DOE/NV/11718–708

Cost and Performance Report

Accelerated Site Technology Deployment Program

Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) Deployment at the Nevada Test Site, Area 25 Reactor Maintenance, Assembly, and Disassembly (R-MAD) Compound

U.S. Department of Energy
National Nuclear Security Administration
Nevada Operations Office

May 2002

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Prepared for
U.S. Department of Energy
National Nuclear Security Administration
Nevada Operations Office

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ACRONYMS AND ABBREVIATIONS

Am-241	Americium-241
ASTD	Accelerated Site Technology Deployment
BEGe	Broad-Energy Germanium
BN	Bechtel Nevada
BNL	Brookhaven National Laboratory
CAP	Corrective Action Plan
CFR	Code of Federal Regulations
cm^2	square centimeter
Co-60	Cobalt-60
Cs-137	Cesium-137
DCGL	Derived Concentration Guideline
D&D	Deactivation and Decommissioning
DDFA	Deactivation and Decommissioning Focus Area
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOE/NV	U.S. Department of Energy, Nevada Operations Office
dpm	disintegrations per minute
DQO	data quality objective
E-MAD	Engine Maintenance, Assembly, and Disassembly
EPA	U.S. Environmental Protection Agency
ERD	Environmental Restoration Division
HEPA	High-Efficiency Particulate Air
HPGe	High-Purity Germanium
HSA	Historical Site Assessment
in^2	square inch
ISOCS	In-situ Object Counting System
KeV	kiloelectron volt
LLW	Low-level Waste
m^2	square meter
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MCA	Multichannel Analyzer
MDA	Minimal Detectable Activity
MDC	Minimal Detectable Concentration
mm	millimeter

ACRONYMS AND ABBREVIATIONS (Continued)

NDEP	Nevada Division of Environmental Protection
NNSA/NV	U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office
NRDS	Nuclear Rocket Development Station
NTS	Nevada Test Site
OI	Organization Instruction
pCi/g	picocurie per gram
QA	Quality Assurance
QC	Quality Control
RadCon	Radiological Control
RCO	Radiological Control Organization
R-MAD	Reactor Maintenance, Assembly, and Disassembly
SAFER	Streamlined Approach for Environmental Restoration

1.0 SUMMARY

The U.S. Department of Energy (DOE), National Nuclear Security Administration Nevada Operations Office (NNSA/NV) Environmental Restoration Division (ERD) Industrial Sites Project Deactivation and Decommissioning (D&D) source group has limited budget and is constantly searching for new technologies to reduce programmatic costs. Partnering with the DOE Office of Science and Technology Deactivation and Decommissioning Focus Area (DDFA) reduces NNSA/NV programmatic risk and encourages accelerated deployment of potentially beneficial technologies to the Nevada Test Site (NTS).

1.1 BACKGROUND

One of the time consuming, costly, and potentially hazardous activities associated with the D&D of NTS facilities is the performance of final status surveys. The baseline approach of such surveys requires the performing organization to negotiate the design of the final status survey with the Radiological Control Organization (RCO) for each area of concern. This includes the grid size, number of sample locations within each grid, and how those sample locations are established during the negotiations. The resulting survey design is highly subjective and can vary widely between similar impacted areas. In addition, the statistical basis of the survey often lacks sufficient power to support any conclusions that can be made from the survey results.

The Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) methodology is a statistically based approach that offers a standardized, consistent approach to final status surveys. MARSSIM methodology has been reviewed and accepted by the DOE, the U.S. Nuclear Regulatory Commission, the U.S. Department of Defense (DoD), and the U.S. Environmental Protection Agency (EPA). It was hypothesized that by combining the MARSSIM methodology with the In-situ Object Counting System (ISOCS), a portable gamma spectroscopy system, the final status survey of a radiological facility would result in an increase in worker safety and a decrease in project costs. Deployment of these technologies at the NTS would allow their evaluation in a DOE regulatory environment and determine if they increase worker safety and/or reduce project costs.

1.2 SITE INFORMATION

The NNSA/NV received an Accelerated Site Technology Deployment (ASTD) Program award from the DDFA to implement the MARSSIM at the NTS. The NNSA/NV selected the Reactor Maintenance, Assembly, and Disassembly (R-MAD) D&D project in Area 25 of the NTS as an ideal location to deploy MARSSIM. This report covers work performed by Bechtel Nevada (BN). IT Corporation will be preparing a separate report on the development of a subsurface MARSSIM model.

The R-MAD complex was built to support the nuclear rocket program and was operational from 1959 through 1970. The R-MAD building was used to assemble reactor engines and to disassemble and study reactor parts and fuel elements after reactor tests. The R-MAD building is currently being decontaminated through the NNSA/NV ERD Industrial Sites Project D&D source group.

1.3 DEPLOYMENT

Deployment of the MARSSIM final verification technique was proposed to demonstrate and compare it to the NTS baseline technology for release surveys. In addition to deploying MARSSIM methodology, the project also included funding to train personnel in the use of the ISOCS. The ISOCS portion of the project was supported by Brookhaven National Laboratory (BNL) which had developed expertise, procedures, and quality assurance/quality control (QA/QC) documentation for using ISOCS in their fiscal year 1999/2000 ASTD project.

The techniques developed in the MARSSIM have been widely embraced by the DoD and commercial nuclear industry, but have not been well implemented in the DOE community. In an attempt to standardize radiological release surveys across the DOE complex, DDFA has funded a number of MARSSIM demonstration deployments to obtain cost and performance data. These cost and performance data are necessary to support DOE complex-wide acceptance of this methodology. An analysis of the R-MAD building indicated that the greatest project benefit would result from concentrating on the final status survey of the building exterior.

