M-AREA BASIN CLOSURE - SAVANNAH RIVER SITE (U)

by

S. R. McMullin and J. G. Horvath
Westinghouse Savannah River Company
Savannah River Site
Aiken, SC 29808

A paper proposed for presentation at the
ER '91 Conference
Pasco, WA
September 9-11, 1991

and for publication in the conference proceedings

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

This paper was prepared in connection with work done under Contract No. DE-AC09-89SR18035 with the U. S. Department of Energy. By acceptance of this paper, the publisher and/or recipient acknowledges the U. S. Government's right to retain a nonexclusive, royalty free license in and to any copyright covering this paper, along with the right to reproduce and to authorize others to reproduce all or part of the copyrighted paper.

MASTERS

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED
M-AREA BASIN CLOSURE - SAVANNAH RIVER SITE (U)

by

S.R. McMullin and J.G. Horvath
Westinghouse Savannah River Company
Savannah River Site
Aiken, SC 29808

ABSTRACT

M-Area, on the Savannah River Site, processes raw materials and manufactures fuel and target rods for reactor use. Effluent from these processes were discharged into the M-Area settling basin and Lost Lake, a natural wetland. The closure of this basin began in 1988 and included the removal and stabilization of basin fluids, excavation of all contaminated soils from affected areas and Lost Lake, and placement of all materials in the bottom of the emptied basin. These materials were covered with a RCRA style cap, employing redundant barriers of kaolin clay and geosynthetic material. Restoration of excavated uplands and wetlands is currently underway.

INTRODUCTION

The Savannah River Site is a Department of Energy production facility constructed in the 1950's. This 300-square-mile site is located in western South Carolina, adjacent to the Savannah River. The site contains facilities for the manufacture and production of aluminum clad, enriched uranium fuel tubes, and aluminum clad target rods. Stringent nuclear reactor standards necessitate the use of cleaners and degreasers, more so than other commercial aluminum operations.

M-Area has three production buildings (313-M, 320-M, and 321-M) and two support laboratories (320-M and 322-M). These facilities generate wastewater similar to that produced by commercial aluminum-forming and metal-finishing industries. This effluent was initially discharged to the A-1 outfall and Tims Branch. The M-Area settling basin was constructed in 1958 to receive building 321-M effluent and to eliminate the release of enriched uranium to the surface streams and ecosystem.

The original basin was 100.9 m (331 ft) long x 85.0 m (279 ft) wide x 6.1 m (20 ft) deep, with a design capacity of 30.3 million liters (8 million gal). The Basin had an outlet to channel any overflow into a natural depression, Lost Lake. Discharge into this settling basin was terminated in July 1985, with the completion of the M-Area Liquid Effluent Treatment Facility.
During the 27 years of operation the basin received wastes containing primarily lead, nickel, magnesium, zinc, and uranium, with concentrations of nitrate, phosphate, sulfate, sodium hydroxide, and metal degreasers. Total uranium discharged to the basin between 1974 and 1985 was 1150 Mci. The influent pH varied, due to the use of both acids and caustics in the manufacturing processes. It is estimated that 30,000 kg of heavy metals and 2.0 million kg of volatile organic solvents were discharged to the M-Area basin.

The purpose of this paper is to briefly describe the characterization and the closure of the M-Area Basin. This closure was regulated by South Carolina Department of Health and Environmental Controls (SCDHEC).

CHARACTERIZATION

Geology. The generalized geology in the vicinity of the M-Area basin is that of interbedded sands and clay lenses. This marine environment was subjected to shoreline variation and stream meandering. The groundwater is located approximately 42.7 m (140 ft) below the ground surface and consists of three hydrostatic layers, each confined by clay layers.

Four groundwater monitoring wells were initially installed to identify any groundwater contamination. Determinations from these wells precipitated the closure and remediation activities. An extensive remediation program to remove organic solvents from the groundwater is associated with this closure. Though germane to the contamination problem, a thorough discussion of the groundwater remediation is not included in this paper.

