RESTORING THE COLUMBIA RIVER CORRIDOR AT HANFORD'S N REACTOR

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ABSTRACT

This paper describes the ongoing remedial action of two reactor liquid waste sites near the Columbia River at the U.S. Department of Energy's (DOE's) Hanford Site. The remedial design and remediation process, methods used to reduce worker exposure and minimize the spread of contamination, waste packaging issues, and cultural resource protection, all to be performed under a lump sum contract, are addressed in the following sections.

INTRODUCTION

Soil remediation of past-practice liquid waste disposal sites in the 100 Areas of the DOE's Hanford Site has been proceeding for the past eight years. DOE's Environmental Restoration Contractor, Bechtel Hanford Inc., along with pre-selected subcontractors CH2M HILL Hanford and Eberline Services Hanford, are responsible for remediation of the 100-NR-1 Operable Unit (OU). Remediation of this OU has presented significant challenges not faced at other Hanford soil remediation sites.

The 100-NR-1 OU has the highest radiological contaminant concentrations and associated dose levels of any *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) (1) liquid waste soil remediation sites encountered to date at Hanford. Maximum plutonium-239/240 concentrations exceeded 50,000 pCi/g, and prior to remediation, dose levels in the work area routinely exceeded 100 mR/hr, with hot spots up to 1 R/hr. These dose levels, which would be encountered during removal, necessitated significant work planning to minimize worker dose. In addition, the proximity of the 100-NR-1 OU to the Columbia River made this cleanup effort a high-profile challenge.

N REACTOR HISTORY

The 100-N Reactor is located on a broad strip of land along the Columbia River, approximately 48 km (30 mi) northwest of the city of Richland in the 100 Area of the Hanford Site. The 100-N Reactor began production in December 1963, and both the reactor and the disposal units operated until January 7, 1987. The 100-N Reactor differs from the other reactors at Hanford, not only because of its closed-loop cooling system, but because it is a dual-purpose reactor, capable of producing both special nuclear material and steam generation for electrical power. Although called a “closed-loop cooling system,” it actually operated as a bleed-and-feed system, where a portion of the cooling waters were constantly bled off and replaced with fresh demineralized water. The cooling effluent removed from the loop eventually made its way to the 116-N-1 and 116-N-3 disposal facilities.

The 116-N-1 and 116-N-3 disposal facilities received radioactive liquid wastes containing activation and fission products, as well as small quantities of corrosive liquids and laboratory chemicals generated by various N Reactor operations. The units used the vadose zone to remove radioactive and hazardous materials from the reactor operation’s effluent. As discharged effluent percolated through the soil column, most radioactive and chemical constituents were retained in the soil through filtration, absorption, adsorption, and ion exchange.

The water was discharged to the disposal facilities at an average flow rate of 6,800 L/min (1,800 gal/min). Table I presents calculated cumulative inventories for principal radionuclides in effluent discharged to the disposal facilities.

Table I. Radionuclide Inventory (decayed to 2000)

Isotope	Half-Life (yr)	116-N-1 Ci	116-N-3 Ci
Cobalt-60	5.3	627.4	173.8
Strontium-90	29.1	1,518.2	182.7
Cesium-137	30.2	2,050.8	287.4
Plutonium-239/240	24,111	23.0	2.8
Total		4,219.5	646.7

WASTE SITE DESCRIPTIONS

116-N-1 Crib and Trench

The 116-N-1 disposal facility is composed of two parts: a crib and a zig-zag-shaped trench. The crib area is approximately 88 m (289 ft) long by 38 m (125 ft) wide. The bottom of the crib is approximately 1.5 m (5 ft) below the level of the surrounding grade. A sloped soil and gravel embankment forms the walls of the crib. The crib was originally excavated to a depth of about 4.5 m (15 ft) below the level of the surrounding grade, but has been backfilled at various times with boulders and cobbles to control the spread of contamination. There are four distinct layers of backfill. The lowest layer is 0.9 m (3 ft) thick and consists of large boulders. The next layer is 0.6 m (2 ft) thick and is composed of smaller boulders. The next upper layer is 1.2 to 1.5 m (4 to 5 ft) thick and consists of cobble-sized material. The uppermost layer is 0 to 1 m (3.3 ft) thick and consists of gravely material.

The 116-N-1 zig-zag-shaped trench is 490 m (1,608 ft) long by 15 m (49 ft) wide at the top, with sloped side walls. Water spilled into the trench from a rock-lined weir in the dike located on the north side of the crib. During operation, as wildlife intrusions and airborne contamination became an issue, pre-cast concrete panels were installed to cover the entire trench.

