REMEDIAL ACTION FOR A DEPLETED URANIUM AND TH WASTE POND

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ABSTRACT

Aerojet Heavy Metals Company (AHMC) completed the decommissioning program for an inactive evaporation pond at its facility near Jonesboro, Tennessee during the summer of 1985. The pond had previously been used for process liquid wastes containing depleted uranium (DU) and thorium contamination. The remedial program included a series of projects by several companies. AHMC coordinated and administered all phases of the program. Rogers and Associates was responsible for the final phases of the program. The use of full-time construction monitoring and surveillance and materials testing provided assurance and documentation that the remedial project was completed in accordance with the design criteria and the construction specifications. Detailed certification sampling indicated that the associated project area had been cleaned up according to the specified radiological guides. The inventory in the 30,000 m^3 disposal cell is about 0.48 TBq (13 Ci) of U-238 as depleted uranium and 0.03 TBq (1 Ci) of Th-232.

INTRODUCTION

Aerojet Heavy Metals Company (AHMC) initiated the remedial program for an inactive evaporation pond at its facility near Jonesborough, Tennessee, in 1981 and completed it during the summer of 1985. The pond had previously been used for process liquid wastes containing depleted uranium (DU) and thorium contamination.

The total remedial program included a series of projects by several companies. AHMC, with the assistance of Geotek Engineering Corporation (Geotek), Environmental Management, Planning, and Engineering (EMPE), and Radiation Measurements Corporation (RMC) developed information to characterize the site and develop the pond closure plan. After AHMC emptied the pond the first construction phase of the program was removal of the sludge (i.e., materials containing more mobile and concentrated radioactive material) and disposal of the material as low-level radioactive waste by Hittman Associates during the winter of 1983-84. The final closure activities were: Phase 1, construction of a rockfilled berm to increase the isolation and stability of the site, and Phase 2, excavation of the contaminated materials and emtombment of the materials in a clay cell. Rogers and Associates Engineering (RAE), with the help of Dames & Moore (D&M), prepared construction drawings and technical specifications, and provided construction monitoring and certification for completion of Construction Phases 1 and 2.

Background

The Aerojet Heavy Metals Company (AHMC) fabricates products made of depleted uranium. The AHMC facility, located in Jonesborough, Tennessee, was acquired by the Aerojet Ordnance Company in late 1976. Most of the ongoing operations were continued by Aerojet. Early in the operation of this facility, there was a uranium hexafloride to uranium tetrafloride conversion facility and a small thorium processing facility. Liquid wastes were treated and released to a 10 million liter capacity holding pond. By 1981, it was apparent that the holding pond would not be adequate for planned expansion. The company decided to construct a modern water treatment facility to treat all process liquids. In addition, it was evident that the holding pond would have to be decommissioned. This decommissioning became the major element in a complete environmental action plan.

Objective

This paper briefly describes all of the activities for the remedial program and focuses on the construction and certification for final pond closure.

REMEDIAL ACTION PROGRAM

The remedial program can be portrayed as five basic phases:

I. Site Characterization.

II. Dewatering pond and removing the sludge and more mobile radioactive materials.

III. Development of Remedial Action Criteria, and Engineering Design and Construction Specifications.

IV. Construction Phase 1 -- construction of rockfill berm for isolation and stabilization of site.

V. Construction Phase 2 -- excavation and disposal of wastes, and monitoring and certification of cleanup.

These phases generally occurred cronologically with some overlap. The contractors involved in the various phases were generally selected by AHMC through requests for technical proposals. Management of the program was coordinated by use of a matrix organization headed by the Director of Environmental Health and Safety, AHMC, Tennessee.

The first phase included studies to define groundwater flow, the extent of radiological contamination, and the volume and characteristics of the waste. This work was performed under several contracts and extended from early 1981 to 1984.[1,2,3,4]

Phase II included dewatering the pond in mid 1983 and removal of the sludge in late 1983. AHMC performed the dewatering. Hittman Associates removed the sludge and shipped it to a licensed low-level waste disposal site.

