

Evaluation of Final Radiological Conditions at Areas of the Niagara Falls Storage Site  
Remediated under the Formerly Utilized Sites Remedial Action Program -12184

Christopher Clayton\*, Vijendra Kothari\*\*, Ken Starr\*\*\*,  
Michael Widdop \*\*\*\*, and Joey Gillespie\*\*\*\*

\*U.S Department of Energy Office of Legacy Management, Washington, DC;

\*\* U.S Department of Energy Office of Legacy Management, Morgantown, West Virginia;

\*\*\* U.S Department of Energy Office of Legacy Management, Westminster, Colorado,

\*\*\*\*SM Stoller Corporation, Grand Junction, Colorado

## ABSTRACT

The U. S. Department of Energy (DOE) methods and protocols allow evaluation of remediation and final site conditions to determine if remediated sites remain protective. Two case studies are presented that involve the Niagara Falls Storage Site (NFSS) and associated vicinity properties (VPs), which are being remediated under the Formerly Utilized Sites Remedial Action Program (FUSRAP). These properties are a part of the former Lake Ontario Ordnance Works (LOOW).

In response to stakeholders concerns about whether certain remediated NFSS VPs were putting them at risk, DOE met with stakeholders and agreed to evaluate protectiveness. Documentation in the DOE records collection adequately described assessed and final radiological conditions at the completed VPs. All FUSRAP wastes at the completed sites were cleaned up to meet DOE guidelines for unrestricted use. DOE compiled the results of the investigation in a report that was released for public comment.

In conducting the review of site conditions, DOE found that stakeholders were also concerned about waste from the Separations Process Research Unit (SPRU) at the Knolls Atomic Power Laboratory (KAPL) that was handled at LOOW. DOE agreed to determine if SPRU waste remained at that needed to be remediated. DOE reviewed records of waste characterization, historical handling locations and methods, and assessment and remediation data. DOE concluded that the SPRU waste was remediated on the LOOW to levels that pose no unacceptable risk and allow unrestricted use and unlimited exposure.

This work confirms the following points as tenets of an effective long-term surveillance and maintenance (LTS&M) program:

- Stakeholder interaction must be open and transparent, and DOE must respond promptly to stakeholder concerns.
- DOE, as the long-term custodian, must collect and preserve site records in order to demonstrate that remediated sites pose no unacceptable risk.
- DOE must continue to maintain constructive relationships with the U.S. Army Corps of Engineers and state and federal regulators.

## INTRODUCTION

The Niagara Falls Storage Site (NFSS) and associated vicinity properties (VPs) occupy approximately 607 hectares (1,500 acres) of the original 3036-hectare (7,500-acre) Lake Ontario Ordnance Works (LOOW), a former trinitrotoluene manufacturing facility built during the 1940s. In 1944, the LOOW was reassigned to the Manhattan Engineer District (MED) for use as a storage location for radioactive residues and other radioactive material that resulted from developing the atomic bomb. By 1948, 2428 hectares (6,000 acres) of the site had been sold by the federal government, leaving the remaining 607 hectares (1,500 acres) in the control of the newly formed U.S. Atomic Energy Commission (AEC), the agency that succeeded the MED.

AEC used the property for storage, disposal, and transshipment of radioactive materials. Subsequently, most of the remaining property was transferred to non-federal owners in discrete parcels, leaving the 77-hectare (191-acre) NFSS. These parcels were later addressed as the NFSS VPs.

In 1974, the U. S. Department of Energy (DOE) established the Formerly Utilized Sites Remedial Action Program (FUSRAP) to address contamination at sites formerly used for MED and early AEC operations that were not addressed by other programs. As a result of review of the NFSS and surrounding areas conducted in the 1970s and 1980s, NFSS proper and associated VPs were designated for remediation under FUSRAP.<sup>1</sup>

DOE completed remediation of 23 of the 26 designated VPs before 1997, when Congress transferred FUSRAP cleanup responsibilities to the U.S. Army Corps of Engineers (USACE). The USACE Buffalo, New York, District is responsible for remediating the remaining three VPs and the NFSS proper under FUSRAP.

In 2009, USACE informed DOE of an inquiry from a stakeholder about whether a feature of the remediated VPs, the Central Drainage Ditch, posed a risk to children playing in the area. Additional inquiries were received about the protectiveness of all the remediated VPs. DOE met with stakeholders at a USACE-sponsored public meeting and committed to evaluating the final radiological conditions of the remediated properties. This led to an ongoing interaction with stakeholders as DOE addressed their concerns and made site information available, and resulted in reports of radiological conditions at the completed NFSS VPs and the removal of Knolls Atomic Power Laboratory (KAPL) material from the former LOOW.