116-N-3 Crib and Trench

The 116-N-3 unit comprises two parts: a crib and a straight trench. The 116-N-3 Crib was put into operation as a replacement for 116-N-1, which had reached its disposal capacity. The 116-N-3 Crib is 76 by 73 m (249 by 240 ft) and is covered by pre-cast concrete panels. The cover is approximately 1 m (3.3 ft) below the surrounding surface grade, and the bottom of the crib is 2 m (7 ft) below the cover. A water distribution system formed a network of concrete troughs resting on the bottom of the crib, through which water flowed into the crib. Because of low percolation rates in the soil column, the 116-N-3 Crib was not able to achieve its designed flow capacity, and the straight extension trench was added. Though the trench is 914 m (2,999 ft) long by 16.8 m (55 ft) wide, and is covered with pre-cast concrete panels, only the first third of the trench ever received any waste. The concrete panels are about 1 m (3.3 ft) below the surrounding grade, and the bottom of the trench was about 3 m (10 ft) below the concrete panels.

PROJECT GOALS

Project goals include the remedial action objectives (RAOs) from the Record of Decision (ROD) (2). The RAOs are:

- Protect human and ecological receptors from exposure to radioactive and chemical contaminants in surface and subsurface soils.
- Protect the unconfined groundwater system from adverse impacts by reducing concentrations of radioactive and chemical contaminants present in the soil column that could migrate to the groundwater.
- Protect the Columbia River from adverse impacts from exposure to radioactive and chemical contaminants.
- Prevent destruction of significant cultural resources and sensitive wildlife habitat.

ADDITIONAL PROJECT OPPORTUNITIES

Some of the challenges encountered at the site include:

- Maintaining as low as reasonably achievable (ALARA) levels of exposure in areas of high contamination concentrations and associated dose rates
- Excavation in airborne radioactivity areas
- Concerns from a nearby large non-project work force
- Integration of the *Resource Conservation and Recovery Act of 1976* (RCRA) (3), Washington State "Dangerous Waste Regulations" (4), and CERCLA aspects of this site
- Fire danger
- A lack of up-to-date as-built drawings
- A lump sum subcontract for remediation
- An abundance of cobbles and boulders in the soil
- High customer, management, and regulator expectations.

To meet these challenges, various traditional and innovative methods were employed, as described in the following sections.

REMEDIAL DESIGN

The first step that has paid high dividends is completion of a thorough remedial design. By reviewing old drawings (even those that were not up to date), ground-penetrating radar surveys, test pits, etc, the initial configuration of the waste disposal sites could be determined. Interviews with previous employees, numerous site walkdowns to verify field conditions, and additional sampling to determine detailed information not provided from previous drilling results were initiated in order to provide a clear and detailed design.

DESIGN ELEMENTS

The completed design package was over 200 pages in length and included a detailed scope of work, specifications, drawings, and a surface dose rate survey map. Additional technical characterization reports were included as additional information to assist bidders in evaluating the project. Higher risk elements of the work were specified (e.g., adding grout to shield the dose), while more routine tasks (i.e., excavation, loading, and hauling contaminated soils) were left to subcontractor means and methods.

REMEDIATION PROCESS

The remediation process evolved into an efficient operation that was comprised of numerous elements. Generally, these elements can be grouped into five tasks, which are described in the following subsections.

Container Receipt and Preparation

Containers are received in the queue from the transportation subcontractor, inspected, and prepared for dispatch to the field. This usually entails container cover removal, container radiological control survey, container inspection (looking for proper tailgate seal, etc.), installation of a water absorbent, installation of the container liner, and then dispatch to the field for loading by the remediation subcontractor.

Container Loading

The prepared container is transported to the waste site and loaded, usually by an excavator. During this process the Radiological Control Technician (RCT) monitors the loading in order to maintain contamination control. The RCT also surveys selected excavator buckets to assist in maintaining container dose rates below project-specified maximum levels.

Container Exit Survey

The loaded container is transported to the survey tent where the plastic liner is sealed, the container cover is rolled into place, and the container receives thorough contamination and dose rate surveys. The contamination survey allows the container to be released to the queue, and the dose rate survey is used to determine the proper shipping containers for container transport.

