Rocky Flats Closure Legacy

Environmental Restoration

The Present Landfill was one of 360 areas of environmental contamination that required investigation and disposition. Above, workers install a geosynthetic liner and soil cover. Other technologies used at the Site included thermal desorption of VOCs in soils, excavation and removal of soils, injection of hydrogen releasing compound to accelerate contaminant degradation in-situ, and passive-reactive groundwater treatment cells using zero-valent iron filings as the treatment media.

ENVIRONMENTAL RESTORATION

INTRODUCTION

The Rocky Flats Site after closure was envisioned primarily as open space with minimal infrastructure, including the complete removal of the central area of nuclear weapons-manufacturing buildings. However, the path to realization of that vision was not clear. Many interrelated decisions had to be made before most closure tasks could begin. While Environmental Restoration (ER) is integral to successful Site closure, ER is different from other Site closure activities because ER projects had been underway for many years. It was also the most closely controlled scope by external regulators, and had the most public awareness and historical involvement.

ACCELERATED CLOSURE CONCEPT
CONGRESSIONAL SUPPORT
REGULATORY FRAMEWORK
CONTRACT APPROACH
PROJECTIZATION

SAFETY INTEGRATION
SPECIAL NUCLEAR MATERIAL
DECOMMISSIONING
WASTE DISPOSITION
ENVIRONMENTAL RESTORATION
SECURITY RECONFIGURATION
PROJECT MANAGEMENT
TECHNOLOGY DEPLOYMENT
END STATE AND STEWARDSHIP
FEDERAL WORKFORCE
STAKEHOLDER INVOLVEMENT

The scope of the ER Program encompassed all soil, surface water and ground water remediation at the Site and included removal and remedial actions of buried waste drums, contaminated soil and other buried waste; and closure of waste storage and disposal sites such as pits, trenches, impoundments and landfills. The ER Program included the investigation, remediation and closeout of Potential Areas of Concern (PACs) and Individual Hazardous Substance Sites (IHSSs) at the Rocky Flats Site. There were over 350 PACs including over 175 IHSSs at the Site. These sites contained chemical, hazardous, toxic, radioactive and mixed wastes. Some of the sites have released contaminants to soil, ground water and surface water. Some of the PACs and IHSSs were closed as No Further Action (NFA) sites after investigation.

The historical waste sites and ER activities were regulated by both the Colorado Department of Public Health and Environment (CDPHE) and the U.S. Environmental Protection Agency (EPA), under the Department of Energy (DOE), CDPHE and EPA compliance agreement known as the Rocky Flats Cleanup Agreement (RFCA).[3] RFCA integrates RCRA and CERCLA activities at the Site.

One consistent theme for the ER Program, as well as the Site as a whole, was the need to change the culture.

Much of the success of the Rocky Flats Closure Project has come from defining and organizing the work scope, and from adjusting the organizational structure to facilitate management focus on the critical tasks. The Closure Project itself was organized into six major "Projects" and all closure activities were managed within one of the major projects. Within the Closure Project, ER management activities occurred at three levels:

- Management of the ER Program by DOE, including both the Rocky Flats Field Office (RFFO) and the Headquarters Program Office.
- Management of the Remediation, Industrial Area D&D, and Site Services (RISS) Project.
- Management of the ER Project.

ENVIRONMENTAL RESTORATION

During the decades of weapons component production and operations the Site had been organized and activities budgeted and funded based primarily on weapons production needs within key organizations such as Plutonium Operations and Production Operations, plus Waste Operations, Engineering, and Health, Safety and Environment (HS&E).

Development of Interim Cleanup Standards allowed other closure activities to move forward.

Prior to the mid-1980s, environmental monitoring, analysis, and compliance activities were performed within the HS&E organization. The ER Program was initiated in 1984 as the Comprehensive Environmental Assessment and Response Program (CEARP) under the auspices of HS&E. In 1986, RCRA and CERCLA functions, including the CEARP, were transferred as a separate program office to Plutonium Operations in order to provide higher visibility as part of an operating unit of the Plant. This focus was also necessary to support preparation of the required RCRA Part A and Part B permits, which still garnered the majority of the management attention. In 1988, the CEARP became the ER Program. During those years, most of the ER activities were focused on:

Limited, near-term remediation was based on interim cleanup standards and Interim Measures/Interim Remedial Actions (IM/IRAs) in order to move forward on the highest ER risks.

- Identifying historical waste sites.
- Prioritizing sites.
- Performing site characterizations and monitoring including geology, hydrology, sources and plumes.
- Preparing closure and post-closure plans for hazardous waste units to be closed.
- Conducting remedial investigations (RIs), feasibility studies (FSs), and risk assessments.
- Developing a remedial/corrective action program for the high priority sites.

The ER Program included both RCRA and CERCLA projects, and was regulated under the first compliance agreement signed in 1986 by the DOE, EPA, and CDPHE (Colorado Department of Health at that time). The agreement focused primarily on characterization and prioritization of remedial investigation. Following the EPA and FBI raid in June 1989, the Site was listed on the National Priorities List (NPL) in September 1989. This listing served as impetus for a major revision to the tri-party regulatory agreement. The new agreement built upon the information and data collected under the 1986 agreement, but attempted to better structure and organize the work. Signed in February 1991 by the same three parties, the Interagency Agreement (IAG) divided the Site into 16 Operable Units (OUs), identified 178 IHSSs and set 266 enforceable compliance deadlines stretching out over ten years. The ER Program was funded to perform the activities negotiated with the regulatory agencies.

The NPL listing and the new IAG increased the visibility and focus on environmental restoration. Funding increased substantially to support the rigorous schedule of enforceable milestones. In addition to conducting remedial investigations, feasibility studies and risk assessments, which were the primary focus of the IAG, three interim remedial actions, one each for surface water and for ground water contamination control at the 881 Hillside (OU No.1), and one for the 903 Pad Area (OU No. 2), were planned and implemented between 1989 and 1994.

This Environmental Restoration section is divided into four subsections:

1. History and Evolution of Site Closure and an Accelerated Environmental Restoration Program.
2. Key Environmental Restoration Issues, Obstacles and Resolution.
3. Environmental Restoration Success Factors and Key Innovations.
4. Environmental Restoration Key Learning Points.

Have regulatory agencies provide on-site representatives with decision-making authority during field work.

The discussion is focused on elements that address the main ER scope. Because of the integrated nature of many activities of the Closure Project there is overlap with other sections, including *Regulatory Interface, Future Site Use, End State and Stewardship, Stakeholder Involvement, Waste Disposition, Decommissioning,* and *Safety Integration*.

DISCUSSION

Environmental Restoration Acceleration Strategy

Although the 1991 IAG served to substantially increase ER activities and visibility, the effort was focused primarily on investigation and analysis. Except for the three high-priority interim actions mandated in the IAG (mentioned above), physical cleanup was almost an afterthought. This led to significant frustration from the public, Congress, and DOE Headquarters who saw tens of millions of dollars being expended for a program that "cleaned up" very little. In 1994, the ER Program developed a strategy to accelerate cleanup activities. The strategy was called "An Analysis of the Potential for Redirection of the Rocky Flats Environmental Restoration Program[194]." More commonly known as the "SPIRIT Report", it was published in draft and never finalized, but was widely shared and discussed with stakeholders and generally received favorable comments. The strategy revised the ER approach to improve cost efficiencies and accelerate scheduled projects. The revised approach included the following key features:

- Regroup OUs and IHSSs to achieve efficiency including integrating the Industrial Area (IA) OUs.

- Focus remedial actions on IHSSs rather than OUs.
- Take early remedial action to reduce risk (e.g., hot spot removals), rather than deferring action until a Record of Decision/Corrective Action Decision (ROD/CAD) is completed.
- Defer remedial actions on low risk IHSSs within the IA and integrate with Site transition and decommissioning of IA buildings.
- Perform limited field investigations to acquire sufficient data to make decisions on early remedial actions.
- Achieve waste storage flexibility by using Corrective Action Management Units (CAMUs) or regrouping of OUs.
- Combine RI/FS phases.
- Streamline National Environmental Policy Act (NEPA), Safety Analysis Reports (SARs) and Site procedures for applicability to ER activities.
- Expedite document approval through team preparation and parallel reviews.
- Have the regulatory agencies provide on-site representatives with decision-making authority during fieldwork.
- Ensure early and continuous stakeholder involvement.
- Integrate storage, disposal, potential end-state land use(s), cost, risk assessment and other systems considerations.

The new strategy pointed in the right direction. Several simple but high profile projects helped prove the validity of the principles. Most workable was a contaminated soil cleanup near the 881 Hillside that had been planned and estimated to cost over $30 million. It was completed under the new strategy in less than a week for less than $100,000. While all ER projects would not enjoy this same success, it showed that real, cost-effective cleanup was achievable. The fact that the RFFO and Contractor had voluntarily brought forth the strategy, rather than being "forced" into it by external regulatory requirements, did much to increase the DOE's credibility. The strategy and revised approach developed in 1994 became the basis for the accelerated ER Program.

The fact that the RFFO and Contractor had voluntarily brought forth the strategy, rather than being "forced" into it by external regulatory requirements, increasing DOE's credibility.

1995 Performance-Based Integrating Management Contract (PBMIC)

With the implementation of the Performance-Based Integrating Management Contract awarded to Kaiser-Hill (K-H)[37] in 1995, greater emphasis was placed on Site Closure. K-H, as the prime contractor, became the "integrating" contractor responsible for overall management and planning. Four major subcontractors with specific areas of expertise were responsible for execution within their scope boundaries: nuclear operations; waste management, environmental restoration and decommissioning; infrastructure; and security services. There were

numerous lower-tier subcontractors, typically contracted through the four major subcontractors, which provided specific services or staff.

One of the initial actions after award of the PBIMC was the negotiation and approval of RFCA, which established a new regulatory framework between DOE, the State of Colorado, and the EPA Region 8. Much of what went into RFCA started from the SPIRIT Report principles and experience for what to focus on and how to conduct ER activities. RFCA also established decommissioning as a remedial action, and outlined the major requirements for decommissioning. Despite the approval of RFCA, much effort remained to establish the daily operational details of the new regulatory process, including responsibilities and decision documents. An implementing document, the Implementation Guidance Document (IGD) was prepared as an attachment to RFCA to guide the process. The IGD served as the guidebook for the daily interface between the DOE, contractor, and regulators, and was very important to translate the regulatory intent into everyday behavior.

The 2000 Closure Contract

In January 2000, DOE awarded K-H a sole-source contract to complete the Rocky Flats Closure Project. The principal purpose was to facilitate the accelerated closure of the Site, building on the planning and prerequisite activities that had taken place over the previous few years. The contract contained substantial incentives and penalties for performance, and changed a number of duties and responsibilities between DOE and K-H. A key feature of the 2000 Closure Contract[33] was the responsibility that it placed on both DOE and K-H. One element was risk sharing. While it was a cost-plus contract, K-H assumed the risk to its fee from performance – if cost or schedule targets were not made its fee was impacted, and if safety performance was unsatisfactory then all fee was at risk. DOE assumed the risk of external impacts – the burden of providing disposal or disposition sites (and sometimes transportation), the risk that final soil cleanup standards (Radioactive Soil Action Levels or RSALs) could substantially different from interim cleanup standards.

Characterization of soils under buildings was coordinated with facility decommissioning even while building characterization and decontamination was taking place; soil remediation was scheduled as soon as it was feasible.

The new contract also substantially replaced the multi-tiered contractor concept. One of the first post-contract activities was the K-H reorganization. With the pending reconfiguration of operations and the protected area and a better concept of the overall effort required for closure, it was possible to change the focus of the Site to Decommissioning, and ER and other closure support had to adjust their organizations accordingly. The scope of work was reorganized into six execution "Projects": the four plutonium buildings (771 Project, 776 Project, 707 Project, and 371 Project); RISS for all other facility

decommissioning, environmental restoration, and infrastructure; and Material Stewardship, which included plutonium stabilization, waste management and security. Several other support organizations were responsible for business processes, planning and project control, engineering and safety oversight, regulatory compliance, construction support, etc. However, the reorganization placed the responsibility and authority for almost all activities necessary for execution with the Projects, and promoted the project managers to vice-presidents. It divided activities such as engineering, safety support, procurement, project control and similar functions, and redistributed individuals to Projects.

Planning for Site Closure

In the 1990's as the site regulatory and contract frameworks underwent evolution, the ER program was the one most impacted. Several concurrent, and sometimes conflicting, planning processes discussed in more detail in other sections were proceeding: RFCA, the Future Site Use Working Group, the Baseline Environmental Management Report, the Site-wide Environmental Impact Statement, the K-H Accelerated Closure Planning process, and annual Site budget planning. With the signing of RFCA in 1996, which better defined the regulatory framework of closure, the Accelerated Closure Planning process moved to the forefront.

Take early remedial action to reduce risk (e.g., hot spot removals), rather than deferring action until a CAD/ROD is completed.

Initial approaches as the Site began to try to define the path to closure focused on laying out the general activities and trying to prioritize them. As dialogue continued with the regulators and the public, there came to be a general agreement to initially focus discretionary funding on the higher risk nuclear activities, at the expense of decommissioning and environmental restoration. Part was a result of better "bounding" of uncertainties such as the ability to ship waste off-site and an "interim end-state" definition for project completion. The final part was an aggressive Site planning process that included active participation by DOE, EPA, CDPHE, interested stakeholders, and technical and management input from the execution subcontractors to continually refine the closure scope. This included uncompromising management pressure to continually reduce costs and accelerate the schedule. See the *Creating and Implementing a Closure Project, Regulatory Framework,* and *Accelerated Closure* sections for additional information on the Site Closure planning process.

Environmental Restoration Execution

Remediation activities began at the Site with investigations and a few accelerated removals in the 1990s. The remediation activities were initially a relatively small component of the closure work, but became a

significant feature of Site activity after 2002 through final Site Closure in 2005. The Site environmental restoration program thoroughly investigated and dispositioned 421 historical IHSSs, PACs, and UBCs. Of these, 260 required remedial actions and the rest were classified as no further action. The remedial actions included approximately 100 accelerated actions.

One of the principal and highest visibility actions included the excavation of plutonium-contaminated soil caused by open-air storage of waste drums in the 1950s and 1960s. The "903 Pad", a long standing priority with the stakeholders and the surrounding communities, required the removal and offsite disposal of soil from about an acre to a depth of as much as several feet deep. Adjacent downwind "lip" areas that had become contaminated from windblown 903 Pad radioactivity required the removal of several inches of soil over an area several times as large. Use of a large, moveable tent structure was a very successful innovation for this project. Originally intended primarily to address public contamination control concerns, it served to provide a more consistent work environment for the remedial action workers. Significant improvements in safety and productivity were realized, the project being significantly isolated from the weather. This approach was shared as a lesson learned early on with both staff and managers for the Idaho Pit 9 project.

The three remedial actions that involved excavation and offsite disposal of contaminated soil resulted in substantially more waste generation than had been originally estimated.

Other lower profile accelerated actions removed drums and associated uranium and chemically-contaminated soil in several relatively small drum burial sites. The majority of the liquid waste lines were characterized and allowed to remain in place based on the results of a risk analysis. Two historic sanitary (i.e., non-radioactive) waste landfills were capped to meet final closure criteria, the only waste that remains on Site.

Three contaminated groundwater plume barriers, a seep collection system, and associated passive treatment systems were installed and will continue to be operated and maintained by Legacy Management. The systems treat groundwater contaminated with nitrates, uranium, and volatile organic compounds.

The three remedial actions that involved excavation and offsite disposal of contaminated soil resulted in substantially more waste generation than had been originally estimated. The additional waste at the 903 Pad was the result of deeper than expected excavation in the pad area and unanticipated soil removed from the "lip" area. Several "ponds" downstream of the original radiological liquid waste treatment areas, with accumulated sediments containing low concentrations of plutonium, also required deeper excavation than anticipated. Likewise, the process of

"chasing" a plume of carbon tetrachloride resulted in several times the estimated waste volume.

The remedial actions mentioned above could each be their own section due to the degree of documentation. With the exception of some specific lessons-learned material prepared from the 903 Pad experience and horizontal characterization drilling, most of the experience from the dozens of remediation projects is captured in the closeout reports which are part of the administrative record.[195]

ENVIRONMENTAL RESTORATION FEATURES

Risk and ER Remedial Actions

Shortly after the PBIMC went into effect in 1995, the Site developed a revised priority list for ER projects based on risk analysis of all site risks. The risk analysis showed substantially lower environmental risks compared to the nuclear safety risks, resulting in a management decision to postpone or cancel most of the planned ER projects.

Although the regulators generally agreed that the environmental hazards presented lower risk to the public, the lack of ER projects raised both public and regulatory concerns. The concern was that the Site would use all of the money appropriated for the Rocky Flats Closure Project on the other tasks, including decommissioning and bringing down the buildings, and that everything but ER projects would be completed. The public expectation and regulatory concern was that DOE and K-H would demolish the site, then "declare victory" and walk away, and that remediation of soil and water would not get done. The public was particularly concerned about plutonium levels in the soils at and around Rocky Flats.

Remediation decisions could be made in the field using portable analytical instrumentation and mobile labs, which provided real-time analyses, characterization, and delineation of the extent of soil contamination.

Following discussions with the regulatory agencies, and as part of 1996 RFCA, some of the ER projects were rescheduled as a series of accelerated actions. These actions would demonstrate the DOE willingness and capability to see all of the ER work through to completion. The relative risk of the IHSSs was assessed and the IHSSs were prioritized for remediation based on risk. The CDPHE and EPA and the Site approved the priority list in September 1995. The interim remedial actions for priority attention included:

- Excavation, soil removal, and treatment at Ryan's Pit in 1995-1996
- Excavation, soil removal, and treatment at the Mound Site in 1997
- Excavation, soil removal, and treatment at Trenches T-3/T-4 in 1997

- Excavation, drum, soil, and debris removal at Trench T-1 in 1998
- Installation and operation of a passive ground water barrier and treatment cell at the Mound Plume in 1998
- Installation and operation of a passive ground water barrier and treatment cell at the East Trenches Plume in 1999
- Installation and operation of passive ground water barrier and treatment cell at the Solar Ponds Plume in 1999

The use of passive ground water collection and treatment systems is preferred to active systems since the Site will be closed and operation and maintenance of facilities after closure will be minimized as much as possible.

Project Document Requirements

One of the lessons learned from planning and implementation of these remedial actions was that there were an excessive number of documents utilized to plan, approve, and execute an ER project. The Decommissioning projects had the same problem. The ER documentation requirements for a project included:

- The Project Plan (either a PAM or IM/IRA Decision Document)
- Project Management Plan
- Work Plan
- Sampling and Analysis Plan
- Health and Safety Plan
- Activity Hazard Analysis
- Authorization Basis
- Auditable Safety Analysis
- Activity Control Envelope
- ALARA Job Review
- Field Implementation Plan
- Waste Management Plan
- Air Monitoring Plan
- Water Monitoring Plan
- Conduct of Operations Implementation Plan
- Integrated Work Control Program
- Integrated Safety Management Implementation
- Radiation Work Permit
- Training Plan
- Operations Orders
- Work Procedures
- Readiness Assessment

Expedite document approval by using team preparation and parallel reviews.

- Pre-Job Walkdown Checklist
- Pre-Evolution Briefing
- Technical Memoranda
- Closeout Report
- Completion Report
- Lessons Learned Report

Many of these documents were important, even critical to performing a project effectively and safely. However, many of the documents were overlapping, sometimes conflicting, and all of them had to be approved by various organizations and in place before different aspects of work could start.

The ER RSOP for Routine Soil Remediation, was developed for typical soil removal actions. This document, once approved, was used as a standard protocol without the need to repeat each of the long approval steps.

The results of the lessons learned from the ER remediation projects were streamlined project document requirements and a streamlined approval process. One decision document, the ER RSOP for Routine Soil Remediation,[24] was developed for typical soil removal actions. This document underwent public review and comment, and once approved could be used as a standard protocol without the need to repeat each of the long approval steps. Non-routine remedial actions, including ground water remediation and closure of impoundments and landfills still required project-specific decision documents. Another ER RSOP, the Asphalt and Soil Management RSOP,[25] was developed for management of asphalt, excavated and disturbed soil, sediment, debris, and investigation-derived waste. This RSOP supported the significant acceleration of the final site closure steps (removal of roads, parking lots, etc.). Each of these RSOPs incorporated Long Term Stewardship considerations (see the *Future Site Use, End State and Stewardship* section).

Two major Sampling and Analysis Plans (SAPs) were written, one for the Industrial Area and the other for the Buffer Zone. The SAPs underwent public review and comment and were approved by the regulatory agencies. Addenda to these plans were written annually. The annual addenda described specific projects scheduled for the following year. The two SAPS replaced approximately 150 project-specific SAPs.

Programmatic plans and analyses were also developed for other key documents including a Field Operations Management Implementation Plan,[102] Health and Safety Plan,[103] and Nuclear and Criticality Safety Analyses. These plans and analyses were not considered "decision documents" and therefore were not reviewed by the public nor approved by the regulatory agencies. However, they still served as unifying and integrating documentation that facilitated the overall execution of the ER program. Addenda were prepared, if necessary, for each project.

RFCA Action Levels

Ensure early and continuous stakeholder involvement.

One of the key ER issues involved the setting of appropriate cleanup standards and action levels for the Site. This issue required several years of discussions because establishing appropriate cleanup standards and action levels depends on the ultimate land use. A working group from DOE, CDPHE, EPA, and K-H was formed to develop a consensus proposal for surface water, ground water, and soil standards and action levels. The proposal, called the Action Level Framework, incorporated comments from stakeholders. The Framework was developed as part of RFCA and incorporated as an attachment.

The action levels are numeric standards that, when exceeded, trigger an evaluation, management action or remedial action. The RFCA Soil Action Levels (RSALs)[105] were reviewed annually until final RSALs were established and approved. RSALs were based on risk and established for the Industrial Area and the Buffer Zone. Setting interim RSALs allowed interim remedial actions to proceed rather than waiting for final standards to be in place before implementing remedial actions. This approach protected the regulators and the stakeholders since the actions were interim, and if not sufficiently protective could always be followed by a final remedial action. DOE and K-H were also aware of the potential for an additional remedial action, and therefore used a conservative approach in the interim actions to mitigate the risk of having to do a second cleanup. DOE benefited by moving ahead with the Site closure, and the stakeholders benefited by getting a more conservative cleanup than they might have been able to get with final standards.

DOE benefited [from the RSAL approach] by moving ahead with the Site closure, and the stakeholders benefited by getting a more conservative cleanup than they might have been able to get with final standards.

RSALs were established with different "tiers", Tier I and Tier II. Soils with radionuclide levels above Tier I required remediation, soils with radionuclide levels below Tier II could be put back in the ground, while the disposition of soils with radionuclide levels between Tiers I and II was handled on a case by case basis. All of the soil removal actions listed in the Risk and ER Remedial Action section above involved the implementation of different actions based on RSAL levels.

Integration of Decommissioning and ER Activities

Decommissioning Planning was begun to deactivate and decommission two surplus facilities: Building 123, a laboratory facility originally constructed in the 1950s; and Building 779, the Plutonium Metallurgical Laboratory. The Building 123 Project was completed in September 1998 and the Building 779 Project was completed in March 2000. The projects decommissioned the building structure leaving a decontaminated slab. All

work below the slab, including any environmental medial characterization, foundation removal or disposition of under-building contamination, was "ER scope" to be left until later. At that time, there was little interaction between the ER and decommissioning projects. As time went on the integration improved significantly.

Plan D&D actions to minimize the generation of ER remediation waste, and coordinate ER waste generation activities to maximize the efficiency of waste transfer and disposal.

Following the decommissioning of Building 123, the ER Program initiated a pilot program to test the use of horizontal drilling to characterize under-building contamination. Following the decommissioning of Building 779, the ER Program (and the Site Integrated Monitoring Program) developed a ground water and building-drain monitoring plan in consultation with CDPHE, the lead regulatory agency for the building. The monitoring plan was attached to the Building 779 Closeout Report as an appendix. Although both of these ER projects were conducted as separate actions from the decommissioning projects, it was a start towards working more efficiently together. At Building 886, horizontal drilling was implemented during the decommissioning of the building.

In 2000, the K-H ER Program developed an agreement with other programs including decommissioning, Waste Management, the Integrated Monitoring Program, and the Analytical Services Division to ensure that appropriate planning and coordination would occur for the benefit of the Site mission. The ER Program assigned representatives to the other groups in order to better plan, communicate and coordinate the projects, including identifying and resolving issues in a timely manner. The agreement included the following requirements:

- Proposed decommissioning actions are consistent with the ER/decommissioning transition provisions described in the Facility Disposition RFCA Standard Operating Protocol (RSOP);[31]
- Proposed decommissioning actions are consistent with the assumptions in the ER Project Management Plan and baseline;[106]
- Proposed decommissioning actions are planned to minimize the generation of ER remediation waste;
- Proposed decommissioning actions are planned in consideration of existing IHSSs, Potential Areas of Concern (PACs), and other soil, surface water, and ground water issues;
- ER waste generation activities are coordinated with Material Stewardship to maximize the efficiency of waste transfer and disposal;
- ER activities are coordinated with the Integrated Monitoring Program to enable maximum use of air, surface water and ground water information and resources;
- ER activities are coordinated with ASD to facilitate characterization, offsite laboratory analysis and data management;
- Decommissioning/ER transition activities are implemented as planned;

- Waste generated from ER activities is shipped from point of generation directly to the offsite disposal location whenever possible; and
- ER closure activities are compliant with surface water protection standards on Site and at the Site boundary during and after final remediation activities.

Coordinate ER activities with the Deactivation and Decommissioning of buildings, and define clear demarcation lines between where D&D ends and ER starts.

Starting in 2000, it became common practice to plan decommissioning and ER work together and collect ER characterization data, including drilling through building foundations, concurrently with decommissioning activities. Planning for the use of decommissioning equipment and structures for follow-on ER remediation projects also became the norm. Developing this integrated approach to planning and communication eliminated surprises and fundamentally enabled the acceleration of closure activities that would come to fruition in the last two years of the Closure Project.

In 2001, Guidelines for the ER/decommissioning interface were finalized. Decommissioning and ER activities were coordinated in order to achieve an integrated process that minimizes risk to workers and the environment, minimizes the generation of remediation wastes, streamlines the overall remediation process and reduces costs. As part of the Guidelines, and the Facility RSOP and the ER RSOP, the demarcation lines between where decommissioning ended and ER started were clarified. Issues that were addressed included:

Emphasize utilization of passive ground water remediation systems to decrease long-term costs for operation and maintenance.

- Building foundations
- Associated structures and tanks
- Closure of RCRA units
- Building and under-building characterization
- Process waste lines
- Other underground piping and utilities
- Depth below grade for completion of decommissioning task
- Depth of soil removal
- Backfilling, site regrading, and revegetation

Despite the success of these guidelines to facilitate integration, problems still developed. Near the end of the project several high americium contamination samples were discovered in upper Walnut Creek. Some quick sampling traced the release back to the location of the former Building 771, which had been decontaminated, demolished, and the hillside regraded and replanted. Investigation later revealed that some water used in decontamination efforts had found its way into formerly clean pipes that had been abandoned underground and not adequately

plugged. The water flushed some contamination through the pipe acting as a conduit for contamination to the surface, and thus to the surface water. This event highlighted again the importance of very clear and complete coordination between D&D and ER activities.

Investigation later revealed that some water used in Building 771 decontamination efforts had found its way into formerly clean pipes that had been abandoned underground and not adequately plugged. The water flushed some contamination through the pipe to the surface, and thus to the surface water.

Independent Cleanup Verification

Many of the actions described above helped the ER program to perform ahead of schedule and perform better than regulatory minimums. Despite that progress a number of issues were continuous challenges:

- The public was focused on environmental risks.
- There were differences between public perceptions of risk and results of risk modeling (in general, there was public distrust of risk modeling).
- There was continuing disagreement between competing experts on how to apply risk modeling.
- There were ongoing discussions about the relative risk from contamination in the surface soil vs. subsurface soil and buried contamination, and how to prioritize the cleanup.
- There were concerns that some unknown contamination might be left in the subsurface or that known contamination with unacceptable risk might be left behind.
- There was a long-term community distrust of Rocky Flats that needed to be overcome.

As the closure project was nearing completion the RFPO attempted to address several of these issues by arranging for independent verification of the cleanup. The independent verification effort had mixed success in addressing stakeholder concerns and is described more completely in the *Stakeholder Involvement* section. DOE Order 5400.5, Radiation Protection of the Public and the Environment, also has requirements regarding verification. The RFPO effort identified several topics within DOE Order 5400.5 that were confusing for a cleanup and closure site:

- Verification of residual contamination within authorized limits is required for land being released to the public for unrestricted use. The Rocky Flats land is staying within Federal control by transferring to the Department of Interior and with clear use restrictions as a wildlife refuge. For this circumstance the requirements were unclear.
- The degree of “independence” required for verification is not clear, whether independence relates to methodology, previous work, relationship to contractor, or relationship to the DOE, site or HQ.

- The DOE Order standard is based on limiting dose to the public, while the CERCLA cleanup approach is based on limiting risk to the public. The comparison of these approaches is neither direct nor obvious.
- Regulators were less familiar and therefore less comfortable with the DOE Order approach. They understood their cleanup approach and standards to be more conservative and thus more protective (9.8 pCi/g vs. 231 pCi/g)[209] and were resistant to additional analysis they believed would only add confusion.
- Radiation standards were very difficult for stakeholders to understand even after almost eight years of focused effort at Rocky Flats. The DOE Order approach for verification, which was different from the cleanup standard they had focused on, was not understood and led to skepticism, rather than providing the confidence an independent check should provide.
- "Hot spot" used for radiological contamination has a specific definition and meaning in environmental regulations and DOE Orders, and the definitions may differ. Adding to the confusion, "hot spot" is often misused as a generic term. The majority of the areas sampled with elevated radiological contamination were not "hot spots" by regulatory or DOE Order definition, and thus required no action.
- Land is widely variable in size, nature and extent of potential contamination, and other variables that require significant application of judgment to apply the DOE Order. DOE guidance related to the Order further directs application of judgment to design sampling and verification techniques appropriate to the situation. The broad use of judgment invites disagreement between knowledgeable experts.

From the Rocky Flats experience it is clear that additional work is needed early in the cleanup process to align the appropriate application of DOE Order 5400.5 for sites undergoing closure and releasing land. Additional guidance may be useful as indicated by the topics above, but even more importantly better advanced coordination and communication between the field, Headquarters, regulators, and stakeholders to ensure common expectations and understanding.

Other Issues and Obstacles

There were a number of other issues to resolve and obstacles to overcome as part of Site closure and the acceleration of ER projects:

- The ER scope was initially not well organized for execution of remediation projects and for interface with other closure work.
- Without defined final cleanup standards there were potential large investigation, remediation, and waste treatment and disposal costs.

- A large-scale, costly, and long CERCLA remedial investigation / feasibility study (RI/FS) process was being followed and some investigations involved several phases of plans and fieldwork.
- There were long review schedules and multiple revisions to ER plans and reports by regulators and their subcontractors.
- The regulatory review and approval process was long and cumbersome.
- Certain RFCA provisions could be and were interpreted differently.
- RFCA left final cleanup standards vague and there was continued community concern over cleanup standards.
- There were competing community interests (somewhat resolved with Wildlife Refuge legislation).
- Long-term advocacy groups often dominated the debate.
- The Site needed to maintain some continuity of workforce to achieve safe closure.
- Closure would require integrating commercially-trained staff into the more safety-conscious nuclear environment.

Many of these issues were not unique to the ER program or isolated to those discussions. However, the nature of the Site history and mandated public involvement for ER made the ER program the focus for many broader public and regulatory concerns. The issues were interwoven throughout the ER program and were addressed many times, often with only subtle changes, for multiple projects. The repetitive and persistent nature of some of these issues was largely due to the accelerated approach for closure. Use of interim remedial actions allowed extensive cleanup and risk reduction years earlier than would have been possible under a standard regulatory approach. However, because the actions were interim, it invited stakeholders to continue to champion their issues or agenda throughout the closure project. Resolution of some of these issues has been discussed in this section and other sections. The next paragraphs describe and summarize the resolution of issues in terms of factors and key innovations that facilitated ER success.

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KEY SUCCESS FACTORS

1. The Site took advantage of a change in the national regulatory climate and EPA and CDPHE priorities, both of which allowed acceleration to take place.

2. The Site hired specialists from the regulatory agencies and outside environmental groups (in some cases former opponents) to assist in negotiations and in streamlining the regulatory process. This added

credibility to the DOE effort and increased the trust between the agencies.

3. Interim Cleanup Standards[107] were developed as part of the Rocky Flats Cleanup Agreement (RFCA) to allow other closure activities to move forward (e.g., negotiation of the Closure Contract), despite some stakeholders concerns that they would now have limited input.

4. Limited, near-term remediation was based on conservative interim cleanup standards and Interim Measures/Interim Remedial Actions (IM/IRAs) in order to move forward on the highest ER risks. This allowed remediation to take place and time to work towards final cleanup standards in a more inclusive and deliberate manner.

5. The Site minimized the number of internally-required documents and streamlined the decision process (through RFCA) for all regulatory-required decision documents including Sampling and Analysis Plans (SAPs), Proposed Action Memoranda (PAMs), IM/IRAs and the ER RSOPs. The resource savings from this effort were substantial.

6. ER Decision documents evolved to include a "long-term stewardship" component, i.e., a section that identified ongoing actions that would be required after the remedial action was complete. This facilitated coordination with the US Fish and Wildlife Service, which would become more important after passage of the Wildlife Refuge Act.

7. The Site and the regulatory agencies negotiated "trade-offs" for minimal or no remediation at low-risk sites in return for more extensive soil remediation at higher-risk sites, resulting in greater overall risk reduction. This was a classic "win-win" where the regulators, stakeholders, and DOE all benefited.

8. Minimizing potential surface water impacts and achieving surface water standards became the primary water resources-protection goal, adding clarity to the development of other remedial actions.

9. Ground water and deep soil remedial actions were only implemented where there was a potential pathway to surface water.

10. Temporary structures were used to provide weather shelters to allow continued work during inclement weather. An initial justification was that they would provide contamination control for contaminated soil removal and airborne releases at remediation sites. However, as more experience was gained with approaches for contaminated work in open air environments it was determined that (for the levels of

contamination encountered) there was no need for this level of contamination control, but the safety, efficiency, and worker morale improvements more than justified their use.

11. Operable Unit and Individual Hazardous Substance Site (IHSS) characterization and remediation activities were reorganized and scheduled to maximize integration with the other Site closure activities.

12. Characterization of soils under buildings was coordinated with facility decommissioning while building characterization and decontamination was taking place; soil remediation was scheduled as soon as it was feasible. The integration between D&D and ER was vital to overall closure project success.