RAE was the prime contractor for Phases III, IV, and V, which extended from early 1984 to October 1985. The construction activities were performed by construction contractors under contract to AHMC.

Phase III layed the basis for completion of the closure. This was the first commercial project of this type and there were not specifically applicable radiological guides and design criteria available. This phase included developing the remedial radiation guides, developing design specifications, preparing sampling and safety plans, obtaining regulatory agency approval, and preparing construction specifications and bid packages for retaining construction contractors.

RAE developed radiological guides for performing the cleanup and for disposal of contaminated soils from the Phase IV and V construction activities in an on-site internment cell.[5] RAE assisted AHMC in obtaining concurrence of the licensing authority, the State of Tennessee, and AHMC obtaining a license amendment for Phases IV and V.

RAE developed design specifications for cleanup of the site and an on-site internment cell for the contaminated soils. Based on the design specifications and stability analyses of the site, in August of 1985 it was decided to construct a rockfill berm to provide more conservative stability and additional isolation for the disposal area.[6] RAE, with the assistance of D&M, prepared technical specifications and bid packages for Construction Phase 1, the "Rockfill Berm" and Construction Phase 2, the "Excavation of Wastes and Construction of the Disposal Cell."

Construction Objectives and Design Criteria For Closure

The final closure operations included excavation of contaminated materials sampling and certifying the adequacy of excavation, constructing the internment cell, placing the excavated soils and contaminated soil from a storage pad in the internment cell, closing the cell, and certifying the cleanup. A map of the site is given in Fig. 1. The areas of interest are the subject pond (central right of the figure), the final internment site (the hillside and northwest area of the pond), an existing waste stockpile (upper left part of figure) which was moved to the internment site, and the clay borrow area (lower left part of figure). Clay and soil from the borrow site were used to construct the internment cell and for top soil for landscaping. The construction contractor built a temporary road and creek crossing to transport the borrow material versus using the existing road which looped westerly beyond the boundary of the figure.

The basic objectives of the construction activities and the design specifications were:

- Excavate all soils and material with concentrations of depleted uranium or thorium-232 above the cleanup criteria within the specified remedial program area. Excavate contaminated soil from the temporary storage pad about 0.5 km southwest of the pond.
- Build clay lined disposal cell using pretested clay from the borrow pit about 1 km southeast of the pond. Compact clay to 95 percent optimum density.
- Construct rockfill berm to increase stability of the disposal site and provide additional isolation for the site.
- Compacted clay cell; with wall thickness of 1.22 m (4 ft), compaction to 95 percent and hydraulic conductivity less than 10^{-6} cm/sec.
- All wastes located above 485.4 m (1592 ft) MSL; above the 100- and 500-year reoccurrence flood based on the flood survey report.[2]
- Place excavated soil in the disposal cell and compact it to about 85 percent or more.
- Close the disposal cell by placing a 1.22 m thick cover of clay compacted to 95 percent and a top layer of cover soil.
- Grade the disposal site (2 percent or more) and associated excavated areas and the storage pile for drainage, cover with top soil, and plant with grass.

The radiological criteria for the cleanup and for the inventory in the disposal site are:

- Level 1 - For unrestricted land use - 1.3 Bq/g (35 pCi/g) of depleted uranium and 0.18 Bq/g (5 pCi/g) of Th-232.

