

**Lessons Learned...and Not Learned:
A Case Study in Regulatory Evolution**

J. F. Conant
ABB Inc.
2000 Day Hill Road, Windsor, CT 06095

R. C. Woodard
TLG Services/Entergy
148 New Milford Road East, Bridgewater, CT 06752

ABSTRACT

“Are you better off than you were four years ago?” “You’ve come a long way, baby!” Eschewing politics and advertising, these idioms are applied to the evolution of regulatory processes for Decontamination & Decommissioning (D&D) of nuclear facilities. We use a case study of a (nearly) completed D&D project at a large nuclear fuel manufacturing facility, to chronicle one licensee’s experience with US Nuclear Regulatory Commission (NRC) D&D regulations from the 1990’s to the present. Historical milestones include the birth of a D&D project, a false start and resultant consequences, a D&D “moratorium” with subsequent planning and stakeholder integration, a second start which included the challenge of parallel path D&D physical work and regulatory processes, and the “lessons learned” contributions to timely project progress. Further discussion includes a look at the “declaration of victory” and examines what it really means to be finished. The rich contextual experience from the case study and the observations of other industry members provides the basis for answers to several key questions: How far has the regulatory process for D&D really evolved, and in what direction? Are licensees generally satisfied or dissatisfied with the methods? What has not improved? Which improvements looked promising, but languished in recent years? How far have we really come and are we better off? What are the opportunities for further improvement? The summary answer to each question, using compendious engineering terms is...“it depends”.

INTRODUCTION

This case study examines the birth of a D&D project and early lessons learned; consequences of an aborted start; the subsequent years of planning and stakeholder integration; D&D project restart; the trials and tribulations of parallel D&D and regulatory processes; a forced D&D “moratorium” leading to a second restart; how lessons learned were advantageous to timely D&D project performance; and finally, when is victory declared and what do you really have at the end? A U.S. Environmental Protection Agency (EPA) Voluntary Corrective Action (VCA) project and a U.S. Army Corps of Engineers Formerly Utilized Sites Remedial Action Program (FUSRAP) project further complicate the D&D effort. “Phased”, “accelerated”, and “streamed-lined” decommissioning concepts are discussed in the context of “are we better off?” Additional

topics addressed include partial site releases, broad vs. discrete cleanup levels (i.e. DCGLs), material clearance practices, and (non-agreement) State intervention. Mutable regulatory processes resulted in positive and negative effects, and while often painful, much was learned. The authors posit that specific options will satisfy the industry-regulator dyad, resulting in more efficient and effective D&D experiences.

A BRIEF HISTORY OF DECOMMISSIONING REGULATIONS

In the beginning...

The nuclear materials regulations have always included requirements to decommission licensed facilities at the end of their operating life. Until the mid-1980's, there was little guidance to licensees on how to satisfy these requirements. Regulatory Guide 1.86, "Termination of Operating Licenses for Nuclear Reactors" (1974) promulgated surface contamination levels below which material could be released for unrestricted use. Licensees performed remedial actions to meet these contamination levels, and asked the NRC to agree by review and approval of survey documentation. The 1980's Synar congressional hearings on decommissioning cost issues raised NRC concerns about the efficacy of prior license terminations. Subsequently, new owners of these early-terminated sites discovered substantial residual radioactive material long after the original licensee had vacated or sold the property. Unless the responsible prior licensee could be located and held accountable, the current owner was stuck with a "legacy" site that was often unusable pending further cleanup.

"On July 13, 1988, the staff briefed the Commission on contamination problems at the Safety Light Corporation site in Pennsylvania. After the briefing, the Commission became increasingly interested in the Nuclear Regulatory Commission program for decommissioning and requested additional information on the program and on any significantly contaminated sites. In May 1989, the General Accounting Office (GAO) issued a report entitled "NRC's Decommissioning Procedures and Criteria Need to Be Strengthened". The findings contained in the GAO report were the subject of an August 3, 1989, Congressional hearing on "Decommissioning and Decontamination Requirements for Closing Nuclear Facilities", at which former NRC Chairman Carr testified. After the hearing, the Commission issued a Staff Requirements Memorandum (SRM) that expressed concern that the staff might not be exhausting its options or applying a consistent strategy to ensure timely decommissioning of sites." [1]

In essence, the Congressional inquiry precipitated NRC review of the license termination regulatory framework to correct prior inadequacies, and assure timely and responsible decommissioning for the future.