## **FUSRAP PROGRAM**

FUSRAP was created in 1974. Cleanup of eligible FUSRAP sites was the responsibility of the AEC and its successor agencies, the Energy Research and Development Administration and DOE, until 1997. These agencies were self-regulated and established cleanup criteria and remediation processes for FUSRAP that reflected internationally-accepted standards for radiological protection. More than 600 properties were evaluated for inclusion in FUSRAP. A site is eligible for remediation under FUSRAP if the following criteria are met:

- The location supported MED or early AEC activities,
- Radioactive materials were used at the site,
- There is a potential for radioactive contamination to remain at the site, and
- The contamination is not addressed by another program.

**Agency roles and responsibilities**—DOE and USACE are responsible for different portions of the remediation lifecycle for a FUSRAP site. In March 1999, DOE and USACE entered into a Memorandum of Understanding (MOU) for the purpose of delineation, administration, and execution of responsibilities for FUSRAP [1].

**DOE**—The MOU establishes that DOE is responsible for determining if a site is eligible for remedial action under FUSRAP. DOE has no authority to conduct assessment activities, determine if remediation is required, or select a remedy. When remedial action is complete, DOE assumes responsibility for performing long-term surveillance and maintenance (LTS&M) of a remediated FUSRAP site.

---

<sup>1</sup> NFSS proper refers to the 77-hectare (191-acre) parcel owned by DOE and containing the Interim Waste Containment Structure. The NFSS VPs are nearby properties that were found to contain MED/AEC radiological contamination and are owned by other entities.



**U.S. Army Corps of Engineers**—USACE is authorized by Congress to administer and execute cleanup activities at eligible FUSRAP sites following guidance for implementing the Comprehensive Environmental Response, Compensation and Liability Act.[2] Except as noted in the MOU, USACE is responsible for all environmental response activities at a FUSRAP site until two years after remedial action is complete, at which time DOE assumes responsibility for LTS&M of the site.

**State and Federal Regulatory Agencies**—The New York State Department of Environmental Conservation (NYDEC), New York State Department of Health (NYSDOH), and Region 2 of the U.S. Environmental Protection Agency (EPA) have regulatory roles at the NFSS.

NYSDOH maintains land use controls over portions of the NFSS and VPs. These were first imposed in 1972 because stored radioactive uranium ore processing residues were potentially hazardous to the public. These controls, in the form of use restrictions, are still in effect and prevent the properties from development or disturbance of the surface without an acceptable plan approved by the Commissioner of Health [3, 4].

EPA Region 2 provides regulatory oversight of the USACE operations and assists NYDEC in its oversight of the municipal and hazardous waste landfill operations.

**Stakeholders**—USACE currently has a public outreach program for the LOOW and NFSS. USACE has allowed DOE to present information to stakeholders at USACE public meetings. DOE has provided contact information to stakeholders and DOE will respond to stakeholder inquiries. The Interested stakeholder community included residents and local, state, and federal officials.

## **CASE STUDY- NFSS**

### **Summary of Evaluation**

USACE forwarded a stakeholder inquiry about a report commissioned by the Community LOOW Project, which concluded that the final radiological conditions in the Central Drainage Ditch resulted in a total effective dose equivalent (TEDE) of 57.6 millirems per year (mrem/year) [5]. This dose rate exceeds the State of New York dose limit of 10 mrem/year. DOE reviewed the report and also assessment and remediation records and determined the dose calculation seemed to assume constant exposure, i.e., 24 hours a day and 365 days a year, at the location of highest gamma activity. DOE reviewed the final radiological conditions and likely land use, and confirmed that under a reasonable exposure scenario no unacceptable risk was presented to residents or workers in the area. State regulators concurred in the findings. DOE presented these conclusions to the stakeholders and copied USACE and State regulators with the results.

DOE received additional stakeholder inquiries about protectiveness of the remediated VPs and asked USACE for an opportunity to meet stakeholders at a USACE public meeting. DOE staff wanted to understand the extent of stakeholder concerns, ensure that good information was available to the community, and solicit additional information about site conditions from the community that was not available in DOE records.

USACE invited DOE to meet NFSS stakeholders in September 2009. At this meeting, DOE explained that they are responsible for LTS&M of remediated sites and would review records to address stakeholder concerns about the safety of the remediated properties. DOE explained the division of responsibilities stipulated in the MOU and provided contact information.

USACE provided DOE time on the agenda of the next NFSS public meeting, where DOE presented an evaluation plan and requested that stakeholders provide information about issues concerning the remediated VPs. DOE selected six properties that had the greatest potential to expose members of the public to residual hazards, mostly on the basis of access controls. The Central Drainage Ditch was included in the evaluation (Figure 2).

DOE summarized the findings of the evaluation in a report that was released to the public and regulators for comment in March 2010 [6]. Comments were received from the public and local, state, and federal officials and regulators. Comments presented concerns about aspects of the DOE process for determining site eligibility; no technical comments were received contesting the DOE conclusion that the remediated properties are protective. The report and source documents are available on the DOE Office of Legacy Management website.