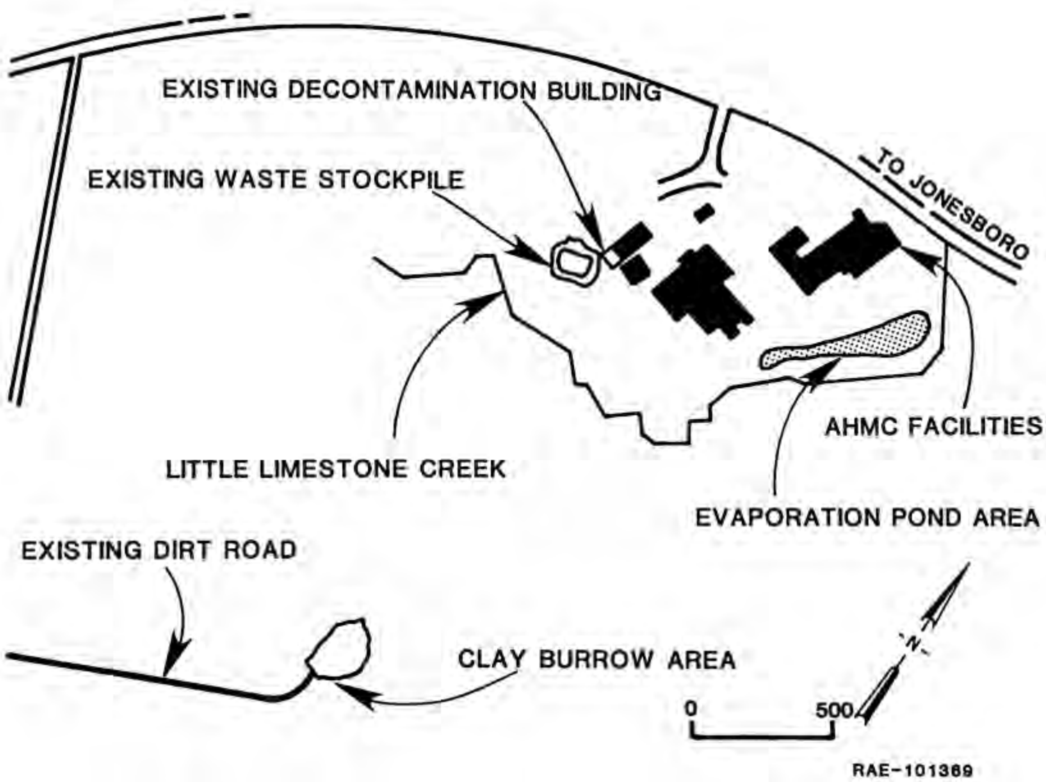

Fig. 1. AHMC Site.

- Level 2 - For a designed disposal site, with land use restrictions - 74 Bq/g (2000 pCi/g) of depleted uranium and 1.8 Bq/g (50 pCi/g) of Th-232.

The Level 1 guides apply to the average concentration over a 100 m^2 area to a depth of 15 cm.[5] These cleanup criteria were approved by the State of Tennessee, the licensing agency for the site.

Since an uneven bedrock surface was known to exist in the proposed excavation area, alternate guides were established for materials at the bedrock interface or hard to excavate material that would be covered by several feet of soil. These guides, to be applied over limited areas, were three times the Level 1 *guides*, or 3.7 Bq (100 pCi) U-238/g and 0.55 Bq (15 pCi) Th-232/g.

CONSTRUCTION ACTIVITIES

The construction phases were: (1) building the rockfill berm, and (2) excavation of contaminated soil, building the internment cell, and placement of the waste and closure of the cell. RAE and D&M, as a sub to RAE, prepared construction drawings and technical specifications for these construction activities. RAE/D&M also provided fulltime construction monitoring and quality assurance for the construction. Geotek Engineering Corp (Geotek), under contract to AHMC, under the supervision of the RAE/D&M Engineer provided soil testing support.

Rockfill Berm

Bid documents for the rockfill berm were issued in late September 1984, and construction was started October 29 and completed on December 18, 1984. Construction of the rockfill berm consisted of clearing, excavation to bedrock, preparation of bedrock surface, placement of 5-cm gravel, placement of Polyfelt TS 500 geotextile fabric and covering it with approximately 30-cm thickness of 5-cm gravel fill, placement of minus 25-cm graded riprap, and placement of a compacted clay berm on the closure cell side of the rockfill berm. The trench for the berm was excavated to bedrock. After placing the foundation of gravel, geotextile fabric, and gravel to protect the fabric, the wall was built of riprap type rock. The berm, after construction of the cell, is shown in Fig. 2. The quantities for construction are given in Table I.

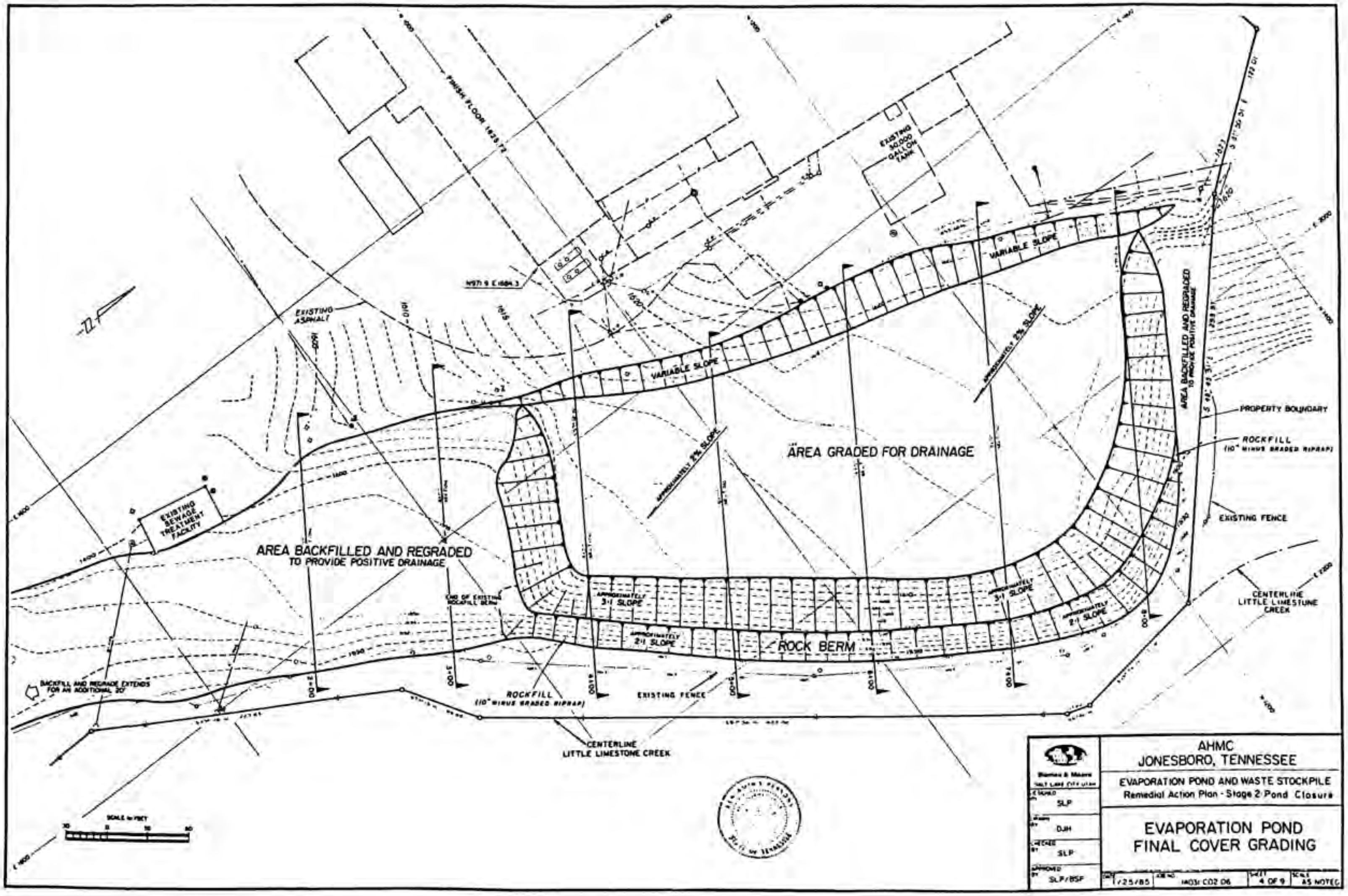

Fig. 2. As Built Disposal Site.