The intermediate steps

"The Site Decommissioning Management Plan (SDMP) was developed and submitted to the Commission on March 29, 1990 (SECY-90-121). The SDMP was intended to focus management attention on: 1) identifying and resolving generic and site-specific policy issues affecting decommissioning; and 2) setting priorities and schedules for the decommissioning of sites that presented significant challenges." [1]

In the early 1990's, the Commission commenced a long-term rulemaking effort intended to bolster decommissioning regulatory requirements. Significant outcomes of this work include Radiological Criteria for License Termination, the "Timeliness Rule", Clarification of Decommissioning Funding Requirements, record keeping, and the License Termination Rule (LTR). Concurrent with this rulemaking, the Staff produced regulatory guides to assist both licensees and NRC staff with interpretation of the new regulations. Some of the early guides were not practical to implement in the field, so new guides evolved into the fairly well developed guides now available. However, the progression to mature, practical, performance-based regulations and guides is not finished and will continue to unfold. Therein lies the importance of decommissioning lessons learned, and a responsibility that falls on both licensees and regulators to implement the significant lessons.

In 1997, the Commission promulgated Staff Requirement Memorandum "Strategic Assessment, Direction-Setting Issue No. 9 Decommissioning of Non-Reactor Facilities" (DSI-9). This memorandum directed the staff to: 1) evaluate new and different approaches to the decommissioning process, including decommissioning plans commensurate with complexity and risk, and 2) conduct a pilot program and workshop to encourage decommissioning of sites that are relatively straightforward. In other words, the Commission recognized that "one size fits all" was not conducive to efficient, effective, and cost-conscious decommissioning. The staff was challenged to balance expeditious license termination (protective of public health and safety), with cost effective use of NRC and licensee resources. The pilot program would demonstrate that such a balance could be practical and efficient.

Test Driving the Pilot Program – "Phased" Decommissioning

Decommissioning and license termination for large, complex sites has the potential to be extremely complicated and time consuming. In many situations, a licensee may want to cease operations in only one area or building of the licensed complex, or phase out operations over a period. Partial decommissioning is considered by the NRC on a case-by-case basis, which exposes the licensee to an uncertain process. For example, if a licensee ceases operations in a small building in the middle of a fully operating site, requiring a decommissioning process based on complete license termination results in squandering resources of the licensee and the NRC. The licensee remains handcuffed by the Timeliness Rule, and is therefore obligated to commence decommissioning.

The NRC and industry cooperatively addressed these issues via the NRC Nuclear Materials Safety and Safeguards (NMSS) decommissioning Pilot Program (1998-2002). Several industry volunteers from small and non-complex sites worked with the NRC to demonstrate that efficient and effective decommissioning could take place using alternate criteria without further rulemaking.

Industry, as represented by the Fuel Cycle Facility Forum (FCFF), termed the Pilot Program "phased" decommissioning and produced a White Paper [2] outlining the process. Under phased decommissioning, the licensee submits license amendments that coincide with stages of decommissioning specific to the licensee's site. Actual implementation depends on existing license conditions and decommissioning objectives, which in turn determine the license amendments required. Where significant additional authorizations (e.g. DCGL development and

approval), are needed, the phased concept simplifies and spreads out the NRC review and approval process, thereby allowing a smoother, more continuous workflow for the decommissioning project.

The inherent variability in materials sites' size, complexity, and license conditions precludes defining a set structure for phased decommissioning. Individual licensees must work with the NRC to develop their own process for licensing actions that correlate to project milestones. For example, a simple phase structure for decommissioning a building could be as simple as characterization and interior decontamination, above-slab dismantlement, and sub-slab remediation and closure. Standard license amendments are easily used to accomplish the first two steps. The final step may warrant a formal Decommissioning Plan (DP), depending on the results of the previous steps. This model encourages timely decommissioning by allowing the licensee to perform routine work without delay, while seeking NRC approval of a more complex DP application.

Licensees may find it practical to submit a partial DP that lacks certain elements (e.g., the Final Status Survey description), and then amend the DP when better information is available. Further, it may be highly beneficial to seek early NRC approval of elements of the DP that typically require long review times (e.g., soil cleanup criteria). These scenarios relieve the licensee and NRC from attempting to address overly generalized information and commitments that could better be described later or separately in the decommissioning process. Alternatively, under certain circumstances, a DP may not be needed at all if the existing license permits the activities necessary for decommissioning. Regardless of the approach chosen, the licensee uses NRC guidance to propose their own specific requirements, up to and including exemption from elements of the regulations.