Container Preparation for Transport

Once the container is unloaded in the queue, shipping paperwork is applied to the container and a final inspection is performed. This inspection checks the tailgate for visual leaks, container cover for tightness, and general conditions of the container.

Container Transport

A transport subcontractor loads the full containers and transports them to the Environmental Restoration Disposal Facility (ERDF), located near the Hanford 200 West Area, where they are transferred to a disposal subcontractor. The containers are emptied and transferred back to the transport subcontractor for eventual return to the 100-N site.

REDUCING WORKER EXPOSURE

One challenge at the 100-NR-1 OU was to minimize worker exposure during remediation. Some of the methods used to accomplish this goal included the following:

- A requirement was included in the design to reduce worker exposure by thoroughly mixing the entire depth of contaminated soil prior to excavation. This mixing of high-activity soil with low-activity soil produced a much lower overall dose to workers.
- The design called for grout to be pumped into the system at multiple locations in order to lower worker exposure and fix any remaining sludge in the distribution system. The use of grout reduced dose levels from over 250 mR/hr to less than 100 mR/hr. An extremely tough polyurea spray-on coating was also applied to accessible portions of the distribution system in order to minimize the spread of contamination from demolition of concrete structures.
- The distribution system was covered with concrete panels that were pinned and cemented in place. To further reduce dose, a remotely operated diamond saw was used to cut the panels free.
- A crane was used to remotely lift and remove the panels. Instead of a having a worker guide the load with a tag line, a worker ALARA suggestion was implemented where cables operated by the crane operator were used to stabilize each panel load.
- An earthen berm was constructed along the side of the waste site to shield equipment operators and teamsters during excavation operations.
- Trucks were routed along the waste site so the driver's side of the truck was opposite the waste site.
- Lead blankets were strategically used in excavators to shield the operator, and in the survey tent to shield laborers and RCTs
- In order to motivate the subcontractor to keep the dose ALARA, the subcontract contained a requirement for each container load of soil to have a dose reading of less than 50 mR/hr on contact after thoroughly mixing the soil. This limit has been enforced throughout the remediation work.
- To motivate the workers to keep the dose ALARA, the subcontract contained a requirement for an incentive payment directly to the workers if specified ALARA goals were met.

SIZE REDUCTION

Large concrete girders and panels required size reduction prior to loading in containers. To better contain contamination associated with the size-reduction effort, a separate lined size-reduction area was established. After the items were placed remotely by crane, a covering of slightly contaminated soil was spread over the items, and an excavator-mounted concrete processor was used to size-reduce the items. The jaws of the processor contacted the items under the cover of soil. This method contains the concrete shards and potentially airborne debris under the soil, and the lined size-reduction area contains all of the size-reduced waste until load-out.

REDUCE CONTAMINATION SPREAD

Some of the excavated surfaces were posted as high contamination areas. These areas contained concentrations up to 3 million dpm/100 cm^2 (15.5 $in.^2$) removable beta gamma and 11,000 dpm/100 cm^2 (15.5 $in.^2$) removable alpha. Using water or soil fixatives to prevent blowing dust and migrating contamination was not enough. After investigating alternatives, a commercially available product was selected. The product is a bonded fiber matrix with a stabilizer included, which is similar to that used for hydroseeding, but without the seeds. This product worked very well to stabilize the surface.

MANAGEMENT INVOLVEMENT

Due to the high doses and concentrations anticipated, and the highly visible nature of the project, close management involvement and an experienced on-site oversight group were necessary. This core team works to ensure optimum environmental, engineering, and subcontractor performance, which enables the project to meet customer and regulator expectations.

CULTURAL RESOURCES

Two key elements were included in the design to protect the nearby culturally sensitive areas, restrict site access to authorized project personnel, and calm the nearby non-project work force. First, nearly the entire project site was enclosed by an orange fence and posted with warning signs. Second, a manned access control station, using picture identification access control badges similar to the brass tag system, is used to trace every person within the project area.

LUMP SUM REMEDIATION CONTRACT

With a clear design, the subcontractor selected is able to perform the scope of work in a manner that is more cost-effective than a time-and-materials contract. By having high-risk items specified in detail, and low-risk items performance- or end-state-specified, the subcontractor is able to plan and execute the work more efficiently.

WASTE PACKAGING

Typically, contaminated soil is packaged in roll-off containers. The containers are lined to help contain dust and contamination, which also serves to keep the containers clean for easier reuse.

