REMEDIATION OF TWO BASINS CONTAINING RADIOACTIVE SLUDGE AT THE OAK RIDGE NATIONAL LAB – LOW TECH MEETS HIGH TECH

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ABSTRACT

This paper will focus on the remediation of two basins containing over 18,000 cu-ft of radioactive sludge using low-tech equipment with high tech results. These basins are located at the Old Hydrofracture Facility (OHF) in the Melton Valley Watershed of Oak Ridge National Laboratory (ORNL). This is a U.S. Department of Energy (DOE) facility with management and integration (M&I) provided by Bechtel Jacobs Company, LLC (BJC). The project was completed on time and within budget meeting all regulatory criteria and milestones. The goals of this paper will be as follows:

- Provide history of basins,
- Describe simplistic remediation approach,
- Streamlined regulatory approach using removal action process,
- Describe use of Integrated Safety Management System (ISMS) principles to improve process and safety,
- Present lessons learned for future implementations,
- Discuss equipment decontamination challenges, and
- Provide ingredients for successful project execution.

An Engineering Evaluation/Cost Analysis (EE/CA) was prepared in 1998, which determined the preferred alternative to be stabilization/removal of Process Waste Sludge Basin (PWSB) sludge with consolidation in the OHF Pond (DOE 1998a). The Action Memorandum for this preferred alternative was issued later in 1998 (DOE1998b). The Removal Action Work Plan was issued in 1999 (DOE 1999). The actual fieldwork was initiated in May 2000 and completed in August 2000.

The remediation of these two ponds required treatment and consolidation of the sludge/sediment to form a stable monolith in the OHF Pond. The treatment/stabilization of the sludge involved mixing a byproduct from Kiln operations – Quicklime containing calcium oxide – to solidify the sludge and provide the desired physical properties to support the watershed Record of Decision (ROD) remediation goals. The Quicklime pellets were added and mixed with sludge within the PWSB using a track hoe. Thus the basin was used like a large mixing bowl without the need for design of an elaborate ex situ treatment system. Once the stabilized material was mixed to the approximate 5 to 1 ratio it was excavated and placed in a lined dump truck and transported to the OHF Pond just one-half mile south of the basin. The stabilized material was then consolidated with the existing OHF Pond sediments to form a stable monolith.

The PWSB and OHF Pond were backfilled and covered with topsoil, graded and contoured utilizing a dozer, and seeded for vegetative covering. Upon completion of these remedial activities, both the OHF Pond and PWSB sites were surveyed for radiation and the radiation postings were removed.

The paper will expand upon this simplistic remediation approach described above and give a view of the activities that went on behind the scenes to make this a successful remediation project. It should be acknowledge that one of the big keys to this success was the true integration of the M&I contractor BJC and the remediation subcontractor Safety and Ecology Corporation (SEC) working with DOE and regulators.

SITE DESCRIPTION

The OHF was used for deep shale injections of waste/grout mixtures from 1963 until 1980 and required 5 underground liquid low-level radioactive waste (LLLW) tanks, a waste pit, and a pond to support disposition of LLLW. The OHF Pond was constructed in 1963 with bottom dimensions of 6.1m by 30.5m, a depth of 1.5m, and a capacity of 378,541.2 liters. The sides were lined with riprap (15.3- to 30.5-cm. in diameter) at a slope of 1 to 1.5. The pond received inflow via two vitrified clay pipes originating from the injection well cell and waste pit. The estimated volume of sediments in the pond prior to remediation was 55.3 cubic m, based on an assumed sediment depth of 28 cm. containing approximately 78 Ci of activity.

The PWSB was constructed between 1974 and 1975 and was used from 1976 to 1981 for the storage of decanted sludge from the Process Waste Treatment Plant. The PWSB dimensions were 25.9 x 25.9 x 2.4 m deep with side slopes of 4 to 1. The basin was constructed with a PVC liner on a compacted clay bottom with a protective sand layer covering the liner. The basin contained approximately 458.7 cubic m of sludge with an inventory of approximately 10 Ci.

Fig. 1. Basins before and after remediation.

REGULATORY PROCESS

These removal activities were performed as a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) non-time critical removal action as described in the *Action Memorandum for the Old Hydrofracture Facility Tanks and Pond* (DOE 1998b). Implementation of the preferred Alternative 2 included the following activities.

- Stabilization of the PWSB sludge.
- Excavation, transportation, and consolidation of the treated PWSB sludge into the OHF Pond.
- Backfilling, covering, and re-grading both the pond and basin sites.