A CASE STUDY OF D&D REGULATORY EVOLUTION

The Case Study examined in this paper concerns the decommissioning activities of a commercial fuel manufacturing facility from 1990 through 2005. Corporate business decisions drove the strategic planning for specific decommissioning events; these events are used to illustrate the regulatory metamorphosis over the 15 years. The lessons learned emerge from retrospective analysis of the processes chosen by the licensee, and will hopefully assist other licensees in planning their own D&D projects.

Decommissioning – Round 1

In the early 1990's, the Licensee, a commercial nuclear fuel developer and manufacturer, decided to consolidate manufacturing operations from multiple facilities to a single site. By September 1993, they had terminated fuel-manufacturing activities at their northeast facility, removed all special nuclear material (SNM) from the site, and notified the NRC that no further fuel manufacturing was planned. The Licensee used the license amendment process to: submit a Decommissioning Plan (DP), delete authority for fuel manufacturing, reduce enriched uranium possession limits, and authorize performance of decommissioning. The DP was consistent with NRC Regulatory Guide 3.65, "Standard Format and Content of Decommissioning Plans for Licensees Under 10 CFR Parts 30, 40, and 70", but was not written with license termination as

the objective. Other activities continued at the site, including nuclear fuel research and development, and commercial nuclear power plant outage services. The NRC “Timeliness Rule” was in draft, and therefore not applicable to the Licensee.

The materials license contained authorization that allowed the Licensee to perform limited decommissioning and release of specific rooms and areas. This allowed performance of physical decontamination activities under the general authority of the license while waiting for DP approval. Guidance for surveys was contained in NUREG/CR-2082, “Monitoring for Compliance with Decommissioning Termination Survey Criteria”, Parts I and II. A draft version of NUREG/CR-5849, “Manual for Conducting Radiological Surveys in Support of License Termination”, (which would eventually supersede NUREG/CR-2082), had been issued, but was considered to be less “performance-based” and more “prescriptive”. Cleanup criteria were set in the license as Annex B, “Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material”, 1993; this was virtually identical to Regulatory Guide 1.86, referenced earlier.

The project scope included two buildings, the main manufacturing facility (B17) and warehouse (B21), and the surrounding grounds and drainage areas. Characterization activities and decontamination began in 1994 and continued through early 1995, when the decommissioning contractor concluded that decontamination of the “hot shop” area in B17 was cost prohibitive; this section of the building, including roof, walls, and floor, would have to be packaged, shipped and disposed of as contaminated waste (LLRW). Concurrently, the Licensee was considering construction of additional space for its growing nuclear services business, so they decided to convert B17 for outage services use. This strategy saved construction cost of a new building, and avoided the cost and use of scarce LLRW disposal space. The remaining interior and exterior areas of B17 were cleared for unrestricted release or removed for disposal (such as contaminated pipelines) by early 1996. The B21 final status survey was completed and submitted to the NRC; the NRC performed verification surveys, determined the Licensee had met the criteria for unrestricted release, and approved an amendment removing B21 from the license. Four years elapsed between DP submittal and release of B21, an exceptionally long time for a slightly contaminated warehouse.

Decommissioning – Round 2

The second decommissioning project, initiated in 2001, was based on a well-established suite of NRC decommissioning regulations and guides. This was the first fuel cycle facility to commence decommissioning following completion of the Pilot Program, and provided the opportunity to apply the Pilot Program process to a large, complex facility. Three major fuel manufacturing “complexes”, consisting of 11 buildings and underground piping, would be decommissioned.

Drawing on lessons learned from the Pilot Program, the NRC workshops on D&D regulations, and evolving regulatory guides, the Licensee developed a strategic plan to complete the project in about three years. The project plan incorporated elements of both “phased” and “partial” decommissioning because license termination was not the primary goal. Contaminants were limited to low enriched UO₂ and very small amounts of byproduct material. The Materials License limited the activities to storage, monitoring, and characterization work; therefore, a

significant license amendment was required to decontaminate, remediate, and dismantle buildings down to slab level.