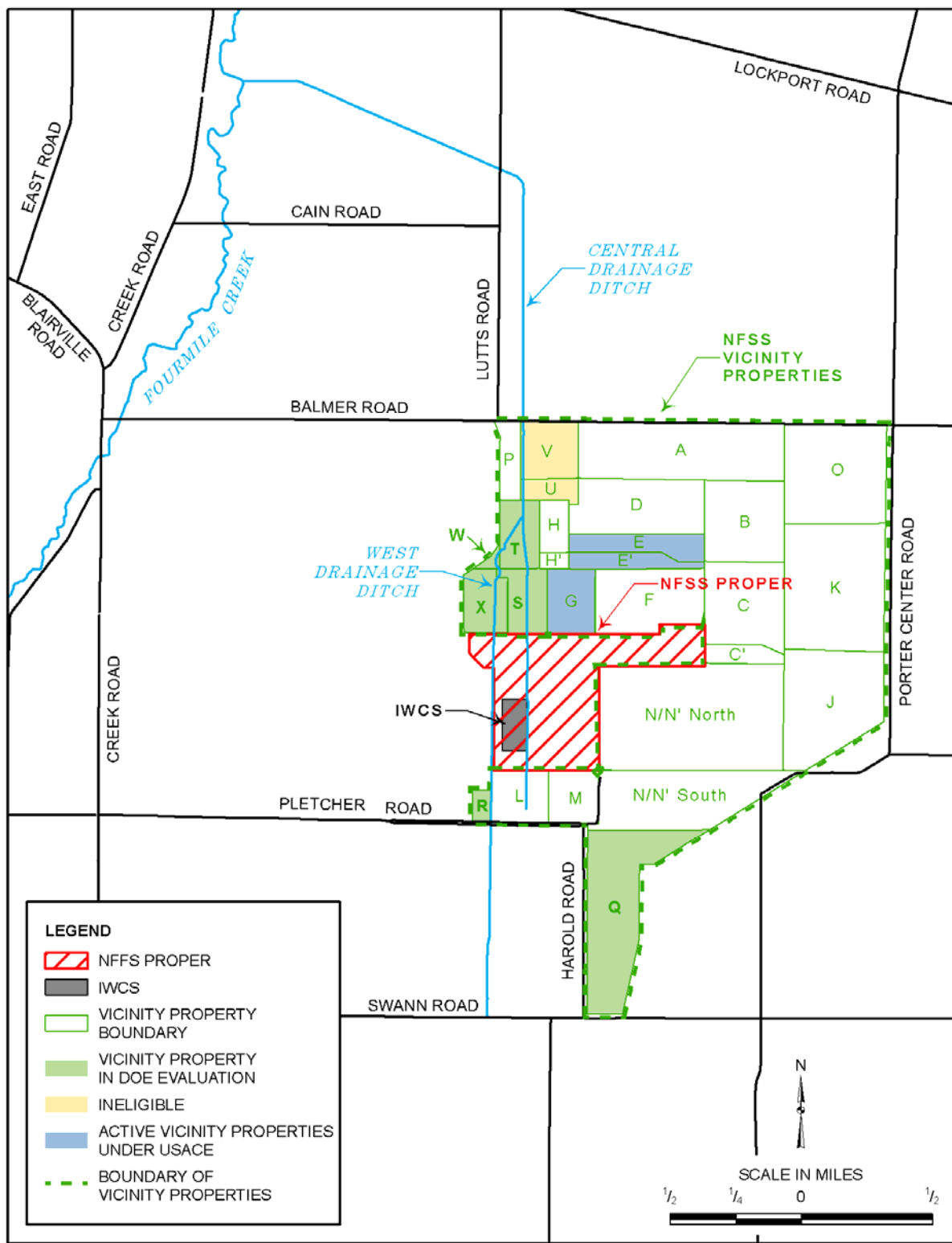


Figure 2. Vicinity Properties Selected for Evaluation at the Niagara Falls Storage Site, New York

DOE has determined that its assessment, remediation, and verification processes were thorough, and that FUSRAP wastes from the VPs have been remediated in accordance with DOE guidelines for unrestricted use. The evaluation results are summarized in the following sections.

## NFSS Operations History

The federal government constructed a trinitrotoluene (TNT) manufacturing facility on the LOOW in 1943. The TNT plant operated for about 9 months and was shut down. By 1944, 607 hectares (1,500 acres) of the LOOW had been reassigned to MED. In 1947, the MED property was transferred to AEC. Site ownership subsequently passed from AEC to its successor agencies, the U.S. Energy Research and Development Administration, and, for the NFSS proper, DOE. The VPs are currently owned by private parties or local government.

The majority of the activities at LOOW were conducted on 607 hectares (1,500 acres) of the site referred to as the “Developed Area” [7]. The “Undeveloped Area” was a 6,000-acre tract that surrounded the active process areas and served as a buffer for the site. From 1955 to 1975, more than 526 hectares (1,300 acres) of the Developed Area were transferred or sold to private concerns, leaving the current interior 77 hectares (191 acres) that the NFSS comprises. The surrounding acreage that had been sold or transferred became known as the NFSS VPs [8].

Between 1944 and 1954, MED and AEC stored low-level wastes on the Developed Area. These wastes consisted primarily of residues from uranium processing operations, but also included contaminated rubble and scrap from decommissioning activities, other biological and miscellaneous wastes from the University of Rochester, and low-level fission-product wastes from Separations Process Research Unit (SPRU) activities at KAPL.

## Remedial Action History

**Early Decontamination Activities**—During October 1970 and June 1971, radiological surveys of the approximately 526 hectares (1,300 acres) formerly owned by AEC indicated that about 2.6 hectares (6.5 acres) exceeded the AEC exposure criterion of 50 microroentgens per hour ( $\mu\text{R/h}$ ). As a result of this survey, 3,800 to 15,000 cubic meters (5,000 to 20,000 cubic yards) of contaminated soil and debris were excavated and stockpiled at the NFSS proper.

In 1971, AEC conducted an aerial survey of the greater Niagara Falls area. This survey identified several areas of elevated gamma radiation. Most of these areas were later shown to contain slag generated from phosphorous extraction processes that contains naturally-occurring radioactive material. In April 1972, following a review of AEC’s survey data, NYSDOH placed land-use restrictions on all the VP s.

**FUSRAP Activities at NFSS Vicinity Property**—Following is a chronology of the FUSRAP-related activities undertaken by DOE for the NFSS and NFSS VPs:

- **1978:** DOE conducted aerial and vehicle-mounted surveys and identified gamma anomalies in the drainage ditches.
- **1979 and 1980:** DOE conducted a comprehensive radiological characterization of the NFSS proper and the VPs, including the West and Central Drainage Ditches, both on site and off site. This survey identified contamination that exceeded DOE guidelines along the entire length of the West Drainage Ditch and the upstream portion of the Central Drainage Ditch. This initiated a resurvey of the off-site areas to determine whether any residual contamination existed in other areas.
- **1981–1985:** DOE performed comprehensive radiological surveys of the individual VPs, including 100-percent gamma scans and surface and subsurface sampling. Gamma exposure rates on 21 of the 26 properties exceeded DOE guidelines.
- **1983–1986:** DOE conducted remedial action on the individual VPs.

- **1983–1984:** Supplemental Residual Contamination Guidelines were developed as part of the remedial/post-remedial action being performed on the Central Drainage Ditch.
- **1983–1989:** Oak Ridge Associated Universities, under contract to DOE for FUSRAP, performed independent verification surveys on each of the VPs, which support release of the remediated VPs for unrestricted use and unlimited exposure. DOE could not complete remediation of three VPs due to inaccessible areas (ponds and paved areas). These VPs (VP-E, and VP-E' and G) will be remediated by USACE.

DOE removed approximately 38,000 cubic meters (50,000 cubic yards) of low-level radiologically contaminated soil. The contaminated soil and the uranium residues are stored in an Interim Waste Containment Structure located on the NFSS proper. USACE is actively performing a Remedial Investigation/Feasibility Study on the NFSS. proper

### **Outcome of NFSS VP Evaluation**

DOE found that the assessment surveys were designed to identify gamma-emitting radionuclides that exceeded cleanup limits and to allow delineation of uncontaminated areas. Excavation of radiological contamination was conducted using gamma surveys to ensure that contamination was removed. DOE conducted independent verification of remediated areas. Surveys were designed with knowledge of historical activities and were capable of detecting radionuclides of concern. Gamma scan density was adequate to detect gamma anomalies that could exceed cleanup criteria. Soil samples adequately represented radiological conditions with a high degree of confidence. Radiological contamination was assessed and remediated areas meet the conditions for unrestricted use and unlimited exposure.

No comments from stakeholders challenged these conclusions, and the report provides a ready summary of remediation and protectiveness for use in the future.

### **EVALUATION OF THE KAPL WASTE STREAM**

During the course of evaluating radiological conditions at NFSS VPs and working with USACE, stakeholders, and regulators, DOE became aware of another issue at the NFSS and the NFSS VPs. Three waste streams were identified in historical assessment documentation for which responsibility had not been established with regulators and USACE:

- Slag was imported to LOOW and used for construction. This slag, a byproduct of phosphate production, contains equal activities of uranium and radium, ranging from approximately 5 to 50 picocuries per gram (pCi/g). It is not regarded as a FUSRAP waste originating from AEC/MED operations, but instead as part of the construction materials brought in by contractors constructing the LOOW in the early 1940s.
- KAPL SPRU wastes consisting of semisolid neutralized radioactive waste containing fission products from evaporator bottoms of a Pu extraction pilot plant where the PUREX and REDOX processes were developed.
- University of Rochester waste that originated from radiation safety research performed under MED sponsorship. Waste from metabolic studies was buried at the site and consisted of animal carcasses and other material contaminated with radioactive isotopes. Additionally, igniters containing Sr-90 or Cs-137 were buried near the University of Rochester waste.