13. Innovative and commercially-available technologies were used as much as possible for ER projects.

14. Cost-sharing with DOE EM-50 for technology implementation enabled the ER budget to be effectively augmented. Examples include:
    - planning and conceptual design of evapotranspiration covers for closure of impoundments and landfills;
    - design, installation, and monitoring of a passive barrier and treatment system for ground water collection and control at the Mound, Solar Ponds, and Eat Trenches plume sites;
    - an enhanced natural attenuation treatability field study at the PU&D Yard, and
    - the use of "Hydrogen Release Compound.

15. The Site emphasized the use of passive ground water remediation systems to decrease long-term costs for operation and maintenance.

16. Site characterization was closely coordinated with remediation activities to allow almost immediate transfer of lessons learned within the ER program.

17. The Site established a streamlined contracting process with two primary ER contractors; one for characterization and the other for remediation projects.

18. Onsite analytical chemistry and radiological laboratories and mobile analytical instrumentation were used allow real-time analyses and enable characterization and delineation of the extent of soil contamination to proceed concurrently with remediation activities.

The Site emphasized the use of passive ground water remediation systems to decrease long-term costs for operation and maintenance.

19. The Site established a computer-based remedial action decision management system to provide contamination maps quickly and expedite remediation decisions in the field. This was an upfront investment that provided substantial benefit, especially in the final years of site closure.

20. A Site-wide water balance study supported the development of the hydrologic design basis for closure. It included modeling of how the Site-wide water balance would change from existing, operating conditions to closure conditions; predicted potential surface water impacts; and assisted in determining the final configuration of Site drainages.

21. A land configuration study was conduced to provide the engineering data required to design engineering controls and the final site configuration at closure, including consideration of soil erosion and sediment transport, actinide migration, ponds, dams, drainages, and a stable geomorphic surface. This became a very useful and powerful tool for discussions with the regulators and the contractor regarding the Site appearance after closure.

22. The Site developed a RFCA Integrating Decision Document (which later evolved into the Land Configuration Design Basis[109]) that provided the framework, strategy and decisions necessary to achieve the final Site condition. It addressed water quality and protection, the final land configuration, monitoring, long-term stewardship and a comprehensive Site risk assessment in support of the final CAD/ROD.

23. The Site implemented an "ER Documents Team" consisting of DOE-RFFO, EPA, CDPHE, K-H, and sometimes the Fish and Wildlife Service. The purpose of the team was to ensure rapid approval of ER documents such as SAP addenda, RSOP notifications, and documents closing out IHSSs (Closeout Reports or Data Summaries). The team met nominally every two weeks with a goal of achieving regulatory agency approval of documents within 20 business days. It dispositioned comments real-time with the resolution recorded in meeting minutes included in the administrative record. The approach was made possible by comprehensive "generic" decision documents (i.e., the ER RSOP and the Industrial Area and Buffer Zone Sampling and Analysis Plan[110]). These plans provided the process and framework and allowed the sampling, execution, and closeout documents for each IHSS to be very specific and relatively short which allowed a short review turnaround. Also, the onsite regulator presence ensured that they viewed the work activities on essentially a

The ER Documents Team would achieve regulatory agency approval of documents within 20 business days.

daily basis, which provided assurance in the execution process that reinforced their confidence in the expedited review process.

24. As remedial actions were completed within various predetermined sectors of the Site, those areas were placed off limits to routine access[111]. The Site implemented a personnel- and vehicle-control system where employees were required to obtain "permits" to re-enter remediated areas. This allowed the Site to confirm that the areas did not become recontaminated and provided controls for restoration and revegetation.

Additional Learning Points

1. Identify difficult problems early and begin working toward solutions.

2. Work closely with regulatory agency and community representatives.

3. Elevate key unresolved, regulatory issues early to Compliance Agreement Coordinators (i.e., above the working-level negotiations) in order to reach agreement and stay on schedule.

4. Negotiate interim soil and water cleanup standards, if necessary, to allow work to proceed.

5. Prioritize projects based on risk and risk reduction, but accept that some "low risk" ER work may be required to maintain good faith with the regulators and the stakeholders.

6. Closely coordinate and integrate site characterization and remediation activities.

7. Utilize portable analytical instrumentation and quick-turnaround mobile laboratories to make remediation decisions in the field.

8. Perform interim remedial actions to achieve progress toward Site closure consistent with the overall closure plan and strategy.

9. Coordinate expectations and plans for independent verification of cleanup with all interested parties well in advance of project completion. Use planning and scoping tools to get written agreements and ensure detail is adequate to eliminate misunderstanding, especially for contract scope and quality requirements.

10. Minimize the number of project documents, eliminate all unnecessary document requirements, and streamline the document approval process.

11. Organize and schedule ER projects to maximize integration with the other Site closure activities.

12. Decisions to use Site radiation/construction workers vs. fixed price contracting depend on how similar the work is to routine construction, and whether traditional construction accident rates are acceptable to the Site.

13. Staff projects with both outside ER expertise and incumbents knowledgeable of Site processes and infrastructure.

14. Bringing the Site to closure requires coordinated completion of environmental restoration as well as decommissioning of the buildings.

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