In April 2001, the Licensee conducted a D&D Strategic Kick-off Meeting at the site, including participants from NRC Headquarters and Region I, Connecticut Department of Environmental Protection (CTDEP), the local Town, and the US Army Corps of Engineers (USACE). The Army Corps was invited because other buildings and areas on the site have residues of enriched uranium derived from historic US Atomic Energy Commission (AEC) contract work, and is designated as part of the Formerly Utilized Sites Remedial Action Program (FUSRAP). Several areas, including one building, contain both commercial and AEC uranium residues. These areas fall under the USACE domain in accordance with a Memorandum of Understanding (MOU) between the USACE and the NRC; they were not included in the decommissioning project that is the basis for this paper.

The Kick-off meeting was critical to involving stakeholders early in the planning process and obtaining feedback on the Licensee's proposed strategy for streamlined decommissioning. The participants were familiar with the site from previous activities, and a site tour brought them current on site status. The Licensee presented the "phased" decommissioning concept, including the use of license amendments to conduct decontamination and source reduction activities; a DP would be submitted for subsurface work (remediating soils and pipelines). The project timeline, including the parallel regulatory actions, illustrated the steps necessary to facilitate a smooth, continuous work effort.

The meeting participants accepted in principal, the key points of the proposed decommissioning strategy:

- To facilitate the development and approval process for Decontamination Concentration Guideline Levels (DCGLs), a "steering group" comprised of CTDEP, USACE, Town, and Licensee representatives would meet at significant production or decision points. The meetings would ensure stakeholder understanding of the basis for parameters used in the calculations, and the regulatory protocol for DCGL development. The goal was to have DCGLs that were acceptable to the regulators at the end of the development process. Regulatory DCGL approval is a time-intensive activity, so early stakeholder participation during development was viewed as a critical component of the plan.
- Characterization of the building complexes would commence under the existing NRC license.
- Decontamination and source reduction activities for the buildings (non-soil) would be approved by the NRC via license amendments.
- The initial version of the Decommissioning Plan (DP) would address soil, and below-grade structure/systems removal. This "partial" DP would be submitted to the NRC for approval, with an explanation that the remaining sections would be submitted later as amendments (e.g. DCGLs, Final Status Survey Plan, and ALARA).

A number of points not directly related to D&D strategy were debated, clarified, or emphasized, and are summarized below:

- The NRC emphasized the importance of adequate financial assurance. The Licensee responded that management was strongly committed to removing all legacy issues from the Site, both nuclear and chemical, and had committed adequate reserves.
- The NRC commented that the defining threshold for performing activities under an approved license (or amended license) in lieu of a Decommissioning Plan, is that no significant increase in health & safety risk (relative to prior activities), would occur, in conformance with industry practice.
- With respect to the “phased” approach to decommissioning, NRC emphasized that only one Decommissioning Plan should be submitted, and appended or revised as the project progresses. The licensee should offer credible reasons for omissions at the time of submittal and commit to later submittal.
- NRC emphasized that the rules for the release of volumetric materials off-site are different (in fact, non-existent) than for materials left on site at license termination.
- NRC commented that the Licensee’s license could cover decontamination activities under license amendments. The Licensee would perform subsurface work under an approved Decommissioning Plan.
- NRC commented that no materials with volumetrically incorporated residual radioactivity could be released from the site except for disposal to a licensed radioactive waste disposal facility. The surface contamination criteria for offsite releases would be those in Regulatory Guide 1.86 or FC 83-23.
- CTDEP and the NRC asked about the Licensee’s plan for public outreach. The Licensee discussed its past outreach programs and current plans under the US Environmental Protection Agency (EPA) Voluntary Corrective Actions (VCA) program.
- NRC described the regulatory requirements for public hearings as a discrete element of the public outreach program. The rules require that an opportunity for public hearing be made before the NRC takes action on a DP. A federal register notice is required when the commission takes action to amend a license.

In the summer of 2001, the Licensee selected a primary decommissioning vendor (D&D Vendor) and an independent Oversight Support Contractor (OSC). The D&D Vendor was commissioned to provide “turnkey” decontamination and dismantlement functions, including industrial and radiological safety, quality controls and assurance, waste handling and shipping/disposal, and preparations of licenses, permits, fees, and submittals to the NRC and other agencies as required by any law. The Licensee retained responsibility for direct interface with all regulators and stakeholder agencies. The OSC was commissioned to provide a Radiation Safety Officer (RSO) for the site licenses, among other responsibilities beyond the decommissioning project. The primary oversight function was providing continuous assurance to the Licensee that D&D and other site radiological operations were conducted in compliance with NRC requirements. The OSC was not to participate in or become responsible for the D&D project per se. However, the RSO retained responsibility for final approval of all Radiation Protection Procedures (RPP), approval of Radiation Work Permits, (RWPs) for D&D work. Additional RSO responsibilities extended to nuclear material accountability and management control of regulatory and license requirements.

As stated earlier, the Kick-Off meeting included a presentation of the proposed strategy for conduct of the D&D project, including discussion, comment, and general consensus of the stakeholders. However, expecting a project of this magnitude and complexity to proceed without unforeseen events is fatuous. A list of the actual events and timeline is listed below:

- The license in effect at the beginning of D&D allowed characterization activities.
- The amendment to authorize decontamination and source reduction was submitted in mid-2001 and approved by the NRC in about ten weeks, an expeditious approval.
- The DCGL Steering Group was formed in June 2001, and met several times; a draft DCGL report was submitted to the NRC for review/approval in February 2002.
- The Phase I DP was submitted to the NRC in December 2001, which would have allowed building removal and subsurface work “at risk” (because DCGLs would not be approved before the work). During the 30-day Federal Register notice in May 2002, the State formerly submitted a request for hearing and petition to intervene in the decommissioning. The State took issue with submission of an incomplete DP (even though a phased and partial DP process had been presented at the earlier meetings). The Licensee agreed to re-submit a DP for the entire site (not just the three Complexes being decommissioned) and would incorporate the parts of the DP that had been deferred for later submission via amendment. The NRC approved the Phase I DP by license amendment, allowing building dismantlement down to slabs/foundations at grade level, but no work on soil and below grade systems. This amendment was issued in October 2002, with “complete” DP submitted in November 2002. The Licensee made additional concessions to the State by adopting a more conservative “resident farmer” scenario rather than the more realistic “suburban resident” scenario in deriving DCGLs. Furthermore, the State imposed a more conservative annual dose limit of 19 mREM/yr rather than the NRC regulatory value of 25 mREM/yr. Additional concessions were made during DCGL development, resulting in final DCGL values at 30 to 40 percent of what the NRC would likely have approved without concessions to the State (estimated by the Licensee). The DCGLs and DP were formally approved by license amendment in June 2004. It took two and one-half years for review and approval, which caused a one-year project delay, resulting in unexpected (and unnecessary) costs associated with a contractor de-mobilization and remobilization.
- The preparation of a Phase II DP amendment became moot.

Decommissioning Round II fieldwork was completed in December 2005; Final Status Survey reports are in progress for the B2, B5, and B17 complexes, and scheduled for submission to the NRC in 2006.

LESSONS LEARNED...AND NOT LEARNED

An Industry Perspective

The concept of “lessons learned” may appear to be a straightforward, facile process: make a list of lessons learned, publish the results in industry journals, present the results at meetings or conferences, and watch other licensees reap the benefits. However, effective and efficient dissemination of lessons learned to the nuclear community is a difficult task. A November 30, 2005 public meeting at NRC Headquarters identified several challenges concerning

decommissioning lessons learned. Meeting participants struggled to identify a responsible party for maintenance of a lessons learned database. How should lessons be categorized, and how many years do lessons remain relevant and applicable? In other words, how should the thousands of lessons learned be managed to provide the maximum benefit to the industry, regulators, and stakeholders? These questions and more must be addressed to achieve broad dissemination of innovative approaches that demonstrate consistent and cost-effective application of the decommissioning regulations

Most of the lessons learned and regulator experience presented in this paper are specific to the Licensee's site; there was no meta-analysis of other licensee experiences, industry concerns, or satisfaction with decommissioning regulations and guides. However, anecdotal evidence from other licensees' experience with the Pilot Program suggests several categories of issues common to the industry:

- Management control and adequate funding
- QA program to assess performance and compliance in process
- Early and frequent communication with NRC
- Advance scheduling of activities with NRC – opportunity for review
- Importance of robust local and state government involvement
- Licensee access to competent and experienced assistance
- Public outreach and opportunity for hearings

The “phased” decommissioning process is effective only if the licensee works concomitantly with the NRC and all stakeholders; while primary objectives and schedule are paramount, extraordinary attention to planning and detail is essential. A single missed element could delay work, resulting in missed schedule milestones, escalating project costs, and the potential loss of valuable personnel with institutional or historical knowledge.

Case Study Lessons Learned

As the first large materials site to use the pilot program model for D&D, some costly events were, in retrospect, preventable. We separate the lessons learned from decommissioning a major fuel-manufacturing site, during two separate times, and under significantly different regulations and guides, into two categories. We must keep in mind that lessons learned are not beneficial in and of themselves, without responsibility and accountability of those in positions to effect changes. Our analysis of this case study identifies lessons learned that we are responsible and accountable for implementing, and those over which we have no control. Licensees must accept ownership and responsibility for lessons learned that include strategic planning, technical improvements, and communication with regulators, stakeholders, and the public. Licensees do not have responsibility or accountability for regulatory issues: rulemaking, regulator policy (individual and collective), regulatory guidance, and interpretation by NRC Staff for review/approval or inspection purposes. Table I illustrates the division of lessons learned:

Table I. Lessons Learned Responsibility by Domain

Industry	Regulator
<ul style="list-style-type: none"> ▪ Strategic planning ▪ Technical improvements ▪ Communication with regulators ▪ Stakeholder outreach 	<ul style="list-style-type: none"> ▪ Rulemaking ▪ Regulator policy ▪ Regulatory guidance ▪ Staff interpretation

In the sections that follow, lessons learned are divided by accountability, into Licensee and Regulator domain.

Licensee Domain

- Meet with the NRC and stakeholders early in the D&D process and frequently thereafter concerning planning, status, and issues.

The two Case Study decommissioning projects occurred years apart, under significantly different regulatory conditions. Early and frequent stakeholder involvement was solicited and employed for both projects; stakeholder interests had a significant impact on the conduct of operations for each project. Communications with the NRC were opened early for both projects, with the licensee providing frequent updates and status reports to the NRC Project Manager; the Town appreciated the operational briefings, but sought no role other than observer. The State (NRC “non-agreement”) was minimally involved in “Round I”, since site licensed operations would continue after D&D of B17/B21. For “Round II”, with all licensed operations shut down, and license termination as an end point, the State assumed a significant regulatory role that proved to be both helpful and obstructing.

From the start of the second decommissioning project, stakeholder participants were represented on the DCGL Steering group, and provided valuable input to the development effort. Consensus was reached – or so the licensee believed - on the “partial” and “phased” approach to D&D. The NRC published the requisite notice about the DP in the Federal Register, to allow a thirty-day opportunity for interveners to request further hearings concerning the plan. The State formally submitted a request for hearing and petition to intervene in the decommissioning. The ensuing delays resulted in demobilization of work crews and equipment while responding to the intervention concerns.

Subsequent analysis of the seemingly inexplicable State intervention action produced an exiguous explanation for their actions. The State attended the Kick-off meeting, the DCGL Steering Group meetings, other relevant meetings, and was informed of all submittals. In retrospect, the State provided minimal feedback on any of the submittals to the NRC, which the Licensee erroneously interpreted as “no news is good news”. The lesson learned: when stakeholders do not voluntarily initiate dialogue or comment regarding critical decommissioning elements, the Licensee must have an aggressive communication strategy. Meeting with State personnel on a regular schedule to actively and robustly pursue input, and address concerns, may have prevented their intervention.

Following the delay, the Licensee forged a closer working relationship with the State through aggressive solicitation of their comments, and providing regular informational updates concerning the project status. The State performed field validation of the licensee final surveys to independently ensure their ability to address any public concerns.

- Submit DCGLs early for NRC approval; resolutely include stakeholders in the process

For the second decommissioning event, dose-based cleanup criteria were developed for soils and sediment. Production of dose-based cleanup criteria, the process of developing DCGLs, and obtaining NRC approval is easily the longest single task in most decommissioning projects, whether terminating a license or not. The issues encountered at this site have been described earlier in this paper.

Begin the DCGL development process as early as possible. Choose competent, experienced (both technical and regulatory) consultants for assistance, who are experienced working with the anticipated radiological constituents. In other words, do not hire a consultant with only reactor byproduct materials experience, if you are decommissioning a uranium/thorium site.

Involve the NRC, the State, and other stakeholders as soon as possible, and keep them appraised and involved in the project process. If DCGLs are required, dose-based modeling may produce large values, depending on the chosen parameters. To avoid “sticker shock” by the NRC and stakeholders, proactively involve them during development of the DCGLs, including the selection of input parameters. If the final values are achieved by consensus, the process is self-validating, results in fewer disagreements, and reduces the probability of rework.

DCGL development is greatly assisted by first producing a robust historical site assessment. Site characterization is important to determining the constituents of concern, and other input parameters required to derive DCGLs. The historical investigation, including interviews with older workers, review of past inspection reports, records, logs, etc., can be important to locating constituents and media that may exist but are difficult to characterize due to of detection capability. Residual material in pipelines, old land burial disposals on site, abandoned laboratories, etc. are examples.

It is entirely possible, if not desirable, to produce DCGLs and have them approved by NRC license amendment prior to DP review/approval by the NRC. Producing uniform site DCGLs for a uranium facility, where the entire site is assumed to be contaminated uniformly, can obviate a NRC concern that “postage stamp” releases could result in a cumulative dose greater than individual area doses, and collectively exceed the NRC 0.25 mSv/yr (25 mRem/yr) standard.

- Develop and Implement “Phased” Decommissioning Process

“Phased” decommissioning is a strategy designed to create a smooth and continuous workflow for the licensee and regulator throughout the decommissioning process. The licensee, NRC, and stakeholders all benefit from a project where the schedule is predictable

and adhered to. For the licensee, benefits include a work pattern with fewer interruptions, license amendments when needed, continuity of institutional knowledge (both licensee staff and vendors), and a consequential lower cost for decommissioning. The NRC and other regulators reap the benefits including a higher assurance of safety and compliance (derived from continuity of licensee's institutional knowledge), license amendment requirements and associated workloads being spread out, and decommissioning that is more timely and efficient. For the stakeholders, the benefits include those similar to the NRC's, and a faster return of the properties to the tax rolls if redevelopment or other reuse occurs.

Consider the Case Study "Round II" decommissioning: The strategy was laid out early with the NRC, State, Town, and other stakeholders in a Kick-off meeting. The license was very limited and only permitted characterization activities and minor decontamination. The DCGL development effort commenced even before a D&D vendor and Oversight Support Contractor were selected, but required three years to gain approval. The first regulatory product of the phased approach was a license amendment to permit gross decontamination of buildings and removal of interior systems and structures; it took about ten weeks to approve. A small amendment to align organization and administration changes with our contractors was needed and was approved within a month. The "partial" DP followed, which only applied to three building complexes, allowed building deconstruction, and would permit subsurface remediation work "at risk" while DCGLs were being in progress; this submittal was eventually approved as a license amendment, with a limiting condition to not work "below slab". The partial DP concept was rejected by the State; although the State has no regulatory authority concerning the facility radioactive materials license, they wield considerable influence in cleanup criteria applicable for land transfers even after NRC license termination. It was less painful to simply produce a full DP and submit it for approval, an effort completed in about eight months. The original decommissioning strategic plan projected about three years to completion; the actual time is closer to five years. The delay, and associated extra cost to the Licensee, is directly attributable to the forced departure from the original phased approach.

Regulatory Domain

- **In-Process NRC Confirmation Versus Post-Decommissioning Verification**

The NRC used in-process inspections and confirmation of measurements to verify the Licensee's program and measurements ensure compliance with requirements. In-process surveys and inspections can demonstrate that a quality decommissioning program, supported by an effective QA/QC program will consistently support compliance with release requirements. As a result, NRC should develop confidence that a site's final status surveys will produce high-quality data that meet all NRC release requirements. If the NRC is able to rely on "in-process" confirmation, rather than performing post-decommissioning verification surveys, substantial time and resources, both for the NRC and the licensee, can be achieved. This practice is proving to expedite the license termination process – with no degradation in NRC's confidence that a site complies with decommissioning criteria. NRC is already improving the decommissioning process in this one area.

- **License Amendments; Phased and Partial Decommissioning Plans**

In order to produce a smooth and continuous process, certain regulatory policy concessions are needed from the NRC. Those concessions include the use of simple license amendments instead of requiring all actions to be performed under a DP, and allowance of a “phased” decommissioning strategy. The phased strategy would permit submittal/approval of an initial “partial” DP and then subsequent amendments for the deferred elements in order to streamline the regulatory course of action. This process would spread out the workload for the licensee and NRC staff, while allowing the licensee to proceed on early phases of decommissioning. With a “just-in-time” production of the required license or DP amendments, decommissioning work would proceed more smoothly and continuously, without loss of safety, thus keeping key workforce resources in place, retaining critical institutional knowledge, and making budgets more predictable. The pilot program demonstrated the value of this approach; however, recent experience with the NRC does not uphold phased and partial decommissioning as a component of D&D regulatory policy. Greater acceptance of these components is needed.

▪ Staff flexibility interpreting regulations and guidance

On occasion, the NRC staff defaults to the most rigid interpretation of regulations and regulatory guidance. While this is the most secure position for the Staff, it often impedes progress in decommissioning with no defined commensurate benefit to public health and safety or safeguards. NRC staff should be empowered and encouraged to exercise appropriate discretion while ensuring that safety and safeguards are not compromised. Examples of such rigor are:

- The Timeliness Rule includes a provision for alternate schedule. Under certain circumstances, it makes more sense to perform remediation under license authority for an area possibly subject to the Rule, and defer formal decommissioning to a future date under the alternate schedule provision. As an example, interior portions of operating facilities should not be subject to formal decommissioning, due to continuing operations surrounding such areas. NRC’s Decommissioning Directorate understands this problem, and believes that the “alternate schedule” provision of the Timeliness Rule provides for source term removal prior to license termination. The acceptability of this approach should be emphasized to all NRC staff, Regional Offices, and Agreement State Agencies.
- Many licensees do not release solid materials unless the contamination level is indistinguishable from background. This occurs because *the NRC has failed to produce a rule concerning volumetric release limits*. It is possible to develop “final status survey” type measurements, based on unrestricted release criteria, to determine the “releasability” of volumetrically contaminated material, but this remains a NRC case-by-case decision for individual licensees. Developing volumetric release criteria would enable release of very low-level material for offsite disposal at a non-licensed facility. However, it also requires that the licensee proceed under an assumption that “reasonable” NRC interpretation of the practice, by all staff members, would prevail. NRC should establish regulatory guidance on methods to determine volumetric contamination limits, and publish a volumetric release regulation. This would remove the obstacles to beneficial re-

use of recyclable materials, and allow for reasonable disposal of materials with very low levels of contamination.

- Although NUREG-1757 provides flexibility, it has been NRC's practice not to approve DCGLs until characterization is complete. This can be problematic, in that licensees cannot be certain that characterization is complete until they know their DCGLs. DCGLs can be developed without extensive site characterization. Licensees need only know the isotopes of concern, the affected media, the exposure scenario, and in some cases certain hydrogeological and/or geochemical parameters, to calculate. DCGLs should be established prior to the completion of characterization surveys, because characterization can be most effectively planned based upon known DCGLs.

- Continued effective interaction with the regulated community

The NRC Decommissioning Directorate occasionally attends meetings of the Fuel Cycle Facilities Forum (FCFF). This voluntary industry group is composed of fuel cycle materials licensees who meet to discuss decommissioning and any other issues affecting the member licensees. Regulatory developments, implementation of regulatory guidance, technical issues associated with decommissioning, and "lessons learned" are agenda topics for discussion at every FCFF meeting. Members of the Nuclear Energy Institute and the National Mining Association often attend these meetings as well.

When NRC personnel attend these meetings, licensees and the NRC staff are able to discuss technical and regulatory concerns, the potential impact of pending regulatory developments, and approaches that licensees or the NRC have proposed in an effort to overcome obstacles to effective decommissioning. This is a true "win-win" scenario; licensees gain understanding and appreciation for NRC concerns, while the NRC staff recognizes the issues confronting licensees. Continued interaction between the NRC staff and the regulated community via meetings, NRC Workshops, or any other means provides a forum for effective exchange of issues, concerns, and ideas.

CONCLUSION

The phased decommissioning process is effective if the licensee works closely with the NRC and stakeholders, and commits to intensive planning and attention-to-detail for project objectives and schedule. A single missed element can delay project progress by many months, resulting in lost time, money, and (potentially) loss of institutional knowledge by attrition of key personnel.

Regulatory lessons learned significantly affected this project by impacting time, continuity, and cost. A comparison of regulatory conditions during the decommissioning Round I with those for Round II result in findings that affect lessons learned overall. A comparison of lessons learned from the NRC Pilot Program with those from Round II is quite distressing; it appears that regulatory regression - not evolution - remains inveterate in some areas. Many lessons learned remain disregarded, when implementation would create improvements in future decommissioning project efficiency and effectiveness.

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Technical lessons learned tend to affect project cost and efficiency and are not the focus of this paper. This is an area for further research as rising costs continue to impact business strategies and economics.

The case study was a successful decommissioning project, despite the two-year extension beyond the planned completion date. Acceptance and implementation of the phased, streamlined approach by all stakeholders would have obviated the extension and allowed for project completion in three years.

REFERENCES

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