# INTEGRATION OF HEALTH PHYSICS, SAFETY AND OPERATIONAL PROCESSES FOR MANAGEMENT AND DISPOSITION OF RECYCLED URANIUM WASTES AT THE FERNALD ENVIRONMENTAL MANAGEMENT PROJECT (FEMP).

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## ABSTRACT

Fluor Fernald, Inc. (Fluor Fernald), the contractor for the U.S. Department of Energy (DOE) Fernald Environmental Management Project (FEMP), recently submitted a new baseline plan for achieving site closure by the end of calendar year 2006. This plan was submitted at DOE's request, as the FEMP was selected as one of the sites for their accelerated closure initiative.

In accordance with the accelerated baseline, the FEMP Waste Management Project (WMP) is actively evaluating innovative processes for the management and disposition of low-level uranium, fissile material, and thorium, all of which have been classified as waste. These activities are being conducted by the Low Level Waste (LLW) and Uranium Waste Disposition (UWD) projects. Alternatives associated with operational processing of individual waste streams, each of which poses potentially unique health physics, industrial hygiene and industrial hazards, are being evaluated for determination of the most cost effective and safe method for handling and disposition. Low-level Mixed Waste (LLMW) projects are not addressed in this paper.

This paper summarizes historical uranium recycling programs and resultant trace quantity contamination of uranium waste streams with radionuclides, other than uranium. The presentation then describes how waste characterization data is reviewed for radiological and/or chemical hazards and exposure mitigation techniques, in conjunction with proposed operations for handling and disposition. The final part of the presentation consists of an overview of recent operations within LLW and UWD project dispositions, which have been safely completed, and a description of several current operations.

## INTRODUCTION

In November of 2000, the Department of Energy awarded Fluor Fernald to whom Duratek Federal Services (Duratek), Jacobs Engineering, and Nuclear Fuel Services are teaming subcontractors, the closure contract for the Fernald Environmental Management Project (FEMP).

In 1986, the U.S. Environmental Protection Agency (USEPA) and DOE entered into a Federal Facility Compliance Agreement covering environmental impacts associated with site operations. The Fernald site was placed on the Environmental Protection Agency's National Priorities List in 1989, which identifies sites requiring cleanup under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Consistent with the requirements of CERCLA Section 120, DOE and USEPA signed a consent agreement in 1990 that outlines activities and schedules for FEMP remediation.

The Agreement, which was amended in 1991 and 1993, divided the FEMP into Operable Units (OU) so that the site investigation portion of the CERCLA remedial response process could be effectively managed. Five Operable Units, described below, were defined based on location or the potential for similar technologies to be used for remediation. The Agreement set schedules for completion of the Remedial Investigation (RI) and Feasibility Study (FS) activities for each Operable Unit, and initiated Removal Actions (RA) for tasks to abate immediate threats to the environment and public health. The final phase of the remedial response process under CERCLA is Remedial Design (RD) and implementation of remedial actions in accordance with Records of Decision (ROD) approved by DOE and USEPA. The FEMP is now in this final phase with an accelerated closure schedule targeted for 2006.

OU1 is comprised of the Waste Pits Area covering approximately 23 acres of the FEMP. These six pits were used during Fernald's operational period to dispose of low level radioactive waste. This area is currently being remediated under the Waste Pit Remedial Action Project (WPRAP), with radioactively contaminated soils being bulked, transported and dispositioned by rail to Envirocare of Utah, Inc.

OU2 is comprised of other waste areas and/or facilities used in the past for storage of solid wastes generated during plant operations. The wastes largely consisted of small quantities of radioactive contamination and hazardous chemicals stored at the inactive flyash disposal area, active flyash disposal area, south field disposal area, lime sludge ponds, and the solid waste landfills. These areas are being remediated with the wastes disposed of principally at the On-site Disposal Facility (OSDF).

OU3 is the former production area, and wastes are generated in the facilities and equipment, which are now undergoing Dismantlement and Demolition (D&D). These wastes consist of process area scrap, containerized materials, contaminated construction and/or removal action wastes, high and low grade uranium products and residues, and contaminated trash.

OU4 consists of four concrete silos that are approximately 80 feet in diameter and 36 feet high at the center of each dome. Silos 1 and 2 contain K-65 process residues, following recovery of uranium from high concentration ores. The principle radionuclide is radium-226 with 3.2 kCi in Silo1 and 1.5 kCi in Silo 2. Radium-226 was separated from wastes during the processing of ores destined for Silo 3. Calcining prior to transfer to Silo 3 reduced waste volume. Thorium-230 is the principle radionuclide, with 210 Ci in Silo 3. Silo 4 has not been used for storage, but has been used for testing and mock-ups in preparation for work on the other three silos.

