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Recent experiences re-categorizing former nuclear facilities, Sandia NL and Los Alamos NL

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By:

Thomas Beckman, PE, Safety Basis Engineer

(tdbeckm@sandia.gov)

Sandia National Laboratories

In association with:

Dr. Chris James, Deputy Associate Director

LANL Nuclear & High Hazard Operations

Michael Greutman, Manager

Nuclear Safety Analysis Dept., SNL

And:

Bruce White, Safety Basis Engineer

Dan Schmitt, Safety Basis Engineer

Los Alamos National Security, LLC

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Recent Experiences in Facility Recategorization and the Lessons Learned

If Capital Line Item Construction Projects are the darlings of the NNSA community, then the decontamination, decommissioning, and downgrading (DD&D) of old facilities is the blue-collar work that must be accomplished as missions change and facilities continue to age. In the most recent 8- to 10-year period, some larger, more complex, time-consuming, and, in some cases, expensive, DD&D projects have been undertaken at the two national laboratories in New Mexico. Chief among these were:

- The recategorization of the Manzano Nuclear Facilities (MNF) bunkers and the termination of the Hazard Category 3 Transportation Program (HC3T) missions at Sandia National Laboratories (SNL), NM,
- The de-inventory of SNM and chemicals , the mission move, and finally the downgrade of the TA-18 Facilities at Los Alamos National Laboratory (LANL),
- The elimination of the fuels inventory at the Sandia Pulsed Reactor Facility (SPRF, 'spur') at SNL,
- The decontamination and partial demolition of Wings 2 & 4 at the Chemistry and Metallurgy Research (CMR) Facility at LANL, and
- The recategorization of the Gamma Irradiation Facility (GIF) at SNL. To name a few.

All of these projects, as well as others at sites outside New Mexico, present an interesting stories, however, this paper will only focus on the lessons that can be learned from the first two projects. We will explore a brief history of the two projects; discuss the policies and techniques that were employed to accomplish each; and derive a set of lessons learned that can be carried forward for consideration by future "footprint reduction" projects.

The NNSA has, over the years, taken aggressive action to improve the security of the nuclear weapons material under its control (often referred to as special nuclear material, or SNM) and the nuclear weapons in its custody. One major challenge has been, and remains, to ensure that SNM is well-protected, while, at the same time, remaining accessible for use in the critical work activities of U.S. national security missions – maintaining a safe, reliable, and credible nuclear deterrent, supporting the nation's nuclear non-proliferation efforts, and advancing energy security. Management of the nuclear facility 'footprint', complex-wide, is a vital part of that responsibility.

Downgrading the MNF/HC3T Complex

The SNL Waste Management and Pollution Prevention Department (WMPPD, Org. 4144) operated two Hazard Category 3 (HC-3) nuclear facilities at SNL: the MNF, which operated for more than a decade, and HC3T, which operated for approximately four years. The MNF and HC3T "facilities" supported the handling, management, storage, and on-site transportation of HC-3 quantities of radioactive waste and materials. The MNF consisted of multiple 1940s-era storage bunkers (Manzano Base) tucked into the Manzano Mountains on the eastern edge of the Kirtland Air Force Base (KAFB). Each bunker was considered an independent segment for the purposes of categorization, in accordance with DOE-STD-1027-92. HC3T was not a physical facility, but rather an operation authorized to move HC-3 quantities of radioactive waste/materials in closed containers. Each HC3T transfer could move one or more containers between the MNF bunkers and SNL Technical Area V (TA-V). Neither the MNF nor the HC3T operation performed work involving open containers.

In early 2014 Sandia Labs launched a concerted effort to downgrade both facilities from nuclear facility status. DOE's imperative to conclude the MNF and HC3T HC-3 nuclear operations was driven by the objective to continue the reduction of the nuclear facility "footprint" and the associated oversight support.

During the downgrade process, some vital actions had to be accomplished to ensure the project's success:

- All individual HC-3 packages were transferred from the MNF to TA-V facilities by the end of FY13.
- Radiological containers were moved or sent to other bunkers, as needed, to achieve below HC-3 roll-up.
- Positive verification of inventory was performed to ensure that the total radiological inventory for each bunker (segment) was less than the HC-3 threshold quantities (TQ).
- WMPPD's set of technical work documents (TWDs) was modified to remove those controls specific to HC-3 nuclear operations, and to ensure that those documents met the IFSB criteria.
- The WMPPD's computer-based tracking system was modified to ensure that each bunker's inventory was calculated based on HC-3 TQs using the latest DOE-STD-1027 sum-of-the-ratios methodology.
- Once the radiological inventory had been verified, a readiness review was performed to ensure that the bunkers were ready to operate as an industrial facility under the revised safety basis.
- The NNSA Sandia Field Office (SFO) staff was notified when the bunkers were downgraded, when HC-3 onsite transportation activities were discontinued, and when the two nuclear facility safety basis documents were inactivated (an authority not specifically, but implicitly, belonging to SNL).

The actions described in the transition plan were completed, and the SFO was informed of the downgrade on March 26, 2014. With the termination of nuclear operations at the MNF and HC3T, the DSAs and TSRs were retired (i.e., the requirements of 10 CFR 830 Subpart B no longer applied), and the industrial facility safety basis infrastructure took over.

The Documented Safety Analyses (DSAs) and Technical Safety Requirements (TSRs) that formed the safety basis for MNF and HC3T activities have been retired. The bunkers still operate as radiological storage facilities, but neither their demolition nor their return to KAFB custody is planned at this time. Currently the operational infrastructure is driven by Industrial Facility Safety Basis (IFSB) imperatives, as defined in the Sandia National Laboratories *Safety Basis Manual*. Onsite HC-3 transfers between technical areas are no longer conducted as approved activities.

The TA-18 Downgrade Story

TA-18 (Pajarito Site) Critical Experiment Facility (CEF) at Los Alamos is located in the bottom of a canyon at the confluence of Pajarito and Threemile Canyons at the Los Alamos National Lab (LANL). TA-18 was established in 1943, first to study the properties of radioactive materials, and later as a firing site. Beginning in 1946, it was the site of nuclear criticality experiments. The research conducted at this facility paved the way for investigating leakage, resonance, cross-sections, etc. associated with the criticality phenomenon. In 1945 and 1946, fatal criticality experiments occurred while manipulating critical assemblies by hand. Thus the age of remote machine operations came to be.

After the events of September 11, 2001, the Department of Energy developed a set of new requirements, called the Design Basis Threat (DBT), for use in securing the nation's nuclear weapons and weapons material. Design Basis Threat standards look at details such as how many people may be involved in a given attack, and what type of weapons those individuals are likely to use.

NNSA set about to meet the goals of the first Design Basis Threat (DBT) policy at sites having nuclear materials. At LANL, TA-18 was one of those sites. TA-18 had large inventories of materials with high-vulnerability and high-attractiveness levels, all of which were the fuels for the critical experiment machines. The DBT implementation decreed that, because TA-18 could not effectively be secured, it was necessary to move the materials, i.e., to move the mission out of LANL and off to another, more easily secured location. The decision was made, further spurred by the Cerro Grande fire of May 2000, to de-inventory, downgrade, and re-categorize (STD-1027) Technical Area 18 and the Criticality Experiment Facility at LANL. The "TA-18 Early Move Project" was born. It is interesting to note that this same DBT imperative resulted in the removal of all of the Sandia Pulsed Reactor Facility (SPRF) fuels to the Nevada National Security Site (NNSS) for safe, secure storage (circa 2008).

Following a long period of machine redesign and refurbishment, and a protracted readiness review period, criticality experiments continue today to meet the needs of the nation. The experiments now are performed at the NNSS Device Assembly Facility (DAF).

But in 2005, none of that infrastructure was in place. The TA-18 Early Move Project had, as its core goals, several challenging tasks:

- Inventory and categorize all of the materials at the site, including both SNM and chemicals.
- Establish and initiate a shipping campaign to remove all of the SNM to other locations, e.g., NNSS, other LANL locations, and other nationwide and worldwide repositories.
- Calculate both the current and the ongoing Sum-of-Fractions (SOF) values for all SNM. (Attachment 1 describes the technique used to develop the conversion factors.)
- Develop a final disposition plan for the ultimate demolition or re-missioning of the TA-18 location.
- Develop a revised safety basis for facility operations after downgrading to a Moderate Hazard Radiological Facility, and
- Plan for and perform a Readiness Review to confirm that the facility was ready to operate as a non-nuclear radiological facility.

As the project progressed, these key project imperatives continued on parallel paths. The area of interest to the Safety Basis community was the requirement to "prove" that the SNM inventory had dropped below the Threshold Quantity (TQ) of materials needed to re-categorize the facility as non-nuclear. To that end, a seminal report, the Facility Hazard Categorization Report (or FHCR) was developed to address the entire array of materials at the site that required dispositioning. The FHCR was complemented by the Facility Disposition Report (FDR), which developed a "snap shot in time" of all of the constituents of concern, both nuclear and chemical.

The FHCR served as a form of industrial-grade Documented Safety Analysis for the facility, as the facility would exist on the day after the Sum of Fractions dropped below 1.0. It also served to define the suite of tasks that had to be accomplished to achieve the downgrade. As such, the FHCR contains sections that discuss the following:

- Facility and Program Activity Descriptions. This section defined, in detail, both the historic mission of all of the site's buildings and, as far as they were understood, the enduring missions associated with the site. This document also served as the repository for top-level process knowledge, as defined in the outgoing BIO and as derived from extensive interviews and visits with the facility staff. This section also defined the key utility infrastructure systems that were important both to continuing "cold and dark" operations and to the ultimate demolition of the site.
- Section 3 of the report defined the top level hazards (hazard identification, HI). The HI effort ultimately was incorporated into a Facility Safety Plan, the LANL standard document used to define safe operations for a non-nuclear facility. As an interesting, and key, element of collaboration, the Safety Plan was developed by the Industrial Facilities Group, not the Nuclear and High Hazard Operations Group that had operated the facility until its downgrade. The reasoning associated with this change in responsibility was based on the fact that Industrial Operations would be the enduring "owner of the facility" following the downgrade. Therefore, the safety plan by which Industrial Operations would maintain safe operations would need to be developed by them.
- Finally, Section 4 of the report established the facility hazard categorization, both nuclear and chemical, and also described the Nuclear Material Management Program (NMMP) that would be used to ensure that all SNM would be tracked during removal. The NMMP, did, on rare occasions, allow for the acceptance of new SNM onto the site, but only for a short, well defined time, and only for as long as the material would not compromise the non-nuclear categorization of the site.

However, several items that remained in the inventory became almost as problematic to disposition as the SNM, if not more so. Among these were the following:

- A variety of sealed sources and experimental foils;
- More than 350,000 pounds of beryllium;
- 106,000 pounds of lead, both inert and activated; and

- Approximately 220 pounds of cadmium.

At the point that the facility was declared ready to operate as a Radiological Facility, many of the non-SNM materials, which had been assigned disposition paths, still required shipment offsite. Because these items were not part or the overall SNM SOF, they did not adversely impact the downgrade imperative. Thus, the main goal of the Early Move Project was realized, with the full understanding on the part of Industrial Facility Operations that these non SNM materials would eventually have to leave site. Furthermore, the NNSA office in Los Alamos made it clear, in the Conditions of Approval provided with approval of the downgrade strategy, that the Depleted and Natural Uranium needed to leave the site within one year of the downgrade declaration. Ultimately, that deadline had to be extended to complete the DU and NU shipments.

Lessons Learned and Common Themes

With facility downgrades of the type we see with MNF, HC3T and TA-18, the following themes typically repeat:

- Each downgrade/reclass effort is a unique project, and must be treated as such. A project plan is in order. As a minimum that plan should contain the complete scope of the effort, assignment of roles and responsibilities, a schedule, a budget and an analysis of the risks for the project both business and technical.
- Each project must first address the nuclear material management challenge:
    - Where is the nuclear material?
    - How have we inventoried that material?
    - How have we recorded the accounting of that material?
    - How do we account for the movement and subsequent recalculating of a real-time sum-of-the-fractions value?
- Questions associated with ‘process knowledge’ or ‘acceptable knowledge’ will challenge the organization to recreate the facility’s operational history.
- The most tedious part of the downgrade process is often the wall-to-wall inventory of materials present in a facility. This inventory must address not only SNM, but, in many cases, the presence of materials that were never expected to be used or located in that facility.
- Another imperative of a downgrade is that, paradoxically, even as you clean house, a painstaking search for smaller forms of materials, such as sealed sources and foils, must take place before beginning the process of moving the materials to their new locations. Inevitably, issues such as how many foils and how many sealed sources are in how many different desk drawers will have to be resolved to establish the complete inventory.
- Prepare to be flexible, creative, and willing to accept a negotiated answer to almost all of the elements of the downgrade/reclassification process, even those elements that are, or appear to be, statutorily driven ”requirements”.
- In the end plan and enjoy.

Attachment #1

The Safety Basis staff developed a concept that utilized plutonium equivalent mass to

1. help determine the total inventory, and
2. to track that inventory.

This concept was used in determining that the facility category was, or would be, less than HC 3. However, there were many species of nuclides in use in the facility, and most were identified as a Material Type (MT) defined in DOE M 470.4-6, Nuclear Material Control and Accountability (archived). Although MTs are still identified in DOE M 441.1-1, Nuclear Material Packaging Manual, they are no longer used and have fallen out vogue in the current set of DOE Orders.

Because some of the materials found did not have a specific activity defined, a quick calculation of the specific activity was performed, using a spreadsheet, as defined below:

$$SpA\left({}^{Ci}\!/_{g}\right) = \frac{\ln(2) N_A \left({}^{atoms}\!/_{gmole}\right)}{MW\left({}^{g}\!/_{gmole}\right) 3.7\times 10^{10}\left({}^{\text{disintegrations}}\!/_{\text{sec}-Ci}\right) t_{1/2}(\text{sec})}$$

$N_A = 6.022 \times 10^{23}$

The Specific Activity (SpA) was used to derive the plutonium equivalent mass:

$$Pu-E\left({}^{g\ Pu-239}\!/_{g\ MT}\right) = \sum(\text{weight fraction})\left(\frac{SpA_i}{SpA_{Pu-239}}\right)\left(\frac{\text{Dose Conversion Factor}_i}{\text{Dose Conversion Factor}_{\text{Pu-239}}}\right)$$

(NOTE: Where Dose Conversion Factors (DCFs) had units of Sieverts per Bequerel, the units were converted to rem per Curie.)

In the case of uranium, which included uranium metal and various solutions, the established safety basis provided an acceptable assumption. The uranium inventory was in different chemical forms: 30 % W-Class (lung clearance as determined in Federal Report 11) and 70 % Y-Class. Different lung clearance classes meant different solubility, and, therefore, different dose conversion factors. The plutonium equivalent equation was derived then as approximately,

$$Pu-E\left({}^{g\ Pu-239}\!/_{g\ MT}\right) = (0.30)(Pu-E)_{W-Class} + (0.70)(Pu-E)_{Y-Class}$$

In addition, some of the uranium was pure metal with traces of other fissile material. In such cases, it was assumed that the pure metal was 100 % for the weight fraction, but, conservatively, the trace amounts of fissile material were simply added. So, essentially, the 100 % weight fraction was exceeded by a very small amount. Essentially, all of the U-233 present onsite was found to be that form of material.

The material types (MTs) ranged from depleted uranium to isotopes, such as Cm-244 and Cf-252. The MTs set up for depleted uranium, slightly enriched uranium, highly enriched uranium, and plutonium all had several isotopes to consider. For example, a plutonium MT could consist of Pu-238, Pu-239, Pu-240, Pu-241 and Pu-242. In addition, Am-241 would also be considered for in-growth from the decay of Pu-241.

The hazard category defined the inventory that was required to be reached before TA-18 could be considered a “less than HC 3” facility (i.e., a radiological facility). The inventory focused on fissile materials, but the site contained a significantly large quantity of other metals. Therefore, the evaluation team was sensitive to questions concerning how the chemical hazards associated with these metals would, or should, figure into the hazard categorization.

To comply with DOE-STD-1027, various means of segregation were explored to address an overabundance of depleted and natural uranium. Ultimately, 3 transportainers were moved on site to accommodate the DU and NU. Because the CASAs and transportainers were far enough apart to warrant a determination of independence, different release scenarios that involved wildfires, liquid fuel pool fires, etc., were developed.