



# LESSONS LEARNED FROM INDEPENDENT VERIFICATION ACTIVITIES

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Prepared for the  
U.S. Department of Energy

 **ORISE**

Oak Ridge Institute for Science and Education

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## FOREWORD

The mission of the Department of Energy's Office of Environmental Management is the cleanup or closure of the Department's facilities. This activity almost always involves the radiological release of real or personal property. The radiological release of property must be conducted in a manner that is technically defensible and which meets the applicable Departmental requirements.

The Oak Ridge Institute for Science and Education (ORISE) maintains a high level of expertise in the conduct of radiological surveys. This includes the development of radiological survey techniques, authorship of radiological survey manuals, conduct of radiological surveys, and training in radiological survey approaches. This expertise has been recognized by outside organizations; for example, the U.S. Nuclear Regulatory Commission (NRC) has contracted with ORISE for "confirmatory" radiological surveys at sites licensed by the NRC.

At the Department's facilities, ORISE has conducted a number of independent verification surveys of the radiological status of real and personal property. While these activities have supported individual projects, there has been no framework or methodology for sharing experience, best practices, and lessons learned. EM-23 funded ORISE to prepare this report in order to share these experiences and to foster an atmosphere of continuous improvement in the radiological release of property and in the conduct of radiological surveys.

I note, with much interest, that there are some patterns among different sites of both best practices and lessons learned. The best practices includes (1) the early and clear identification of authorized limits (or other radiological release criteria), (2) the early development of radiological survey plans for demonstrating compliance with the authorized limits, and (3) the early engagement of independent verification personnel, enabling problems to be addressed early without significant impact to budget and schedule. Lessons learned identified in this report include deficiencies in authorized limits (lack of clarity, details not identified, and poor communication), survey plans (not clearly matching requirements or poorly implemented), and implementation of independent verification as an afterthought on projects already underway. Many of these problems can be avoided by the early approval of authorized limits and early engagement of independent verification activities.

Within the Department, we must have proper control on the radiological release of property for the protection of our employees, the public, and the environment. We also need to avoid the inadvertent release of property that does not meet the Department's stringent requirements. This report makes an important contribution to the improvement of our radiological release activities.

Mark Gilbertson

## Background and Findings

### “Lessons Learned from Independent Verification Activities”

During the verification of the Final Status Survey of the sites discussed in the report, similar problems were identified at different sites. Here is a discrepancy summary:

**Need:** The early and clear identification of authorized limits (or other radiological release criteria):

Fernald Closure Project – The release criteria were based on a CERCLA risk evaluation. However, during independent verification activities, ORISE requested “clarification” of the criteria, which was provided. Consequently, this need was only partially met.

Mound – Miamisburg Closure Project – A deviation for detection of surface tritium was implemented, for unknown reasons. This need was partially met.

**Lesson Learned:** The optimum solution is for authorized limits or other radiological release criteria to be identified early, before CD-2.

**Need:** The early development of radiological survey plans for demonstrating compliance with the authorized limits and proper execution of the radiological survey plan:

Argonne National Laboratory ZPR- D&D – Some issues with the radiological survey plan were resolved after ORISE conducted on-site verification activities. This need was met partially, after some re-work of documentation and measurement activities.

Ashtabula Closure Project – Some radiological survey methods were deficient in minor ways and were corrected through procedure or documentation changes. This need was met partially, after re-work of documents, measurements, and additional cleanup.

Battelle Columbus Closure Project – A number of minor deficiencies in radiological survey procedures and execution were resolved, some in a very expeditious manner. This need was met for the most part.

Brookhaven National Laboratory waste facilities – Many findings of residual radioactivity at levels above the release criteria were identified in “completed” areas. This need was partially met, only after significant rework and additional cleanup.

East Tennessee Technology Park Three Building D&D – Numerous elevated areas of radioactivity were remediated only after ORISE identified them. The radiological survey plan was developed in a timely manner, but the execution was only partially met.

Fernald Closure Project – Some minor discrepancies were identified by ORISE. However, the participation of ORISE very late in the project limits the conclusions that can be drawn. This need was apparently met.

Mound - Miamisburg Closure Project – Some elevated areas of radioactivity remained after “cleanup.” This need was partially met.

Rocky Flats Environmental Technology Site – Some elevated areas of radioactivity on building surfaces and in open land were identified. At the request of stakeholders, a different survey approach was used for independent verification of the open land (MARSSIM) vis a vis the cleanup contractor’s approach. This need was partially met.

**Lesson Learned:** Radiological survey plans need to be approved and in place early, before CD-3 and then properly executed.

**Need:** The early engagement of independent verification personnel, enabling problems to be addressed early without significant impact to budget and schedule:

Argonne National Laboratory ZPR- D&D – Some discrepancies in radiological survey procedures and results were identified and resolved. This need was met partially.

Ashtabula Closure Project – Independent verification of soil was planned in advance but not for building D&D. This need was not met in the buildings.

Brookhaven National Laboratory waste facilities – Numerous elevated areas identified by ORISE suggest that better and earlier planning could have avoided the deficiencies that were identified.

Fernald Closure Project – Independent verification of the final status of the site was requested only at the end of cleanup and after backfilling of remediated areas.

Mound – Miamisburg Closure Project – This need was partially met. Some verification activities were executed only after cleanup was completed.

Rocky Flats Environmental Technology Site – Independent verification of buildings was planned in advance, but the independent verification of open land was implemented after excavations had been filled. No corrective action plan addressed the independent verification findings.

**Lesson Learned:** Independent verification activities need to be planned early in the project, before CD-3, before significant time and cost are committed.

**Summary:**

In short, as demonstrated in the report, there is a continuing, systematic problem in all three areas, with the same difficulties and deficiencies being evident at different sites. We are developing a program plan to address these areas in a systematic manner.

## ACRONYMS

ACP	Ashtabula Closure Project
ANL	Argonne National Laboratory
BNL	Brookhaven National Laboratory
CCP	Columbus Closure Project
CFR	Code of Federal Regulations
D&D	decontamination and decommissioning
DCGL	derived concentration guideline levels
DOE	U.S. Department of Energy
EMC	elevated measurement comparison
EPC	end point criteria
ETTP	East Tennessee Technology Park
FCP	Fernald Closure Project
FHWMF	Former Hazardous Waste Management Facility
FRL	final remediation levels
FSS	final status survey
GAO	Government Accountability Office
IV	independent verification
MARSSIM	Multi Agency Radiation Survey and Site Investigation Manual
MCP	Miamisburg Closure Project
MDC	minimum detectable concentration
NRC	U.S. Nuclear Regulatory Commission
ORISE	Oak Ridge Institute for Science and Education
pCi/g	picocuries per gram
PRS	potential release site
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
SEP	sitewide excavation plan
SU	survey unit
VSAP	Verification Sampling & Analysis Plan
ZPR-6	Zero Power Reactor – 6 at Argonne National Laboratory

## **1.0 EXECUTIVE SUMMARY**

The U.S. Department of Energy (DOE) requested that the Oak Ridge Institute for Science and Education (ORISE) prepare a “Lessons Learned” document that summarizes recent independent verification (IV) activities performed at various DOE sites. This request stemmed from a report released by the Government Accountability Office (GAO) entitled *Nuclear Cleanup of Rocky Flats-DOE Can Use Lessons Learned to Improve Oversight of Other Sites’ Cleanup Activities* (GAO 2006). The Lessons Learned document is a compilation of the major issues that were observed and documented by ORISE during IV activities performed at the Argonne National Laboratory, the Ashtabula Closure Project, the Battelle Columbus Closure Project, the Brookhaven National Laboratory, the East Tennessee Technology Park, the Fernald Closure Project, the Miamisburg Closure Project (Mound), and the Rocky Flats Environmental Technology Site. ORISE serves as the primary independent (third party) verification contractor for DOE Decontamination and Decommissioning (D&D) projects and is the only verification contractor for the Nuclear Regulatory Commission (NRC). ORISE uses its technical expertise to rigorously evaluate and verify that previously contaminated areas meet federal guidelines for release.