OU5 is the Environmental Media unit which consists of concerns related to the affects of activities and conditions on groundwater, surface water, soils, sediments, air, vegetation and wildlife at the FEMP and surrounding areas.

Duratek Federal Services primarily supports Fluor Fernald programs by supplying professional expertise in the areas of waste management, treatment activities, transportation and disposition of waste under interim storage and/or still remaining at the FEMP.

**Recycled Uranium and Cross Contamination of Uranium Wastes with Other Radionuclides**

In or around 1952, the Atomic Energy Commission (AEC, precursor to the Department of Energy) initiated processes across the weapons production complex for the recovery of plutonium and uranium from irradiated fuel and associated by-products. Some of the early processes included the Reduction-Oxidation Plant (REDOX), and Plutonium-Uranium Extraction Plant (PUREX) processes.

Both the REDOX and PUREX processes functioned to recover uranium (U), plutonium (Pu), neptunium (Np) and other valuable transuranic (TRU) elements as fission products from spent reactor fuel. The overall process consisted of removing the spent fuel from reactors after a specified degree of burn-up that optimized the formation of selected plutonium isotopes. The fission reaction converted uranium into Pu and other TRUs with co-production of by-product fission products, such as cesium-137 and strontium-90. Fuel assemblies were stored underwater for periods up to six months before they could be safely removed for wet-chemical processing. The first step was to shear the assemblies for leaching the components in hot nitric acid. Acidic leach liquor became the feed solution for the REDOX process, which was eventually replaced by PUREX as a process improvement.

The PUREX process utilized solvent extraction processes for separating U, Pu and Np from the fission products. Subsequent processing, including ion exchange, provided further separation into individual acidic nitrate component streams. Acidic uranyl-nitrate solution was converted to uranium trioxide (UO3) using a denitration process. Plutonium nitrate solution was then processed to produce high-purity plutonium metal buttons for shipment to other facilities in the DOE complex. Uranium trioxide was a valuable byproduct that was initially recycled to Paducah, KY and eventually to the FEMP.

Both processes resulted in $UO_3$ compounds with trace quantities of transuranic and/or fission product constituents. These compounds were shipped to other AEC/DOE facilities for further recovery and concentration of uranium stock for conversion and fabrication of reactor fuel targets of specified enrichment.

Fernald served as the Feed Material Production Center (FMPC) from the early 1950's through 1989, at which time the site mission changed from that of production to environmental restoration. In 1991, following a two-year transition period, Fernald formally changed from a Defense Programs (DP) site to an Environmental Restoration site under DOE-Environmental Management (EM).

During the production years, Fernald was actively engaged in uranium recovery processes, and received, processed and shipped approximately 246,682 metric tons (MTU) of recycled uranium products from 1955 through 1989. Historical receipts identify sources of recycled uranium, as compiled in Table 1 below.

**Table 1: Sources of Recycled Uranium**

| Source Facility | MTU |
|---|---|
| Oak Ridge (K-25) | 2,721 |
| Oak Ridge (Y-12) | 128 |
| Portsmouth | 1,714 |
| Paducah | 59,700 |
| RMI | 57,811 |
| West Valley | 621 |
| Weldon Spring | 45,363 |
| Hanford | 22,769 |
| Savannah River | 6,392 |
| Rocky Flats | 1,324 |
| Other Sites | 48,139 |
| **Total** | **246,682** |

As recycled uranium was utilized in all FEMP production operations subsequent to 1961, cross contaminants included plutonium, neptunium and technetium (not all inclusive) which were present in varying degrees of concentration. Ratios of contamination to uranium were principally dependent on the processes performed on the material. Chemical processing at the FEMP tended to increase the contaminant-to-uranium ratios in by-product waste, as uranium was purified and extracted as product.

In addition to the routine handling and processing of recycled uranium, Fernald produced various thorium products from metals and compounds during the1950's, 1960's and 1970's for the DOE. Fernald also served as the DOE repository for thorium materials produced at other facilities. In 1992 the DOE declared this material waste, with the remaining materials comprised of: thorium tetrafluoride, thorium dioxide, thorium hydroxide, thorium oxalate, thoria gel, thorium metal and surface contaminated waste such as plastic, wood, anti-c clothing and specific general area trash. Of additional interest is that the introduction of thorium processing through existing facility operations resulted in generation of uranium waste having concentrations of thorium as well.