M-Area Basins and Adjacent Areas. An extended characterization program was initiated to address the organic and inorganic constituents in four basic areas (1, 2, 3). These areas are the basin, the process sewer line, the overflow seepage area, and Lost Lake (Fig. 1).

The basin fluids were characterized by three distinct zones. The upper and middle zones were defined and separated by a chemocline, with both experiencing mixing induced by thermal heating and flow from the process sewer. The majority of the metals contained in the basin resided in the lower zone, a semiconsolidated sludge. High levels of chlorocarbon solvents were detected in the sludge in 1982, but they were not detected at significant levels when reanalyzed in 1984. Apparently they had volatilized or infiltrated down into the soil.
The process sewer line was a 609.6 m (2000 ft), gravity flow system, constructed out of 76.2 cm (30 in) vitrified clay pipe (VCP). This pipe had been relined with a 30.5 cm (12 in) polyethylene liner to prevent leakage. The extent of contamination from leakage was partially characterized, but was indeterminate until excavation. At the time of excavation, heavy metals were found to a depth of 1.2 m (4 ft) below sewer grade. Low concentrations of volatile organic compounds were also found within this depth range.

The sludge composition in the overflow ditch and seepage area were similar to the basin, but at lower concentrations. Soils beneath the overflow ditch contained elevated levels of metals to a depth of 15.2 cm (6 in), with nickel and uranium ranging to depths of as much as 0.9 m (3 ft). Low-level organic contamination was also found in the top 15.2 cm (6 in) of these soils.

Slightly elevated concentrations of metals were found in the surface soils below the normal water line at Lost Lake. Only one soil sample from Lost Lake contained a measurable amount of tetrachloroethylene.

Figs. 2 and 3, show the generalized concentrations for the different areas characterized relative to SRS background levels. These background concentrations area listed in Table I, and have been used to normalize the concentration levels displayed on Figs. 2 and 3.

EXCAVATION ACTIVITIES

The M-Area Basin Closure Plan identified the Hazardous Waste Management Facility (HWMF) as encompassing the M-Area basin, the process sewer line, the overflow seepage area, and Lost Lake (Fig. 1), (3). The strategy was to remove, treat, and release the fluids. The sludge from the bottom layer in the basin, together with sludge from the overflow ditch and seepage area, were stabilized and placed into the bottom of the empty basin (Fig. 4). The remainder of the contaminated soils was excavated and placed on top of the stabilized material. These materials were then protected with a RCRA style cap, minimizing potential for constituent migration. The following discussions will briefly treat the closure activities for each element of the HWMF.

Site Preparation. Site preparation included removing and disposing of the dense vegetation within the HWMF, and grading the laydown area for construction. These operations were done to facilitate access to contaminated soils and to preclude any spread of contamination that might be associated with the timber. Several options were contemplated for disposal of the grubbed vegetation. Among these were transportation off the site, constructing an incinerator, and open-air burning. After extensive negotiations with SCDHEC, the final decision was to allow open-air burning, with constraints on allowable wind speed and direction, after which the vegetation was grubbed, piled, and then burned.
The area adjacent to the basin was grubbed and graded to facilitate construction of a temporary Wastewater Treatment Facility (WTF) and a laydown area for materials and equipment. The work area was diked, forcing any drainage to flow into the basin. Access to the area was restricted and a decontamination pad for equipment and personnel was constructed.

**Settling Basin.** The liquids contained in the basin were pumped to the temporary WTF, treated, and discharged to the NPDES-permitted outfall M-004A. The temporary WTF implemented both chemical and physical treatment stages. These treatment steps included pH adjustment, polymer addition, and clarification by precipitation and filtration (Fig. 5). Treated effluents were to the outfall through a 10.2 cm (4 in) sealed pipeline.

The fluids and sludge were removed from the basin using pumps and a horizontal auger-cutter and pump assembly, supported by a floating dredge. The dredge pumped the sludge into a mixing tank where diatomaceous earth was added to act as a flocculent and filter aid. The mixture was then pumped to and processed by a portable filter press, separating the liquids from the solids. The filtrates were sent to the WTF for processing and discharge to the outfall. The (clay-like) filter cake was staged and covered adjacent to the basin for later stabilization and deposition.