## Agreement with USACE, NYSDOH, and NYDEC

FUSRAP addresses wastes generated through MED/AEC activities that are on sites that are not included in another program. In the case of potential SPRU waste on the former LOOW, the material is currently being remediated by the DOE Office of Environmental Management (EM) at the former SPRU facility at the KAPL Schenectady, New York, location. Although a formal waste eligibility determination was not conducted by USACE, EM may have been responsible for remediation of any remaining KAPL waste found on the NFSS or NFSS VPs.

DOE met with EPA and State regulators and USACE. The agencies agreed that the State of New York would address slag at the former LOOW, USACE would remediate any University of Rochester waste encountered on the NFSS and active VPs, and DOE would pursue referral of SPRU waste to EM for remediation.

## Evaluation of KAPL Waste at NFSS

DOE evaluated the former LOOW to determine if SPRU waste remained on the site that exceeded cleanup criteria. This evaluation consisted of the following:

- Assembling and reviewing documentation describing where KAPL wastes may have been handled, stored, or incinerated at LOOW and the waste stream profile;
- Reviewing process knowledge of KAPL waste from LOOW site documentation and from current SPRU remediation activities at the KAPL facility; and
- Reviewing the results of NFSS and VP assessment, post-remediation, and verification surveys, including USACE assessment data from NFSS, to identify any areas that may need further evaluation and possible remedial action.

**History of KAPL Waste at LOOW**—SPRU commenced operation at the KAPL facility in 1950. Beginning in 1952, LOOW began receiving low-level radioactive waste from SPRU at KAPL. The waste resulted from extraction of Pu from irradiated uranium [9].

NYSDOH personnel provided shipping information on radioactive waste that was shipped from KAPL to LOOW and eventually repackaged and shipped from LOOW to Oak Ridge, Tennessee. The shipping information provides general information about the amounts and types of containers but does not provide sufficient detail to establish that all material received at LOOW was eventually shipped to Oak Ridge or to determine what amount of waste might remain at the prior storage locations [10]. DOE contacted staff at Oak Ridge National Laboratory (ORNL) to obtain quantitative information about the volumes and radionuclide concentrations of the KAPL material received from LOOW. ORNL staff had corresponding disposal records but reported that no quantitative information exists for the material [11].

The KAPL waste stream consisted of (1) sludge from "evaporator bottoms" (i.e., the contents remaining after liquid wastes were evaporated to reduce their volume) and (2) associated contaminated material such as protective clothing and combustible materials, with a radioactivity of approximately 12 milliroentgens per hour from mixed fission products. Approximately 320,000 kilograms (700,000 pounds) of contaminated waste in 16 boxcars was shipped from KAPL to LOOW through September 1952. The shipments included 675 boxes and 394 slurry drums. KAPL wastes consisted of the following types of waste:

- **Miscellaneous scrap** consisting of materials contaminated with low-level fission products, such as air filters, glass, metals, wood, and all materials that could not be bailed.
- **Bailed materials** composed of dry waste (such as paper, rags, floor sweepings, gloves, and lagging) contaminated with low-levels of fission products.



- **Solid waste** containing of high-level fission products, including both miscellaneous scrap and bailed materials.
- **Pu-contaminated waste** composed of all materials contaminated with Pu. This type of waste was placed into 1-gallon paint cans and sealed into 55-gallon drums.
- **Slurry** composed of neutralized evaporator bottom sludge contaminated with high-levels of fission products. The slurry waste contained some residual Pu not extracted by the SPRU processes. This slurry would have accounted for most of the radioactivity in the KAPL waste received at LOOW.
- **Oils** composed of degreasing fluid and cutting oils, contaminated with low-levels of fission products [12].

KAPL waste was received at LOOW at a railroad loading facility straddling the boundary between VP-X and the NFSS proper. Drummed materials were placed in various building at LOOW. Some combustible waste was incinerated at LOOW to reduce volume, and the ashes were placed in drums. All KAPL waste was shipped by rail to Oak Ridge, Tennessee, in 1958.

**Radiological Data**—According to historical process knowledge and waste profile information from remediation at the KAPL facility, the predominant radionuclide was Cs-137, with minor amounts of Sr-90 and Am-241.