As a result of the 37 years of operations at the FEMP, 28 of which involved recycled uranium, and many involving thorium processing, all uranium waste forms are considered to potentially contain trace quantities of plutonium, neptunium, technetium, thorium and associated decay products. Thorium waste streams have been found to contain both Th-230 and Th-232 isotopes in various ratios, without trace quantities of recycled uranium cross contaminants.

## WASTE MANAGEMENT PROJECTS

As of the end of fiscal year 2002, approximately ninety-four percent (94%) of FEMP waste has been fully characterized and disposed. Some major accomplishments include:

- 6.3 million cubic feet of low level waste has been transported to the Nevada Test Site;
- 165,860 gallons of low level liquid mixed waste has been transferred off-site for incineration; and
- Nuclear Material Disposition projects completed 148 shipments, constituting 258 metric tons of uranium.

At the start of fiscal year 2003, there were approximately 15,000 waste containers remaining in inventory within the LLW and UWD projects. The current goal for WMP is to dispose the remaining containerized waste, either on-site or off-site, by the close of fiscal year 2003.

**LLW Disposition Projects**

At the start of fiscal year 2003, there are 6,731 containers of LLW, which fall into one of two categories, low-grade residues or high-grade residues. Low-grade residues generally contain between 0.1 percent and 20 percent total uranium by weight, and 0.2 to 2.0 percent U-235 of total uranium. High-grade residues generally contain between 20 percent and 100 percent total uranium by weight, and 0.2 to 1.0 percent U-235, of total uranium. As site closure has been accelerated, the Waste Management Project has initiated a series of material evaluations with respect to waste characterization and compatibility with established waste acceptance criteria (WAC), for various disposition pathways. These evaluations aid in the determination of cost effective and timely methods of disposition, through identifying various options, taking consideration of and without compromising site personnel safety.

**Low-Grade Legacy Uranium Residues**

Examples of low-grade LLW include process residues, sump cakes, waste slurries, raffinates, contaminated soil, rock, sand, ceramics, bricks, sludges, dust collector bags and scrap salts.

**High-Grade Legacy Uranium Residues**

These wastes are typically intermediate products in the uranium metal process, contain impurities and/or mixtures of various uranium compounds, have been determined to have no economic value and thus are classified as LLW. Examples of high-grade LLW includes uranium metals (such as croppings for remelt), scrap uranium oxide ($U_3O_8$, black oxide), reject uranium trioxide ($UO_3$, orange oxide), and uranium tetrafluoride ($UF_4$, off-spec green salt).

**Table 2: Remaining LLW Inventory**

| Material Description Codes | Containers 10/01/02 | Volume ($ft^3$) | Containers 01/14/03 | Volume ($ft^3$) | Fraction of Volume Dispositioned |
|---|---|---|---|---|---|
| Low grade | 6,054 | 255,110 | 5,341 | 211,473 | .18 |
| High grade | 677 | 13,503 | 558 | 11,776 | .13 |
| TOTALS | 6,731 | 268,613 | 5,899 | 223,249 | .17 |

UWD Projects

During fiscal year 2002, UWD completed the inspection, repackaging and disposition of 2,754 containers of uranium waste constituting 60,294 $ft^3$ , sent to the Nevada Test Site (NTS). At the start of fiscal year 2003, there were 9,000 containers of uranium materials and compounds remaining.

**Table 3: Remaining UWD Inventory**

| Containers | Material Description |
|---|---|
| 1595 | Fissile excepted and depleted metal |
| 667 | Fissile metal |
| 4031 | Fissile excepted and $< 1\%$ $U^{235}$ compounds |
| 2310 | Fissile compounds |
| 256 | Fissile excepted RCRA compounds |
| 132 | Fissile RCRA compounds |
| 7 | RCRA / TRU materials |
| 2 | Empty RCRA / TRU T-hoppers |

## INTEGRATION OF HEALTH PHYSICS, SAFETY AND OPERATIONAL PROCESSES FOR MANAGEMENT AND DISPOSITION

As the FEMP site closure schedule has been accelerated, many individual projects within WMP are challenged with the need to quickly evaluate current processes against site closure goals.

One major constraint facing the Waste Management Project is the availability of adequate facilities on site in which to initiate new activities. This is a direct result of the Demolition Closure Project effectively reducing the number of existing buildings through their activities. Presently, there are four remaining permanent structures and three temporary structures available to WMP, all of which are occupied and operational with LLW and UWD project activities.