The ISOCS deployment resulted from seeing BNL's successful deployment during the 2000 DDFA midyear review. Based on a site visit to BNL to talk with project staff, the NNSA/NV ERD decided to purchase ISOCS and deploy it to support the NTS D&D source group. One of the possible deployment opportunities for ISOCS was to support MARSSIM final verification surveys of multilayered material (i.e., R-MAD roof). The project included funding to BNL for the NTS deployment of ISOCS. The goal was to reduce the trial and error associated with implementing this new technology by receiving hands-on training and adaptation of BNL ISOCS procedures and QA/QC documentation. In addition to deploying ISOCS to support MARSSIM surveys, ISOCS was used to characterize soil and duct work and to release equipment and debris from contaminated areas.

1.4 SYSTEM DESCRIPTION

MARSSIM is not a system but rather a standardized methodology that can be applied to final verification surveys of buildings and soil. Provided below is a brief description of the ISOCS system used in the verification surveys. Additional information is provided in Section 4.0.

ISOCS is comprised of a broad-energy germanium (BEGe) detector, a multi-attitude cryostat that allows positioning of the detector in all positions (downward and upward looking), a modular ISOCS shield system, a battery-powered digital multichannel analyzer (MCA), a tripod, and a laptop computer with software for operation of the detector and the unique software that allows the user to generate the efficiency calibration curves.

1.5 SYSTEM PERFORMANCE AND BENEFITS

The performance and benefits of the MARSSIM approach was compared to the requirements of BN Organization Instruction (OI) OI-0441.212, "Controlled and Unrestricted Release." This OI is the baseline guidance for the final status survey of the R-MAD building. It invokes the requirements of 10 Code of Federal Regulations (CFR) 835 and the NV/YMP Radiological Control Manual (U.S. Department of Energy, Nevada Operations Office [DOE/NV], 2000).

The criteria for surface contamination is outlined in Table 4-2 of the Radiological Control (RadCon) Manual. The derived concentration guidelines (DCGL) in this table are used for an unrestricted release of equipment, materials, and structures. The differences in implementation of the OI and MARSSIM approach to assess surface or volumetric contamination are striking. Examples include:

1. Volume contaminated material is not covered by the OI and will be handled on a case-by-case basis. The MARSSIM methodology can be applied to the top 15 centimeters of a surface such as soil or the R-MAD roof if DCGLs are determined.

2. The OI requires a survey plan be written and approved for each final status survey. This requires the negotiation of grid size, sample numbers, and statistical basis for each new final status survey. The MARSSIM approach provides consistent guidance and sound statistical basis, greatly reducing the time and effort required to prepare the survey plan.

3. The OI's default grid size for documenting the final survey data remains at 1 square meter (m^2). MARSSIM guidance allows the grid size to be dependent on risk and known measurement variance.

MARSSIM was not applied to a Class I Area.

1.6 REALIZED AND POTENTIAL COST SAVINGS FOR ISOCS AND MARSSIM

1.6.1 ISOCS Deployment

With the ASTD award, the NTS was able to capitalize on the lessons learned and knowledge base that BNL had developed to accelerate their deployment of ISOCS. This accelerated deployment of ISOCS has resulted in an estimated savings of 465 man-hours in labor costs to the NTS. The majority of this saving results from the NTS adopting BNL's quality assurance plan (QAP) and operating procedures. In addition, ISOCS has become the baseline technology for waste characterization and package activity quantification for all D&D projects at the NTS, which has essentially eliminated the need for sending samples off-site for gamma spectroscopy.

1.6.2 MARSSIM Implementation

The majority of potential cost savings associated with the implementation of the MARSSIM methodology is associated with the standardization of the final verification surveys process and elimination of unnecessary sample locations. Having a standard approach has eliminated the need to renegotiate all the parameter for a final status survey with the regulator. Utilizing the MARSSIM methodology at the R-MAD building has saved an estimated 755 man-hours in labor costs.

1.7 REGULATORY/INSTITUTIONAL ISSUES

The Nevada Division of Environmental Protection (NDEP) and NNSA/NV have had several discussions regarding the use of MARSSIM for release of sites regulated by the NDEP under the Federal Facility Agreement and Consent Order. The NDEP is authorizing the use of MARSSIM on a site-by-site basis. The intended use of MARSSIM needs to be specified in the Corrective Action Plan (CAP) and approved by NDEP prior to implementation in the field.

Use of the ISOCS does not require NDEP authorization; specific instrumentation requirements are not specified within a CAP. Instead, instrument detection levels required to meet corrective action release criteria are specified. Release criteria for the MARSSIM verification survey are specified in Table 4-2 of the RadCon Manual. The ISOCS minimum detection limit is substantially below Table 4-2 release levels.

1.8 SCHEDULE

The schedule for this ASTD is provided in Section 80.

1.9 `OBSERVATIONS AND LESSONS LEARNED

Presented below are lessons learned identified during the field deployment of MARSSIM and ISOCS at the NTS:

- Deployment of the MARSSIM approach helps organize the release process by identifying the criteria that need to be negotiated with the regulator.
- Reach agreement with the regulator on DCGLs early to minimize survey design time.
- Obtain regulator agreement on the types of survey instruments to be used to meet agreed-upon DCGLs.
- Negotiate upfront with regulators on a course of action if a survey unit exceeds the agreed DCGL. Determine whether the survey unit has to be reclassified and surveyed or whether a greater percentage of the area be scan-surveyed.
- Application of MARSSIM allowed the design of a safer survey grid. Locations which require putting workers at risk (i.e., high wall locations, near roof edges, etc.) can be identified and avoided in the final survey design.
- Involve all regulatory agencies, internal and external, in development of ISOCS QA documentation.
- Before purchasing ISOCS, visit with sites that have already deployed ISOCS to gain knowledge of system and design limitations.