The removal action resulted in a monolith of stabilized sludge/sediment, located within the area of the OHF Pond, with a permeability less than the surrounding soil, thus reducing the potential for radioactive contaminant releases into the adjacent stream, White Oak Creek. At the completion of these actions, the PWSB area was no longer a radiological controlled area. Additionally, the removal action stabilized the OHF Pond, which is consistent with the future cap planned for this area as identified in the Record of Decision for Interim Actions for the Melton Valley Watershed at the Oak Ridge National Laboratory, Oak Ridge, Tennessee (DOE/OR/01-1826&D3).

Remediation of these two basins using the EE/CA process expedited the remediation of these two basins. . This streamlined approach focused on remediating the two basins in accordance with the final remedial action objectives specified for this watershed in the ROD for this area. This enabled BJC to use existing funds to complete remediation of these areas before the ROD was finalized.

OHF POND AND PWSB STABILIZATION

The remediation of these two ponds involved treatment and consolidation of the sludge/sediment to form a stable monolith in the OHF Pond. The liquid covering the sludge and the fencing surrounding the PWSB were removed prior to initiating stabilization of the sludge. Additional liquid was removed after rain events, as required during sludge stabilization activities. Stabilization of the PWSB sludge was initiated on May 17, 2000, utilizing a 5 to 1 ratio of sludge to Quicklime pellets within the PWSB. The Quicklime pellets were staged on the PWSB southern boundary and added and mixed with sludge using a track hoe. The track hoe bucket was used in a method similar to kneading dough to blend the Quicklime into the sludge to achieve the desired consistency (Figure 2). Visual observation of the consistency of the stabilized material was used to determine that the appropriate ratio of sludge to stabilization material was achieved. Once the stabilized material was mixed to the desired 5 to 1 ratio it was excavated and placed in a lined dump truck and transported to the OHF Pond. The stabilized PWSB sludge was transferred into the OHF Pond by positioning the dump truck at the edge of the pond and dumping the material directly onto the side slope of the pond.

As PWSB stabilized materials were transferred to the OHF Pond, the material was evenly placed over the pond and blended using a track hoe to ensure a homogeneous mix. Additionally, cement kiln dust was added to this mixture in the OHF Pond to improve the physical properties of the stabilized material. Samples of the stabilized material were collected from this homogeneous mixture to determine the permeability. The permeability of this material ranged from 10^{-6} to 10^{-7} cm/sec. The remediation criteria for the OHF Pond required that the permeability of the stabilized material monolith be less than that of the surrounding soils. The permeability of the surrounding soils in this area is 5.6×10^{-5} cm/sec (DOE 1995). As evidenced by the permeability results identified above, the remediation criteria for the OHF Pond had been met.

Once the stabilized material had been removed from the PWSB, the liner and approximately 0.3m of soil was removed and placed on top of the stabilized material in the OHF Pond. The Maryville Limestone unit was encountered at the base of the pond and partially up the sides of the PWSB. Through consultation with the regulators, a radiation walkover survey was performed in lieu of post-remediation soil sampling at the PWSB to confirm that the remediation criteria had been met. This determination was made by evaluating the post-removal action conditions as compared to the remedial action objectives set forth for this area in the Melton Valley Watershed ROD.

The PWSB and OHF Pond were backfilled and covered with topsoil, then graded and contoured utilizing a dozer. The grading directed surface water flow away from the site to facilitate proper drainage and to avoid erosion. Erosion control measures (e.g., hay bales and silt fencing) were provided to stabilize the area and promote vegetative growth and prevent sediment runoff. The area was seeded using Kentucky 31 fescue and covered with straw for protection. The seed was applied at 50 lb/acre. Upon completion of these remedial activities, both the OHF Pond and PWSB sites were surveyed for radiation and the radiation postings were removed.

Fig. 2. Basin Remediation Activities.

EQUIPMENT DECONTAMINATION

All equipment used during the excavation and mixing of the basin contents required decontamination for off-site release for reuse. Decontamination methods include use of 2.07 MPa steam cleaner, abrasive scraping, brushing and grinding techniques that removed contamination from localized spots. Once all fieldwork was completed, a decontamination area was established where both dry and wet decontamination methods were used to decontaminate equipment. Equipment that required decontamination included the track-hoe, dump truck, and bulldozers that came into direct contact with the radioactively contaminated material. The decontamination activities occurred over a plastic lined pit were the free liquid and abrasive material was collected. This liquid was subsequently pumped into a holding tank prior to transfer to ORNL waste operations for disposition.

Following equipment decontamination, the equipment was surveyed by a radiation control technician to establish that the equipment was within the allowed applicable limits for release. When elevated levels of contamination remained more aggressive techniques were used followed by additional radiological survey. Equipment that was decontaminated to acceptable levels was removed from the site for reuse. The project team was unable to remove the fixed contamination from the track hoe buckets and operating accessories thus requiring waste disposition of these items. In addition, the track hoe bushings had to be cut out to release the arm for reuse.

In hindsight it is recognized that greater contamination prevention measures should have been taken to reduce or prevent the amount of fixed contamination requiring deconning. Future projects of this nature will use coating methods on track hoe bucket and truck bed. These coating methods will act as a protective barrier preventing contamination from embedding itself in cracks and on welds – seal metal surface. In addition, the joints will be greased daily on track hoe operating parts on arm to prevent contamination from entering bushings.

Fig. 3. Heavy Equipment Decontamination Activities.

INTEGRATED SAFETY MANAGEMENT SYSTEM

SEC's execution of ISMS to enhance worker safety consists of a process involving the following steps.

- Required safety and ISMS training at all levels of management and project execution including solicitation of lessons learned from workers' past experience
- Promulgation of safety policies, programs and procedures and acknowledgement from workers of their acceptance
- Requiring subcontractor commitment to **ZERO ACCIDENT PERFORMANCE** and to the core functions of ISMS from the contractual, training and practical standpoints and full integration of subcontractors and craft workers into the BJC safety culture
- Reiteration, reinforcement and feedback through daily safety meetings and active solicitation of worker input to address safety concerns or suggestions for improvement
- Enforcement of safety policies, programs and procedures

An intermediate step between the development/implementation of controls and the performance of work involved a work team pre-task evaluation that was conducted based on the complexity of the planned activity and the degree of associated hazards. At the activity level, implementation of a worker protection program is tailored to the activity/work, but always in a manner consistent with programs, policies, and procedures. Lessons Learned on safety-related issues are collected and incorporated into work procedures and ultimately into ES&H Program requirements.

All workers were required to attend "tailgate" or "toolbox" meetings at the start of each day's work. At such meetings, specific topics of discussion include: the schedule of the day's activities: any applicable changes to the work; requests for worker suggestions on project improvement; reiteration of the ISMS core functions and guiding principles; reinforcement of general and site-specific safety requirements; and solicitation of project worker comments and feedback on safety issues.

Prior to the start of project activities, the project team conducted an investigation (Activity Hazards Analysis, or AHA) to identify all potential hazards. The team (consisting of the project personnel) identified hazards by examining available site radiological and chemical data, facility industrial hazards, interviewing people with knowledge of the area or process, and by performing site walk-downs. For activity or task hazard categorization, engineering judgment and general health and safety guidance were used in categorizing the hazards.

The final step prior to implementation of the selected controls identified in the AHA wasinvolving workers at all levels to ensure:

- Hazards are eliminated through the substitution of materials or implementation of engineering controls,
- Project plans, task work plans, AHAs, work permits, procedures, ES&H Plan, work instructions, etc. are adhered to,
- Design changes are implemented,
- Signs, markings and other postings are posted as necessary,
- Applicable personnel training is conducted,
- Individual ownership and responsibility for safety through Line Management is emphasized, and
- Project worker authority for stopping work based on non-compliance to safety requirements is provided.

This was demonstrated during the construction of the decontamination pits that required large railroad ties to be placed over plastic lined pit to support the weight of the heavy equipment. The AHA had evaluated the hazard of handling these large ties and determined that a counted two- to four-person lift was required to avoid back strain. Lifts performed using this procedure proved to be difficult and more hazardous than necessary. One of the more experienced workers suggested the use of a "log dog" used in the railroad industry to facilitate distribution of the weight. The AHA was modified to reflect the change and the necessary equipment was procured. Use of the "log dogs" proved to be beneficial and re-enforced to the project team that all have the obligation to make suggestions and stop work as necessary to provide a safer working environment (see Figure 4).

Fig. 4. Use of log dogs for lifting and team involvement.

LESSON LEARNED

The following subsections breaks these activities down into the areas where the largest lessons learned were encountered.

Contamination Prevention – Contamination prevention measures were not taken on track hoe to minimize the need for aggressive decontamination of equipment at end of field activities. A protective coating should have been placed on the track hoe arm and bucket used to mix the radioactively contaminated sludge and stabilizing agent. Also joints should have been greased daily so as to minimize the intrusion of contamination in the bearing racings where the bucket and actuator are connected to track hoe arm.