Permanent Buildings, all of which are operational:

> Building 56 (Old RCRA Warehouse) is being used in the processing of 667 containers of fissile metals, which are being repackaged into approximately 2,900 fissile transport containers for shipment to NTS.
>
> Building 30A (Old Chemical Warehouse) serves as the storage location for material that is packaged and ready for transport to the NTS. This building also houses the onsite Real Time Radiography (RTR) unit used to inspect packages prior to processing and/or shipping.

Building 80 (Plant 8 Warehouse) accommodates two separate WMP activities. UWD is inspecting and re-packaging uranium metals for shipment to NTS, and LLW is inspecting and re-packaging thorium waste for shipment to NTS.

Building 71 (Old Chemical Processing) is used for activities conducted by both LLW and UWD projects. This facility is configured for sealand repackaging and inspection, as well as waste container inspection, segregation, repackaging and empty drum crushing.

Temporary Structures include TS-4 and TS-5, where containerized, enriched materials are presently stored and TS-6 which houses mixed waste inventories.

With the limited facilities available, WMP has been evaluating options for the disposition of waste through processes that do not require use of existing facilities. As LLW and UWD projects consider logistics and resources necessary to realize the projected completion schedule, personnel from project management, waste characterization, operations, project engineering, safety and health, as well as the workforce have actively engaged in the process of operational improvements.

During these evaluations the LLW and UWD projects have identified and implemented several alternative processing and disposition methods which have resulted, or are expected to result, in more streamlined and efficient means to accomplish site closure objectives, without compromising safety.

One of the first steps in this process involves identification of subject containerized waste to be handled and dispositioned. Once this material is identified, Waste Characterization personnel perform material characterization evaluations from existing data, for comparison with WAC established for several alternative disposition pathways. This includes consideration of shipment to NTS through highway transport, shipment to Envirocare through existing rail capabilities, and/or transport and disposal at the OSDF. The majority of uranium residues are precluded from acceptance into the OSDF based on the CERCLA Record of Decision (ROD) therefore, the predominance of decisions are based on the analysis of "life cycle costs" for off-site disposition alternatives (e.g. NTS, and Envirocare). This approach is consistent with the DOE - Office of Environmental Management's conclusions in it's July 2002 -Report to Congress " The Cost of Waste Disposal: Life Cycle Cost Analysis of Disposal of Department of Energy Low Level Radioactive Waste at Federal and Commercial Facilities". The further description of the evaluations below support the predisposal cost component of the life cycle cost analysis with emphasis on integrating safety and good management practices.

Once material evaluations are completed, WMP is then able to evaluate the existing and/or alternative processes and associated costs necessary to meet all of the particular requirements for each option. Part of this evaluation includes safety and health reviews by assigned professionals from Chemistry, Radiological Control, Occupational Safety, Industrial Hygiene, and Nuclear and System Safety. Brief descriptions of their involvement are provided below:

- Chemists are available that have extensive knowledge of organic, and inorganic chemistry, as well as the processes conducted at Fernald. These individuals assess the chemical compatibility of various waste materials prior to co-packaging or mixing waste. These chemists also evaluate conditions when liquid absorbent materials may be required for shipment, or when water will be used for dust suppression. WMP recognizes that some of the waste materials have chemical components, which alone are stable but could react if mixed together. In addition, Fernald has chemists with expertise in actinide metals and compounds that support safety basis evaluations for the handling of thorium and uranium product and waste.

- Radiological Engineers assess characterization data and ensure appropriate programmatic controls are defined and established for radiological boundary configurations, radiological area access, contamination control, area monitoring, personnel monitoring, and exposure mitigation. Co-located or adjacent workforce members and/or facilities are protected through project boundary air monitoring. WMP recognizes that radiological (isotopic) constituents and physical characteristics of the material, coupled with different operational processes, pose potential wide ranging conditional variables that require identification and analysis.

- Safety Engineers assess operational processes involving worker interface as well as operation of mechanical or motorized equipment, hand/power tools, walking/working surfaces, and compressed gas or air equipment.

- Industrial Hygienists assess characterization data to identify materials that may pose hazards such as methane gas, hydrogen generation, bio-hazards, asbestos and/or corrosives. In addition, operational processes are evaluated for potential hazards such as heat/cold stress, noise and confined space entry.