The filter cake was stabilized using a mixture of Portland Cement and flyash, at a ratio of 4 parts cement to 1 part flyash. This mixture was then blended with the filter cake at a ratio of 1:10. A pug mill was used to process the filter cake; however, at the initial mix ratio, the material was very difficult to work and impeded the pug mill operations. After iterative trial runs, the optimal mixture was determined to be a ratio of 1:6, cement and flyash to the filter cake. This ratio cost the contractor more in cement costs, but these costs were more than offset by the reduction in downtime and manhours to keep the pug mill operational. The pug mill was equipped with a conveyor system to deposit the stabilized filter cake directly into the basin, where it was mechanically spread and compacted.

**Process Sewer.** Excavation of the process sewer included the removal of piping and all contaminated soils that were within the range of normal excavation activities. The polyethylene pipe was withdrawn intact and cut up into workable 2.4 m (8 ft) lengths. These pieces were taken to the now empty basin, filled with concrete, and buried. The clay-tile pipe was also deposited in the basin and crushed by mechanical equipment to minimize void space.

Monitoring for heavy metals in the soil below the process sewer revealed contamination some 1.2 m (4 ft) below grade. Over 1530 cubic meters (2000 yds³) of contaminated soil were removed and compacted into the basin. The uncontaminated overlying soils were staged for later recompaction after the removal of the process sewer line.
Monitoring indicated residual organic contamination in the deeper soils that were not within the range of surface excavation. This contamination is being addressed in Part B of the Post Closure Care Permit and as part of the corrective action program.

Overflow Ditch and Seepage Area. The natural seepage area (Fig. 6) allowed a portion of the basin overflow to dissipate into the ground by infiltration. Soils within this 1.5 ha (3.8 ac) drainage area were excavated to depths ranging from 10.2 to 61 cm (4 to 24 in). Nearly 13,006.9 cubic meters (17,000 yds³) of soil were excavated and transported to the basin for deposition.

The sludge was removed from the bottom of the overflow ditch. The sludge was similar to that found in the basin, though at lower concentrations. This material was dewatered and stabilized with the basin sludge. The contaminated soil was excavated to a depth of 1.8 m (6 ft), and placed on top of the stabilized sludge.

Lost Lake. The Carolina bay, known as Lost Lake, is a naturally occurring wetland. This 11.7 ha (29 ac) wetland is a geomorphological anomaly, with no apparent outlet. Seasonal weather and rainfall fluctuations cause changes in water level, ranging from completely full to dry.

Prior to excavation, Lost Lake was pumped dry to facilitate excavation. Approximately 45.4 million liters (12 million gal) of water were removed and spread in areas outside the watershed. Prior to discharge, these waters were fully tested. Test result evaluation prompted SCDHEC to require monitoring only for total suspended solids (TSS) prior to discharge. The water was pumped into one of three 189,270 liter (50,000 gal) holding tanks, tested for TSS, and then discharged to a land disposal system.

Based on the levels of standing water, soil types, and the concentration of metals, the lake was divided into three distinct remediation zones (Fig. 6). The first zone, labeled C, encompassed all those areas below 102.4 m (336 ft) in elevation; 30.5 to 45.1 cm (12 to 18 in) of soil were removed, extending into the underlying hardpan. The second zone, labeled D, included those areas lying between 102.4 and 103.0 m (336 and 338 ft) in elevation; 15.2 to 30.5 cm (6 to 12 in) of soil were removed, depending upon characterization findings and supplemental monitoring. The third and last zone, labeled E, included those areas between 103.0 and 103.6 m (338 and 340 ft) in elevation; 5.1 to 10.2 cm (2 to 4 in) of soil were removed. All these soils were transported to and compacted in the basin.

Summary of Excavations. Table II presents the volumes of materials processed and deposited into the basin.
CLOSURE CAP

The closure cap is an integrated system employing redundant barriers (Fig. 4). The system used 61.0 cm (24 in) of kaolin clay, overlain with a 36-mil-thick geosynthetic material, embedded between two 15.2 cm (6 in) layers of sand. A 61.0 cm (24 in) gravel drainage layer was placed next, overlain by a geotextile filter material. Finally, the system was protected with 61.0 cm (24 in) of topsoil and a vegetative cover.

