
100	1.7200	1.00
150	0.6250	1.00
200	0.3340	1.00
300	0.1670	0.99
400	0.1170	0.96
500	0.0955	0.93
600	0.0826	0.90
800	0.0676	0.85
1000	0.0586	0.81
1500	0.0469	0.73
2000	0.0413	0.68
3000	0.0366	0.64

Table A-3
Relative Detector Response (RDR)

Gamma Energy (keV)	FRER	P	RDR
40	0.3906	1.00	0.3906
50	0.5208	1.00	0.5208
60	0.5708	1.00	0.5708
80	0.5297	1.00	0.5297
100	0.4329	1.00	0.4329
150	0.2656	1.00	0.2656
200	0.1866	1.00	0.1866
300	0.1157	0.99	0.1147
400	0.0845	0.96	0.0813
500	0.0673	0.93	0.0627
600	0.0563	0.90	0.0507
800	0.0433	0.85	0.0367
1000	0.0357	0.81	0.0288
1500	0.0261	0.73	0.0191
2000	0.0214	0.68	0.0146
3000	0.0163	0.64	0.0104

Table A-4
3-in x 3-in NaI Detector Response vs. Energy

Gamma Energy (keV)	RDR	CPM per microR/hr
40	0.3906	21344
50	0.5208	30858
60	0.5708	33817
80	0.5297	31381
100	0.4329	25648
150	0.2656	15736
200	0.1866	11053
300	0.1147	6793
400	0.0813	4814
500	0.0627	3714
600	0.0507	3005
800	0.0367	2700
1000	0.0288	2176
1500	0.0191	1705
2000	0.0146	1132
3000	0.0104	867

Table A-6
Weighted CPM per microR/hr vs. Energy for Th-232

Gamma Energy (keV)	Microshield Exposure Rate for 1pCi/g (microR/hr w/buildup)	CPM per microR/hr Table C-4	CPM per microR/hr (weighted)
40	5.28E-05	23144	1
60	6.97E-03	33817	239
80	7.55E-03	31381	240
100	1.90E-03	25648	49
150	2.21E-03	15736	35
200	4.28E-02	11053	480
300	3.36E-02	6793	231
400	4.16E-03	4814	20
500	3.07E-02	3714	116
600	8.35E-02	3005	254
800	1.09E-01	2176	241
1000	2.43E-01	1705	420
1500	7.76E-02	1132	89
2000	2.19E-03	867	2
3000	3.48E-01	617	218
TOTAL	**9.86E-01**		**2637**

Table A-7
Weighted CPM per microR/hr vs. Energy for Total Uranium with Short-Lived Progeny

Gamma Energy (keV)	Microshield Exposure Rate for 1pCi/g (microR/hr w/buildup)	CPM per microR/hr Table C-4	CPM per microR/hr (weighted)
40	4.97E-09	21344	0
50	4.10E-06	30858	24
60	1.95E-04	33817	1244
80	5.69E-05	31381	337
100	8.73E-04	25648	4225
150	1.91E-04	15736	567
200	1.07E-03	11053	2232
300	7.35E-06	6793	9
400	8.48E-06	4814	8
500	1.58E-05	3714	11
600	7.69E-05	3005	44
800	5.57E-04	2176	229
1000	2.17E-03	1705	698
1500	6.36E-05	1132	14
2000	1.02E-05	867	2
TOTAL	**5.30E-03**		**9643**

Table A-5
Weighted CPM per microR/hr vs. Energy for Ra-226

Gamma Energy (keV)	Microshield Exposure Rate for 1pCi/g (microR/hr w/buildup)	CPM per microR/hr Table C-4	CPM per microR/hr (weighted)
50	8.72E-05	30858	4
80	4.05E-03	31381	180
100	3.64E-05	25648	1
200	8.51E-03	11053	133
300	2.67E-02	6793	257
400	6.74E-02	4814	460
500	3.96E-03	3714	21
600	1.27E-01	3005	541
800	3.24E-02	2176	100
1000	1.31E-01	1705	317
1500	1.10E-01	1132	177
2000	1.94E-01	867	239
TOTAL	**7.05E-01**		**2430**

Table A-8
Weighted CPM per microR/hr vs. Energy
for Total Uranium Full Equilibrium

Gamma Energy (keV)	Microshield Exposure Rate for 1pCi/g (microR/hr w/buildup)	CPM per microR/hr Table C-4	CPM per microR/hr (weighted)
40	4.27E-07	21344	0
50	1.97E-04	30858	17
60	2.13E-04	33817	20
80	2.23E-03	31381	198
100	9.94E-04	25648	72
150	3.37E-04	15736	15
200	5.50E-03	11053	172
300	1.47E-02	6793	282
400	3.40E-02	4814	462
500	1.98E-03	3714	21
600	6.22E-02	3005	528
800	1.67E-02	2176	103
1000	6.61E-02	1705	318
1500	5.41E-02	1132	173
2000	9.48E-02	867	232
TOTAL	**3.54E-01**		**2613**

APPENDIX B

NJ COMMENT RESPONSE MATRIX

Regulatory Agency: NJDEP

Status: USACE/S&W Review

Date Received: 9/24/01

Date of Comment Review: 10/04/01

Master Final Status Survey Plan

No.	Comment	Discussion	Resolution
1.	Page numbering is inconsistent or absent.	Error in the format of the header/footer area of the document.	Pagination corrected. Numbering is consistent and viewable on all pages.
2.	There are no final decision documents. Once the ROD is signed, there may need to be minor adjustments to this report relating to release criteria. For examples, how is it determined that the ALARA goal was met for commercial subsurface soils? Is the WRS test run against the ALARA goals? The State believes that the MARSSIM methodology addresses areas of elevated activity and that the cleanup criteria for commercial subsurface soils should be 5 pCi/g Ra226+Th232 and 100 pCi/g total U.	Once the decision documents are presented, the Master FSS will be revised accordingly.	The Master FSS will be revised accordingly when the decision documents are issued.
3.	Section 3.4.1 "is set at 0.05" is without a sentence.	Typographical error. The related paragraph was relocated to section 2.6.1.	Text "is set at 0.05" is deleted.
4.	Section 3.4.1: Next to the last sentence in this section "…will be determined based on the area being surveyed…"	Typographical error. Text "…area being surveys." is revised.	Text amended to read "…area being surveyed."
5.	Section 4.4.3: L = ~~square~~ triangular grid spacing for survey unit (m).	Typographical error.	Text amended to read "triangular grid."
6.	Section 4.5.3: Add to end of next to the last sentence "...deemed to be appropriate for release, assuming all EMC are addressed."	The statement was incorporated into the last sentence.	Text amended to read "…deemed to be appropriate for release, assuming all EMC are addressed.
7.	Table 1 footnote 2: Subsurface radionuclides.	Typographical error.	Text amended to read "Subsurface radionuclides are those…"

8.	Table 5 Outdoor Area Factors. The following table is taken from the NJDEP Sample Procedures Manual, Chapter 12. Please use.	The Area Factors were reviewed and found to be acceptable.	Table 5 is amended to include the area factors from the NJDEP Sample Procedures Manual, Chapter 12.
9.	A discussion of investigation levels should be included in the report.	Class specific investigation levels are discussed in the MARSSIM. Although not specifically identified as investigation levels, the Master FSS plan includes similar actions to related events based on the Data Quality Objectives (Sec 2.0). Class 1 areas that employ an EMC test and exceed the EMC criterion are investigated by further remediation (Sec. 3.4.2). Area scan surveys are investigated at z-scores >3 (Sec. 4.5.2) with biased samples. Class 2 survey units that exceed the $DCGL_w$ are reclassified from a class 2 to a class 1 (Sec. 4.0).	. Plan modified to state:, "If the survey unit does not meet the DCGLs, further investigation is warranted. This application of decision rules (Section 4.5) or investigation levels may prompt; additional samples, further remediation, or reclassification of the survey unit."
10.	Duplicates and blanks should be addressed under section 6.3.1 of this report.	Duplicate and blanks will be described in accordance with the site CDQMP.	Text amended as follows, "The approved laboratory shall analyze method blanks, matrix spike samples, laboratory control samples and replicates at the minimum frequencies in accordance with the CDQMP (USACE, 2000)."
11.	If subsurface samples will be collected, how will this data be used to show that the sub surface meets the cleanup criteria?	Subsurface samples will be compared to the criteria as described in Section 3.1 and summarized in Table 1 of the Master FSS plan. Subsurface samples are also compared with the WRS test (Sec 4.5.3), where applicable. Property specific Addenda include the relevant clean-up criteria in the Property Specific FSS Design.	Addenda text is revised to include the relevant clean-up criteria.

12.	Since the State cleanup levels depend on the depth of contamination, the vertical extent of contamination must be demonstrated, even in areas that were excavated.	Currently, criteria is based on the DOE EPA dispute resolution. Vertical limits of excavation are based on pre-design investigation data. Remedial scans and gamma walkover surveys are performed in the areas of excavation to verify contamination within excavations is addressed. Previous removal actions have demonstrated VE in excavated areas to be less than 6 inches. Gamma logging to 1 foot below csuspected contamination will determine vertical extent in non-excavated areas.	The Master FSS will be revised accordingly when the decision documents are issued.
Addenda C-1			
No.	**Comment**	**Discussion**	**Resolution**
13a.	The posting plot should show the concentration of all samples collected and analyzed for the property.	Inclusion of sample data on posting plots is cumbersome. Concentrations of samples used in survey unit analyses are tabulated in the Addenda.	Sample data used in survey unit analyses are tabulated in the property specific Addenda.
13b.	Does the MDC_{scan} take into account shielding from concrete and broken pavement? Or is this material excavated before the scan is performed?	The material is excavated before the scan is performed in remediated areas. The MDC_{scan} assumption is for a uniformly deposited activity in soil at a depth of 15 cm, in accordance with NUREG 1507.	No resolution currently required.
13c.	Shouldn't the Class 1 Survey Unit be closer to the size of the excavation? The rest of the property should be Class 2. The way it is designed presently, there are only 3 FSS samples within the excavation area.	The Class 1 Survey Units are designed to the suggested area as presented in MARSSIM. Survey units will be designed to best profile the areas of excavation, where practical. To constrict survey units to the immediate areas of excavation provides limited investigation data for determining the sample standard deviations of the survey unit used in the calculation of relative shift.	Survey units are designed to best profile the areas of excavation, and group areas of similar contamination potential.

APPENDIX C-1

FINAL STATUS SURVEY PLAN
72 SIDNEY ST