- Nuclear and System Safety personnel review proposed activities and prepare safety basis documentation for the operational processes.

WMP relies on these safety professionals to integrate the process, including the involvement of work supervisors and workforce personnel. This ensures that the

FEMP Integrated Safety Management System is fully implemented through clearly defined objectives and scope of work. Hazards are analyzed and the required controls are implemented during the work. This also includes communication with the workforce for feedback and development of process improvements. Work authorization is not approved or granted, nor can it be obtained, without this cooperative effort and agreement.

During fiscal year 2002, WMP initiated two such process improvements. The first is an operational process referred to as the Direct Haul Project and the second is the purchase of a temporary structure referred to as the UWD Portable Packaging Unit (PPU). Both of these are expected to produce positive results with respect to the projected completion schedule.

## Direct Haul Project

Early in fiscal year 2002, LLW initiated a process improvement involving the bulking of legacy uranium-contaminated waste materials and residues into roll-off boxes for transfer ("direct haul") to the Waste Pits Remedial Action Project (WPRAP). The materials being transferred initially were comprised of waste generated from former on-site and off-site production processes (pre-1990), and from more recent safe shutdown, construction, laboratory, and decontamination and dismantling activities, as well as waste treatment activities that had been conducted since the late 1980s. The scope of this project is now being expanded to accept additional containers from the UWD project, which are also being evaluated and approved for disposition through this process.

At the close of fiscal year 2002, approximately 2,500 containers of low level waste had been processed through this operation, and it is expected that in excess of 5,000 more containers, including those from the UWD project, will be disposed through this process.

Once the materials are transferred to WPRAP, the waste is processed through the WPRAP Material Handling Building where it is blended with excavated waste pit material, loaded into rail cars, and transported to Envirocare of Utah, Inc.

This mode of disposition has proven to be a cost effective, efficient and safe approach for reducing the targeted waste inventories.

The project initially started this activity in an area that was later determined, by the project, to be unsuitable for safe radiological operations. No significant radiological or safety incidents occurred, however it was found that bulking the waste into roll-off containers from individual drums in an open environment, from an elevated drop point, caused material to be dispersed. This condition required the use of respiratory protection and expansion of radiological boundaries. Water misting was used to suppress airborne particulates. The amount of water added into the roll-off containers could not be readily controlled, and later seeped out during transport from the area. The activity was temporarily halted, and the processes and logistics were again reviewed.

At the completion of this review, the project activities were moved to a new location referred to as Soil Pile 7 (SP-7). This location is closer to the WPRAP transfer point and there are no co-located activities ongoing. It was determined to be ideally suited for this operation and after minor ground preparation in the area, to accommodate the use of heavy equipment, it became operational.

The materials being processed through this operation are in many cases uranium waste streams that contain radionuclides associated with recycled uranium and/or from the thorium processing conducted at the FEMP, as previously discussed.

Characterization data, available from historical sampling and analysis, is reviewed by the project Chemists, Radiological Engineers and Industrial Hygienists prior to approval of the material for processing at SP-7. It has been found that while this data is representative of the overall chemical and radiological constituents in a particular waste stream, it cannot predict the characteristics of every individual container. Single and/or groupings of containers can vary and occasionally present unique characteristics, such as the material being finer and dryer than most, and therefore more easily suspended on air currents. Individual containers have been found to have higher concentrations of cross contaminants, other than uranium, which can pose potential radiological exposure issues if proper monitoring and analysis is not in place.

With these potential hazards, WMP has required that certain work controls and mitigation techniques be implemented prior to or during the bulking of contaminated waste streams at SP-7. These include the following:

- Performance of visual inspections, and/or real-time radiographic screening (industrial x-ray) on the drums of material prior to movement from storage to the SP-7 work area are conducted, as requested.

- Material approved for the operation is staged at SP-7 in defined compatibility groupings.

- Roll-off boxes to be filled are selected and staged.

- Roll-off boxes are lined with (6 mil) plastic, to minimize potential leakage of water during transfer to WPRAP.

- Dust control is implemented through misting with water in general work areas.
- A trench is prepared for placement of waste containers to be sheared open and emptied of material.
- Remnants of containers are segregated for sizing and disposal at the OSDF.
- Staged low-level contaminated soil and sludge can be used as blend material in the trench to reduce overall radioactivity concentrations.
- Blended material is then removed from the trench and placed in the plastic-lined roll-off box.
- A tarp is then placed on the roll-off container in order to minimize infiltration of rainwater, which could lead to potential release of material during movement.
- Roll-off containers are then removed from the bulking area and staged for transfer to WPRAP.
- Container handling and shearing operations are conducted by personnel in heavy equipment with enclosed cabs.
- Uranium is the assigned isotope of concern for this project, for both general area airborne radioactive material concentrations and surface contamination controls.

General area and boundary air samples are collected and analyzed through counting gross alpha activity, which is then assessed against the Derived Air Concentration (DAC) for class Y, U-238 (2 E-11 $\mu$Ci/ml). Airborne radioactive material concentrations are then compared against the more restrictive DAC assigned to isotopes such as class W, Th-230 (3 E-12 $\mu$Ci/ml) or class W, Pu-239 (2 E-12 $\mu$Ci/ml).

While uranium is the assigned isotope of concern related to this project, potential internal exposures are assessed by assuming worst case scenarios, where the airborne isotope of concern could be more restrictive than uranium. Personal air sampling (breathing zone) is conducted through the use of battery powered, personnel mounted sampling units. These samples are analyzed through the same gross alpha activity counting mechanism, with the exception that they are assessed against the more restrictive DAC assigned to Th-230. Personal air sampling results are compiled and tracked through weekly DAC-hour reports prepared by the Internal Dosimetry group. This protocol is based on the inability to predict the exact physical and isotopic characteristics of individual containers being bulk processed. Whereupon, if a single, or group of, personal air sampling results indicate internal exposure above predetermined thresholds, these filters are sent off-site through an existing contract for radiochemical analysis. The results can then be adjusted and evaluated against individual isotopic DAC's.

All project personnel directly involved with the field activities are in the FEMP routine bioassay (urinalysis) program. The FEMP Internal Dosimetry program is approved for uranium bioassay by the Department of Energy Laboratory Accreditation Program (DOELAP).

Benefits realized by this project include:

- Reduction of personnel in close proximity or direct contact with material and containers,
- Reduction in the use of personnel protective equipment, such as anti-contamination clothing and respirators,
- Enlarged safe work areas, which are well configured for heavy equipment use, and,
- SP-7 bulk processing location is adjacent to the Waste Pits Remedial Action Project (WPRAP) transfer point.

WMP is presently negotiating a process change with the WPRAP to include accepting the containers and performing the activities presently conducted at SP-7, at WPRAP. This change is also expected to enhance the ability of WMP to meet the accelerated schedule, and at the same time, result in a reduction of hazards and produce a net positive safety effect.

## Portable Packaging Unit

Recognizing that an accelerated schedule bound by the constraints associated with existing container processing and re-packaging operations, compounded with a lack of existing facilities to initiate new processes, UWD has purchased a temporary facility referred to as the Portable Packaging Unit (PPU). This facility will initially be erected adjacent to TS-4 and TS-5 and will be used in the inspection and repackaging of fissile uranium compounds and metals, which are presently stored therein. This facility consists of two oval shaped structures having dimensions of approximately 50 x 70 feet. Work areas inside these structures are covered and will be heated, allowing for a comfortable work environment year round, especially during inclement weather conditions.

A roller conveyor system will be utilized to bring containers of enriched uranium compounds and metals into this facility, in a controlled manner, limited to one safe mass grouping at a time. Each individual container will then be opened under local HEPA ventilation, providing an engineering control to reduce concentrations of airborne radioactive material and/or vapors and gasses. The contents will then be visually inspected for water and/or prohibited items per the NTS Waste Acceptance Criteria. After conditions are determined to be in compliance, the containers will be re-lidded and moved via the conveyor system to a re-packaging station within the structure, loaded into shipping containers and staged for transport.

## Summary Analysis

The paper deals with specific approaches to containerized low level wastes associated with the Fluor Fernald Waste Management Project, however the problem solving approaches fundamentally reinforce the benefits of integrating safety and life cycle cost considerations into work planning and execution. The baseline approaches and subsequent process improvements discussed, represent cost effective, schedule sensitive solutions that support the FEMP site closure.

The Fernald case study is an example of the importance of proper work planning incorporating safety evaluations and hazard analysis applicable to the site cleanup process for containerized wastes which demonstrates good value to the government, and enhances safety for the workforce and the environment.

A key component in developing this continuous improvement in processing is involving the right competencies in the planning and operations phases of the work and responding to worker and compliance/oversight issues openly and with a sense of urgency. A site closure schedule is dependent on ensuring safety is integrated into all of the work, with effective solutions, competent personnel, and good project management.



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