Kaolin Clay. Kaolin clay is the primary element in the moisture barrier and is locally available. In 1987-88, SRS initiated a study to prequalify local clay sources and to determine optimum construction methods. This study was conducted by Mueser Rutledge Consulting Engineers of New York (5,6). The evaluation parameters included clay workability, construction procedures and equipment, and final clay permeability. The final report recommendations were implemented into the construction of the M-Area basin closure cap.

Construction of the clay cap was done using four, 20.3 cm (8 in) lifts, which were compacted to a depth of 15.2 cm (6 in). Each of the four separate lifts were placed and compacted, bringing the thickness of the clay to 61.0 cm (24 in). A total of 10,329.0 cubic meters (13,500 yds$^3$) of kaolin clay were incorporated into the closure cap.

Testing was performed on the clay material prior to, during, and after placement. Prior to placement, the clay was sampled and tested at delivery to verify quality and optimum moisture density. During placement, moisture content and density were checked using both the sand cone and nuclear testing equipment. After placement, several random samples were taken of the cap profile and bench tested for quality and permeability. Each of the holes was filled and sealed, using multiple lifts of compacted bentonite clay pellets.

Geosynthetic Material. After laying down a 15.2 cm (6 in) thick layer of sand, a geosynthetic material by the trade name of Hypalon was placed, covering the cap. Over 9290 square meters (100,000 ft$^2$) of the 36-mil material were used, providing a redundant barrier to the kaolin clay. The Hypalon panels were overlapped 15.2 cm (6 in), and bonded using a cold-applied Hypalon bonding adhesive. The geosynthetic cap was visually inspected for holes, and the seams were tested using an air lance, supplemented by laboratory seam testing. Any holes or faulty seams were patched and repaired. The edges of the material were secured using an anchor trench.

Drainage Layer. The cap drainage system overlying the geosynthetic layer, functions to preclude the development of a hydrostatic head over the more impermeable portions of the cap. Infiltrating rain water is channeled laterally by the permeable gravel to a perimeter drain and discharged into a bypass channel along the outside of the basin. The system consisted of three primary components:
• A 30.5 cm (12 in) thick layer of stone graded to ASTM C7 specifications.

• A perimeter drain consisting of a 15.2 cm (6 in) perforated collection pipe, embedded in crushed stone in the liner anchor trench.

• A protective cover of 90-mil-thick geotextile filter fabric. The filter fabric prevents the downward migration of the topsoil, which would clog the drainage layer.

**Final Cover.** The final protective cover consisted of 45.7 cm (18 in) of clean fill, covered with 15.2 cm (6 in) of topsoil. Compaction was minimized for the upper portion of the fill to facilitate plant growth. The surface of the cap was contoured to maximize runoff and minimize erosion potential. The topsoil was disked and seeded with a blended seed mix. The U.S. Forest Service (USFS), Savannah River Station and the U.S. Soil conservation Service (SCS) provided support to design the vegetative cover. The cap was fertilized and seeded with a comprehensive plant mixture that included perennial rye grass, kobe lespedeza, winter wheat, crimson clover, and bermuda grass.

**REVEGETATION OF AFFECTED AREAS**

The revegetation efforts are divided into two elements, the uplands and the wetlands. The uplands consist of all disturbed areas, excluding the Lost Lake wetlands. Final construction operations included grading and contouring the excavated areas. After construction was completed, the USFS and the SCS immediately disked and seeded the areas to prevent erosion. The long range revegetation plan was created and is being implemented by a multidiscipline task team consisting of personnel from the: U.S. Forest Service, Soil Conservation Service, Savannah River Lab, Savannah River Ecology Lab, Environmental Restoration Department (Westinghouse), NUS Corporation, and Department of Energy. Grasses were reseeded where necessary, and select hardwood trees were planted. The loblolly pine, predominant in the region, will be allowed to reseed naturally.

The revegetation plan also involved the restoration of the Carolina bay wetland. The wetland is being used as a study site, to optimize soil treatments and vegetative types to be used in future wetland restoration efforts at SRS.

**CONCLUSIONS**

The final cost to close this 1.0 ha (2.4 ac) basin and to restore approximately 10.1 ha (25 ac) of affected area was $5.4 million. Construction began in July 1988 and continued until January 1990. The basin was officially closed on January 1, 1991 and certified on February 26, 1991.
The closure of the M-Area settling basin was among the first mixed waste surface impoundments closed in the nation and at SRS. Hazardous and radioactive constituents contained in the basin and surrounding areas were removed, stabilized, and deposited back into the basin confines. This closure was then covered and protected with a state-of-the-art moisture barrier to preclude moisture infiltration. Those native areas adversely affected by closure activities are being revegetated and restored, enhancing the quality of the SRS environment.

The revegetation and restoration of the HWMF has been successful. Animal and bird life have returned to Lost Lake, and the wetland vegetation is thriving. The project has established a standard for all SRS restoration activities by demonstrating that not only can environmental cleanup be performed without further adverse environmental impact, but that it can also improve the ecological setting. Studies centered on the Lost Lake wetland and renewal of life in a Carolina bay will provide information to restore other disturbed areas.

ACKNOWLEDGMENT

The information contained in this article was developed during the course of work done under Contract No. DE-AC09-89SR18035 with the U.S. Department of Energy.
REFERENCES


### Table I
Savannah River Site Background Levels

<table>
<thead>
<tr>
<th>CONSTITUENT</th>
<th>CONCENTRATION (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pb</td>
<td>5</td>
</tr>
<tr>
<td>Ni</td>
<td>14</td>
</tr>
<tr>
<td>Mg</td>
<td>96</td>
</tr>
<tr>
<td>Zn</td>
<td>12</td>
</tr>
<tr>
<td>Al</td>
<td>13,000</td>
</tr>
<tr>
<td>U</td>
<td>2</td>
</tr>
</tbody>
</table>

### Table II
Summary of Excavated Volumes, M-Area HWMF.

<table>
<thead>
<tr>
<th>NAME</th>
<th>AREA</th>
<th>VOLUME</th>
</tr>
</thead>
<tbody>
<tr>
<td>M-Area Setting Basin:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid Phase</td>
<td></td>
<td>3,000,000 gal</td>
</tr>
<tr>
<td>Sludge Phase</td>
<td></td>
<td>2,000,000 gal</td>
</tr>
<tr>
<td>Process Sewer</td>
<td></td>
<td>2100 yd³</td>
</tr>
<tr>
<td>Overflow/seepage</td>
<td>3.8 ac</td>
<td>17,200 yd³</td>
</tr>
<tr>
<td>Lost Lake:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area &quot;C&quot;</td>
<td>9.9 ac</td>
<td>16,000 yd³</td>
</tr>
<tr>
<td>Area &quot;D&quot;</td>
<td>11.3 ac</td>
<td>9100 yd³</td>
</tr>
<tr>
<td>Area &quot;E&quot;</td>
<td>8.2 ac</td>
<td>2200 yd³</td>
</tr>
</tbody>
</table>
Fig. 1 Plan view of the M-Area Settling Basin Hazardous Waste Management Facility (HWMF).

Fig. 2 Normalized semilog graph displaying heavy metal concentrations contained in the sludge (Pickett, July 1985). Includes areas within the HWMF where sludge was found.
Fig. 3 Normalized semilog graph displaying heavy metal concentrations located in the HWMF soils (Pickett, July 1985).

Fig. 4 Cross-section of the closure of the M-Area Settling Basin showing the deposition of stabilized materials and the RCRA style closure cap.
Flow Diagram of the M-Basin Wastewater Treatment Facility

Fig. 5 Schematic of the temporary Wastewater Treatment Facility constructed at the M-Area Settling Basin.

Excavation of Contaminated Soil

Fig. 6 Plan view of the excavation of contaminated areas of the M-Area Settling Basin HWMF, not including the process sewer line.
END

DATE FILMED
4 1291 92