At the former LOOW, DOE established that Cs-137 is a valid surrogate for locating KAPL material, because (1) Cs-137 is the predominant radionuclide and (2) concentrations of other radionuclides are much lower than the Cs-137 concentrations [13]. As an example, in a sample set of 115 Pu-239/240 results and more than 300 Cs-137 results, the average Pu-239/240 concentration was about 0.2 pCi/g, while the average Cs-137 concentration was 21 pCi/g or approximately 2 orders of magnitude greater. The maximum Pu-239/240 result was 6.7 pCi/g. The SPRU Derived Concentration Guideline Level (DCGL) for Pu-239/240 under a subsistence farmer exposure scenario is 13.3 pCi/g. There is no statistical rigor in this analysis, and the Cs-137 to Pu-239/240 ratios in the sample set were not constant, but it illustrates that Pu-239/240 concentrations are much less than Cs-137 concentrations and are therefore less than a risk-based guideline set for the KAPL facility. The low concentrations of Pu-239 in the KAPL waste streams was confirmed in the *Nuclear Facility Historical Site Assessment for the Separations Process Research Unit (SPRU) Disposition Project* [9].

History on the storage locations, types of waste, and waste characteristics was used to plan and design the assessment and remediation activities during the early decontamination efforts on the LOOW [7]. DOE assessment, remediation, and verification processes were designed to investigate known locations where KAPL wastes were handled. Because Cs-137 was used as an indicator for KAPL waste, suspected areas were investigated through the use of gamma measurements, subsurface explorations, tighter, more closely spaced surveys, and targeted analytical programs in the areas where KAPL wastes were known to have been stored or incinerated [14,15].

DOE reviewed site records of the assessment, remediation, and verification activities conducted on the former LOOW. The evaluation concluded that the assessment methods were adequate to identify contaminated areas and eliminate uncontaminated areas from further consideration. The remedial action records demonstrated that assessed contamination was removed to the cleanup criteria established for the site. The records of the verification conducted by an independent party confirmed that the remediation achieved cleanup goals and the VPs could be released for unrestricted use.

Cs-137 results for the KAPL-affected VPs prior to remediation ranged from background (less than 0.02 to 1.05 pCi/g) to 33.0 pCi/g. Areas on the completed VPs with Cs-137 contamination were remediated by DOE, resulting in Cs-137 concentrations typically less than 2 pCi/g.

During the remedial investigation of the NFSS proper, USACE detected traces of Am-241 in approximately 1 percent of samples from the NFSS, and so determined that it is not a contaminant of concern. This also suggests that other transuranic elements are unlikely to be present at significant concentrations or to be widespread in the NFSS or on the vicinity properties in soils or sediment. Pu-239 was also detected, but only in trace amounts, which reflected the purpose of the SPRU process: to remove the valuable Pu-239 from the irradiated uranium. SPRU process flow diagrams indicate that Pu and U was removed and sent to other locations such as Los Alamos National Laboratory and the KAPL analytical laboratory [9].

### **Protectiveness**

This analysis demonstrates that residual KAPL waste does not remain on the NFSS proper and NFSS VPs at concentrations that would require assessment and, if necessary, remediation.

**Land Use**—To evaluate the protectiveness of remediated NFSS VPs to future occupants, assumptions are needed for future land use. Land use assumptions will determine the exposure scenarios that are reasonable for future occupants [16]. Future land use is an important factor used in developing site cleanup levels.

Most of the NFSS VPs are privately owned and zoned for industrial or commercial use. This land use can be assumed to persist for longer than Cs-137 residuals would remain above background levels.<sup>2</sup> Therefore, a reasonable exposure scenario would be for a site worker who spends 40 hours per week and 50 weeks per year on the surface of the site. This worker would not eat food grown on the site (produce, cereal grains, fish, and meat) or drink site groundwater. Other pathways such as direct radiation, dermal absorption, and dust inhalation may be plausible.

Land use restrictions on NFSS VPs and drainages were imposed by NYSDOH in 1972 and restated in 2004 [17]. These restrictions stipulate that existing use can continue but not be expanded or broadened, occasional recreation use may be permitted, NYSDOH must be notified of a transfer of ownership, NYSDOH will determine if radiation levels are safe, and NYSDOH must approve decontamination and excavation plans.

Under the NYSDOH land-use restrictions, a residential or subsistence farming scenario is unreasonable and unlikely. This is consistent with USACE findings regarding a subsistence farmer exposure scenario:

It should be noted that the subsistence farmer land use scenario was evaluated in the [human health risk assessment] as an overly conservative worst case. This scenario is highly unlikely due to the proximity of the site to surrounding landfills and the poor yield and quality of on-site groundwater resources [18].

Historical site information and remediation data indicate that KAPL activities mostly occurred on the developed area of the former LOOW in areas that can reasonably be anticipated to remain in industrial use.

**Radionuclide Limits and Exposure**—Preliminary-Remediation Goals (PRGs) were developed by EPA for radionuclides under different exposure scenarios. The default PRGs correspond to a

---

<sup>2</sup> A Cs-137 occurrence of 5 pCi/g in 2007 would decay to less than 1 pCi/g in less than 90 years.

risk of  $1 \times 10^{-6}$  (or an excess cancer risk of 1 in 1,000,000). EPA's "acceptable" risk range (40 CFR 300) is between  $1 \times 10^{-6}$  and  $1 \times 10^{-4}$  (excess cancer risk of 1 in 10,000).