TABLE I

SUMMARY OF MATERIALS AND SAMPLING FOR POND CLOSURE

ITEM	QUANTITY
ROCKFILL BERM	
Soil Excavated for Rockfill Berm	
Common Excavation	6,300 m^3
Contaminated Soil	300 m^3
Rock Placement for Rockfill Berm	
Initial	14×10^6 kg
Extension	1.8×10^6 kg
Clay Berm Fill	1,500 m^3
POND CLOSURE	
Excavated and Placed Contaminated Soil	30,000 m^3
Contaminated Concrete	300 m^3
Placement of Clean Soil	
Clay Base	16,000 m^3
Clay Cap and Fill	23,000 m^3
Top Soil	4,600 m^3
Gravel Base for Disposal Site	7.6×10^6 kg
Samples for Certification	1,170
Quality Assurance	54
Soil Compaction Tests	326
Clay Cap and Base	117
Waste Material	209
Totals:	
Contaminated Soil Excavated and Placed	30,000 m^3
Clean Soil Placed	45,000 m^3
Common Excavation (Excludes Borrow)	7,000 m^3
Rock Placed	23×10^6 kg
Soil Samples for Rad Analysis	1,170
Soil Compaction Tests	

Excavation and Internment of Waste

The bid documents for the construction activities of the final closure phase were issued on March 5, 1985. The contractor, Thomas Construction of Johnson City, TN, was competitively selected on March 26, and construction was initiated on May 10th. The internment cell was closed and certification activities completed by August 31, 1985, within the prescribed 90 construction days (excluded about 16 rain days). The construction was performed with only four minor change orders (e.g., clarified construction period and geofabric) which did not increase the cost of the construction contract. All of the construction was performed with standard earth moving equipment. The basic equipment items were bulldozers, backhoe, scraper/pans with four-wheel drive, and dumptrucks. Compaction was done with bulldozers, sheeps-foot roller, and hydraulic compactor.

The final closure construction activities were excavation of contaminated soil and placement in the internment cell. Vegetation was stripped from the construction area prior to excavation of the contaminated soil. The excavation of contaminated soil, construction of the internment cell, and final placement of the contaminated soil was designed to minimize the spread of contamination and the need to double handle material. The initial excavation included removal of about 10,000 m^3 from the northern section of the pond and hillside primarily using a Cat 235 backhoe/excavator. This material was hauled by trucks and temporarily placed south of about Station 6+00 (see Fig. 2). Much of the northern section of the pond was excavated to bedrock. After sampling was performed to certify the adequacy of excavation, the crevasses in the bedrock were backfilled with 5-cm crushed rock and the clay base of the internment cell was built to the design elevation of 485.4 meters. The contaminated soil which had been placed on the southern section of the pond was then moved to the cell, using 4-wheel drive pan/scrapers (Terex TS14B). The placed material was primarily compacted by the hauling vehicles and a D8 or similar bulldozer.

The central and southern areas of the pond were excavated using the pans and excavator and the material was placed directly in the cell on the northern section. The contractor was able to schedule subsequent excavation and placement of waste material and building additional areas of the cell to eliminate additional double handling of the waste material.

The soil and clay from the borrow pit and contaminated soil from the storage pad were primarily transported using the pan/scrapers with some supplemental hauling with dump trucks. All equipment was decontaminated and monitored when it was shifted from work in contaminated areas to hauling clean materials.

The quantities of materials for the various operations are summarized in Table I. The primary difference from the original design projections and actual as-built quantities was the amount of crushed rock used to fill crevasses in the bedrock and provide the foundation layer for the clay base of the cell.