## **2.0 OBJECTIVE**

The objective of this document is to summarize the primary issues observed and documented by ORISE that uniquely influenced or impacted D&D activities at various DOE sites. The compilation of this information into one document will serve as a useful tool for review and reference for both ongoing and future DOE cleanup activities.

## **3.0 INDEPENDENT VERIFICATION OVERVIEW**

ORISE directly supports DOE’s goal to build public trust and confidence in environmental cleanup activities. Independent verification is an important quality assurance step that ensures cleanup goals have been achieved. The objectives of ORISE IV activities are to independently evaluate final site conditions and the contractor’s final status survey (FSS) procedures, results, and documentation. When ORISE is able to validate the D&D contractor’s methods against the requirements and commitments, public credibility concerning DOE operations and cleanup objectives are greatly enhanced.

The DOE has established a good practice policy stating “Independent Verification should be an integral part of site restoration and cleanup projects” (DOE 2006a). All verification survey activities are performed in accordance with the ORISE Survey Procedures and Quality Program Manuals (ORISE 2007a and 2007b). There are two types of ORISE IV activities:

### Type A Verification

Type A verification is a “limited” verification that consists of comprehensive document reviews, validation of the contractor’s data, and confirmatory analyses of contractor samples. Document reviews are very important specifically in evaluating the contractor’s instrument selection, calibration procedures, minimum detectable concentration (MDC) calculations, statistical sample size determination, scanning procedures, measurement technique, sampling procedures, analytical laboratory techniques, and the FSS results.

### Type B Verification

Type B verification is a “full” verification which includes on-site field survey activities in addition to the Type A verification activities. Field survey activities include performing scans, surface activity measurements, collecting samples, and can also include in-process inspections of the D&D contractor performing FSS activities. The in-process inspection is used to identify areas in the final survey project design or procedures that could potentially result in significant and unresolved issues requiring resolution prior to the completion of the FSS.

## **4.0 LESSONS LEARNED**

### **4.1 Argonne National Laboratory**

In 2006, ORISE performed verification survey activities in selected portions of the Building 315 Zero Power Reactor-6 (ZPR-6) at the Argonne National Laboratory-East (ANL) facility in Argonne, Illinois. The FSS methodology, per the contractor’s FSS plan (ANL 2006a), was based on NUREG/CR-5849, *Draft Manual for Conducting Radiological Surveys in Support of License Termination* (NRC 1992) and portions of NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)* (NRC 2000). The applicable surface activity guidelines for the ZPR-6 facility were those for transuranics and beta-gamma emitters from DOE Order 5400.5 (DOE 1993 and 1995).

Prior to on-site verification activities, ORISE reviewed ANL’s Decommissioning and FSS Plans and provided a comment letter to the DOE documenting the findings (ORISE 2006a). The procedures, methods, and data submitted by ANL were considered to be lacking critical information and/or details that were needed to evaluate procedures for surface scans (scan rates), calculations for direct measurements and MDCs, procedures for grid block averaging relative to the recommendations in Draft NUREG/CR-5849, and other quality control procedures. ORISE also requested that ANL provide instrument calibration information in order to evaluate the adequacy of the calibration sources and the calculated efficiencies. These questions were not sufficiently addressed by ANL prior to the ORISE on-site verification survey activities. However, after conducting on-site verification survey activities which included instrument comparisons and performing reviews of the raw data and procedures, ORISE determined that the discrepancies in surface activity measurements collected by ORISE and the contractor at the same locations were

attributed to the differences in instrument calibration methods and direct measurement procedures (i.e., beta shielding and background subtraction). The ORISE measurements were consistently higher than ANL's measurements. ORISE implements the ISO-7503 recommendations (ISO 1988) where the total efficiency for each instrument/detector combination consists of the product of the  $2\pi$  instrument efficiency ( $\epsilon_i$ ) and surface efficiency ( $\epsilon_s$ ):  $\epsilon_{\text{total}} = \epsilon_i \times \epsilon_s$ . ANL calibrated instruments in accordance with ANSI N323A-1997 (ANSI 1997) but did not account for surface efficiency as recommended by ISO-7503. ANL developed an appropriate efficiency factor which they applied to their data in order to prove that the measurements were comparable to the data collected by ORISE. Once ANL's procedures and methods were clearly understood and appropriately documented in a revised FSS plan (ANL 2006a) and FSS report (ANL 2006b), ORISE was able to reevaluate ANL's raw data against their procedures, and determined the data did appropriately represent the radiological status of the ZPR-6 facility. Although ORISE recommends the use of ISO-7503 for calibrating instrumentation, the ANL method was determined to be acceptable. Complete documentation of the calibration differences and findings in both the ORISE and ANL documentation should resolve any questions resulting from reference of the ANL/ORISE documents in the future. The ORISE conclusions are documented in the ZPR-6 final report (ORISE 2007c).

Ultimately, the IV activities performed for ANL's ZPR-6 facility validated the contractor's procedures and final results. The lessons learned are:

- Contractor must provide complete FSS documentation of procedures including calibration information and equations to be used for calculations to enable independent parties to evaluate the appropriateness of the procedures and the reported data.

## 4.2 Ashtabula Closure Project

In 2006, ORISE conducted comprehensive IV activities at the Ashtabula Closure Project (ACP) in Ashtabula, Ohio. Type A and Type B verifications were performed. The ACP site soil release criteria specified in the Decommissioning Plan were developed in accordance with 10 CFR 20.1401 and approved by the NRC (RMI 1995). The final status survey methodology was based on NUREG/CR-5849, *Draft Manual for Conducting Radiological Surveys in Support of License Termination* (NRC 1992).

### Land Areas

ORISE reviewed and provided formal comments to the DOE for 18 of the contractor's draft and final FSS land area reports (ORISE 2006b to s). The document reviews identified numerous items requiring clarification or correction. Some examples of items requiring clarification included survey and sampling procedures, the specific locations of soil samples, grid boundaries, and inputs into calculations. Items requiring correction included misinterpreted results and the use of incorrect formulas. The contractor had misinterpreted the IV findings of a survey

performed at the site in 1990. The contractor's FSS Report stated that ORAU (ORISE) determined that the gravel road (which the contractor referred to as area B West – I) met the NRC unrestricted release criteria. However, ORAU findings for the gravel road were that 4 locations exceeded the uranium guideline of 35 pCi/g in 1990 (ORAU 1991). The ORAU report also indicated that the site was planning to address the gravel road during the Building RF-6 decontamination activities at a later date. ORAU did not conduct a follow-up survey of the gravel road until the recent ORISE survey in 2006. The 1991 ORAU report determined that only the area south of the gravel road (where modular offices were located) satisfied the uranium guideline. In several of the FSS reports issued by the contractor the formula used to calculate the weighted mean was incorrect; specifically, the variables  $X_{>30}$  and Y identified for the formula;  $X_{>30}$  should have been  $X_{<30}$  = average concentration for samples < 30 pCi/g uranium and Y should have been the average concentration for samples > 30 pCi/g, per the equation in NUREG/CR-5849.

During on-site verification activities, ORISE identified numerous locations of elevated activity that the contractor had missed while performing gamma surface scans. After observing the contractor's technicians, ORISE determined the likely cause was that the survey instrument's audible response was not being utilized with headphones. There was continuous heavy equipment background noise on-site and relying on visual inspections of the instrument's readings in a noisy environment while navigating rough terrain is not recommended and could potentially allow areas above the guideline to be missed. The contractor was notified; however, this recommendation was never implemented by the contractor. ORISE continued to find radioactivity above the site guidelines in areas in which the contractor had reported all the FSS data below the guidelines. The DOE subsequently tasked ORISE with performing Type B verification activities in every land area within the site fence.

Approximately 20% (50 of 252) of the verification soil samples collected by ORISE were above the site's radiological release criteria. In most instances, these were areas where the contractor had finished final status soil sampling and provided ORISE with their results (all below the release criteria). Additional areas with elevated radiation levels were identified by ORISE but were not sampled because the contractor opted to remediate the locations. Based on the ORISE findings, the samples that individually exceeded the radiological release criteria were either removed through remediation (this conservative approach was most often selected by the contractor), or the concentrations were averaged within a grid if they were less than the site's maximum soil release criteria. Several land areas required numerous IV surveys before remediation by the contractor was successful. ORISE also requested that the contractor's final FSS reports be updated to include the ORISE findings and the additional remediation and sampling activities that were performed.

Following the submission of each ORISE comment letter, the contractor subsequently amended the FSS reports or provided a formal response to DOE and ORISE describing the resolution or an explanation for all of the comments generated by ORISE.

## Buildings

ORISE was not tasked with surveying any buildings. However, DOE requested that ORISE perform Type A reviews of the contractor's FSS reports for six buildings. Unfortunately, ORISE was not tasked with these building reviews until approximately two weeks after the contractor had declared successful completion of remediation activities at the site and approximately two weeks prior to the remaining health physics staff departing the site. The initial technical reviews of the six building reports identified that the reports did not contain all necessary information needed to demonstrate that the approach implemented for conducting the final status surveys followed the guidance provided in Draft NUREG/CR-5849, nor did the reports contain all information necessary to independently assess the final radiological status of the buildings. Numerous comments were generated regarding the contractor's final radiological procedures, instrumentation information, survey unit classification, and sample size determination needed for data interpretation. ORISE only submitted formal comments to the DOE for three of the six building reports (ORISE 2006t to v) because the DOE requested resolution of the issues by the contractor prior to the submission of remaining three reports. These findings were issued two weeks after the contractor had formally declared physical completion of all remediation activities and resulted in the contractor having to gather additional information and revise all six reports within a two week period before health physics personnel were scheduled to leave the site. Although the document reviews identified insufficient documentation, the contractor's final reports were improved and provided adequate documentation regarding the radiological status of the buildings. ORISE provided a Type A letter report for each of the buildings stating these conclusions (ORISE 2006 w to bb).

The IV activities performed for the ACP validated the contractor's final status survey (FSS) procedures, results, and documentation. These conclusions above are documented in the ACP final report (ORISE 2006cc). The lessons learned are:

- Contractor must provide complete FSS documentation including procedures, calibration information and equations to be used for calculations to enable independent parties to evaluate the appropriateness of the procedures and the reported data.
- IV recommendations should be implemented if possible. The recommendation to use headphones in a noisy environment may have assisted technicians in identifying many of the hot spots later identified by ORISE.
- IV should be performed to minimize the risk of unidentified contamination remaining at the site following the completion of remediation activities. Type B verification surveys identified numerous locations of elevated activity requiring additional remediation after receiving final data (below the release criteria) from the contractor. These elevated areas would have otherwise remained at the site after closure.

- Post remediation verification activities should be performed to ensure successful remediation in areas where elevated results are identified.
- IV should be integrated into the FSS planning stages. Onsite IV activities were successfully coordinated and performed in parallel with the contractor with the exception of the Type A building reviews which were identified near the completion of a project, and could have adversely affected the schedule, budget, and outcome.

### 4.3 Battelle Columbus Closure Project

During the period of September 2004 through April 2006, ORISE performed a comprehensive independent verification of the FSS activities at the Battelle Columbus Closure Project (CCP) West Jefferson North site. The scope of the ORISE verification included in-process inspections of the contractor's procedures and measurement techniques, verification surveys, document review, and inter-laboratory comparisons of the contractor's data. ORISE performed radiological verification survey activities of buildings, structures (above-grade), foundations, open land areas, and miscellaneous piping designated for release for unrestricted use. The building, structural, and foundation surveys included alpha and beta surface scans, surface measurements for total and removable activity, exposure rate measurements, and miscellaneous samples. Land area surveys included gamma surface scans, exposure rate measurements, and soil sampling.

The FSS methodology, per the Decommissioning Plan (BDP 1993), was based on NUREG/CR-5849, *Draft Manual for Conducting Radiological Surveys in Support of License Termination* (NRC 1992). The applicable surface activity guidelines were taken from DOE Order 5400.5 (DOE 1993 and 1995) as specified in the Decommissioning Plan. In most cases, the site elected to compare residual beta activity levels with the most restrictive beta activity guideline because the site's radionuclide mixture included Sr-90, which has a more restrictive guideline if present as a result of separation from other fission products. The less restrictive uranium surface contamination limits were only applied to the JN-1 Fuel Pool Sump (inside), because radioanalytical analysis of samples collected from the sump did not indicate the presence of Sr-90. Alpha activity levels were also compared to the more restrictive transuranic guidelines due to the potential presence of plutonium isotopes.

ORISE provided technical review and comments on 29 documents associated with the FSS process including technical basis documentation and FSS reports of Columbus Closure Project activities. Additionally, ORISE reviewed survey procedures and plans to evaluate the application of survey methodology to meet the site guidelines. The document reviews identified numerous items requiring clarification or correction. Two recurrent issues included a need for the contractor to clearly explain why there was a significant increase in the exposure rate when obtaining the data from an open trench, and a need to clarify the technical approach to determine initial ratios used to calculate the modified Cs-137 guideline. ORISE issued a final document review summary letter following the review of all the contractor's FSS reports (ORISE 2006dd).

## In-Process Inspections

In-process inspections were performed during various stages of FSS activities at the CCP, specifically to observe the contractor's field activities. One in-process inspection of the contractor's FSS approach for scanning deep excavations from an aerial-lift basket identified several recommendations for improvement. The inspection noted that the technician needed to utilize the instrument's audible indication (preferably with headphones) to identify and pinpoint elevated radioactivity. ORISE also observed that the technician did not have any forms to document findings in the field. ORISE also questioned how the technician in the aerial-lift could physically mark an observed elevated area in the excavation below once identified. ORISE recommended that the contractor provide additional technicians to assist in surveying. DOE and the contractor were notified of these findings and recommendations; the contractor immediately responded with a review and modification to the work instruction for excavation and trench surveying and sampling as to how these types of activities would be performed in the future.

ORISE also identified two instances in which the contractor was utilizing inappropriate survey techniques/instrumentation.

1. ORISE performed a verification survey of two well caissons at the CCP and identified a discrepancy between the ORISE data and the contractor's FSS data. Subsequent discussion between ORISE, the contractor, and DOE identified that the contractor's field survey technique used for the caissons was inappropriate. The surface to detector distance was not maintained in an appropriate geometry to quantify residual radioactivity. This prompted a resurvey of the caissons by the contractor and a revision to the FSS report to reflect the correction of the finding. The revised FSS report was reviewed by ORISE and determined that the contractor had adequately documented the final radiological status of the caissons.
2. DOE requested that ORISE perform in-process surveys of two vitrified clay pipes in the Filter Bed area of the CCP. DOE's decommissioning contractor had performed gamma measurement surveys (which provided qualitative results) and sampling of the soils surrounding the subject pipes. However, quantitative beta surface activity measurements of the interior surfaces of the pipes were needed to compare the results with the beta-gamma surface activity guidelines. An ORISE-designed, Geiger-Mueller detector-based pipe monitor, calibrated to the configuration of the subject pipes, was used to scan the interior surfaces of both pipes for beta-gamma radiation. Direct measurements for beta activity were collected within each pipe based on the locations of the maximum count rates observed during scanning. ORISE was able to determine that there were no indications of residual contamination identified in the accessible pipe sections that were contrary to the contractor's investigative survey conclusions.

## Buildings

Several areas of elevated beta surface activity above the release criteria that required additional remediation were identified by ORISE on the JN-1 Fuel Pool and Transfer Canal surfaces, and in Buildings JN-2 and JN-3. In most instances, these were areas in which the contractor had completed their FSS scans and measurements and provided ORISE with FSS data (all below the release criteria). Based on ORISE findings, these areas were subsequently remediated by the contractor and resurveyed. The post-remediation surveys indicated that all surfaces met the guideline limits and the appropriate revisions were made to the contractor's FSS reports to reflect the findings.

## Land Areas

Gamma scans performed by ORISE identified several localized "hot spots" which were remediated by the contractor prior to ORISE collecting verification samples.

ORISE identified two land areas where Cs-137 concentrations in one of the soil samples from each area exceeded the maximum allowable soil guideline. The two areas were within the Abandoned Middle Filter Bed and the JN-1B Foundation excavation and were also remediated and subsequently resurveyed by the contractor and ORISE. All other individual sample results that exceeded the average soil guidelines and that were not remediated by the contractor were verified to meet the average limit for the contiguous square meter, per requirements of NUREG/CR-5849 (NRC 1992). When additional soil sample data were not available within the contiguous square meter, ORISE verified that the guideline limit for a weighted average had been met, based on guidance provided in NUREG/CR-5849 (ORISE 2006ee).

Ultimately, the IV activities performed for the CCP validated the contractor's procedures and final results. These conclusions above are documented in the CCP final report (ORISE 2006ee). The lessons learned are:

- IV recommendations should be implemented when possible. The CCP contractor corrected the inappropriate survey techniques which increased the probability of locating elevated activity and specifically increased the contractor's surface activity values collected in the well caissons. The contractor also provided additional technicians to assist in trench surveys as recommended by ORISE.
- IV should be performed to minimize the risk of unidentified contamination remaining at the site following the completion of remediation activities. Type B verification surveys identified numerous locations of elevated activity requiring additional remediation after receiving final data (below the release criteria) from the contractor. These elevated areas would have otherwise remained at the site after closure.

- IV should be integrated into the FSS planning stages. IV was integrated into the FSS planning stages; therefore, onsite IV activities were successfully coordinated and performed in parallel with the contractor.

Upon successful completion of the CCP, ORISE received letters of commendation from both DOE site personnel and the D&D contractor for the significant contributions IV made in the closure process (DOE 2006a and CS 2006).

#### 4.4 Brookhaven National Laboratory

In 2005, ORISE performed verification survey activities of the 811 Waste Concentration Facility and the Former Hazardous Waste Management Facility at Brookhaven National Laboratory (BNL) in Upton, New York. The FSS methodology was based on a hybrid of NUREG/CR-5849, *Draft Manual for Conducting Radiological Surveys in Support of License Termination* (NRC 1992) and NUREG-1575, MARSSIM (NRC 2000). DOE approved dose based site-specific release criteria (developed in accordance with Draft 10 CFR Part 834) were used for many areas of the site; DOE Order 5400.5 (DOE 1993 and 1995) was applied for limited areas of the site.

##### 811 Waste Concentration Facility

ORISE reviewed BNL's Remedial Action Field Sampling Plan and Remedial Action Work Plan for Area of Concern 10 the Building 811 Waste Concentration Facility and provided a comment letter to the DOE documenting the review's findings (ORISE 2001). The document reviews identified numerous items requiring clarification or correction; specifically items pertaining to the application of MARSSIM. For example, ORISE noted that for Class 1 survey units, the number of required samples should not have been calculated until the remediation work had been completed, because of expected changes in the mean and standard deviations of the contaminants and the possible change in the radionuclide ratios. ORISE recommended that pre-remediation assumptions be removed from the Class 1 design and that post-remediation data be used as the input for design. Additional issues identified included the need to calculate a scan MDC for Cs-137 gamma scans and then verifying that the sample spacing is appropriate for the calculated scan MDC, and verifying and documenting that radionuclide ratios did not change following remediation.

ORISE performed surface scans and measurements of the Building 811 vaults and identified locations of elevated activity that required additional measurements to satisfy the 1 square meter average residual activity guidelines. Gamma scans performed by ORISE identified several areas of elevated activity in the C and D yards. Several localized "hot spots" as well as several large areas of contamination were identified and subsequently remediated by the contractor; often prior to ORISE collecting verification samples. Work activities in the C and D yards had to be suspended several times for additional remediation.

During the final verification survey of the C and D yards, ORISE identified two areas where Cs-137 concentrations in surface soil exceeded the Cs-137 site specific guideline and also exceeded the SOF limit of one (Sr-90 and Ra-226 were the additional contaminants). DOE and BNL were notified of the findings. One location was from an area where there were active waste lines and the second location was adjacent to a non-functioning sewer line. The ambient gamma radiation level between Buildings 810 and 811 was elevated as a result of gamma radiation originating from the active waste lines and remediated soil staged nearby. ORISE was informed that this area would be addressed in future remediation projects for Buildings 810 and 811 due to the active lines.

#### Former Hazardous Waste Management Facility (FHWMF)

The contractor provided ORISE with a preliminary FSS package summarizing sample data and walkover count rate data prior to verification surveys. The data indicated that the area had met the project-specific release criteria. However, gamma scans performed by ORISE identified numerous areas of elevated activity (one location was in a building pad borehole). Many of these locations were well above BNL's gamma field action level of 30,000 counts per minute. In addition to performing scans, ORISE collected 119 samples during three site visits, of which 26 exceeded the average Cs-137 site-specific guideline and eleven of these samples exceeded the Elevated Measurement Comparison (EMC) guideline level. The locations were marked and the data were provided to BNL. Ten of these eleven locations were re-sampled by ORISE at a later date to determine if additional remediation by BNL removed or reduced the initial radionuclide concentrations. A visual inspection at each of these locations identified several locations where it appeared that no additional remediation had even been performed. Two locations previously identified were noted as still having Cs-137 concentrations exceeding the EMC guideline after the re-sampling effort. Therefore, because BNL reported final survey data indicating that no areas exhibited Cs-137 levels above the release criteria and because follow-up remediation that should have been performed was not, ORISE was not able to confirm that BNL's documentation adequately described the existing radiological conditions in the FHWMF. During ORISE's re-evaluation of areas above the EMC guideline, contamination still remained above the guideline. BNL remediated the contaminated areas identified by the ORISE during a later site visit. However, given the number of samples identified as exceeding the release criteria, and the necessary remediation that followed each independent verification sampling campaign, it was ORISE's determination that additional contamination at concentrations greater than the release criteria are likely, particularly even in subsurface soils.

In this case, the IV activities were not able to validate the contractor's field activities and final results. These conclusions above are documented in the final reports (ORISE 2005a ORISE 2005b). The lessons learned are:

- IV should be performed to minimize the risk of unidentified contamination remaining at the site following the completion of remediation activities. Type B verification surveys identified numerous locations of elevated activity

requiring additional remediation after receiving final data (below the release criteria) from the contractor. These elevated areas would have otherwise remained at the site after closure.

- Post remediation verification activities should be performed to ensure successful remediation in areas where elevated results are identified.

#### **4.5 East Tennessee Technology Park – Three Building Decommissioning Project**

During the period of September 2003 to November 2005, ORISE performed comprehensive IV survey activities of Building K-31 and Building K-33 at the East Tennessee Technology Park (ETTP) in Oak Ridge, Tennessee. As part of the comprehensive independent verification, ORISE conducted document reviews of specific technical basis documents, procedures, plans, and reports; performed surface scans; and collected surface activity and exposure rate measurements. The FSS methodology was based on NUREG/CR-5849, *Draft Manual for Conducting Radiological Surveys in Support of License Termination* (NRC 1992).

##### Building K-31

The ORISE independent verification team performed in-depth technical reviews of the FSS Plan, which went through several revisions to incorporate higher dose-based supplemental release criteria for overheads (above 2 meters) in K-31 and K-33. ORISE reviewed the dose based information as it was modified and provided numerous comments via email. The technical basis for developing these supplemental release criteria for Building K-31 was extensively evaluated by ORISE and the Community Reuse Organization of East Tennessee. Additionally, ORISE provided comments and feedback to ensure that the technical basis would satisfy the DOE, the State of Tennessee, and other regulatory entities.

There were two distinct end-point criteria (EPCs) used for the project. The contract EPCs for the Three Building Project were those defined in DOE Order 5400.5 for the unrestricted release of material and surfaces in the building (DOE 1993 and 1995). The floor surfaces and lower walls, up to an elevation of two meters, were required to meet the 5400.5 surface limits and account for the radionuclide mixture that was present. Dose-based EPCs were developed for surfaces greater than 2 m above the Operations and Cell floors based on the following considerations: the DOE policy to reduce radiation exposures to as low as reasonably achievable (ALARA); to account for the presence of multiple radionuclides; and ensure that surfaces greater than 2 m above the floor were modified such that an acceptable dose for a building occupant would not exceed 2 mrem/y. The dose-based EPCs developed by the contractor and approved by DOE were expressed as derived concentration guideline levels (DCGLs) for each of the radionuclides of concern. The square meter average activity levels were compared to the applicable surface activity guideline (SAG). Surface locations having residual activity exceeding the SAG but limited to a small localized area were permitted to remain at three times the SAG; however, the remaining activity also had to satisfy the average limit within the contiguous one square meter. Therefore, residual surface activity was required to

satisfy the one square meter average and hot spot maximum activity levels for both the DOE 5400.5 guidelines and the dose-based EPCs.

After the initial ORISE verification surveys indicated the presence of additional contamination not previously identified during the contractor's FSS, DOE requested that ORISE perform scoping surveys of the Cell Floor upper surfaces. The ORISE findings of an excessive number of locations/areas with elevated activity not previously identified above the dose-based EPCs resulted in a request by DOE for ORISE to perform additional characterization surveys of 100% of the overhead areas up to the crane rail on the Cell Floor.

Numerous areas of residual contamination, exceeding the applicable EPCs, were identified throughout the building during the verification surveys, even after the modification to the higher dose-based release criteria for the Operations and Cell floor overheads. Several of these areas were remediated, yet others could not be decontaminated to levels below the EPC because aggressive remediation of these areas could have potentially compromised the integrity of the building structure; these specific locations were noted as exceptions by the contractor. Exceptions were areas in which the level of activity exceeded the guideline criteria after the contractor had met the contractual obligations for reducing levels to within the guideline criteria. Prior to additional decontamination efforts, the number of survey units exceeding the EPC was 442 (128 on the Operations Floor level and 314 on the Cell Floor level). After decontamination, ORISE performed additional scans and determined the number of survey units exceeding the EPC (and that were not identified as DOE excepted areas) was 51 (6 on the Operations Floor and 45 on the Cell Floor). In addition, several areas of elevated activity exceeding the EPCs were also identified on the supercompactor building foundation pad which is adjacent to Building K-31.

Two locations designated as contamination areas remained at the end of the IV activities. These locations were identified prior to the contractor's demobilization from the site. After the contractor departed the site, ORISE also identified a vent on the west wall with radioactivity levels above surface activity and removable guidelines.

The ultimate ORISE conclusion was that with the exception of the 51 survey units listed above, those areas accepted by DOE as exceptions, the adjacent supercompactor pad, and the west wall vent any remaining radiological contamination on Building K-31 surfaces meets the applicable EPC (ORISE 2006ff).

### Building K-33

During the course of work at K-33, ORISE reviewed 8,737 survey unit packages provided by the contractor. Because of changes in the scope of work, of the 8,182 packages that were designated for a Type A review, only 7,526 reviews were completed. Type A reviews identified 555 survey packages requiring Type B verification surveys. The number of Type A survey packages that were determined to exceed the EPC based on the ORISE review was 177 (27 on the Operations Floor

and 150 on the Cell Floor). ORISE determined that twenty-one Type B survey packages exceeded the EPC (10 units on the Cell Floor and 11 on the Operations Floor) based on verification survey results.

IV surveys were completed in process units (PUs) 1 through 4 on the Cell Floor. However, due to a number of factors, including significant decontamination work on the Cell Floor above and the effort by the contractor to modify the EPC for surfaces greater than two meters, the IV team was not directed to return to Building K-33.

The Type B surveys that were completed identified numerous areas of residual contamination exceeding the EPC on the floors, stairways, lower walls, and upper surfaces. Several areas were remediated, yet others could not be remediated below the EPC because aggressive remediation of these areas could have potentially compromised the integrity of the building structure. These areas were noted as exceptions by the contractor. This is reflective of the large number of Type A reviews that resulted in a “does not meet” for various survey units.

ORISE ultimately concluded that IV activities of Building K-33 were limited in scope and therefore, not representative of the final overall radiological status of the facility. The data reported for Type B survey packages from the Cell Floor is not representative of the significant activity that was known to exist (ORISE 2006gg). ORISE was not directed to return to the Cell Floor; however, additional Type A reviews of Cell Floor survey packages identified numerous packages exceeding the EPC. Many were determined to be exceptions by the contractor.

The lessons learned for the Three Building Decommissioning Project are:

- IV should be performed to minimize the risk of unidentified contamination remaining at the site following the completion of remediation activities. Type B verification surveys identified hundreds of locations of elevated activity requiring additional remediation that were not previously identified (or not identified above the EPCs) by the contractor. Many of these locations remain above the EPCs including two contamination areas within K-31.
- IV should be performed prior to demobilization of the contractor. IV activities continued after the contractor departed the site; therefore, the additional locations that ORISE identified above the EPCs were not addressed.

#### **4.6 East Tennessee Technology Park – Zones 1 and 2**

ORISE initiated verification activities in Zone 1 of the East Tennessee Technology Park in early 2007, and will continue in Zone 2 until remediation activities are complete. The Zone 1 area represents a 1400 acre buffer area around the plant production area (referred to as Zone 2). Because the cleanup of Zones 1 and 2 is a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) action, a remediation process known as the DVS (Dynamic Verification

Strategy) was developed and is being implemented. The DVS was designed as a hybrid between the EPA Triad Approach and the Multi-Agency Radiation Survey and Site Assessment Manual (MARSSIM) in order to focus cleanup actions in areas with a higher potential for contamination and minimize associated costs. A key element of the DVS is the “core team” approach, where all members of the regulatory oversight team agree on a specific cleanup and sampling approach in each area or “Exposure Unit”. The core team includes representatives from the DOE, Environmental Protection Agency (EPA), Tennessee Department of Environment and Conservation (TDEC), and the contractor.

The objectives of the IV in Zones 1 and 2 are to: (1) confirm that the DVS strategy is being implemented consistent with approved protocols to achieve the requirements of the Records of Decision (ROD) for remedial actions; and (2) to confirm that DVS investigation results can be independently reproduced. Because cleanup had nearly been completed in Zone 1 prior to the beginning of IV activities, ORISE focused on document reviews in Zone 1. The document review concluded that the DVS strategy is being properly implemented in accordance with the existing program plan and procedures. ORISE recommended that the DOE Oak Ridge Operations Office (DOE-ORO) document the process followed in developing the DVS to assure compliance with the requirements specified in the RODs. Because limited guidance on the survey approach was specified in the RODs, the core team held numerous roundtable discussions over the one-year period that the DVS was being developed in order to optimize the cleanup actions. The DOE-ORO is in the process of developing this documentation based on a recommendation by ORISE.

IV surveys continue in Zone 1, and the DOE-ORO intends to utilize ORISE for the verification of the Zone 2 cleanup effort. Through past lessons learned, the DOE-ORO has recognized the benefits of integrating the IV contractor early in the cleanup process in order to minimize impacts to project schedule and costs.

#### **4.7 Fernald Closure Project**

In 2006, ORISE performed verification survey activities at the Fernald Closure Project (FCP) in Fernald, Ohio. The objectives of the independent verification were to evaluate the data quality objectives, as defined in the Sitewide Excavation Plan (SEP) (DOE 1998), as to whether or not (1) remedial actions had been effective in meeting final remediation levels (FRLs) established specifically for the FCP, and (2) that the documentation accurately and adequately described the final radiological conditions of the FCP. These objectives were accomplished by reviewing site documentation and data, collecting independent field measurements and samples, and conducting comparisons of field and analytical measurements.

IV activities were not requested by the DOE until very near project completion. ORISE performed a limited review of FCP documentation, including the SEP and a project specific plan and certification report for Area 4A (DOE 2005a and b); and submitted a comment letter to the DOE documenting the review’s findings (ORISE 2006hh). The document review of the SEP identified the need for clarification of the FRLs and hot spot evaluation. Specifically, ORISE requested

further clarification of the relationship between the allowable “hot spot” (maximum FRLs) concentration relative to the corresponding allowable surface area of a “hot spot”. Additionally, ORISE requested clarification as to whether or not an evaluation had been conducted to determine the cumulative health impact of multiple contaminants that were reported to be present at the site. The contractor provided clarification substantiating the methodology using the maximum FRL as a trigger for conducting additional removal of soil to achieve the final project goals. The contractor also provided additional information regarding the individual radionuclide source terms and basis for ensuring that the cumulative cancer risk of 1E-4 to future site users would not be exceeded.

ORISE conducted both an in-process evaluation and IV survey activities during one site visit. It is important to note that ORISE was not involved in the early stages of the project and only performed verification activities after extensive restoration (including backfilling) was completed by the contractor. The results of the in-process evaluation corroborated the contractor’s radiation survey, soil sampling, and radioanalytical techniques used to support the final status survey process. Gamma surface scans identified seven areas of elevated radiation levels in the 30/45 Parking Lot Footprint and in the Admin Area. Samples were collected at each of the seven locations and were then split between ORISE and the contractor for the purpose of conducting a comparison of the analytical technique. The gamma spectroscopy results for the ORISE samples were compared with the results reported by the contractor. The analytical comparison of soil sample results between the site contractor and ORISE was inconclusive. The soil samples appear to be within the assumed expected analytical deviation for the analytical methodology; however, because the comparisons were not performed on the same samples but on split samples, a viable quality assurance evaluation could not be achieved. The results were comparable for several of the soil sample locations. Also, it was evident that the contractor’s analytical capability is comparable to that of ORISE. Two soil sample locations that were collected by ORISE from trenches in the Parking Lot Footprint with elevated Ra-226 activity were remediated by the contractor after ORISE left the site. The contractor’s post-remediation results were provided to ORISE for review; all results were below the FRLs. Based on document reviews and on-site IV activities, ORISE determined that the contractor’s remedial actions were effective in meeting established FRL’s and the final certification reports reviewed by ORISE accurately and adequately describes the radiological conditions of the site (ORISE 2006ii).

The lessons learned from the Fernald Closure Project are:

- IV should be integrated into the FSS planning stages so that onsite IV activities can be successfully coordinated and performed in parallel with the contractor. In this case, IV was not integrated into the FSS planning stages and IV activities were performed near project completion following extensive restoration (including backfilling). Surface scans of backfilled areas cannot verify that the prior excavations met site-specific guidelines.

## 4.8 Mound - Miamisburg Closure Project

In 2006, ORISE performed verification survey activities for the Miamisburg Closure Project (MCP). The applicable surface activity guidelines for the buildings were the more restrictive alpha and beta guidelines from DOE Order 5400.5 (DOE 1993 and 1995). The FSS methodology followed the guidance of NUREG-1575, MARSSIM for format and content and was written to meet the release criteria of DOE Order 5400.5 (BWXTO 1999, CH2 2004, and NRC 2000).

### Type A Verification

Type A verification was performed for the Parcels 6, 7, and 8 land areas, given that remediation activities had already been completed and the area had been backfilled with clean soil. The objective was to perform a comprehensive technical review of the Verification Sampling & Analysis Plan (VSAP) and Data Report for Potential Release Sites (PRS) to be evaluated. Because the number of PRSs associated with Parcels 6, 7, and 8 was large (332 PRSs), ORISE focused the data review on PRS 66, which was a large land area with a high potential for contamination. The scope of ORISE's review included evaluation of the contaminants of concern, the guidelines for each contaminant, the application of the guidelines for demonstrating compliance with cleanup criteria, instrumentation and corresponding minimum MDC, soil sampling procedures, and survey and analytical results. The documentation review indicated that the contractor's verification survey design and data were technically defensible and supports the final site conclusions. However, ORISE recommended that the MCP document the MDC for the detection of Pu-238 during field scans, given that there appeared to be a discrepancy between the estimated *a priori* MDC of 1667 pCi/g and the assumed actual scan MDC of 350 pCi/g which was determined based on field experience and data. The latter value was not documented and was communicated to ORISE by the contractor; therefore, ORISE recommended that the derivation of this value be documented. Comments pertaining to the VSAP and Data Report were sent via email to the DOE for discussion and resolution; all identified comments were appropriately addressed by the contractor via e-mail correspondence and several teleconferences (ORISE 2007d).

### Type B Verification

ORISE performed document reviews of the contractor's data for Buildings 45, 61, OSE, OSW, and the T-Building prior to performing on site activities. The IV surveys of the buildings were performed over an extensive area, with concentrated efforts in the buildings with the highest potential for contamination (Buildings 45, 61, and the T-Building). Six small areas of elevated activity were detected, and these areas were subsequently remediated by the contractor. Three of these locations were identified near the floor/wall interface where contamination could have potentially migrated into a seam; ORISE recommended that the contractor perform an investigation of potential contamination in these areas by removing a portion of the wall such that the floor beneath the wall could be accessed for survey. The results of this investigation were verified by an independent contractor under contract to DOE

Legacy Management and were not re-verified by ORISE. Based on the results of the IV activities performed by ORISE at the MCP, ORISE concluded that the evaluated areas meet the applicable site guidelines (ORISE 2007d).

It should be noted that the Mound 2000 Approach specified a removable tritium limit of 10,000 dpm/100 cm<sup>2</sup> and indicated that tritium smears should be collected with a dry filter. This method deviates from the guidance contained in a 1995 memo from the DOE Office of the Assistant Secretary for Environment, Safety, and Health, "Application of DOE 5400.5 Requirements for Release and Control of Property Containing Residual Radioactive Material," which recommends an interim guideline of 10,000 dpm/100 cm<sup>2</sup> for removable tritium; and states that "The measurements should be conducted by a standard smear measurement but using a wet swipe or piece of styrofoam." As such, ORISE recommended that a further review and evaluation of the Mound 2000 Approach for the assessment of removable tritium activity be performed to assure conformance with the referenced guidance.

The lessons learned from the Miamisburg Closure Project are:

- Contractor must provide complete FSS documentation including procedures, calibration information and equations to be used for calculations to enable independent parties to evaluate the appropriateness of the procedures and the reported data.
- IV should be performed to minimize the risk of unidentified contamination remaining at the site following the completion of remediation activities. Type B verification surveys identified six locations of elevated activity requiring additional remediation; these elevated areas would have otherwise remained at the site after closure. Three of these locations were located at the floor/wall interface and ORISE recommended additional investigations to determine if contamination had migrated into the seams. These investigations were performed by a contractor and were not re-verified by ORISE.
- Applicable and appropriate DOE requirements should be implemented. The procedure for collecting removable tritium with dry smears in the Mound 2000 Approach deviates from the guidance contained in a 1995 memo from the DOE Office of the Assistant Secretary for Environment, Safety, and Health, "Application of DOE 5400.5 Requirements for Release and Control of Property Containing Residual Radioactive Material," which recommends using a wet swipe or piece of styrofoam.

#### **4.9 Rocky Flats Environmental Technology Site**

During the years of 2002 through 2005, ORISE performed a comprehensive independent verification of the FSS activities at the Rocky Flats Environmental Technology Site (RFETS) in Golden, Colorado. Both Type A and Type B verifications were performed. The applicable surface activity guidelines for free

release were those for plutonium from DOE Order 5400.5 (DOE 1993 and 1995); however, the approved Decommissioning Operation Plan specified building-specific volumetric release criteria for the Building 771 structures that were to remain six feet below grade. The Rocky Flats Cleanup Agreement (RFCA) which was signed on July 19, 1996, and revised on May 28, 2003, was the governing agreement for the soils cleanup effort. The RFCA was a legally binding agreement between the DOE, the Environmental Protection Agency, and the Colorado Department of Public Health and Environment to accomplish the required cleanup of the RFETS.

ORISE performed substantial reviews of large volumes of FSS documentation throughout the D&D process. ORISE identified a discrepancy in calibration methods early in the project. ORISE calibrates instrumentation in accordance with ISO-7503 recommendations (ISO 1988); where the total efficiency for each instrument/detector combination consists of the product of the  $2\pi$  instrument efficiency ( $\epsilon_i$ ) and surface efficiency ( $\epsilon_s$ ):  $\epsilon_{\text{total}} = \epsilon_i \times \epsilon_s$ . The contractor did not account for surface efficiency in their calibrations. Therefore, ORISE alpha surface contamination results were nearly twice the contractor's reported activities for the same locations. Considering these differences, ORISE made adjustments for accurately comparing IV surface measurements to the approved release criteria.

On-site IV surveys performed by ORISE identified numerous locations of elevated activity within Buildings 371, 374, 707, 771/774, 776/777, and 865. Several localized "hot spots" as well as several larger areas of contamination were identified and subsequently addressed by the contractor. In most instances the identified contamination was undocumented by the contractor. Specific examples are described below:

#### 771/774 Complex

ORISE document reviews of the contractor's pre-demolition survey report for the 771/774 complex revealed that two locations in a Class 3 survey unit (SU) exceeded the guidelines by 50%. However, based on MARSSIM recommendations, Class 3 SUs that contain radioactivity exceeding 50% of the guideline should be reclassified as Class 2 SUs, and thus, warrant more extensive field investigations to support suitable conclusions. However, contractor conclusions cited in a pre-demolition survey report indicated that the criteria for free release had been met.

At the time of the on-site IV surveys of the 771/774 complex, the contractor's FSS data were not available for review. In addition, interim reports/data subsequently provided to ORISE did not identify any areas where contamination existed at levels exceeding the release criteria. However, the results of survey data collected by ORISE did not corroborate the contractor's findings contained in the interim reports, but instead indicated the presence of contamination at levels exceeding the established guidelines for free release and for structures that would be allowed to remain six feet below grade. Forty-two surface activity measurements taken on above grade surfaces were above the free release guidelines. Nine of fifty static gamma measurements exceeded the surficial criteria for structures that would remain below grade. Since these findings were reported by ORISE to DOE, the contractor

subsequently performed additional remediation and characterization measurements then prepared revised final reports for Building 771/774 that indicated all areas had been decontaminated to levels commensurate with the established guidelines. It should also be noted that many areas of Building 771 within six feet of final grade were removed and packaged as low-level radioactive waste during demolition (ORISE 2005c).

### Building 707

During on-site IV surveys, ORISE identified contamination not previously identified by the contractor in most of the survey units that were verified. ORISE initially concluded that undocumented contamination in excess of the guidelines would likely exist in other unverified building areas. Secondly, because contamination was identified in excess of the maximum guideline in Class 2 areas, ORISE questioned whether Class 2 survey units were appropriately classified.

In an effort to determine factors contributing to these findings, ORISE conducted an instrument comparison study using instrument statistics and calibration data, and previous survey data collected by the contractor. The discrepancies observed between the ORISE and contractor comparison measurements could not be attributed to the difference in measurement methods but likely due to survey technique. Therefore, ORISE recommended that the contractor re-evaluate the bases used for survey unit classification and that they consider reclassification followed by a resurvey of the affected survey units, as necessary. Quality assurance surveys that consisted of surface scans using a graded approach were recommended for areas of the building where ORISE did not perform IV surveys. Based on the interim findings and recommendations by ORISE, the contractor elected to perform additional quality assurance scans in Building 707. A written survey protocol was developed and reviewed by DOE/Rocky Flats Project Office, the Colorado Department of Public Health and Environment, and ORISE representatives that required additional surveys in five survey units. These quality assurance surveys performed by the contractor were a necessary requirement to provide assurance that remaining areas of residual activity exceeding the maximum allowable guideline would be identified and addressed (ORISE 2005d).

### Soils – 903 Lip Area

A comprehensive list of all known and suspected hazardous, radioactive, and mixed sources was compiled for the RFETS and resulted in 360 PRSs. For soils, GPS based aerial gamma scans were the primary method of locating elevated activity by the contractor; targeted ground based scanning was performed in limited areas of the site. The IV activities initially requested were to assess the 1) performance of the aerial and targeted ground based scanning, 2) performance of the contractor's investigations of the aerial and targeted ground based scan results, and 3) adequacy and completeness of the contractor's reports in areas of the site that had not been backfilled with soil (i.e., 903 Lip Area). However, items 1) and 2) were never performed due to DOE's decision to de-scope the IV work effort. ORISE only performed IV of soil in the 903 Lip Area. The IV activities were to specifically

assess whether the conclusion determined using the MARSSIM process would be consistent with the results reached by the contractor using the approach specified in the RFCA which was endorsed by the regulators.

ORISE conducted surveys of the 903 Lip Area in June and September 2005. The first survey was performed in accordance with MARSSIM and included gamma radiation scanning and systematic and judgmental soil sampling in two SUs within the 903 Lip Area. The 100% scan coverage in these areas resulted in a number of elevated radiation readings that were subsequently investigated and sampled. Three areas with elevated gamma radiation levels were identified in the Inner Lip SU, while 10 were identified in the Outer Lip SU. All of the Pu-239/240 concentrations in the MARSSIM systematic locations were below the RFCA action level. However, the analyses of the judgmental soil samples confirmed the presence of Pu-239/240 at concentrations greater than the RFCA soil action level of 50 pCi/g in all of the samples in both SUs. This information was provided to the DOE and they requested that ORISE determine the areal size of each elevated area. Additional scanning, static measurements, and soil sampling activities were conducted at various distances and directions from the hot spots to map out the size and shape of each location. Following the second survey it was determined that several of the original 13 elevated locations were part of the same area resulting in a total of nine elevated areas. Nineteen of the 20 samples that were collected for bounding the hot spots were above the RFCA Pu-239/240 action level. Nine of the judgmental samples collected exceeded the maximum hot spot criteria of 150 pCi/g.

ORISE findings were that the contractor would have needed to perform a 100% scan of the 903 Lip Area to identify these small areas of elevated contamination. The MARSSIM provides guidance on how to assess the presence of hot spots through the use of area factors. Area Factors were not developed for the RFETS closure project, therefore a MARSSIM assessment of these elevated areas, specifically the magnitude (factor) at which they could exceed the guideline, was not possible. Consistent with the MARSSIM approach to evaluate the dose or risk impact from hot spots, ORISE recommended that the effect on risk due to identified contamination levels be assessed to assure compliance with the RFCA agreement (i.e., 1E-5 risk to a future wildlife rescue worker). Similarly, this risk analysis should extend to other soil areas of the site not surveyed by ORISE. ORISE concluded that the results for the two SUs are likely representative of the entire 903 Lip Area (ORISE 2005e).

The lessons learned from the Rocky Flats Environmental Technology Site are:

- IV should be performed to minimize the risk of unidentified contamination remaining at the site following the completion of remediation activities. Type B verification surveys identified numerous locations of elevated activity not previously identified or documented by the contractor that required additional remediation. These elevated areas would have otherwise remained at the site after closure.

- Reclassification of survey units should be performed in accordance with site requirements based on findings by the IVC. The contractor's basis for survey unit classification was questionable after ORISE identified contamination in excess of the maximum guidelines in Class 2 areas.
- Aerial surveys, while an acceptable method for performing the initial characterization of large land areas, are typically not capable of identifying and assessing small areas of elevated contamination.
- A corrective action plan for addressing IVC findings should be developed and implemented. IV surveys of the two SUs within the 903 Pad Area identified hot spots that were not previously identified or documented by the contractor. The ORISE conclusions that similar results are likely for the remaining SUs left the public questioning the final radiological status of the site.

## 5.0 CONCLUSIONS

Numerous instances of improper releases of contaminated property have been averted through IV efforts. The DOE and NRC have determined that IV is a cost-effective way to provide assurance that a site is successfully remediated to the established cleanup criteria. The DOE good practice policy states "As part of their regulatory oversight, DOE site personnel should establish independent verification programs to confirm that survey and evaluation processes are in place and are being properly implemented, and that property released from DOE control meets authorized limits. . . . A well-implemented and documented independent verification program helps demonstrate that DOE property releases are credible and in compliance with authorized limits established for the property" (DOE 2006a).

Independent verification should be integrated into the planning stages rather than after the cleanup contractor has completed the remediation work and demobilized from the site. The IV of onsite remediation and FSS activities should be coordinated and if possible implemented in parallel with the contractor to minimize schedule impacts. A well-implemented and thorough IV program for a site requires IV involvement throughout the D&D process. Independent verification is not a substitute for routine contractor quality assurance; however, IV activities often improve the contractor's performance. IV recommendations often improve the contractor's FSS procedures and results, while increasing the probability of complete remediation and documentation. ORISE is independent of the site contractor and reports the IV results regardless of the outcome. When ORISE is able to validate the D&D contractor's methods and FSS results against the requirements and commitments, public credibility concerning DOE operations and cleanup objectives are greatly enhanced.

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