The default PRG for Cs-137 in residential soils (which includes ingestion of 25 percent of fruits and vegetables from a home garden) is 4.02 pCi/g [19]. The DOE remediation limit for Cs-137, based on pathway analysis, was 33 pCi/g [20]. This is approximately an order of magnitude greater than the default PRG and would result in risks on the order of  $1 \times 10^{-5}$  for residential soil—the midpoint of the acceptable risk range. The U.S. Nuclear Regulatory Commission's surface soil screening level for decommissioning (to meet a dose limit of 25 mrem/year, which allows unrestricted use) of 11 pCi/g Cs-137 provides another benchmark for protectiveness [21].

DOE analyses for Cs-137 indicate that concentrations in the mid-1980s were generally less than 2 pCi/g. Residual Cs-137 levels would be about one half the levels found in the 1980s because the half life of Cs-137 is 30.2 years. Cs-137 concentrations are less than the PRG of 4.02 pCi/g for residential soil, indicating that potential risks from Cs-137 residues on the completed NFSS VPs would be within the acceptable risk range established by EPA for unrestricted residential use.

USACE found Cs-137 concentrations as high as 5.15 pCi/g on the NFSS proper [18]. Sample locations were biased to areas with elevated gamma activities. The USACE data set consisted of 1,087 Cs-137 results, of which 24 exceeded the upper bound of background (0.8 pCi/g) established by DOE [22]. Cs-137 occurrences also appear to be sporadic, limited in extent, and correspond to PRGs within the acceptable risk range for residential soil. On the basis of comparison of measured Cs-137 concentrations to EPA risk-based PRGs, residual KAPL waste would not pose an unacceptable human health risk for a residential land-use scenario.

## CONCLUSIONS

After review of historical site documentation, DOE reports, and USACE radiological data, DOE concluded the following:

- DOE had access to adequate documentation to evaluate site conditions at the former LOOW. This is important to confirm now, while institutional knowledge of early FUSRAP work remains available.
- DOE remediated the completed VPs to conditions that are protective for unrestricted residential use. Sample and walkover gamma scan results indicate that no wastes remain that exceed cleanup criteria.
- Process knowledge and field observations establish that Cs-137 is the predominant radionuclide in the KAPL waste stream. Cs-137, a strong gamma emitter, was used as an indicator for remediation of KAPL waste. Other radionuclides were present in much lower relative concentrations and were likely also removed during remediation of the VPs.
- KAPL contaminants were removed during remedial activities at the former LOOW as either co-located or comingled with other radionuclides.
- For the active VPs (VP-E, VP-E', and VP-G), results of DOE's cleanup of the accessible portions of these properties indicate that KAPL waste does not remain at concentrations greater than the DOE cleanup limit:
  - Inaccessible areas were not associated with historic KAPL waste handling. Therefore, it is unlikely that KAPL waste remains on the active VPs.
  - Because gamma activity was used by DOE during remediation/verification activities for excavation control, additional USACE cleanup of FUSRAP wastes on these properties

will likely result in the remediation of any co-located residual KAPL wastes to acceptable levels or identification of KAPL waste that is not co-located.

- Although USACE has not established a cleanup level for Cs-137 on the active NFSS VPs, DOE assessment and remediation data indicate that assessed Cs-137 was remediated and significant Cs-137 is unlikely to remain. Because of the low likelihood of encountering significant KAPL waste on the active NFSS VPs, additional remediation is not anticipated at these properties.
- USACE assessment soil sampling results on the NFSS proper indicate that KAPL waste does not exceed the DOE cleanup level for Cs-137. USACE has not established a cleanup level for Cs-137 on NFSS proper. The USACE cleanup of FUSRAP wastes on the NFSS proper will likely result in the remediation of any co-located residual KAPL wastes or identification of KAPL waste that is not co-located.

DOE is drafting a report of the investigation of KAPL waste at LOOW. The report will be released to the public for comment when the draft is complete.

DOE responses to stakeholder inquiries resulted in a common understanding of site conditions and site risk. DOE expects additional interaction with stakeholders at the former LOOW as USACE completes remediation of the active VPs and the NFSS proper, and these relationships will hopefully have built trust between DOE and the stakeholders that DOE will perform its duties in an open and transparent manner that includes stakeholders as stewards for remediated FUSRAP sites.

## REFERENCES

1. DOE (U.S. Department of Energy) and USACE (U.S. Army Corps of Engineers), 1999. *Memorandum of Understanding Between U.S. Department of Energy and U.S. Army Corps of Engineers Regarding Program Administration and Execution of the Formerly Utilized Sites Remedial Action Program (FUSRAP)*.
2. Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). Title 42 *United States Code* § 9601 et seq.
3. Wallo, A., 1980. Correspondence from Andrew Wallo, The Aerospace Corporation, to William E. Mott, DOE, attachment: April 1972 NYSDOH Commissioner's land use restrictions on 1,511 acres of the former LOOW, August 11.
4. DOE (U.S. Department of Energy), 1980a. Correspondence from William E. Mott, DOE, to Ms. Mary Beth Brado, Town of Lewiston, concerning NYSDOH land use restrictions on 1,511 acres of former LOOW, May 29.
5. Niagara County, New York, Community LOOW Project, see <http://www.niagaracounty.com/Health/loow.asp>. See in particular "Presentation by R Harris and M Resnikoff," presented June 13, 2007.
6. DOE (U.S. Department of Energy), 2010. *Formerly Utilized Sites Remedial Action Program Niagara Falls Storage Site Vicinity Properties, New York: Review of Radiological Conditions at Six Vicinity Properties and Two Drainage Ditches*, Document No. LMS/NFS/S06246, October.
7. AEC (U.S. Atomic Energy Commission), 1973. Radiation Survey and Decontamination Report of the Lake Ontario Ordnance Works Site, Oak Ridge Operations, DOL-08-02978, January 18.

8. USACE (U.S. Army Corps of Engineers), 2009. *Public Involvement Plan Former Lake Ontario Ordnance Works Site Defense Environmental Restoration Program for Formerly Used Defense Sites and Niagara Falls Storage Site Formerly Utilized Sites Remedial Action Program Lewiston and Porter, New York for 2009 – 2010*, May.
9. DOE (U.S. Department of Energy), 2006. Nuclear Facility Historical Site Assessment for the Separations Process Research Unit (SPRU) Disposition Project, prepared by Environmental Resource Group, LLC, April.
10. DOE (U.S. Department of Energy), 2005. KAPL Radioactive Waste Information Related to the Lake Ontario Ordnance Works, correspondence with eight attachments from J. Hughes Robillard, Dir. Radiological /Environmental Controls and Safety Division (DOE), to Steven Gavitt, Assistant Bureau Director (NYSDOH), August 10.
11. DOE (U.S. Department of Energy), 2011. "Knolls Atomic Power Laboratory Waste Disposition Records," telephone call log between Joey Gillespie, S.M. Stoller Corporation, contractor for LM, and David Hamron, Oak Ridge National Laboratory, September 15.
12. DOE (U.S. Department of Energy), 2005. *KAPL Radioactive Waste Information Related to the Lake Ontario Ordnance Works*, correspondence with eight attachments from J. Hughes Robillard, Dir. Radiological /Environmental Controls and Safety Division (DOE), to Steven Gavitt, Assistant Bureau Director (NYSDOH), August 10, NY.17-21.
13. DOE (U.S. Department of Energy), 2006b. *Radiological Characterization Report for SPRU Outside Areas Separations Process Research Unit Project*, TSM-26, prepared by CH2MHILL, Rev. 2, June.
14. DOE (U.S. Department of Energy), 1981. *Final Report on a Comprehensive Characterization and Hazard Assessment of the DOE-Niagara Falls Storage Site*, BMI-2074 (revised), UC011, June.
15. Berger, J., 2010. Phone conversations between Joey Gillespie, geologist, S.M. Stoller Corporation, and Jim Berger, verification officer for DeNuke Services, February 12 and September 20.
16. EPA (EPA (U.S. Environmental Protection Agency) 1995. "Land Use in the CERCLA Remedy Selection Process," Office of Solid Waste and Emergency Response Directive No. 9355.7-04, Washington, D.C., May 25.
17. NYSDOH (New York State Department of Health), 2004. *A Summary of "Commissioners Orders" for Surplus Properties Formerly Part of the Lake Ontario Ordnance Works*, email correspondence from S.M. Gavitt, NYSDOH, November 19.
18. USACE (U.S. Army Corps of Engineers), 2007b. *Remedial Investigation Report for the Niagara Falls Storage Site*, Science Applications International Corporation (SAIC), December.
19. EPA (U.S. Environmental Protection Agency) 2010. *Preliminary Remediation Goals for Radionuclides*, available at <http://epa-prgs.ornl.gov/radionuclides>.
20. DOE (U.S. Department of Energy), 1988. *Derivation of Uranium and Cesium-137 Residual Radioactive Material Guidelines for the Niagara Falls Storage Site*, Argonne National Laboratory, August.

21. NRC (U.S. Nuclear Regulatory Commission) 2006, *Consolidated Decommissioning Guidance, Decommissioning Process for Materials Licenses, Final Report*, NUREG-1757, Vol. 1, Rev. 2, September.
22. DOE (U.S. Department of Energy), 1986a. *Post-Remedial Action Report for the Niagara Falls Storage Site Vicinity Properties—1983 and 1984*, Lewiston, New York, DOE/RO/20722-84, December.