The design specifications included the use of crushed rock to fill selected areas. However, since the DU wastes had migrated to a somewhat greater depth than expected, more rock was needed to fill the areas between bedrock pinnacles than originally projected.

The wastes in the internment cell included contaminated soil from the pond and hillside, contaminated soil from the area to the south of the pond, the contaminated soil from the waste storage pad, and about 300 m^3 of contaminated concrete. The contaminated concrete was from reconstruction at the facility and was placed along the northeast area of the cell to further increase the stability of the site.

Full time monitoring of the construction activities ensured that the project was completed according to the specifications. Soil compaction tests by Geotek (326 samples) for both the in place waste, and cell lining and cap demonstrated that the materials were placed as specified.

CERTIFICATION OF CLOSURE AND HEALTH AND SAFETY PROGRAM

Special sampling programs were designed to document the adequacy of the cleanup, the inventory of the internment site, and the longterm performance of the site. The documentation of the cleanup was based on taking samples at depth increments of 0 to 15, 15 to 30, and 30 to 60 cm for each 100 m^2 area. This sampling plan was patterned after the requirements specified by the U.S. Environmental Protection Agency for 40CFR192.(7) Each sample was based on an average concentration for three to six aliquots (e.g., an aliquot from each corner of the area and two from the central area). The inventory is based on samples taken from each 100 m^2 area for depth increments of 75 cm (30 inches). The longterm monitoring program includes stability and settling measurements, visual verification of the performance of the cover, and groundwater sampling.

The certification sampling resulted in the collection of about 1120 samples and the analysis of some 1167 samples. Fifty-four of the analyses represented quality assurance samples analyzed as blind duplicates. Samples were also exchanged with the state laboratory. The analyses were performed by AHMC using a coaxial Ge-Li detector and gamma spectroscopy analysis. The system was calibrated with a mixed gamma standard, traceable to the U.S. National Bureau of Standards, which had the same geometry as the samples. The analysis was based on the 63 and 93 keV x-rays and the 1001 keV gamma ray from Pa-234m, a daughter of uranium-238 and the 727 keV gamma ray for analysis of thorium.

Over 850 samples were collected and analyzed to certify the adequacy of the excavation of contaminated soil and the cleanup of the project areas. This includes having to resample areas where additional excavation was required. Approximately 13,000 m^2 were certified as clean. Most of the area was well below the cleanup criteria; however, the alternate criteria for the bedrock interface and difficult to excavate areas was applied in limited areas. Although it was not necessary to excavate any bedrock, several bedrock pennicles were removed to provide a more uniform base for the waste cell.

Over 250 samples were collected and analyzed for the inventory sampling program. The concentrations ranged from below the cleanup criteria for DU and thorium to about 45 Bq/g (1210 pCi/g) of U-238. Only about 5 of the samples were above 45 Bq/g of U-238. The average concentration of materials in the internment cell is about 9.6 Bq/g (260 pCi/g) of U-238 and 0.7 Bq/g (19 pCi/g) of Th-232. The coefficients of variation for these values are over 100 percent.

The inventory is about 0.48 TBq (13 Ci) of U-238 as depleted uranium and 0.03 TBq (1 Ci) of Th-232.

The health physics program included TLD's, bioassay urine samples, area and selected personal air samples, and wearing coveralls and shoe covers. The program which documented that there was minimal radiation exposure, had a limited impact on the construction activities. All construction equipment was surveyed before release. Decontamination was performed with shovels and a fire hose.

SUMMARY AND CONCLUSIONS

The use of full-time construction monitoring and surveillance and materials testing provided assurance and documentation that the remedial project was completed in accordance with the design criteria and the construction specifications. Detailed certification sampling indicated that the associated project area had been cleaned up according to the specified radiological guides. The inventory in the 30,000 m^3 disposal cell is about 0.48 TBq of U-238 as DU and 0.037 TBq of Th-232.

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