Two methods are used to minimize the potential for leaking containers. The first method requires "just the right amount" of dust suppressants and water at the excavation site. This truly is a balancing act. Radiological Control personnel wanted lots of water to keep dust down, while Waste Transportation personnel wanted minimal water used to prevent leaking containers. An educational effort was initiated to train supervisors and workers in the field, including laborers manning the fixative hose and RCTs, so that all personnel understood the need for "just the right amount" of dust suppressants and water. The second method used to eliminate leaking containers is the installation of a water absorber at the tailgate area of each container. This absorber (also known as a "sock") is a tube-shaped fabric bag containing a high-volume water absorber.

CONTAINER MANAGEMENT

Container management was an important element of project success. Designing a queue large enough to support simultaneous loading and unloading from the excavation subcontractor and the transportation subcontractor reduced many potential problems. Accounting for containers is an important consideration, and over time, the project determined it necessary for a full-time person to be present in the queue. This person facilitates container pickup and drop-off; interfaces with the transportation drivers; ensures that containers were inspected, lined, and properly prepared; and ensures that associated daily paperwork is completed.

HIGH VISIBILITY PROJECT

As a highly visible project, efforts were undertaken to meet high management expectations. To reassure a close non-project workforce, many briefing sessions were held to describe the project, what was being done to promote safety, and to answer questions. Due to the project's proximity to the Columbia River (<0.4 km [<0.25 mi]), two environmental continuous air monitors were installed to detect plutonium-239/240. The results are sent by remote telemetry to computers in the project office, and even after dust storms, there is no measurable contamination.

PLUMES

This project has encountered many plumes beyond the original waste site design location. While this is a difficulty, the use of the observational approach permits faster field remediation than a lengthy drilling campaign that would provide reams of data that may or may not be proven accurate during remediation. Using hand-held instruments in the field, preliminary results are adequate to confirm the existence of a plume. If hand-held instruments indicate that remediation may be complete, then more sophisticated instruments and sample collection are used to confirm that the site is clean. The additional volume of plumes was paid for on a pre-approved unit rate, which allows continued excavation when plumes are encountered. The substantial increase in volume attributed to plumes impacted schedule, but the increase in schedule is considerably less than the five-fold increase in volumes excavated.

TEST PITS

When needed, test pits are excavated by the remediation subcontractor to "look ahead" and allow planning by Radiological Control personnel and the project team. These test pits are excavated to confirm plume locations and to bound higher contaminant concentrations.

RESULTS

The ROD estimate was for excavation of 40,000 tons at 116-N-3. In reality 155,000 tons have been excavated from 116-N-3 and shipped to the ERDF on the Hanford Site, an increase of approximately a factor of four. The 116-N-1 Trench facility ROD estimate was 31,000 tons. In reality, over 200,000 tons of contaminated material has been excavated. A ROD estimate of 71,000 tons of contaminated soil and debris for both sites has proven to be smaller than the 355,000 tons excavated to date, with one of the larger sites only partially remediated.

Removal of this contaminated soil has reduced contaminant exposure to human and ecological receptors. In addition, this removal has protected both groundwater and the Columbia River by lowering the potential for contamination from these source sites. Using an access control system and a cultural exclusion fence has successfully protected significant cultural resources and sensitive wildlife habitat.

Remediation at 116-N-3 has been completed and the RAOs have been attained. After backfilling, this site will begin the RCRA closure process. The 116-N-1 Crib is still undergoing remediation.

ACCOMPLISHMENTS

- The initial dose estimate for remediation of 116-N-3 (one of the principal sites at the 100-NR-1 OU) was 10 person-rem. The actual dose received at 116-N-3 was 7 person-rem.
- No skin contaminations.
- No lost-time accidents (over 1,300 days).
- The cost-per-ton of contaminated material removed has decreased by 20%.

LESSONS LEARNED

Key lessons learned on this project include:

- Use incentives to keep dose ALARA.
- Involve workers in work planning.
- Promote teamwork among all – DOE, contractor, subcontractor, regulators, crafts, and tribes.
- Anticipate plume growth.
- Complete as thorough a design as possible.

REFERENCES

1 *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 U.S.C. 9601, et seq.

2 *Interim Remedial Action Record of Decision for the 100-NR-1 Operable Unit, Hanford Site, Benton County, Washington*, January 2000, U.S. Environmental Protection Agency, Region 10, Seattle, Washington.

3 *Resource Conservation and Recovery Act of 1976*, 42 U.S.C. 6901, et seq.

4 WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended.