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TREASURE ISLAND
SSIC NO. 5090.3.A

RADIATION PROTECTION PLAN
(ADDENDUM TO THE HEALTH AND SAFETY PLAN)
Remedial Action
Site 12 Final Remedy Removal Action
Treasure Island
San Francisco, California

Environmental Multiple Award Contract
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Health and Safety Plan Addendum

Radiation Protection Plan

Addendum Number: 2007-01

Project Number: 501136085

Date Effective: August 6, 2007

Addendum Summary

This safety addendum is applicable to the following activities:

- Shallow excavation of top soil and C horizon subsoils for land use conversion. Potential for impact by any of the following: Technically Enhanced Naturally Occurring Radioactive Material (TENORM), source or byproduct material.

The specific requirements of this addendum and the general requirements of the Final Health and Safety Plan are mandatory for all personnel performing the aforementioned activities.

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TREASURE ISLAND
SSIC NO. 5090.3

FINAL
SITE HEALTH AND SAFETY PLAN
FINAL REMEDY REMOVAL ACTION
SITE 12

DATED 26 FEBRUARY 2007

THIS RECORD IS ENTERED IN THE DATABASE AND FILED AS

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RADIATION PROTECTION PLAN
(ADDENDUM TO THE HEALTH AND SAFETY PLAN)
REMEDIAL ACTION
FINAL REMEDY REMOVAL ACTION
SITE 12
REVISION 1

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RADIATION PROTECTION PLAN
(ADDENDUM TO THE HEALTH AND SAFETY PLAN)
REMEDIAL ACTION
FINAL REMEDY REMOVAL ACTION
SITE 12
REVISION 2

DATED 03 DECEMBER 2008

THIS RECORD IS ENTERED IN THE DATABASE AND FILED AS

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RADIATION PROTECTION PLAN
FINAL REMOVAL ACTION WORK PLAN/
REMEDIAL DESIGN
REVISION 3

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Acronyms and Abbreviations

ALARA	As Low As Reasonably Achievable
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CEDE	Committed Effective dose Equivalent
CFR	Code of Federal Regulations
CHP	Certified Health Physicist
DQOs	Data Quality Objectives
HSP	Health and Safety Plan
mrem	millirem
NRC	U.S. Nuclear Regulatory Commission
OSHA	Occupational Safety and Health Administration
PPE	personal protective equipment
PM	Project Manager
QC	quality control
RPP	Radiation Protection Plan
RPT	Radiation Protection Technician
RSM	Radiation Safety Manager
RSO	Radiation Safety Officer
Shaw	Shaw Environmental, Inc.
Shaw E & I	Shaw Environmental and Infrastructure, Inc.
SWDA	Solid Waste Disposal Area

1.0 Purpose/Introduction

This Radiation Protection Plan (RPP) is provided to support work performed by Shaw and its contractor, New World Environmental, Inc., d.b.a New World Technology (NWT) at Site 12, a designated solid waste disposal area (SWDA), on Treasure Island, San Francisco, California.

Primary contaminants of concern included organic hydrocarbons (i.e., polyaromatic hydrocarbons, dioxins, polychlorinated biphenyls) and lead. Radium (Ra-226) is also of concern having been previously found in the area. Ra-226 has been known to have been used for deck markers, decorative illumination devices, and on some dials and gauges used on military equipment. The period of use of these kinds of materials dates from the 1930s through the 1960s. Some disposal may have occurred after the useful life of the commodity. Therefore there is potential for material to be present that meets the new definitions of the most recent revision to NRC's 'byproduct rule.'

All Shaw E&I/Shaw Environmental, Inc. project participants performing work around radioactive material (or suspected radioactive material) at the site must read this RPP and verify that they understand its content by signing the agreement and acknowledgement sheet, included as Appendix A, "Health and Safety Plan Addendum Acknowledgement Form."

NWT has a Radiation Protection Plan (RPP) for this project. Shaw E&I/Shaw Environmental, Inc. also has a policy for Radiation Protection Plans. The Policy, HS700 for developing Radiation Protection Plans cannot be waived. Any element in HS700 not covered in NWT's RPP must be addressed in Shaw E&I/Shaw Environmental, Inc.'s RPP. This document has been prepared to have the information provided by NWT to conform to the organization of HS700 to assist Shaw Staff in establishing meeting all organizational requirements.

1.1 Policy

It is Shaw Environmental, Inc.'s (Shaw) policy that all work with radioactive materials or ionizing radiation be purposeful and performed in a manner that protects workers, members of the general public, and the environment. Work involving radiological hazards may not begin unless that work can be performed in a safe manner, compliant with rules and regulations. Moreover, Shaw E&I/Shaw Environmental, Inc. endorses and applies As Low As Reasonably Achievable (ALARA) principles.

1.2 Project-Specific Radiation Protection Plan

This RPP addresses all key elements required by Shaw Environmental & Infrastructure, Inc. (Shaw E & I) Procedure No. HS700, "Policy and Guidance for Developing Radiation Protection

Plans" (Shaw E & I, 2006). The function of this RPP and associated procedures is to provide all necessary information to meet project or license-specific requirements, regulations, and commitments. Supplemental surveys shall be performed to monitor personnel and equipment to ensure safe operations from handling or contact with radioactive material.

1.3 As Low As Reasonably Achievable Program

The ALARA principles are incorporated into this RPP and supporting documents these are defined by the 'Definitions' found at 10 CFR 20.1003:

> *"Every reasonable effort to maintain exposures to radiation as far below the dose limits in this part as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account the state of the technology, the economic of improvement in relation to the benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest."*

Whether an activity is specifically licensed or not is not really material to the definition. Under NRC's new Byproduct Rule, any material found or stored for later disposition would be licensable material. Several techniques will be used on this project to minimize radiation exposure. Occupancy time in the work area will be limited to necessary work. Handling any radioactive objects can be accomplished with gloved hands and by using a buddy system, the amount of actual handling of any radioactive object can be minimized (e.g., one person holds a gallon or quart size baggy while another in glove hands picks up the item with tongs). Base on experience gained on projects with similar commodities, the actual external exposure for the duration of the project is expected to be less than 10 mrem TEDE. Internal exposure may occur as a result of resuspension of fine material which may be either inhaled or ingested, therefore, measure to control dust are important. This includes using water as a dust suppressant, chemical crusting agents, or stopping work in the event that a high wind event occurs (typically defined as resulting in opacity greater than 10% for fugitive dust from a construction area) and other dust control measures become ineffective. The internal pathways Inhalation/Ingestion are anticipated to be less than 2mrem CEDE. This analysis suggests that the external exposure is limiting, so the most effective ALARA control will be to limit worker's presence, 'occupancy' in the high dose areas only to necessary tasks. In the event that there is generation of excessive dust, then there will be application of water or crusting agents to minimize dust. If very windy conditions make dust control impossible, suspension of work may be implemented until winds subside.

1.4 Authorization to Stop Work

All employees working at the site have authorization to stop work if an unsafe condition exists or a safety procedure(s) is being disregarded in accordance with Shaw E & I Procedure No. HS040, "Stop Work Authority" (Shaw E & I, 2006).

1.5 Scope of Work

The scope of work from a radiological protection perspective will involve the following activities:

- Conduct task-specific training with personnel
- Perform site control and establish work zones associated any excavated area until the excavation and excavated materials have been surveyed and cleared (or radioactive commodities removed, bagged, inventoried and stored in a drum
- Work under NWTs radiation safety program

1.6 Quality Control and Auditing

This section discusses the quality control (QC) and auditing associated with the implementation of this RPP.

1.6.1 Self-Assessment, Reviews, and Corrective Actions

The duration of the project is expected to be several months. Periodic auditing or self-assessments will include evaluation of exposure rates present during excavation. A review of data and implementation of this RPP in the field shall be done by the RSM within the first month of the project. At that time the RSM shall establish the frequency of future reviews. The RSM or delegate may perform annual or more frequent radiation safety/compliance reviews of the project operation and records. The Radiation Safety Officer (RSO), Project Manager (PM), and occupationally exposed individuals shall participate in such audits as requested.

1.6.2 Responses and Corrective Actions

If serious deficiencies are noted, each will be tracked as radiological occurrences. The RSO and PM shall develop and implement a Corrective Action Plan with specifically assigned tasks and a schedule for completion. Corrective actions must be taken in a timely manner. The Corrective Action Plan is subject to review by the RSM.

1.6.3 Daily Instrumentation Check

It is anticipated that instrumentation will be used, operated and maintained by NWT. It is routine practice and an NWT commitment, that each day a radiation protection instrument is used for making a field measurement, the instrument shall be checked for background and source response prior to use. If an instrument response does not pass the QC test, the QC test shall be repeated. If the instrument still does not pass the QC test the instrument shall be taken out of service immediately. The RSM shall be informed of the failure of an instrument. Since radiation measurements are a critical activity, certain portions of the project may need to be suspended pending the arrival of an instrument that is qualified on the project site to be capable of making those measurements.

All instruments in use shall have current calibrations. If any of these practices are found to be deficient in NWT's program, NWT's work may be suspended and instrumentation will be acquired by Shaw Environmental, Inc. to continue to implement an effective, competent monitoring program.

2.0 Radiation Protection Personnel

This section defines the responsibilities of key radiation protection personnel for the project. The safety responsibilities of other personnel are specified in the Final HSP (Shaw, 2007a). Table 1, "Radiation Protection Personnel," lists the project-specific Shaw personnel and their respective responsibilities.

2.1 Radiation Safety Manager

The RSM provides guidance to the project field team, which will include at a minimum, daily review and approval of survey findings and instrument performance data. In the event of vacation or travel out of touch with e-mail access, this function may, on occasion be delegated. The RSM will furnish project-specific training to assure that project staff will be informed of potential hazards and pitfalls in conducting radiological surveys, the requirements of daily instrument performance requirements, recordkeeping, documentation, as well as guidance such as when and where to ask for help.

2.2 Radiation Safety Officer

The RSO is that individual assigned authority to implement a site, project, or task order specific RPP. ***Roles not fulfilled by the subcontractor, NWT for the RSO must be provided by Shaw staff.*** Under the direction of the PM, the RSO shall implement the RPP, including task-specific activities. Additionally, the RSO may act as the Radiation Protection Technician (RPT) for this project, or as an RPT supervisor. The RSO is responsible for:

- Ensuring exposure to radiation is maintained ALARA.
- Reporting survey findings and instrument performance data to the RSM who will provide interactive guidance throughout the life of the project (if necessary).
- Ensuring appropriate instrumentation, protective devices, dosimetry (only when and if required, i.e., if not performed by NWT, as they have committed to doing), training, and other items needed to perform work in accordance with elements of this RPP, are available.
- Properly operating radiation-measuring equipment, performing daily source, and background checks (if necessary).
- Maintaining radiation-measuring equipment according to manufacturer recommendations.
- Conducting radiological surveys and performing radiological sampling tasks as specified (spot checking anticipated, more comprehensively, if deficiencies are found in NWT's program).

- Stopping work if necessary to ensure radiation safety
- Maintaining communication to the RSM as needed to ensure that this RPP is fully implemented.
- Participating in the periodic internal and external review of RPP content and implementation.
- Preparing and maintaining reports and notices as required by this RPP.
- Acting as a primary project point of contact for radiation safety related communications.
- Ideally, either the RSO or the RSM will be a CHP, certified by the American Board of Health Physics.

2.3 Project Manager

The PM is responsible for ensuring the following:

- Work is conducted safely and in compliance with all applicable permits, licenses, client contracts, and other applicable controlling documents.
- This RPP is developed and approved in a timely fashion.
- Exposure to radiation is maintained ALARA.
- Adequate resources and staffing are available to develop and implement this RPP in compliance with applicable regulations and requirements.

•

3.0 Task-Specific Hazard Analysis/Controls

The likely and possible radionuclides added to project hazards listed in Section 4.0 of the Final HSP (Shaw, 2007) will be listed in a Table. Uneven terrain, slips, trips, falls sharp objects, pinch points are all hazards in addition to radiation exposure.

3.1 Identification of Radiation Hazards

Ra-226 is the most likely source to be encountered. Source in electron tubes are the most likely other sources, whose isotopes vary isotopes include H-3, C-14, Co-60, Ni-63, Kr-85, Cs-137, Pm-147, Pb-210, Ra-226, and Th-232 in pCi to μCi quantities.

3.2 Identification of Controlling Agencies and Documents

NWT possesses a Type A Broad Scope License from the Nuclear Regulatory Commission, RML #04-27745-01. Work is performed under the Treasure Island Naval Station, Site 12 Final Remedy Removal Action Work Plan. NWT also has a complete set of Field Operations and Technical Procedures. Since California is an agreement state and the License is issued by an NRC, both Federal Regulations 10 CFR 20, and California Code of Regulations, Title 17 apply to radiation control. In addition industrial safety is covered under 29 CFR. EPA regulations under 40 CFR also have applicability for a variety of different regulatory subjects including CERCLA, RCRA, and NESHAPs.

3.3 Evaluation of Potential Exposure to Workers

Dose limits governing this project are those of 10 CFR 20 (and equivalent California Regulations). Workers will be classified as members of the general public unless there is a need for the RSM to reclassify them due to larger quantities and types of sources being. Dose limits are provided in Table 4.

Most of the dose is expected to come from Radium from external radiation exposure, localized at levels up to about 1 mRem/hr., but more typically much less. A job with similar commodities was completed with no measurable dose recorded on Optically Stimulated Luminescent (OSL) dosimetry.

3.4 Evaluation of Public Dose

Based on the scope of work; the limited activity of radionuclides expected; and the involved Naturally Occurring Radioactive Materials levels anticipated on surfaces, public dose due to work activities at this site is anticipated to be less than 1 mrem. This also is below a threshold

for air monitoring under 40 CFR 61 Subpart H, 'Rad NESHAPs.' NWT has committed to performing air sampling.

3.5 Training Program Development

Since worker exposure is substantially under 100 mrem per individual but more likely under 10 mrem, the training required for radiation safety is not too extensive. NWT's radiation safety staff are trained to ANSI 3.1 standards.

3.6 Declared Pregnant Woman Program

Women may claim pregnancy in writing in accordance with 10 CFR 20 and U.S. Nuclear Regulatory Commission (NRC) Regulatory Guides 8.13 (1999) and 8.29 (1996); however, due to the small anticipated dose, it is unlikely that separate dose tracking will be required. It is planned to manage an individual to maintain a dose below 100 mrem (the NRC has established a dose limit of 0.5 rem (i.e., 500 mrem for the dose to the fetus during the term of pregnancy). Given the anticipated dose this issue is moot.

3.7 As Low As Reasonably Achievable Program

See Section 1.3 for this program.

3.8 External Exposure Control

External exposure is from gamma radiation, X-rays and beta radiations. The following steps are taken to control external radiation exposure to levels that are ALARA:

- Concepts of time and distance will be used to reduce dose. Working efficiently in any work area requires advance planning. Morning meetings shall include a review of activities planned and should include a review of radioactive materials encountered and good work practices. Workers who have no tasks to perform in areas known to have radioactive materials and areas that have not been surveyed should not go into those areas.
- Instrumentation shall be used to determine the external radiation fields. Gamma survey instruments shall be on prior to and as approaching work areas, shall be on at all times that materials are being moved closer to workers, and shall be used for screening materials.
- Workers shall be trained to (visually) look for objects that might be radioactive, or objects that are unfamiliar.
- PPE is used to reduce the exposure of the eyes and skin to very low-energy gamma radiation as well as a wide range of beta energies.

3.9 Internal Exposure Control

Due to the expected inventory and magnitude of the activity of objects anticipated in this project and the ease with which the material can be handled to minimize the potential for internal exposure, the best practices implemented will preclude the potential for internal deposition. Internal exposure is expected to be less than 1 mrem.

3.10 Monitoring and Measuring External Exposure

NWT has committed to providing external dosimetry (the vendor and type will be verified prior to the project start, but it is anticipated to be a suitable vendor, i.e., NVLAP accreddited (either film badge, OSL or TLD media, any of which is acceptable).

3.11 Monitoring and Measuring Internal Exposure

Due to the low levels of internal exposure anticipated, monitoring of internal exposure is not required. The RSO will re-evaluate the risk of internal exposure, appropriate measures, and may change this if certain unanticipated items are found. At the present time, while this topic could be dispensed as "not applicable," NWT has committed to performing air sampling to confirm that bioassay is not needed.

3.12 Surveys and Monitoring

NWT has provided extensive survey and monitoring information in sections 4.8 through 6.1.6 of their Final Radiological Sampling and Analysis Plan, Site 12 Removal Remedy Action, Rev. 3, dated July 4, 2007. These steps are spelled out in the sub-sections below to add completeness to the plan. Ultimately, protection of both workers, the public and the environment require meeting the clean-up criteria established by the stakeholders and these are achieved by surveying with field instruments, or soil sampling and subsequent analysis in accordance with prescribed and approved procedures.

3.12.1 Radiation Detection Instrumentation

Various instruments will be used to detect the radioactive material that may be present within the excavation areas. Instrument calibration, performance checks and operation shall be done 1) as applicable, the NWT SOP(s) governing preparation of portable radiation and contamination survey meters and instruments for field use, and 2) in accordance with any additional instructions specified in this plan. The instruments selected shall be able to detect the radionuclide of concern (^{226}Ra) and are, in relation to the survey or analytical technique, capable of measuring levels that are sufficient to support the DQOs presented in this plan. Table 3.12-1 identifies the instrumentation that may be used for radiological surveys.

Radiation detection instrumentation used during the survey will be maintained and calibrated to operate within manufacturers' specifications, so that the required sensitivity and precision will be maintained. Specific calibration and maintenance will be conducted by personnel familiar with the equipment or by manufacturers' technical representatives.
Operational procedures have been developed for all field equipment to verify that the equipment is operating properly and that the data will be valid with instrument calibrations that are traceable. These procedures include functional operational checks, routine maintenance, calibration procedures, and operational instructions.

Instrumentation used during the FSS will be field-checked prior to starting work each day. All of the instruments are required to be within the +/- 20 percent criteria established when setting up background information for the instruments. If an instrument does not meet the criteria, it will be removed from service and returned to the manufacturer for maintenance and calibration.

Table 3.12-1: Instrumentation for Radiological Surveys

Measurement/ Technique	Primary Use	Type of Instrumentation: Detector Type and Ludlum Model Number(s)	Type of Instrumentation: Meter Description and Ludlum Model Number(s)	Typical Background	Typical Total Efficiency (%)	Detection Sensitivity	Typical Minimum Detectable Concentration
Surface alpha/beta scans	Equipment, materials, and debris	Large-area gas - proportional 43-68 (126 cm^2)	Data logger 2350-1, 2360	150-250 cpm β 0-2 cpm α	~6 β total efficiency	900 dpm/100 cm^2 β 100 dpm/100 cm^2 α	553 dpm/ 100 cm^2 β 53 dpm/ 100 cm^2 α
Direct measurement static alpha/beta		Scintillation, Ludlum Model 43-89 (100 cm^2)		100-200 cpm β 0-5 cpm α	~6 α total efficiency		
Surface gamma scans	Equipment, materials, debris and excavations	NaI 2-inch x 2-inch scintillation Ludlum Model 44-10	Data Logger 2350-1	5,500 cpm γ	N/A	1,500 cpm γ 1.6 pCi/g ^{137}Cs 1.34 pCi/g ^{226}Ra	353 cpm γ
Direct measurement static gamma	Excavations						
Towed array surface gamma scans	Excavations	(12) NaI 2-inch x 2-inch scintillation Ludlum Model 44-10	Model 4612 Counter	5,500 cpm γ	N/A	0.58 pCi/g ^{226}Ra	353 cpm γ
Surface beta/gamma scans	Equipment, materials, debris, and personnel	Geiger-Mueller Ludlum Model 44-9	Ratemeter 3	20 to 50 cpm β γ	~15 β γ total efficiency	~ 1,000 dpm per probe area β γ	358 dpm/100 cm^2 β γ
Direct measurement static beta/gamma	Equipment, materials, debris, and personnel						
Exposure rates	All inclusive	MicroR Meter with integral 1-inch x 1-inch NaI scintillation	Ratemeter 19	7-8 μR/hr	N/A	2 μR/hr	N/A

Notes:

α – alpha
β – beta
γ – gamma

cm^2 – square centimeters
cpm – counts per minute
dpm – disintegrations per minute

N/A – not applicable
NaI – sodium iodide
pCi/g – picocurie per gram

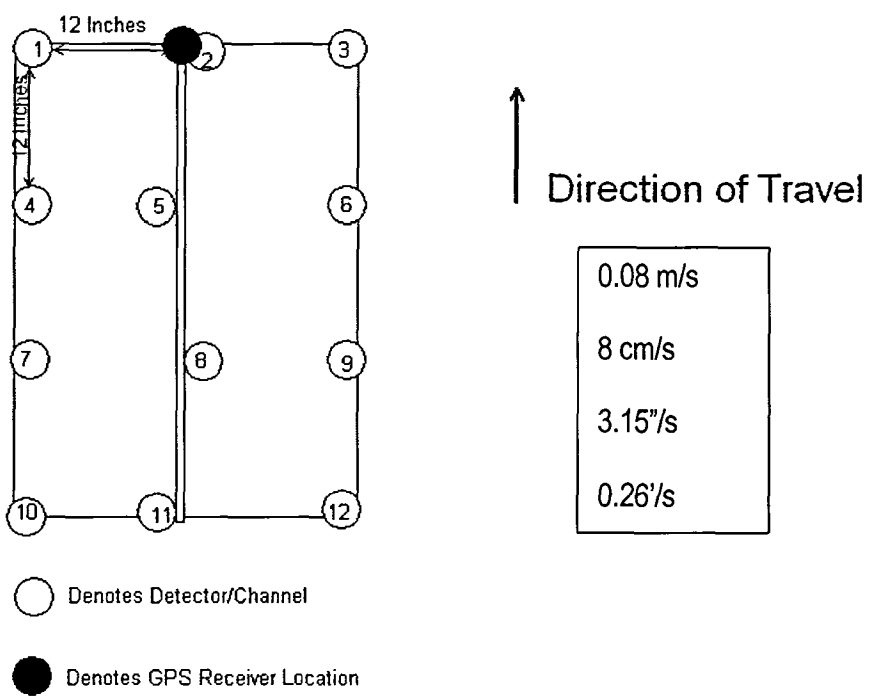
^{226}Ra – radium-226
μR/hr – microroentgen per hour

3.12.1.1 Instruments for Static and Scan Surveys for Gamma Activity

The excavation area gamma scan surveys will be performed using a Ludlum Model 4612. The Ludlum Model 4612 features a single-channel analyzer assembly array equipped with a programmable computer that controls all necessary operating parameters. Up to 12 detector assemblies can be used with the instrument, each with independent high-voltage, threshold, and window parameter settings. Parameters are loaded from a built-in flash memory that initiates during the power-up sequence. The parameters also include settings for upper and lower level discriminator, count time, count time range, output time, and recycle mode or slave mode settings. When connected to a NaI detector, the instrument is capable of detecting gamma photon energies ranging from 60 kilo-electron volts (keV) to 3 mega-electron volts (MeV). The instrument will be programmed to respond to the full spectrum of gamma photon energies.

Four arrays of three Ludlum Model 44-10 2-inch by 2-inch NaI detectors, spaced 12 inches apart, will be connected to a Ludlum Model 4612 instrument and a Global Positioning System (GPS), which will be used to plot and correlate logged data points to specific coordinates. The detectors will be positioned so that each will be maintained at a distance of 4 inches from the surface being surveyed. The instrument array will be positioned on the back of a tow vehicle so as to "follow behind" the path of the vehicle. Readings will be collected for a period of 6 seconds. Diagram 1 shows the layout of the towed array and detectors system.

Diagram 3.12-1



3.12.2 On-Site Radiological Laboratory Instrumentation

An on-site mobile laboratory will be used to analyze the soil samples collected in the field from the surface and down to 3 ft bgs. The samples will be analyzed by gamma spectroscopy in accordance with the analytical procedure presented in Attachment 1 of this plan (NWT, 2004).

3.12.3 Off-Site Radiological Laboratory Instrumentation

An off-site laboratory will be used to analyze the soil samples collected in the field at the final excavation depth of 4 ft bgs. The samples will be analyzed by gamma spectroscopy using the U.S. Department of Energy (DOE) Method 901.1M, (DOE, 1997).

3.12.4 Quality Assurance Checks

QA checks shall be performed on the field instrumentation to ensure proper operation and to maintain calibration. The quality checks shall be documented, reviewed and maintained. Data trends that are outside the tolerance limits shall be investigated to determine the cause and potential effect on measurement results.

3.12.4.1 Gamma Spectroscopy

Gamma spectroscopy analysis is performed using hardware features that include a high-purity Germanium gamma photon detector supported by software. Instrument hardware is calibrated using a multi-energy National Institute of Standards and Technology (NIST)-traceable source ranging from 10 keV to 2 MeV. Data results will be reviewed for QA and reported in units of picocurie per gram (pCi/g). Analysis and review processes will address count integration, efficiency and background corrections, as well as the processing of overlapping peaks. Gamma spectroscopy focuses on energetic photons emitted from ROCs. A spectral region of interest results around a specified energy range allows for identification and quantification of associated nuclides and daughter products.

3.12.5 Instrument Equations

The following equations are used to calculate efficiencies, minimum detectable concentrations (MDCs), and minimum detectable count rates (MDCRs). These equations are presented in Chapter 6 of MARSSIM and in NUREG 1507.

3.12.6 Instrument Efficiency

The instrument efficiency (ε_i) is defined as the ratio between the net count rate, in counts per minute (cpm), of the instrument and the surface emission rate of the calibration source for a specified geometry. The surface emission rate is the 2π particle fluence that is affected by both the attenuation and backscatter of the radiation emitted from the calibration source. *Note the following text is* ***added*** *to NWT's commitments: Due to problems of backscatter of substrates and the application of yet another efficiency factor the efficiency expression may also be express in*

terms of 4π efficiency and a coefficient (ε_s) used in the denominator to correct for the surface roughness and effective electron density ('z') of the substrate, ***see the discussion of this topic in section 3.12.7.***

Equation 3.12-1 will be used to calculate the instrument efficiency in counts per particle; although, efficiency is typically reported as having no units or being unitless.

Equation 3.12-1

$$\varepsilon_i = \frac{R_{S+B} - R_B}{q_{2\pi}\left(\frac{W_A}{S_A}\right)}$$

Where:

ε_i	=	instrument efficiency (count per particle)
R_{S+B}	=	the gross count rate of the calibration measurement (cpm)
R_B	=	the background count rate in cpm
$q_{2\pi}$	=	surface emission rate of the calibration source (NIST-traceable) [particles per minute (min)]
W_A	=	active area of the detector window (cm^2)
S_A	=	area of the source (cm^2)

The instrument efficiency is determined by obtaining static counts with the detector over a calibration source that has a NIST-traceable surface emission rate. The 2π particle fluence rate is corrected for decay, attenuation and scatter. Then the surface emission rate of the source must be corrected for the area subtended by the probe. Factors that can also affect the instrument's efficiency are discussed below:

- Efficiency Check Sources. Efficiency check sources that emit alpha or beta radiation with energies similar to those expected from the contaminant in the field [similar to the expected ROC(s)] will be selected.
- Source Geometry Factors. Instrument efficiency will usually be determined with an efficiency check source equal to or greater than the area of the probe. If a source that is smaller than the probe is used, a conversion factor is applied to the MDC to account for the active region of the probe. It should be noted that Equation 4-1 is used when the calibration source is larger that the probe window active area.
- Source-to-detector Distance. The detector efficiency will be calculated at a source-to-detector distance that is the same as the detector-to-surface distance used in the field.

3.12.7 Surface Efficiency (ε_s) for Surface Activity Measurements

The surface efficiency term in the preceding equations is used to determine the 4π total efficiency for a particular surface and condition. Suitable values are based on the radiation and radiation energy, and are primarily impacted by the backscatter and self-absorption

characteristics of the surface on which the contamination exists in the field. Backscatter is most affected by the energy of the radiation and the density of the surface material. Self-absorption characteristics or attenuation are also a function of the radiation's energy and surface condition.
In the absence of experimentally determined surface efficiencies, ISO-7503-1 [International Organization for Standardization (ISO), 1988] and NUREG-1507 (NRC, 1997), provide conservative recommendations for surface efficiencies. ISO-7503-1 recommends a surface efficiency of 0.5 for maximum beta energies exceeding 0.5 MeV and to use a surface efficiency of 0.25 for beta energies between 0.15 and 0.4 MeV and for alpha emitters (ISO, 1988; NRC, 1997). NUREG-1507 provides surface efficiencies based on studies performed for the NRC. In general, NUREG-1507 indicates that the ISO rule-of-thumb for surface efficiencies is conservative, particularly for beta-emitting radionuclides with end-point energies between 0.25 MeV and 0.4 MeV. At TI, a surface efficiency of 0.25 will be used for alpha and beta emitters.

3.12.8 Minimum Detectable Count Rate and Minimum Detectable Concentration for Gamma Scans

The minimum detectable number of net source counts in the scan interval can be arrived at by multiplying the square root of the number of background counts (in the scan interval) by the detectability value associated with the desired performance (as reflected in d') as shown in Equation 3.12-2.

Equation 3.12-2

$$MDCR = d' \sqrt{b_i} \left(\frac{60}{i} \right)$$

Where:

d' = index of sensitivity [α and β errors (performance criteria)]
b_i = number of background counts in scan time interval (count)
i = scan or observation interval (s)

The required rate of true positives will be 95 percent, and the false positives will be 60 percent. From Table 6.5 of the MARSSIM (NUREG-1575, 2000), the value of d′, representing this performance goal, is 1.38.
The scan MDC is determined from the MDCR by applying conversion factors that account for detector and surface characteristics and surveyor efficiency. As discussed below, the MDCR accounts for the background level, performance criteria (d′), and observation interval. The observation interval during scanning is the actual time that the detector can respond to the contamination source. This interval depends on the scan speed, detector size in the direction of the scan, and area of elevated activity. The towed array will collect a 6-second stationary reading with each detector. Therefore, the observation interval is 6 seconds.

3.12.9 MDC for Gamma Scans of Surface Areas (2-inch by 2-inch NaI Probe)

The scan MDC (in pCi/g) for land areas is based on the area of elevated activity, depth of contamination, and the radionuclide (energy and yield of gamma emissions.) To establish the scan MDC, the relationship between the detector's net count rate to net exposure rate must be established first. This is accomplished by determining the MDCR and then applying a surveyor efficiency factor. The MDCR is calculated using Equation 4-2 with the following variables:

d' = 1.38

b_i = 5,500 cpm / (60 seconds per minute/6 second observation) = 550 counts per second

i = 6 second (see Section 4.11.3 above)

Therefore, MDCR equals 324 cpm.

To get the $MDCR_{Surveyor}$, a surveyor efficiency factor p is applied as shown below in Equation 3.12-3, obtained from Chapter 6 of MARSSIM:

Equation 3.12-3

$$MDCR_{Surveyor} = MDCR / \sqrt{p}$$

The $MDCR_{Surveyor}$ can then be calculated assuming a surveyor efficiency (p) of 0.7 and the estimated background count rate of 5,500 cpm and assuming a 6-second scan observation interval as follows:

$$MDCR_{Surveyor} = \frac{MDCR}{\sqrt{p}} = \frac{324}{\sqrt{0.7}} = 387\,cpm$$

NOTE: The towed array collects static readings at a fixed distance (4 inches) from the surface, and a fixed spacing interval (1 foot). This reduces the probability of a surveyor error during performance of the surveys. Therefore, a surveyor efficiency factor of 0.7 is used in the above calculation.

The $MDCR_{Surveyor}$ is then converted into the corresponding minimum detectable exposure rate (MDER) by use of a calibration constant specific to the detector being used and the ROC. For example, when used with the Ludlum Model 2350-1, the calibration records for the Ludlum Model 44-10 2-inch by 2-inch NaI scintillation detector provide a calibration constant that can be used to determine the ratio of cpm to microroentgen per hour (μR/hr). As shown in Equation 4-4, a dose rate can be calculated for a given count rate and vice versa.

Equation 3.12-4

$$MDER\ (\mu R / hr) = \frac{MDCR_{Surveyor} * 6 \times 10^7}{cc}$$

Where:

$MDCR_{Surveyor}$ = 387 cpm (calculated in Equation 3.12-4)

cc = calibration constant = 4.55×10^{10} counts/R (average)

6×10^7 = a conversion factor accounting for differences in time and activity units [(μR-min)/(R-hr)]

$MDER$ = 0.51 μR/hr

Next, the relationship between the radionuclide concentration and exposure rate is established. This is accomplished by modeling (using MicroShield™ software [Grove Engineering, 1996]) to determine the net exposure rate produced by the radionuclide at a distance above the ground. The factors considered in modeling include:

- The dose point of 10 centimeters (cm) (4 inches) above the soil
- The density of material in grams per cubic centimeter (g/cm^3)
- Derived concentration guideline level (DCGL) of the ROC in pCi/g
- The depth of detection for the DCGL
- The circular dimension of the cylindrical area of detector capability [square meters (m^2)]

The concentration of the ROC (Scan MDC) necessary to yield the MDER may be calculated by taking the ratio of the MDER to the exposure rate calculated by MicroShield (Grove Engineering, 1996) as shown in Equation 3.12-5, using the following input parameters:

- The dose point of 4 inches above the soil was used.
- The density of 1.6 g/cm^3 was used for soil.
- The ^{226}Ra concentration of 1.0 pCi/g was used.
- The depth of the area of elevated activity was 15 cm.
- The circular dimension of the cylindrical area of elevated activity was 0.25 m^2.

MicroShield Version 5.05 (Grove Engineering, 1996) calculates the exposure rate to be 0.7384 μR/hr for ^{226}Ra (which accounts for buildup). The radionuclide concentration of ^{226}Ra (scan MDC) necessary to yield the MDER calculated in Equation 3.12-4 (0.51 μR/hr) may be calculated by taking the ratio of the MDER to the exposure rate calculated by MicroShield.

Equation 3.12-5

$$Scan\ MDC\,(pCi/g) = \frac{DCGL\ pCi/g * MDER\,\mu R/hr}{Microshield\ Exposure\ Rate\,\mu R/hr} = 0.69\ pCi/g$$

Where:

DCGL = 1.0 pCi/g (from Table 3-1)

MDER = 0.51 μR/hr (from Equation 4-4)

MicroShield Exposure Rate = 0.7384 μR/hr

3.12.10 MDC for Static Gamma Measurements

For gamma surveys, MDC is calculated in cpm. Equation 3.12-6 is used to calculate the MDC.

Equation 3.12-6

$$MDC = \frac{3 + 4.65\sqrt{R_B T_B}}{T_B}$$

Where:

3+4.65	=	constant factor provided in MARSSIM
R_B	=	background count rate (cpm)
T_B	=	background counting time (min)

The inputs observed in the reference area will be used in Equation 3.12-6 to calculate the MDC for the Ludlum Model 2350-1 or Model 4612 for ^{226}Ra.

3.12.11 MicroShield ™ Modeling Code Calculations for a 3.0 μCi Ra-226 Device

3.0 μCi is recognized throughout the industry as a nominal level for many types of radium containing devices.

Modeling (using MicroShield ™ Version 5.05) was used to determine the net exposure rate produced by a 3.0 μCi radium gauge at a depth of 12 inches below the soil surface.
The factors considered in the modeling included:

- The radium gauge dimensions were:
  - 3 inches in diameter
  - 0.5 inches thick
- ^{226}Ra and its daughters (^{214}Pb and ^{214}Bi) were assumed to be in equilibrium.
- The dose point of 4 inches above the soil was used.
- The density of 1.6 g/cm^3 was used for soil.
- The depth of the radium gauge was 12 inches below the soil surface.

The corresponding minimum detectable exposure rate was then determined for a 2" by 2" NaI(Tl).

Using Table 6.7 of MARSSIM the count rate to exposure rate for a 2" by 2" NaI(Tl) detector for ^{226}Ra is 760 cpm per μR/hr.

The modeling code performed the appropriate calculations and determined an exposure rate of 3.41 μR/hr for ^{226}Ra (which accounts for buildup).

A count rate due to the presence of a 3.0 μCi radium gauge 12 inches below the soil surface can then be calculated by the following:

$$\frac{760 \text{ cpm}}{\mu\text{R/hr}} x\ 3.41\ \mu\text{R/hr} = 2591 \text{ cpm}$$

3.12.12 Survey Implementation

Radiological control procedures may be implemented to support remediation activities for the three areas to be excavated if radioactive material is found during the radiological screening process. These procedures are intended to protect the health and safety of project personnel and the general public, to comply with NRC license requirements under which the work is to be performed, and to comply with ALARA principles. The following subsections describe the survey procedures that may be performed during implementation of this RSAP.

3.12.12.1 Reference (Background) Areas

Prior to performing surveys in the three SWDAs an average background level will be determined by performing a minimum of 16 measurements at systematic or random locations within a designated background area. There is a possibility that more than one background reference area will be selected. The detector probe will be held approximately 10 cm (4 inches) from the surface area for gamma radiation. Instrumentation will be allowed to stabilize before background readings are taken. The average of the readings taken will determine the background for each energy emission. Background exposure rates will also be collected for reference data.

Site background reference areas will be chosen that have similar characteristics as the survey unit being evaluated. Background reference areas will be selected from non-impacted areas, but will not be limited to natural areas undisturbed by human activities. The reference areas selected should not be part of the survey unit being evaluated.

Some solid samples will need to be collected in the background area for comparative analyses of post-excavation sample analyses. The Site Geologist will record a description of the soil in the background area. Background soil will be compared to soil in the excavations to ensure that like

material is being assessed. In the event that the soils differ significantly, another background location will be sought which has soil similar to that found in the excavation.

The same survey methodology and instruments used to collect the background data will be used to perform measurements within survey units (survey units are defined in Section 3.12.23.)

Data collected in the background reference areas will be statistically evaluated using a graphical format, such as a frequency distribution chart. The purpose of the evaluation is to ensure that the data collected in the reference area are consistent with a normal distribution and that the variability of the background is not too high.

3.12.13 Scan Surveys for Gamma Radiation (Towed Array)

Scan surveys are an evaluation technique performed by moving a detection device over a surface at a specified speed and distance above the surface to detect radiation. It will be used to identify areas that may require additional survey measurements.

Soil scan surveys for gamma radiation will be performed using the towed array described in Section 4.8.4.

3.12.14 Scan Surveys for Gamma Radiation (Walkover)

Surface scan surveys for gamma radiation will be performed by traversing a path at a maximum speed (scan rate) of approximately 0.08 meter per second, while maintaining the detector approximately 10 cm (4 inches) above the area being surveyed.

3.12.15 Static Surveys for Gamma Radiation

Static gamma measurements require positioning the detector assembly approximately 10 cm (4 inches) above the surface and completing a stationary 60-second count accumulation.

3.12.16 Swipe Sample Measurements

Swipe sampling may be performed to assess the presence of radioactive contamination that is readily removed from a surface. If required, swipe samples will be taken to evaluate the presence of alpha and beta/gamma surface activity.

3.12.17 Equipment and Material Surveys

Equipment and material surveys may be performed following the methods in Sections 4.11.2, 4.11.3, and 4.11.5. Table 3.12-2 provides acceptable levels of contamination based on the AEC *Regulatory Guide 1.86* limits (1974). In the event that survey results indicate that levels of contamination exceed the limits listed in Table 4-3, appropriate decontamination methods may be performed to minimize waste. If decontamination methods are unsuccessful, the material will be disposed of as radioactive waste.

Before being put into service or leaving a radiological work area, equipment and/or materials will be surveyed in an area of low-background concentrations to ensure that the equipment and materials release criteria are not exceeded.

3.12.18 Personnel Surveys

Properly trained staff may perform personnel surveys in a pre-designated low-background area, before leaving a radiologically controlled area as specified in the RWP or when deemed necessary by the RCT. Personnel who are not qualified to administer a self-survey will be monitored by a qualified technician.

3.12.19 Soil Sampling

Soil samples will be collected for radiological analysis. Shaw personnel will collect the samples under the supervision of the NWT RCT. Subsequent sections of this plan and the site Sampling and Analysis Plan (Shaw 2006) describe the methods for collecting samples, sample numbering, sample labeling, sample shipment, and completion of the associated chain-of-custody and other required documentation. Soil samples will be analyzed by an on site mobile laboratory and an off site (samples collected at the final excavation depth of 4 feet bgs) laboratory by gamma spectroscopy analysis.

3.12.20 Air Sampling

Note the italicized sentence is added to NWT's program for clarification. NWT has committed to doing this to confirm not needing a bioassay program. Given the most likely inventory of material present, this activity may not be required under Shaw's HS 700 policy for the development of RPPs. Airborne activity monitoring (either as continuous or 'grab samples') will be used during the course of work. In order to control occupational exposures, establish PPE, and determine respiratory protection requirements, monitoring and trending for airborne radioactive material will be performed as necessary. Engineered controls, with concurrence from RASO, will be implemented if required to maintain airborne concentrations below 10 percent of the applicable derived airborne concentration (DAC) value for the ROCs (Table 3-3). At a minimum, air sampling for radionuclides will be performed upwind, downwind, and at the excavation location.

If, during the course of work, an airborne concentration exceeds 10 percent of the DAC, ongoing activities will cease and the affected location will be posted until the source of the airborne concentration is eliminated and levels are confirmed to be below 10 percent of the DAC.

3.12.21 Sampling Protocol

In support of this RSAP, numerous soil samples will be collected to determine the radionuclide concentrations in the soil. Direct surface radiation measurements will be performed at each location before initiating sampling to identify any presence of gross contamination if the

sampling area is not submerged. If elevated radiation levels are present, samples and equipment will be treated as radioactive and handled accordingly. Section 7.0 also discusses the various types and quantities of samples that will be collected during the performance of this work.

3.12.22 Decontamination Procedures

If required, NWT SOPs will be used to decontaminate equipment and materials. Equipment or materials that cannot be easily or cost-effectively decontaminated will be evaluated for possible limited use in radioactive material use areas, or disposed of as radioactive waste. Decontamination water will be collected and sampled before being disposed of.

3.12.23 Final Status Surveys

The MARSSIM (DoD et al., 2000), the *Nonparametric Statistical Methodology for the Design and Analysis of the Final Status Decommissioning Survey Guide* (NUREG-1505; NRC, 1998), and the *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions Guide* (NUREG-1507; NRC, 1997) were used as guidance in designing and conducting the FSS.

3.12.24 Objective of the Final Status Survey

MARSSIM (DoD et al., 2000), NUREG-1505 (NRC, 1998), and NUREG-1507 (NRC, 1997) were used as guidance documents in the design and conduct of this RSAP. The objective of the FSS is to demonstrate that residual radioactivity levels inside the excavated area meet the release criterion. In demonstrating that this objective is met, the null hypothesis (H_o) is tested for residual contamination that exceeds the release criterion; the alternative hypothesis (H_a) is then tested for residual contamination that meets the release criterion.

3.12.25 Survey Area Classification

The classification of areas for the FSS is a critical step in the survey design process so that each site area receives adequate survey coverage. The working hypothesis of MARSSIM (DoD et al., 2000) is that all impacted areas being evaluated for release have a potential for radioactive contamination above the DCGL. MARSSIM sets forth three possible area classifications: Class 1, Class 2, and Class 3. Class 3, which has the least stringent survey requirements, will not be used at any of the Site 12 SWDAs. Class 1 and Class 2 criteria are described below.

Class 1 Areas: Areas that have, or had prior to remediation, a potential for radioactive contamination (based on site operational history) or known contamination (based on previous radiation surveys) above the release limits. Examples of Class 1 areas include:

- site areas previously subjected to remedial actions

- locations where leaks or spills are known (or suspected) to have occurred
- radioactive material storage areas
- areas with contaminants in discrete solid pieces of material or high specific activity

Class 2 Areas: Areas that have, or had prior to remediation, a potential for radioactive contamination or known contamination but are not expected to exceed the soil activity release limits provided in Table 3-1. To justify changing the classification from Class 1 to Class 2, there should be measurement data that provides a high degree of confidence that no individual measurement would exceed the release limits. Other justifications for reclassifying an area, as Class 2 may be appropriate, based on site-specific considerations. Examples of areas that might be classified as Class 2 include:

- locations where radioactive materials were present in an unsealed form
- areas downwind from the main areas of concern (AOC)
- areas handling radioactive materials
- areas on the perimeter of former contamination control areas

Class 1 areas have the greatest potential for contamination and, therefore, receive the highest degree of survey effort, followed by Class 2 and then Class 3 areas.

Based upon process knowledge, and the operational history, the three SWDAs to be excavated will be classified as *Class 1* areas.
Survey units for Class 1 surveys are limited in size based on classification and site-specific conditions. MARSSIM (DoD et al., 2000) recommends areas for survey units according to the following:

Classification	Suggested Area
Class 1 Land Areas	up to 2,000 m^2 (21,527 ft^2)

The limitation on survey unit size ensures that each area is assigned an adequate number of data points.

3.12.26 Survey Units

The three individual SWDAs to be excavated will be divided into *Class 1* survey units. Each survey unit will undergo a one hundred percent scan survey for gamma radiation, before the initial one foot lift, and following each subsequent one foot lift until the target depth of 4 feet bgs is reached, or the presence of free standing water or saturated soils prevents the performance of

the gamma scans, whichever occurs first. The concentrations of radioactive material in each of the survey units are not expected to vary significantly from one survey unit to the other. Although the size of each survey unit may vary, each will receive the same survey and sampling frequency coverage.

A minimum of 16 discrete surveillance points will be spaced using the square grid pattern in Equation 5-1, originating from a random start point during each one foot lift in each survey unit. Table 3.12-2 presents a summary of the three SWDA survey units.

Table 3.12-2: Summary of Site 12 SWDA Survey Units

Area/Survey Unit	Survey Unit Size in m^2 / ft^2	MARSSIM Class	Number of Survey Units [1]	Number of Soil Samples	Length of Grid Pattern in m / ft
SWDA A&B	~ 1,942/ 20,900	1	20	16 per survey unit	11 / 36 See Note 2
SWDA 1207/1209	~ 1,712 / 18,428	1	10	16 per survey unit	10.3 / 34 See Note 2
SWDA 1231/1233	~ 1,416 / 15,237	1	10	16 per survey unit	9.4 / 31 See Note 2

[1] Each area's survey units are in one foot depth increments down to 4 feet bgs.
[2] Actual grid spacing intervals will be calculated in accordance with Sections 5.4 prior to performing the survey.
Abbreviations: ft = feet, ft^2 = square feet, m = meters, m^2 = square meters.

3.12.27 Grid System

A reference coordinate system will be laid out for each survey unit. Shaw personnel will lay out the grid system under the guidance of the NWT RCT. A square grid system will be used for the excavated areas. The length, L, of a side of the square grid is determined by the total number of soil samples to be collected. The length of the square will determine the distance between survey data points. The length or spacing of the grids will be calculated for each of the survey units using Equation 3.12-7 below that was obtained from MARSSIM:

Equation 3.12-7

$$L = \sqrt{\frac{A}{n}}$$

Where:

L = length of squares grids [meters (m) or feet (ft)]
A = surface area of the survey unit (m^2 or ft^2)
n = statistically calculated number of samples

3.12.28 Data Quality Objectives

The DQO process is a series of planning steps for establishing criteria for data quality and survey design development. The level of planning is based on the complexity of the areas to be surveyed.

3.12.28.1 State the Problem

It must be determined if the site-specific release guideline has been met or if remediation is warranted. Therefore, the decision to be made can be stated as, "Do the survey results meet the soil RROs for the radionuclides of concern?"

It is anticipated that successful completion of activities described in this RSAP will provide sufficient data for the unrestricted release of the three SWDA areas to be excavated at Site 12 at NAVSTA TI. Resources available to provide the necessary data include the following:

- Activities outlined in this RSAP
- MARSSIM guidance (DOD et al., 2000) for ensuring statistically valid data
- The use of trained and experienced workers

3.12.29 Identify the Decision

The need to provide data for the unrestricted release of the three SWDA excavation areas in Site 12 requires performing radiological surveys and sampling as specified in this RSAP.
The primary uses of the data expected to result from completion of this RSAP is to provide information and statistical verification of data obtained to support the unrestricted release of the individual areas.

3.12.30 Inputs to the Decision

Radiological surveys required to support the unrestricted release of the three SWDA excavation areas in Site 12 will include:

- One hundred percent gamma scan surveys of each of the survey units at one foot increments in depth with 2-inch by 2-inch NaI detectors or equivalent. Results within 3 sigma of background levels are considered acceptable.
- One hundred percent gamma scan surveys of each of the survey units at the final excavation depth of 4 feet bgs (if soil conditions permit) with 2-inch by 2-inch NaI detectors or equivalent. Results within 3 sigma of background levels are considered acceptable.
- Systematic soil sampling of Class 1 survey units at one foot increments in depth. Results within the release criteria for soil contamination are considered acceptable.

- Systematic soil sampling of Class 1 survey units at the final excavation depth of 4 feet bgs. Results within the release criteria for soil contamination are considered acceptable.
- Laboratory data validation and statistical analysis of collected data.

3.12.31 Definition of Study Boundaries

The spatial boundaries for this FSS effort are confined to the areas to be excavated in the three SWDAs in Site 12. Each survey unit will be one hundred percent gamma scan surveyed. Solid samples will be collected at one foot increments in depth from systematic locations in each of the survey units.

3.12.32 Development of a Decision Rule

3.12.32.1 Release Limits

The release limits for this survey for Ra-226 is 1 pCi/g above background.

3.12.32.2 Alternative Actions

Readings greater than 3 sigma that of background or sample results that exceed the release limits will be further investigated to identify the extent of the contamination.

3.12.33 Limits on Decision Errors

Actions to minimize errors will be instituted during the data collection phase of the radiological survey. Qualified radiation survey personnel will perform the survey and record the data. Automated recording of survey data will be used where possible to minimize errors. Data transcribing is the second phase where errors may arise. To avoid data errors for manual surveys, experienced personnel will record and transcribe data.

The ongoing on-site analyses and evaluation of survey results provides a final check for errors, which if detected, can be corrected.

A knowledgeable individual who is not involved in the direct data collection process (NWT Project Manager) will review the survey data on a daily basis. This will ensure an ongoing independent review for consistency of all survey data collected.

There are two types of decision errors that can be made when performing the statistical tests described in this plan. The first type of decision error, called a Type I error, occurs when the null hypothesis 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. The Type I error rate is often referred to as the significance level or size of the test.

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 hypotheses when it is false. It is numerically equal to $1-\beta$, where β is the Type II error rate.

This survey is designed to limit Type I and Type II errors to 5 percent. It is important to minimize the chances that area grids exceeding the release limits will be missed (Type I Error) and area grids meeting the release limits will be rejected as too high (Type II Error). The probability of either of these occurring will be set at a maximum of 5 percent.
In demonstrating that this objective is met, the null hypothesis (H_o) is tested that residual contamination exceeds the release criterion; the alternative hypothesis (H_a) is then tested that residual contamination meets the release criterion.

3.12.34 Optimizing Data Collection

3.12.34.1 Review Outputs and Existing Data for Consistency

Radioactive source readings will be used to check instruments for consistency prior to use in each daily shift. The instrument will only be used after readings are compared and agree within +/- 20 percent of predetermined responses. The on-site NWT Project Manager will review the information each day to verify that equipment is operating satisfactorily.

A knowledgeable individual who is not involved in the direct data collection process will review the survey data on a daily basis. This will ensure an ongoing independent review for consistency of all survey data collected.

3.12.34.2 Develop Data Collection Design Alternatives

The MARSSIM guidelines (DoD et al., 2000) will be used and a 95 percent confidence level for detecting radioactivity above the release levels will be assumed with Type I and Type II errors limited to 5 percent.

3.12.34.3 Data Collection Design Alternatives

The data collection design alternatives may change slightly if assumptions are revised based on conditions in the field being different than the furnished information derived from historical research and current knowledge of the areas.

3.12.34.4 Select Most Resource-Effective Survey Design

As indicated above, the survey design specified for use in this RSAP was developed to perform radiological FSSs. Combined with the use of qualified and experienced personnel, this design is considered as both efficient and resource effective.

3.12.34.5 Document Operational Details and Theoretical Assumptions

Operational details for the radiological survey process have been developed for and are included as part of this RSAP. The theoretical assumptions are based on guidelines contained in MARSSIM (DOD et al., 2000). Specific assumptions regarding types of radiation measurements, instrument detection capabilities, quantities and locations of data to be collected, and investigation levels are contained in this RSAP.

3.12.35 Null Hypothesis

Using the MARSSIM methodology, the null hypothesis is stated as "the residual activity in the survey unit exceeds the release criteria" (Rev. 1, August 2000). Thus, in order to pass the survey unit (that is, release the area), the null hypothesis must be rejected. If necessary, the Wilcoxon Rank Sum Test will be used on the survey data to test the statistical null hypothesis.

3.12.36 Statistical Tests

Since the ROC is present in background and gross gamma measurements (and not radionuclide specific) are being performed as part of this Final Status Survey, Chapter 8, Subsection 8.2.3 of MARSSIM suggests use of the Wilcoxon Rank Sum Test to test the statistical null hypothesis instead of the Sign Test.

Non-parametric tests are useful when the requirements of the parametric test cannot be met. For example, if observations can only be measured on a categorical scale, the sample size maybe too small, or other distributional assumptions do not hold. In many situations a non-parametric test is the only option, since many do not have parametric equivalents.

Regulatory guidance, as identified in MARSSIM (DoD et al., 2000), recommends use of the WRS test to conservatively evaluate surveillance results that will be obtained from this survey.

3.12.37 Wilcoxon Rank Sum Test

The WRS test is designed to test a hypothesis about the location of a population distribution. It is most often used to test the hypothesis about a population median and often involves the use of matched pairs. For example, reference area and survey unit data are tested for a median difference of zero. This test is also a non-parametric test that may be used when it is only necessary, or possible, to know if observed differences between two conditions are significant. The WRS test is structured to denote change in magnitude, as opposed to any attempt at the quantitative measurement. This effect is further amplified when used with the "Unity Rule" presented in MARSSIM.

The WRS test is a two-sample test that compares the distribution of a set of measurements in a survey unit to that of a set of measurements in a reference area. The test is performed by first adding the value of the release limits to each measurement in the reference area. The combined set of survey unit data and adjusted reference area data are listed, or ranked, in increasing numerical order. If the ranks of the adjusted reference site measurements are significantly higher than the ranks of the survey unit measurements, the survey unit demonstrates compliance with the release criterion. The advantage of this nonparametric test is that it does not assume the data are normally or log-normally distributed. The WRS test also allows for "less than" measurements to be present in the reference area and the survey units.

For this case, the release limit value is added to each of background reference area measurement results that were obtained in the background reference area to obtain the adjusted reference area measurement Z_i.

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 $N = m+n$. For this case N=32.

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

If there are t "less than" 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 "less than" values.

The ranks of the adjusted measurements from the background reference area are then summed, W_r.

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 $W_r = N(N+1)/2 - W_s$.

Compare W_r with the critical value given in Table I.4 found in Appendix I of MARSSIM for the appropriate values of n, m, and α. If W_r is greater than the critical value, the hypothesis that the survey unit exceeds the release criterion is rejected.

If the test shows that the first group is larger than the second, then the release criteria is not met.

3.12.37.1 Determining the Numbers of Data Points for the WRS Test

Since the ROC is present in background, the MARSSIM guidelines will be used and a 95 percent confidence level for detecting radioactivity above the investigation level will be assumed. Using the Wilcoxon Rank Sum Test, a release limit of 1 pCi/g of ^{226}Ra, a LBGR value of 0.5 pCi/g (one half of the release limit value), and a Standard Deviation value of 0.3 pCi/g (conservative estimate of 30% of the release limit value) with a false negative (β) error rate of 5 percent, and a false positive error (α) rate of 5 percent, the number of survey/sampling data points can then be calculated.

The initial step in determining the number of data points is to calculate the relative shift, Δ/σ = (Release Limit Value-LBGR)/σ, from the release limit value, the lower bound of the gray region (LBGR), and the standard deviation of the contaminant in the survey unit, σ. Values of the relative shift that are less than one will result in a large number of measurements needed to demonstrate compliance.

The calculated value of the relative shift is 1.67.

The corresponding value of P_r from Table 5.4 in Chapter 5 of MARSSIM is 0.871014.

The number of direct measurement sample data points (N/2) can then be obtained directly from Table 5.3 in Chapter 5 of MARSSIM. For $\alpha = 0.05$, $\beta = 0.05$ and $\Delta/\sigma = 1.67$, a value of 16 is obtained for N/2. The table value has already been increased by 20% to account for missing or unusable data and uncertainty in the calculated value of N/2.

The Critical Value is 308.

3.12.38 Field Implementation

This section describes the specific activities and procedures involved in preparation for, and field implementation of, the excavation of the areas in Site 12. It will include restoration of the disturbed areas to a stable, safe condition. The planned activities include:

3.12.39 Excavation of Soils

3.12.40 Excavation Approach

The three SWDAs within Site 12 will be excavated in one foot lifts to a maximum depth of 4 feet bgs. Figures 2, 3, and 4 depict the areas that are to be excavated within each SWDA. A gamma scan survey over 50% of each of the areas will be performed after each one foot lift. The survey results will be transmitted to on-site managers in a timely manner so as to avoid delays in excavation of the SWDAs. Following the surface scan, systematic soil samples will be collected from each of the survey units and sent to an offsite laboratory for gamma spectroscopy analysis. The excavation schedule will not be delayed to await laboratory results.

3.12.41 Survey Lanes

Survey lanes will be setup for the towed array. The lanes will be three feet wide and set up over 50 % of the individual SWDAs in Site 12. The areas selected for the 50 % scan survey will be randomly selected in each of the survey units.

3.12.42 Initial Surface Scans

Initial surface scans for radiation will be performed prior to the initial excavation of one foot in each of the areas. A one hundred percent scan survey of each SWDA will be performed using the towed array with a Ludlum Model 4612 Counter and twelve Ludlum Model 44-10 NaI probes supported by GPS equipment. This survey will be completed and the results accepted prior to beginning initial excavation activities.

3.12.43 Subsequent Lift Surface Scans

Surface scans for radiation will be performed following the completion of each one foot lift being excavated in each of the SWDA areas. A one hundred percent scan survey of each SWDA area will be performed using the towed array with a Ludlum Model 4612 Counter and twelve Ludlum Model 44-10 NaI probes supported by GPS equipment. This survey will be completed and the results accepted prior to beginning each subsequent excavation lift. The final "as left" excavation (4 feet bgs) will also receive a 100% surface scan.

NOTE: If free standing liquid is encountered or the soils are saturated, gamma scan surveys cannot be performed in those areas due to shielding and density factors which will decrease the detectors' detection capability. If standing water covers only a portion of the survey unit, then the gamma survey lanes will be set up in unsaturated areas.

3.12.44 Areas Exceeding Investigation Level

Collected field data will be logged and survey points plotted on survey unit grid maps to document survey results. The GPS data will be used to directly tie the locations of any elevated radiation measurements to the corresponding grid coordinates, which will be established during the development of the systematic sampling plan. Data analysis will be performed as it is received, and questionable areas will be flagged in the field for resurvey/verification.

Locations where surface radiation levels appear to be greater than 3 sigma of the mean background level will be noted on a grid map. Hand-held equipment featuring NaI detectors will then be used to perform one-minute static readings and verify the elevated measurements. Areas confirmed as having radiation levels greater than the established 3 sigma of the mean background area level will be evaluated further for the presence of radioactive material and additional biased sampling points. If radioactive material is confirmed, the area will be physically marked and the radioactive material removed, as described in Section 3.12.44.

3.12.45 Soil Sampling

After NWT PM and RASO review of the associated towed array data following each one foot lift in the three SWDAs, a minimum of 16 systematic soil samples will be collected in each survey unit. The samples will be systematically collected based on a random start point and sample spacing utilizing Equation 5-7 from the MARSSIM (NUREG-1575), as shown in Section 5.4. Table 5-1 provides the spacing intervals for each of the three SWDAs. The samples will be analyzed by gamma spectroscopy using an on-site mobile laboratory. In addition, the samples collected the final excavation depth of 4 feet bgs will be sent to an offsite laboratory for gamma spectroscopy analysis, Method 901.1M, (DOE, 1997).

Surface (0-6 inches below present ground surface) samples will be collected from each sampling location using a new disposable plastic soil sampling scoop.

Approximately 200-300 grams of soil will be collected from each sample location. Samples will be prepared by removing vegetation, rocks, and foreign objects exceeding ¼ inch in diameter. The samples, once prepared, will be placed into an appropriate container. Collection methodology, chain of custody, and analysis requirements are detailed in NWT's Field Operation Procedures and the site SAP (Shaw, 2006).

3.12.46 Removal of Radioactive Material

If radioactive material is identified and confirmed during the gamma scan surveys, GPS coordinates will be recorded so the location can be marked and flagged. If the RCT observes a questionable reading during the field survey, the location will be immediately flagged for further inspection. The field survey team or the data group analyzing collected field information will notify the Shaw and NWT PM who will then inform RASO. Radiological support personnel under the supervision of an RCT will remove the radioactive material.

Typical removal actions will involve an area within a radius of 1 foot around the coordinates of the suspected radioactive material. Under RCT oversight, the location with an elevated radiation level will then be excavated using an excavator fitted with a smooth blade bucket and/or hand-digging tools. Soil removal will continue until the source of the elevated gamma activity is removed.

Following removal of the source of elevated gamma activity, an additional foot of soil in all directions from the source will also be removed and disposed of as radioactive waste. After the radioactive material and surrounding soil is excavated, the resulting pit will be resurveyed by the assigned RCT. If elevated gamma emitters persist, further examination of the soil will be made until the source of high gamma radiation is found and removed.

If the source of elevated radioactivity cannot be readily identified as a point source and removed, the material will be segregated for disposal. All soil removed from a location due to elevated radioactivity will be placed in a separate stockpile at TI Site 6, where it will be covered and held until proper disposal has been arranged. If the radioactive material is a point source, it will be given a unique identification number and recorded in a logbook. Radioactive point sources will be placed in plastic bags (if feasible) and stored in a designated and posted radioactive material storage area for subsequent packaging and disposal by a certified waste broker under the direction of the Navy LLRW Disposal Program.

Discovery of radioactive material exceeding the release limits may trigger an upgrade to Class 1 survey of that SWDA. In that event, all work at the SWDA will cease until modification to this RSAP and the Excavation Plan are completed prior to proceeding with further work. Work in other, unaffected, SWDAs will continue uninterrupted.

3.13 Contamination Control

NWT has provided extensive contamination control and control of work procedures which are presented in Sections 3.12.12, 3.12.16, 3.12.17, 3.12.18, 3.12.22, 3.12.38, of this RPP.

In addition, if radioactive materials are discovered during excavation and surveying activities a RWP will be prepared that will specify the radiological safety requirements for activities performed under this RSAP. Personnel assigned to site work will be required to understand the requirements and sign the RWP prior to beginning work.

Only pre-authorized areas will be used to store radioactive materials at TI. These areas will be selected with concurrence of RASO, the RSO, and the CSO. Security measures for these areas will be coordinated with the CSO and the Shaw or subcontractor NRC licensee.
Radioactive material handling activities must be performed in a manner to ensure the following:

- Access to areas is restricted where radioactive materials are known to be present.
- Surveys of radioactive materials storage areas are completed at least weekly.
- Radioactive material inventories are kept up-to-date.

3.14 Instrumentation

NWT has provided extensive instrumentation documentation which is presented beginning in section 3.12.1 and is summarized in Table 3.12-1.

3.15 Radiological Areas Posting/Labeling

A Radioactive Materials Area (RMA) is kept in the Area 6 bin storage area. Only the following two postings (signs) are anticipated: (1) "Caution Radioactive Materials" and (2) "Caution Any Container in this Area May Contain Radioactive Materials."

3.16 Control of Radiological Work

NWT has provided extensive details of how radiological work will be controlled in Sections 4.5-4.6 of their Final Radiological Sampling and Analysis Plan, Site 12 Removal Remedy Action, Rev. 3, dated July 4, 2007, the text of their program is presented in Section 3.13 Contamination Control, above.

3.17 Credentialing of Staff

NWT follows ANSI 3.1 criteria for technician staff. NWT holds a broad scope NRC license and has an RSO who is also NRRPT qualified.

In addition project oversight by Shaw Environmental, Inc. includes an

- American Board of Health Physics Certified Health Physicist, i.e., a CHP

3.18 Procurement, Receipt, and Inventory

The project will not be receiving Radioactive Materials Shipments, except check sources in exempt quantities. The exempt quantity sources do not require leak testing. Sources will be inventoried on 6-month intervals.

3.19 Shipping and Transportation of Radioactive Materials

Not applicable.

3.20 Control of Radioactive Waste

Not applicable.

3.21 Radiation Protection Records

The NWT Project Manager is responsible for reviewing data for accuracy and completeness before on-site activities are concluded. Electronic records may be substituted, provided appropriate access authorization procedures are in place and quality assurance requirements are met.

All data, notes, measurements, calibrations, and other information pertinent to a survey site must be recorded and maintained. Records must conform to the following basic requirements:

- Marked with date of entry.
- Signed or initialed (by hand or electronically) by the author of the entry.
- Written or printed in a legible manner.
- Contain all pertinent information in a concise, accurate entry.

Column headings or requested information on record data forms may be inappropriate or incorrect for specific site situations. If so, appropriate handwritten changes must be made on the forms. When certain information requested on the presented form is not required, the space or columns should be crossed through or marked "NA" (not applicable) as an indication that such information was not required, rather than having possibly been forgotten.

If data corrections are necessary a single line will be drawn through the entry. New data, initials of the surveyor, and date of correction will be recorded. Data will not be obliterated by erasing or with the use of white-out.

All training records and accident investigation documents will be maintained. The training records will include brief biographies (resumes) certifications, or documents that demonstrate the qualifications of the personnel performing the work.

The Final Status Survey Report will contain records and information necessary to document and support the Final Status Survey effort. All generated records for the project shall be maintained in the on-site office. Records that must be controlled and maintained during the project and presented in the Final Status Survey Report, in addition to site activities include but are not limited to:

- Description of survey design;
- ALARA evaluation/discussion;
- Instrument calibration data;
- Description of area to be released and its radiological use and history;
- Daily instrument performance check data;
- Instrument efficiency determination data;
- Survey records;
- Dates surveys were performed;
- Survey results and data;
- Description of instrumentation used;
- Instrumentation MDC calculations;
- Smear sample location records;
- Identification of release limits used;
- Sample analysis results;
- Survey maps and photographs;
- Quality control data;
- Comparison of survey results to release limits; Shipment and receipt of radioactive materials records
- Dose estimates and reports and supporting documents
- Training records
- Dose reports.

Listed records will be maintained on site during project activities. All listed records will be transmitted with the final project report and maintained at the NWT corporate office in Livermore, CA.

In addition to records listed above, records relating to self-assessments, periodic reviews, audits, radiological occurrences, corrective actions and other responses to such findings or incidents also trigger recordkeeping requirements, all of these records will be forwarded to Shaw Environmental, Inc.

Records will be retained for a minimum of three years or as long as contractual requirements specify, whichever is longer.

3.22 Reports and Notifications

Workers who have had previous work history with radiological hazards shall supply the RSO with copies of their estimated or reported dose histories.

If personnel are provided external dosimetry monitoring devices, records of radiation exposures to workers shall be maintained; each employee for whom such records are maintained shall be advised of his/her individual exposure annually.

In addition, some matters such as radiological occurrences and incidents requires reporting, as noted in the previous section.

3.23 Licenses

NWT holds a Type A Broad Scope Radioactive Materials License issued by the NRC for their operations. The Gamma spectroscopy check source is used on a weekly basis but stored at an NWT facility off-site.

3.24 Review and Approvals of Radiation Protection Plans

The PM, RSO, RSM, and Program Health and Safety Manager shall formally review and approve the RPP. In addition, the client will have an opportunity to review, provide input, and provide formal acceptance of the plan.

The RSO may make field changes to the RPP and supporting documents to facilitate use without approval provided radiation safety conditions at the site, Action Levels and expected doses are not impacted.

3.25 Planned Special Exposures

There is no anticipated work within this scope that would require a planned special exposure.

4.0 Personal Protective Equipment

The RSO and Project HSM have established the levels of protection for the site activities. The primary level of PPE, Modified Level D, is sufficient for field survey, excavation, removal, and decontamination activities associated with the remediation of any radioactive commodities or waste found. For details regarding Level D – Modified Protection, refer to the Final HSP (Shaw, 2007).

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5.0 Radiological Survey, Removal, and Decontamination Procedures

NWT will be fulfilling this function. The following section details the procedures for surveying soil and solid waste for radiological materials, removal of any positively identified radiological materials, and decontamination for personnel exposed to such materials.

Gamma exposure rate instruments, surface contamination survey instruments, and a smear counter will be available at all times when work on or around radioactive material is in progress for purposes of detection of unexpected materials or levels, and contamination control.

5.1 Land Disposed Radiological Materials

If the project staff has cleared an area for safe entry and it is amenable to surveillance for any kind of hazard, the area will be visually surveyed. A Ludlum Model 44-10 detector or a Ludlum Model 19 or equivalent instruments will be used for determining the presence of radioactive materials. Since some objects that have been encountered represent a group of well-known category of radioactive items, visual recognition may be possible before an instrument is used to confirm it. In addition, a frisking instrument would be useful in verifying that removable contamination is being controlled.

5.2 Personnel Decontamination

Frisking personnel for surface contamination will be performed using a Ludlum Model 43-89 (or comparable instrument, such as a Ludlum Model 43-93-2 or 43-93 detector). If personnel are found to have skin contamination, soap and water are most likely to be highly effective in eliminating contamination. Due to the long period that any potential radioactive material has been in contact with soil, the potential for its reactivity to skin resulting in persistent skin contamination is low. If two rounds of decontamination by soap and water is unsuccessful in reducing contamination on the skin to an acceptable level, the individual will be referred for prompt medical assistance.

5.3 Equipment Decontamination

Equipment will be surveyed for fixed contamination with a Ludlum Model 43-89, a Ludlum Model 43-93, or Ludlum Model 43-93-2 detector or equivalent. Removable contamination will be determined by collecting ***and*** by counting smears with a Ludlum Model 2929 detector to verify that the free-release criteria are met (see Table 3). Since contamination on surfaces involves a limited amount of material with limited thickness, a gamma scintillator or such as a Ludlum Model 19 has low efficacy for screening purposes for free release of equipment.

6.0 Air Monitoring

Air monitoring for radioactive material is not anticipated. Dust monitoring such as a 'PM-10' passive monitoring device may be used to verify the efficacy of dust control measures.

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7.0 Shipping and Transportation of Radioactive Materials

Not applicable, because analysis will be performed on-site using a gamma spectroscopy system.

In the event samples are to be shipped for off-site analysis, DOT regulations require determining a transportation index (external exposure rate at about 1 foot), the surface contamination level on the package (determined by counting wipe samples in a Ludlum Model 2929 smear counter), and an estimate of the activity of the samples (available because the gamma spectroscopy system will furnish an estimate of the activity of the sample).

8.0 References

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NUREG 1575, 2000, *Multi-Agency Radiological Site Survey Investigation Manual (NRC, EPA, DOD, DOE), Revision 01*, August, 2000.

Shaw Environmental & Infrastructure, Inc. (Shaw E & I), 2006, *Health and Safety Policies and Procedures Manual*, <http://shawnet3.shawgrp.com/sites/handspps/default.aspx>.

U.S. Army Corps of Engineers (USACE), 2003, *Safety and Health Requirements Manual*, EM 385-1-1, Washington, D.C., November 3.

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U.S. Nuclear Regulatory Commission (NRC), 1996, Regulatory Guide 8.29, *Instruction Concerning Risks from Occupational Radiation Exposure*, Revision 1, Washington, D.C., February.

U.S. Nuclear Regulatory Commission (NRC), 1999, Regulatory Guide 8.13, *Instruction Concerning Prenatal Radiation Exposure*, Revision 3, Washington, D.C., June.

Tables

Table ~~2~~ 1
Radiation Protection Personnel

Organization/ Company	Individual/ Phone Number	Project Role/ Responsibility	Phone Number	Email
Shaw Environmental, Inc.	Dennis Brown	Radiation Safety Officer /	(303) 741-7507 (720) 272-9915	Dennis.Brown@shawgrp.com
	David Hillyer	Radiation Protection Manager	(617) 589-1115 (217) 521-4721 (Cell)	David.hillyer@shawgrp.com
	Barry Conaway	Project Health and Safety Manager	(609) 588-6394 (609) 510-11348 (Cell)	Barry.Conaway@shawgrp.com
	Greg McElroy	Program Health and Safety Manager	(412) 858-1542 (412) 759-5302 (Cell)	Greg.McElroy@shawgrp.com
	Steve Petty	Project Manager	(609) 584-6838	Steven.petty@shawgrp.com
NWT	Doc Dennis	Radiation Safety Officer	(916) 929-6977	doc@greer-construction.com

CHP denotes Certified Health Physicist.
CSP denotes Certified Safety Professional.

Table 2
Controlling Agency Contact Information

1. **United States Nuclear Regulatory Commission Region IV**
   Attention: Director, Division of Nuclear Material Safety
   611 Ryan Plaza Drive, Suite 400
   Arlington, Texas 76011
   Phone: (817) 860-8221 Fax: (817) 860-8263

2. **United States Environmental Protection Agency Region 9**
   75 Hawthorne St., SFD-8-1
   San Francisco, CA 94105-3901
   Attn: Christine Katin
   Phone: (415) 972-3112 Fax: (415) 947-3520

3. **State of California**
   Department of Health Services
   Radiologic Health Branch
   P.O. Box 942732
   Sacramento, CA 94235-7320

4. State of California
   Department of Health Services
   California Environmental Management Branch
   P.O. Box 997413 Mail Station 7405
   Sacramento, CA 95899-7413
   Attn: Diedre Dement
   Phone: (916) 449-5675

5. State of California
   Department of Health Services
   Department of Toxic Substances Control
   700 Heinz Ave., Suite 200
   Berkeley, CA 94710
   Attn: Henry Wong
   Phone: (510) 540-3770 Fax: (510) 849-5285

6. U.S. Department of the Navy
   Southwest Division
   Naval Facilities Engineering Command
   1220 Pacific Highway
   San Diego, California 92132-5187
   Phone: (619) 532-2540 Fax: (619) 532-2607

7. U.S. Department of the Navy
   BRAC RPM
   1455 Frazee Road, Suite 900
   San Diego, CA 92108-4310
   Phone: (619) 532-0936 Fax: (619) 532-0983
   Attn: James Whitcomb

8. U.S. Department of the Navy
   ROICC SF Bay Area
   2450 Saratoga St., Suite 200
   Alameda, CA 94501-7545

Table 3 Free Release Criteria for Surfaces and Threshold for Use of Engineering Controls

• Measured Parameter/ Threshold	• Total Surface Alpha Contamination • (dpm/100cm²)	• Total Surface Beta Contamination • (dpm/100cm²)	• Total Removable Alpha Contamination • (dpm/100cm²)	• Total Removable Beta Contamination • (dpm/100cm²)	• Radiation level (external gamma radiation as seen by a field instrument, uncorrected) • (μR/hr)
• Free Release*	• 500	• 5,000	• 20	• 1,000	• 50 (at contact)
• Minimal Engineering Controls **	• 500< x <50,000	• 5,000< x <500,000	• 20< x <2000	• 1,000< x <100,000	• 50<x< 2,000 • (at 1 foot)

** Material found to exceed the free release criteria shall be segregated from material that does not exceed the free release criteria. Free Release Criteria are developed from Army regulations and NRC Regulatory Guide 1.86.*

***Levels that exceed the upper limiting values for surface contamination triggers evaluation of additional engineering controls and procedures. Work shall be suspended until guidance is received from the RSO.*

Radiological Control of an area formally begins when the 2000 μR/hr. threshold is reached. Work shall also be suspended when the 5000 μR/hr. threshold is reached. Posting as a Radiation area would be required at 5000 μR/hr. At this level there would be a change in work control as a formal radiation work permit program would need to be implemented.

dpm denotes disintegrations per minute

μR/hr denotes microRoentgens/hour

50 μR/hr times 2000 hours = 100 mrem, which is the limit for a non-radiation worker.

Table 4. Regulatory Limits and Action Levels[1]

TYPE	DOSE LIMIT OR ACTION LEVEL
REGULATORY LIMIT	
Public (TEDE)	100 mrem, annual
Total effective dose equivalent (TEDE)	5000 mrem, annual
CDE to any organ except skin & lens of eye	50000 mrem, annual
Lens of eye	15000 mrem, annual
Shallow dose equivalent (SDE) to skin of whole body and extremities	50000 mrem, annual
Dose rate to public	2 mrem in any one hour
ACTION LEVEL	
Action level for additional training	Greater than 100 mrem, annual, expected
Action level for requiring individual monitoring	Greater than 500 mrem , annual, expected
Action level for requiring decontamination or storage/disposal with radioactive materials	Greater than Table 3 release levels
Action level for requiring engineering controls	100 times Table 3 release levels
Action level for RPT assistance and decontamination of personnel	Readings above background levels on personnel
Action Level for notification of RSM and suspending work in the area	Unexpected materials with radiation hazard or high dose rate objects
	High levels of contamination found
	Exit signs

1: RSM may require monitoring at levels below the action level for purposes of ensuring compliance.

Appendix A
Health and Safety Plan Addendum
Acknowledgement Form

Health and Safety Plan Addendum Acknowledgment Form Addendum 2007-01

I have reviewed, understand, and agree to follow the Health and Safety Plan Addendum 2007-01 for the applicable Cabot Corporation Slag Pile stabilization/modification. Additionally, I understand that there are additional safety and health requirements, which are presented in attached Activity Hazard Analyses. I agree to abide by the requirements of the Activity Hazard Analyses for the work that I will perform.

Printed Name	Signature	Representing	Date

Appendix B
Activity Hazard Analysis

APPENDIX B – ACTIVITY HAZARD ANALYSIS

THIS APPENDIX IS NOT AVAILABLE.

EXTENSIVE RESEARCH WAS PERFORMED BY NAVFAC SOUTHWEST RECORDS OFFICE TO LOCATE THE MISSING APPENDIX. THIS PAGE HAS BEEN INSERTED AS A PLACEHOLDER AND WILL BE REPLACED SHOULD THE MISSING ITEM BE LOCATED.

FOR ADDITIONAL INFORMATION, CONTACT:

DIANE C. SILVA, COMMAND RECORDS MANAGER, CODE EV33
NAVAL FACILITIES ENGINEERING COMMAND, SOUTHWEST
1220 PACIFIC HIGHWAY (NBSD BLDG. 3519)
SAN DIEGO, CA 92132

TELEPHONE: (619) 556-1280
E-MAIL: diane.silva@navy.mil