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2.0 GENERAL INFORMATION

This section provides general information about the NTS D&D program and project contacts.

2.1 NEVADA TEST SITE DEACTIVATION & DECOMMISSIONING PROGRAM

The NTS occupies approximately 1,375 square miles in southern Nevada and is located approximately 65 miles northwest of Las Vegas. The NTS was selected as the site to test nuclear reactor engines. The tests were performed in the southwest corner (Area 25) of the NTS in an area designated as the Nuclear Rocket Development Station (NRDS). The NRDS consisted of three test cells (designated as "A," "C," and "ETS-1") and two construction/disassembly facilities (R-MAD and Engine Maintenance, Assembly, and Disassembly [E-MAD]); a Control Point/Technical Operations complex; an administrative area; and a radiological material storage area. These facilities were operated as part of the nuclear rocket testing program from 1959 to 1973, when the project was terminated by Congress. The BN ER D&D program includes buildings from the Test Cell A, Test Cell C, and R-MAD E-MAD compounds. In addition to the NRDS D&D facilities, the NTS D&D program includes the project Pluto (nuclear jet engine tests) Maintenance, Assembly, and Disassembly (MAD) building in Area 26 and the Super Kukla Breeder reactor (weapon component radiation testing reactor) in Area 27.

All of these facilities have radiological contamination that will require either decontamination or demolition and disposal as low-level waste (LLW). Application of MARSSIM and/or use of ISOCS will be required to complete the D&D of these facilities within the baseline schedule of 2008.

2.2 CONTACTS

The following personnel can provide technical information upon request:

Charles Morgan, NNSA/NV, morganc@nv.doe.gov
Jeff Smith, BN, smithjl@nv.doe.gov
Paul Kalb, BNL, kalb@bnl.gov
David Schwartz, U.S. Department of Energy, National Environmental Technology Laboratory, david.schwartz@netl.doe.gov

Information regarding MARSSIM methodology can be obtained from the EPA Web site:

http://www.epa.gov/radiation/marssim/

Information regarding the ISOCS technology can be obtained from the Canberra Web site:

http://ww2.canberra.com/PCatalog.nsf/PCL/5C6C243615AD84038525686C00665C82?OpenDocument&area=product&cat=Nuclear+Measurement+Systems

3.0 SITE APPLICATION

3.1 PROJECT OVERVIEW

A MARSSIM final verification survey was conducted over the exterior of the R-MAD building, shown in Figure 3-1. The purpose of the MARSSIM survey was to document that the exterior condition of the R-MAD building meets the requirements for disposal within the NTS Construction Debris Landfill. Pre-certifying the building waste stream allows for more efficient waste handling during the demolition phase of the project.

The ISOCS system consists of a fully characterized high-purity germanium (HPGe) detector and an MCA that is connected to a laptop computer loaded with specialized software developed by Canberra. The ISOCS software, when used with the characterized detector, allows the geometry of the object to be modeled which will produce an efficiency calibration for that object. This means that an energy calibration curve for a three-dimensional model of a 55-gallon drum, B-25 box, or sample bottle can be developed by simply entering its geometric and physical description into the software model. Afterward, the ISOCS detector scans the container and the acquired spectrum is corrected with the mathematically-developed efficiency curve to accurately quantify the activity within the container. The ISOCS system is being used at the NTS to support waste characterization/verification, MARSSIM final verification surveys, remediation soil screening activities, and preliminary investigations for both waste classification and health and safety considerations.

3.2 TECHNOLOGY APPLICABILITY TO DEACTIVATION & DECOMMISSIONING PROJECTS

3.2.1 MARSSIM

The use of MARSSIM at the NTS is not so much a technology change but rather a methodological change. The same equipment and procedures are used to generate a baseline survey and a MARSSIM survey. The only modification is the implementation of statistics and process knowledge into the development of the survey plan. In areas where there was known radiological contamination, the NTS baseline methodology specified within the RadCon Manual is roughly equivalent to the MARSSIM survey requirements. The real benefit of implementing MARSSIM is for areas that have a low probability of having been impacted with radiological contamination. MARSSIM allows for a graded approach (larger survey grids and fewer

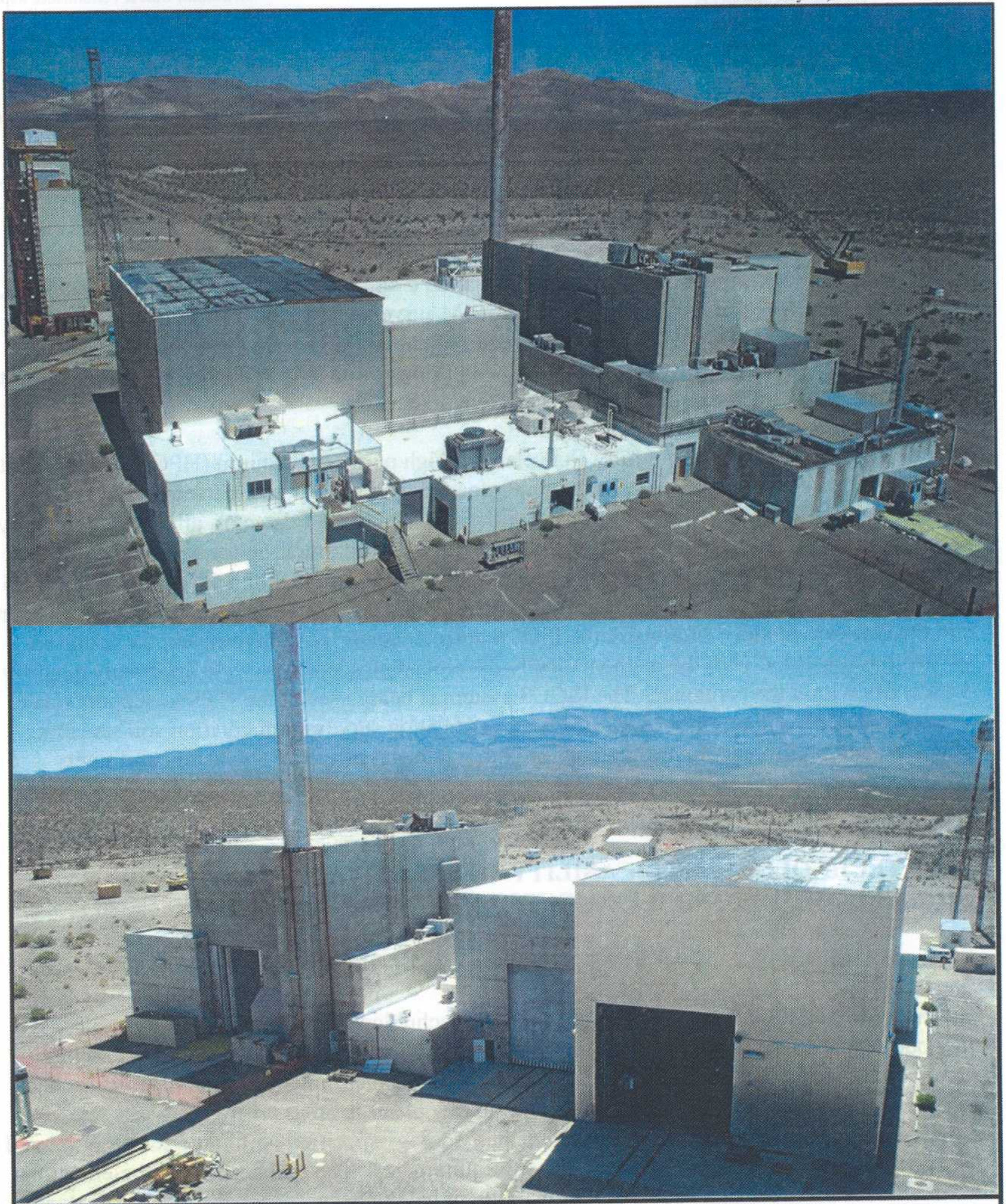

FIGURE 3-1
R-MAD FACILITY

measurements). Since large portions of the buildings associated with the NTS D&D program have not been impacted with radiological contamination, MARSSIM should reduce final verification survey samples/costs.

3.2.2 ISOCS

The use of the ISOCS at the NTS has a huge potential to reduce D&D waste management costs. The ISOCS can be used to characterize waste within B-25 boxes, 55-gallon drums, and other complex geometries. This represents a significant cost and schedule savings. The baseline technology requires the collection of physical samples from the waste containers that would be sent off-site for analysis. This not only exposes workers to additional radiation safety concerns during the collection process, but increases project costs associated with sample collection, waste management, sample analysis costs, and double handling of the waste container.

3.3 SURVEY AREA DESCRIPTION

The final status survey for the exterior of the R-MAD building was identified as the area that could readily be used to show the cost saving benefits of MARSSIM at the NTS. The R-MAD building was constructed between 1958 and 1961 and was used to support the NRDS program. The R-MAD building was used to assemble and disassemble reactor rockets associated with the Nerva, Kiwi, and two Phoebus reactor series.

The R-MAD building was placed into long-term mothball status in 1970. Reactor assembly and disassembly operations were transferred to the E-MAD building.

The exterior horizontal surfaces are comprised of formed magnetite concrete, cement blocks, and sheet metal. The formed magnetite concrete walls vary from 1 to 6 feet in thickness and extend up to a height of 60 feet. The total horizontal surface area is approximately 5,000 m^2. The roofs are a number of rectangular-flat elevation blocks. They are at multiple elevations and made of varied materials. They are covered with various combinations of concrete, asphalt, gravel and foams. The type of material used was driven by the need for radioactive exposure shielding and later subsequent repairs for leakage.

The historical site assessment (HSA) revealed that the exterior of the facility was not seriously impacted by operations conducted inside. The potential sources of contamination to the exterior were limited to radioactive fallout from the nearby nuclear rocket tests or atmospheric nuclear weapon tests being conducted in other areas of the NTS. In addition, there was some potential of radioactive particulate emissions from the R-MAD high-efficiency particulate air (HEPA) exhaust stacks or the ventilation systems. No significant emissions were reported during facility operations, but the roof areas could have accumulated radioactivity from repeated low-level emissions during facility operations.

3.4 SURVEY DESIGN

The MARSSIM methodology is firmly based on the EPA Data Quality Objective (DQO) process. As stressed in the DQO process and MARSSIM, early and frequent communication between the licensee and regulator is crucial. Because much of the statistical methodology for survey design and evaluation is provided in MARSSIM, the majority of the negotiation process of designing and evaluating a final status survey has been eliminated. The major emphasis has been placed upon the negotiation of the basis of the DCGLs, what will happens when the DCGLs are exceeded, and the appropriate classification of each area within the survey.