The dump truck should have been coated in addition to liner and should have never been used without liner when removing the contaminated soil.

The bulldozer should have never been driven in a potentially contaminated environment – bottom of basin, contaminated bricks – but instead kept on top of the clean backfill working from clean to dirty. Bulldozer operator was briefed on this but due to complications with soil unloading method and excess water in bottom of basin approach changed.

Equipment Decontamination – The biggest challenge came from not fully understanding the release criteria at the prior to mobilization. The following is a summary of where future remedial actions of this nature will require improvements to enhance success.

- Work Plan listed all possible decontamination techniques available even if they were not implementable at our site – unrealistic expectations.
- Did not identify release criteria until we were part way through decontamination – did not understand cleanup levels up front.
- Upon completion of pond stabilization did not decontaminate truck and track hoe due to focus on restoring site & meeting regulatory milestone thus incurring excessive rental costs -did not have dedicated decontamination crew.
- Only had commercially available hand tools available for aggressive decontaminate equipment which took more time and resources. (These last two bullets are unclear.)

CONCLUSION

The remediation of these two basins proved that a simplified approach could be used to remediate a big problem with some lessons learned in the process. The success of this project must be credited to an integrated project team with BJC and SEC that was not afraid of being innovative. This is why we have prepared this technical paper to share this approach and our lessons learned.

Surveillance and maintenance activities will be performed at both the PWSB and OHF Pond sites. The sites will be inspected routinely to ensure vegetative cover is in place and soil cover is not undergoing excessive subsidence or erosion. In the current closed condition neither area requires local fencing or signage to protect maintenance workers. No surface water or groundwater monitoring is required to verify effectiveness of the removal action.

Further action will be taken at the OHF Pond site as part of the Solid Waste Storage Area (SWSA) 5 remedial action – remediation of this burial ground. A hydrologic cap will cover the OHF area and a down-gradient groundwater interceptor trench will be constructed. Surveillance and maintenance activities for the OHF Pond will be terminated at the time of the future action and post-construction surveillance and maintenance for the SWSA 5 remedial action will include the OHF Pond area.

The overall project cost for the remediation of the OHF Pond and PWSB was projected to be $1,100,000.00 as cited in the Action Memorandum addendum (DOE 2000). Actual project costs are documented in the table below.

Table I

TASK	**COST**
Project Mgmt/Remedial Action Work Plan	$ 60,000
Procurement & Safety Documentation	$100,000
Work Plans/Mobiliazation/Sampling/Demob./Waste Disposal	$125,000
Remediating PWSB	$340,000
Remediating OHF Pond	$340,000
Remedial Action Report	$ 40,000
Field Oversight/HP support/miscellaneous field activities	$ 30,000
TOTAL	$1,035,000

REFERENCES

(1) U.S Department of Energy (DOE) 2000. *Record of Decision for Interim Actions for the Melton Valley Watershed at the Oak Ridge National Laboratory, Oak Ridge, Tennessee, DOE/OR/01-1826&D3*

(2) 42 U.S.C. 9601 *et seq. Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA).*

(3) U.S. Department of Energy (DOE) 1999a. *Removal Action Work Plan for the OHF Tanks and Pond at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, DOE/OR/01-1834&D2.

(4) DOE 1999a. *Proposed Plan for the Melton Valley Watershed at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, DOE/OR/01-1724&D3.

(5) DOE 1998b. *Action Memorandum Addendum for the OHF Tanks and Pond at Oak Ridge National Laboratory, Oak Ridge, Tennessee,* DOE/OR/01-1866&D2.

(6) DOE 1998a. *Engineering Evaluation/Cost Analysis for the OHF Tanks and Impoundment at Oak Ridge National Laboratory, Oak Ridge, Tennessee,* DOE/OR/01-1706&D2.

(7) DOE 1995. *Remedial Investigation Report* on *Waste Area Grouping 5 at Oak Ridge National Laboratory, Oak Ridge, Tennessee,* DOE/OR/02-1326&D2/V1-V3.

(8) DOE 1992. *Federal Facility Agreement for the Oak Ridge Reservation,* DOE/OR-1014, U.S. Environmental Protection Agency, Region IV, Atlanta, GA, U.S. Department of Energy, Oak Ridge Operations, Oak Ridge, TN, and Tennessee Department of Environment and Conservation, Nashville, TN.