With respect to the use of MARSSIM for the final status survey on the exterior of the R-MAD Building, much of this had been negotiated in the Streamlined Approach for Environmental Restoration (SAFER) Plan for Corrective Action Unit 113: Reactor Maintenance, Assembly, and Disassembly Building (DOE/NV, 2001). This document defines the goal of the remediation of the facility, the release criteria for each area of the building (DCGLs), and the expected final status of the facility. With the the DCGLs defined, the survey design was developed based on the guidance provided in MARSSIM and presented to the RCO for approval. Although the RCO is not considered the regulator, the remediation goals of the SAFER Plan is unrestricted use of the exterior of the building, and the RCO must approve all radiological releases on the NTS.

Based on the probability of the roofing material being contaminated, the R-MAD roofs were classified as a Class II Area with a total surface area of approximately 4,000 m^2. Using the guidelines provided in MARSSIM, 16 sampling locations were determined to be sufficient to accurately characterize the R-MAD roof.

The various roofing materials used on the R-MAD roof made traditional ex-situ sampling methods difficult and introduced safety concerns that precluded taking samples from several locations. For this reason, static measurements were performed using ISOCS, a portable gamma spectroscopy unit (a full description of ISOCS is given in Section 4.0). The MDA for cesium-137 (Cs-137) was 20 becqueral per kilogram (0.5 picocuries per gram [pCi/g]). Twenty-five percent of the R-MAD roof areas would be scanned using Field Instrument for the Detection of Low-Energy Radiation and L101 Pancake Geiger-Mueller instruments.

The exterior walls were designed as four independent Class III areas based on the HSA. The total surface area of the walls is approximately 5,000 m^2. The four survey units consisted of all the vertical wall surfaces of the four major exposures of the exterior building (i.e., north, south, east, and west). The number of sample locations for each wall section varied from four to six. About 10 percent of the wall surfaces was scanned with these instruments.

3.5 SURVEY RESULTS

3.5.1 R-MAD Roof

A 10-minute count time at each of the sample locations using the ISOCS produced a minimal detectable activity (MDC) of less than 3 pCi/g, 10 percent of the DCGL. Actual MDC realized were at or below 1 pCi/g for the majority of sample locations. A summary of the survey results is included in Table 3-1 below. As shown by the +16 tabulated for the statistical test applied, the Sign Test (EPA, 2000), all 16 survey locations were below the DCGL.

TABLE 3-1. ROOF SURVEY RESULTS

Survey Unit	Class	DCGL	Sign Test Results	Pass/Fail
R-MAD Roof	II	30 pCi/g Cs-137	+16	Pass

3.5.2 R-MAD Walls

The results for each of the four exterior wall Class III Areas are shown in Table 3-2 below.

TABLE 3-2. EXTERIOR WALL SURVEY RESULTS

Survey Unit	Class	DCGL	Sign Test Results	Pass/Fail
North	III	5,000 dpm/100 cm^2 $\beta + \gamma$	+18	Pass
South	III	5,000 dpm/100 cm^2 $\beta + \gamma$	+18	Pass
East	III	5,000 dpm/100 cm^2 $\beta + \gamma$	+18	Pass
West	III	5,000 dpm/100 cm^2 $\beta + \gamma$	+18	Pass

4.0 ISOCS DESCRIPTION

4.1 ISOCS TECHNOLOGY

In-situ gamma spectroscopy has been widely used throughout the DOE complex for many years. The level of effort required for its use varies considerably based upon the complexity of the objects (geometry) and the radionuclides present. For deployments beyond cursory studies, considerable time and effort were required for model development and validation. ISOCS eliminates the need for independent model development and validation, greatly reducing the time required to deploy such a system.

The ISOCS is a portable gamma spectroscopy system with a software package that generates calibration efficiency curves, allowing the user to perform quantitative analysis. The software comes with several templates that allows the user to approximate the geometry and physical composition of the item or area being investigated. The software replaces the need for external calibration standards like the ones found in laboratories and source ranges. In addition, the software has undergone extensive internal consistency testing and validation by Canberra Industries, the designer and manufacture of ISOCS. ISOCS can and has been used for LLW characterization, D&D survey, soil remediation projects, and a host of other applications.

4.2 ISOCS COMPONENTS

The ISOCS (Figure 4-1) is comprised of a BEGe detector, a multi-attitude cryostat that allows positioning of the detector in all positions (downward and upward looking), a modular ISOCS shield system, a battery-powered digital MCA, a tripod, and a laptop computer with software for operation of the detector and the unique software that allows the user to generate the calibration efficiency curves.

The detector has a 50-percent nominal efficiency broad-energy crystal mounted in a 5-day cryostat. This configuration allows the user freedom to operate the system for several days without requiring additional liquid nitrogen. The broad-energy crystal is designed to increase the efficiency response of a typical HPGe detector from 3 kiloelectron volt (KeV) to 3,000 KeV, allowing for use in a wide range of activities. The modular cart is equipped with 25-millimeter (mm) and 50-mm thick lead shields and various angled collimators used to define the field of view of the detector. The cart is used to transport the system to measurement sites in a safe manner. The cart also allows the detector to be rotated 360 degrees for better access to radiological targets. In addition, the tripod can be used to position the detector in a downward-looking direction for locations when the cart is not practical because of its size and weight.

As stated previously, much of the equipment utilized by the ISOCS has been in use throughout the DOE complex for many years. What sets ISOCS apart from other in-situ gamma spectroscopy systems is the mathematical efficiency calibration software. The software comes with nine templates resembling generic shapes that can be use to model a wide variety of shapes.

The nine templates are:

- Simple box (basic homogeneous box)
- Complex box (nonuniform source distribution)
- Simple cylinder (drum)
- Complex cylinder (drum with nonuniform source distribution)
- Circular stacked planes (cylinder view from end)
- Rectangular-stacked planes (walls, floors, ceilings)
- Pipe
- Marinelli beaker
- Sphere

FIGURE 4-1
ISOCS MOUNTED ON CART

4.3 NOTABLE CAPABILITIES

ISOCS has many capabilities, but those most beneficial to D&D are:

- More representative results because of the larger sample size. This allows better comparison to the established remediation goals.
- Reduces the cost of sampling by taking a single in-situ measurement where several ex-situ samples would be required.
- Provides near real-time results allowing for better decision making in the field. Reduces the need for repeated trips to the field for multiple sampling event.
- Provides a method to obtain quantitative results for samples that are difficult or unsafe to obtain, greatly reducing the exposure and risk to the workers.

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5.0 ISOCS OPERATION AND PERFORMANCE

System operation and performance is discussed in this section. What is not discussed is the considerable effort that went into the development of the operation procedure and QAP supporting the use of ISOCS. Much of what has been implemented by BN was taken from the BNL ISOCS operating procedures and QAP. Each of these documents was modified to fit the requirements of BN and then adopted. Without such assistance, the utilization of ISOCS at the NTS would have taken considerably longer, and utilization at the R-MAD most likely would have not taken place.

5.1 ISOCS OPERATION

System setup at a measurement location in support of the MARSSIM final status survey varies widely based upon the location and whether the ISOCS cart or tripod will be used. For purposes of this report, only the tripod with no collimators was used. Mobilization to the rooftop measurement location was performed utilizing a man lift. System transport to the roof and setup at the first measurement location took approximately 25 minutes once on-site at the R-MAD compound. System breakdown and setup between sample locations took less than 15 minutes for locations on the same roof elevation, and 30 minutes for the location that required the man-lift for elevation changes.

A QA check is performed each day the system is operated. This check encompass a visual inspection of the system, adding liquid nitrogen to the cryostat as needed, and the counting of a check source containing Cs-137, cobalt-60 (Co-60), and americium-241 (Am-241). The required action for measurements that fall outside predetermined limits is prescribed in BN Organization Instruction OI-2150.002, “Quality Control Measurements When Using Canberra ISOCS System.” If not thermal-cycled on a regular basis, the ISOCS is fairly stable. After the first 45 days of operation, no QA measurement fell outside of the prescribed limits. The time required for the QA check is approximately 30 minutes.

ISOCS power requirements are supplied through a battery on the MCA. One extended life battery is capable of operating the MCA and detector continuously for up to 10 hours. The laptop, capable of operation on battery power, requires recharging approximately every four hours of continuous operation.

The detector is required to be maintained at liquid nitrogen temperatures for operation. A minimum of six hours is required to cool the detector any time the detector is put into operation at room temperature. The multi-attitude cryostat contains 5 liters of liquid nitrogen, enough for four to five days of operation, depending on ambient temperatures and spillage of liquid nitrogen during system transport and positioning.

5.2 ISOCS PERFORMANCE

The performance of ISOCS has been well within the limits that was advertised by Canberra Industries. The majority of problems arose from the lack of knowledge of the operators during the first few weeks of familiarization with ISOCS. During the first 30 days of operation, QA measurements were often reported outside of the prescribed limits. The limits for each of the QA measurements are expressed as multiples of the standard deviation of the first 30 daily performance checks. It was realized that this would occur during the first 30 days of system operation and found to be acceptable. It was decided that all warnings produced by QA measurement exceeding their respective limit would be noted for the first 30 days of operation and no action would be taken.

Both of the liquid crystal displays for the laptop computers used to operate the ISOCS and run the calibration software failed after approximately nine months of operation. Both laptop computers were produced by a reputable manufacturer during the same month. No other problems were noted with the laptop computers. Both laptops were repaired by the manufacturer at no cost.

Achievable MDCs have been below what was expected. The collection efficiency of the BEGe detector for gamma energies between 30 and 2500 KeV has allowed ISOCS to be utilized in a wide array of applications. Currently, ISOCS is being used for waste characterization, in-situ inspection of HEPA systems, and sample screening for verification sampling events.

The majority of performance issues that was encountered were quickly solved with guidance from BNL.

6.0 PROJECT COST

The ASTD program partnered with NNSA/NV in this deployment, with ASTD providing $260,000 of funding split between BN and BNL. NNSA/NV ERD committed an additional $190,000 to purchase equipment and train personnel. This section discusses the associated costs and schedule impacts of utilizing the MARSSIM methodology and accelerated ISOCS deployment at the NTS.

6.1 ACCELERATED ISOCS DEPLOYMENT

The funding received for this portion of the project was for the passing of institutional knowledge that BNL had gained during an earlier ASTD deployment of ISOCS to the NTS. The hope was that many of the lessons BNL learned and much of the knowledge gained from trial and error could be passed on to the NTS to accelerate the deployment schedule of ISOCS at the NTS. This was accomplished by a total of three site visits, one by NTS personnel to BNL before receipt of the ISOCS system at the NTS, and two by BNL personnel to the NTS after receipt of the ISOCS at the NTS.

Significant cost and schedule savings were shown in the area of operational document development. BNL made available their QAP and ISOCS operating procedures to the NTS. The quality of these documents made it relatively easy for NTS personnel to modify them for use at the NTS. Table 6-1 compares the time (in days) and labor (in man-hours) if NTS personnel had to develop these documents from scratch in relation to using the documents provided by BNL. For document development, only tasks in which the resource commitments varied are shown. As can been seen, using the BNL documents as templates saved the NTS 325 man-hours.
Although no direct cost savings or schedule acceleration was estimated for the R-MAD roof, much of the knowledge passed on during the site visits was invaluable in the successful deployment of ISOCS at the NTS. Examples of this include the preferred position of transporting the ISOCS while on the modular cart; the correct cables to ensure the vendor supplies; and the cryostat potion during filling that will not damage system cables. This knowledge did not reduce project costs or accelerate the deployment schedule, but it is believed that knowledge such as this has substantially contributed to the systems operation status, eliminating the negative schedule impacts that system repair can have.

Additional knowledge that was gained from BNL personnel that was difficult to quantify was in the area of efficiency calibration curve development. Considerable time was spent discussing the parameters needed to develop calibration efficiency curves and the sensitivity of each of those parameters. BNL personnel assisted with the analysis of the measurement taken on the roof of the R-MAD building in support of the MARSSIM survey. Also, BNL personnel assisted the analysis of a HEPA ventilation system located in the basement of the R-MAD building by showing NTS personnel how to acquire the gamma spectrum and developing the calibration efficiency curves. This noninvasive characterization method provided quantitative results without exposing personnel to the hazards of breaching the ventilation system and saved the cost of sending samples off-site for analysis.

TABLE 6-1. COMPARISON OF ISOCS DOCUMENT DEVELOPMENT RESOURCE REQUIREMENTS

QUALITY ASSURANCE PLAN				
	Labor (man-hours)		Time (days)	
Activity	Without BNL QAP	With BNL QAP	Without BNL QAP	With BNL QAP
Identification of Applicable Requirements	40	5	10	2
Initial Draft	160	20	30	5
OPERATING PROCEDURE				
Identification of Applicable Requirements	40	5	10	2
Initial Draft	120	5	5	5
TOTAL	360	35	55	14

6.2 MARSSIM IMPLEMENTATION

The major benefit of implementing MARSSIM is the standardization of the final status surveys process. The impact of this benefit can be seen in the reduction of man-hours required to negociate and plan the final status survey, as shown in Table 6-2. The current baseline methodology requires the project to negotiate with the RCO all the parameters of the survey plan including the items such as grid size, number of samples, statistical basis, and data reduction techniques. Applying the MARSSIM methodology eliminated all of the negotiated items except the size of each survey unit (analogous to grid size).

TABLE 6-2. COMPARISON OF MARSSIM TO BASELINE ACTIVITIES

Activity	MARSSIM (man-hours)	Baseline (man-hours)
Negotiations with RCO	5	30
Survey Planning	80	160
Safety Authorization Basis	40	40
Roof and Wall Surveys	30	120
Survey Data Recording	20	100
Survey Support Activities	90	360
Multilayered Roof Analysis	ISOCS - 20	ISOCS - 50
Data Reduction	40	160
Report Preparation	60	120
TOTAL	385	1140

The time required to collect the MARSSIM survey measurements was 30 hours. This is the estimate to perform the actual survey. Analysis of the timecard records indicates that the survey was conducted in three 40-hour weeks. Support activities, including instrument calibration, time required to access the area, and determining the grid location, accounted for the other 90 hours of the survey activity. The deployment of the ISOCS to collect the in-situ radiological readings required two working days. While the MARSSIM methodology required approximately 100, 1-m^2 surveys, the baseline methodology would require approximately 900 1-m^2 surveys to meet the minimum 10 percent surface area criteria. Adding time to conduct the scan surveys to the static scan surveys as required under the MARSSIM methodology still requires four to six times less survey effort then the baseline methodology.

The MARSSIM methodology does reduce the number of survey report forms required. The actual final survey report is structured similarly to the standard report format example in MARSSIM and does incorporate BN-required forms where appropriate. A final status report using the baseline methodology and approved survey plan for a structure similar to the R-MAD has not been produced at the NTS. Therefore, no template exists to develop a final report as is available within MARSSIM. The level of effort required to complete the final survey report is expected to easily exceed that for a MARSSIM report, but how much is difficult to estimate.

Additional savings can be expected by performing in-situ sampling with ISOCS versus sending ex-situ samples off-site to a laboratory for analysis. No additional savings were identified for this survey because of the time ISOCS operators required to analyze each in-situ location, resulting in costs nearly identical to ex-situ sample collection and analysis costs. As ISOCS operators improve in efficiency, considerable cost savings are expected in this area.

7.0 REGULATORY/INSTITUTIONAL ISSUES

This section of the report provides information on regulatory, safety, environmental impact, and community issues and perception. Each of these concerns are addressed below.

7.1 REGULATORY CONSIDERATIONS

The NDEP and NNSA/NV have had several discussions regarding the use of MARSSIM for release of sites regulated by the NDEP under the Federal Facilities Agreement and Consent Order. The NDEP is authorizing the use of MARSSIM on a site-by-site basis. The intended use of MARSSIM needs to be specified in the CAP and approved by NDEP prior to implementation in the field.

Use of ISOCS does not require NDEP authorization; specific instrumentation requirements are not specified within a CAP. Instead, instrument detection levels required to meet corrective action release criteria are specified. The ISOCS minimum detection limit is substantially below the NTS landfill disposal guidelines. At the present, no volumetric DCGLs have been approved by NDEP or NNSA/NV for unrestricted use of soil areas. Site-specific guidelines are specified within a CAP.

The methodology contained within MARSSIM is based on accepted statistical tests and methodologies. It provides a template for a more consistent and defendable release methodology. MARSSIM allows the user and the regulator to agree upon a potential survey failure rate. At the completion of the survey, the regulator can evaluate the information based on the criteria established during the planning phase. This can result in non-project-associated cost savings, such as reducing the number of regulator questions regarding survey results. MARSSIM also provides a common methodology when multiple regulators are involved.

7.2 SAFETY AND HEALTH BENEFITS

The primary benefit of implementing MARSSIM is not that it increases worker safety, but rather that it provides a universally accepted framework to implement final radiological verification surveys. However, the measurement and grid size flexibility allowed by classifying MARSSIM survey areas as either Class II or III increases worker safety by reducing the number of measurements required to complete the survey.

There are a number of safety benefits associated with using the ISOCS system over conventional data collection methods. These safety benefits are presented below:

- Radiological isotope data can be collected remotely using ISOCS. The baseline technology requires that physical samples be collected by hand. This can result in workers being exposed to radiological contamination.
- ISOCS can detect if radiological contamination is present within a container without exposing a worker.
- Real-time processing of data can minimize worker exposure if radiologic contamination is encountered.

7.3 ENVIRONMENTAL IMPACT

There is no adverse environmental impact associated with implementing either the MARSSIM final status survey process or the ISOCS. In fact, there are potential environmental benefits associated with implementing ISOCS. ISOCS can be used to screen containers filled with small debris or complex geometrie,s which can not be readily surveyed using conventional methods. Being able to determine if this type of material meets the criteria for salvage or non-LLW disposal, reduces the volume of material that will require disposal in permitted landfills.

7.4 SOCIOECONOMIC IMPACTS AND COMMUNITY PERCEPTION

There are no expected adverse impacts to community safety or socioeconomic impacts anticipated with the implementation of either the MARSSIM final status survey process or the ISOCS. The public perception of these technologies should be positive. Implementation of MARSSIM will allow a statistically sound and widely accepted methodology to be used to determine if a building or soil area meets the regulatory agreed clean-up criteria. The use of ISOCS will provide remediation contractors with real-time isotopic data that will reduce project costs. Reducing project costs will allow NNSA/NV to start additional environmental work earlier than is scheduled in the life-cycle baseline.

8.0 SCHEDULE

Deployment of MARSSIM/ISOCS at the NTS was performed per the following schedule:

TABLE 8.1. MARSSIM NTS ASTD SCHEDULE

ACTIVITY	SCHEDULE
Procurement	March 2001
Training	March 2001
BNL First Visit	May 2001
MARSSIM Survey Field Work	May 2001
BNL Second Visit	December 2001
MARSSIM Survey Report	October 2001
Draft Cost & Performance Report	January 2002
Final Cost & Performance Report	May 2002

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9.0 OBSERVATIONS AND LESSONS LEARNED

Presented below are lessons learned identified during the field deployment of MARSSIM and ISOCS at the NTS:

- Deployment of the MARSSIM approach helps organize the release process by identifying the criteria that needs to be negotiated with the regulator.
- Reach agreement with regulator on DCGLs early to minimize survey design time.
- Obtain regulator agreement on the type of survey instruments to be used to meet agreed-upon DCGLs.
- Negotiate with the regulator upfront on the course of action if a survey area exceeds the agreed-upon DCGL. Determine whether the survey unit has to be reclassified and surveyed or can a greater percentage of the area be scan-surveyed.
- Application of the MARSSIM allowed the design of a safer survey grid. Locations which require putting workers at risk (i.e., high wall locations, near roof edges, etc.) can be identified and avoided in the final survey design.
- Involve all regulatory agencies, internal and external, in the development of ISOCS QA documentation.
- Before purchasing ISOCS, visit with sites that have already deployed ISOCS to gain knowledge of system and design limitations.

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DISTRIBUTION LIST

U.S. Department of Energy

David Schwartz 1
U.S. Department of Energy
National Environmental Technology Laboratory
19901 Germantown Road
Germantown, MD 20974-1290

Janet Appenzeller-Wing 1
Environmental Restoration Division
U.S. Department of Energy
National Nuclear Security Administration
Nevada Operations Office
P.O. Box 98518 M/S 505
Las Vegas, NV 89193-8518

Richard Betteridge 1
Technology Division
U.S. Department of Energy
National Nuclear Security Administration
Nevada Operations Office
P.O. Box 98518 M/S 505
Las Vegas, NV 89193-8518

Ralph F. Smiecinski 1
Technology Division
U.S. Department of Energy
National Nuclear Security Administration
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P.O. Box 98521 M/S NLV306
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Patrick S. Morris 1
Bechtel Nevada
P.O. Box 98521 M/S NTS306
Las Vegas, NV 89193-8521

Craig Lyons 1
Bechtel Nevada
P.O. Box 98521 M/S NLV
Las Vegas, NV 89193-8521

Thomas Fitzmaurice 1
Bechtel Nevada
P.O. Box 98521 M/S NTS306
Las Vegas, NV 89193-8521

Brookhaven National Laboratory

Paul Kalb 1
Brookhaven Nation Laboratory
Building 830
34 N. Railroad St.

Upton, L.I., NY 11973-5000

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