ABSTRACT

In Situ Techniques for the Characterization and Monitoring of a Radioactively Contaminated Site for In Situ Vitrification

Cline, S.R., Bogle, M.A., Spalding, B.P., and M.T. Naney
Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge, TN 37831-6036

INTRODUCTION AND OBJECTIVE

A treatability study was initiated in October 1993 to evaluate the application of in situ vitrification (ISV) to an old seepage pit used for the disposal of radioactive liquid waste at the Oak Ridge National Laboratory (ORNL). This pit, known as Pit 1, is one of seven inactive seepage pits and trenches at ORNL and was constructed in 1951 by excavating a 115 ft by 30 ft trench to a nominal maximum depth of 15 ft. During the 3 months that the pit was operated as a disposal facility, it is estimated to have received approximately 398 curies of mixed fission products, primarily $^{137}\text{Cs}$, $^{90}\text{Sr}$, and $^{106}\text{Ru}$, though the exact mixture of fission product isotopes was not recorded in disposal records. Based on data from analysis of sludge from another pit, the activities for waste sludge in Pit 1 decay corrected to 1993 have been roughly estimated to be 71 and 17.5 curies of $^{137}\text{Cs}$ and $^{90}\text{Sr}$, respectively. The $^{106}\text{Ru}$, with a half-life of 367 days, has decayed completely in the 42 years since its disposal in the pit. Earthen fill material was added to the pit in 1981, and the pit area was then covered with an approximately 4-6 inch thick asphalt surface. Because so little information necessary for the effective and safe ISV of Pit 1 was available, the first phases of the treatability study focused on site characterization activities. Several in-situ techniques were developed and used during characterization to ascertain the pit’s lateral and vertical dimensions, hydraulic and hydrologic properties, soil composition, contaminant inventory, and lateral and vertical distribution of radionuclides. At the end of the treatability study, this characterization effort will be evaluated to determine which properties were the most useful for designing and controlling the ISV process. Such information will be invaluable in efficiently and safely gathering characterization data for the remediation of the other seepage pits and trenches at ORNL via ISV or alternative remediation techniques. This abstract briefly describes some of the major components of the field characterization activities and their results. More detailed information on radionuclide inventory and distribution, soil composition, etc. will be presented later.

Pit 1 Dimensions

Because of the large inventory of radioactive contaminants present in Pit 1 and the potential for significant exposure to the investigators, characterization parameters were determined in situ when possible. One of the first objectives of the characterization work was to determine the actual dimensions, especially depth, of the pit since this information was critical to establishing a location and target depth for ISV. This task was accomplished by penetrating the subsurface (after the removal of asphalt) with a variety of driven rods (1/2 inch o.d. threaded rod and 2 inch o.d. AQ drilling rod) and pipes (2 inch o.d. stainless steel) and determining the depth of increased resistance to penetration. Over 100 rods and pipes were driven along north-south and east-west transects across Pit 1 (see Figure 1) using an electric jackhammer without any residual cuttings or spoil formation. (All drive point locations were subsequently determined via a civil...
DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.
survey of the Pit 1 site.) The time required to drive each successive foot of rod was recorded. The location of the three dimensional boundaries of the pit were estimated based on the depth at which significant resistance or refusal to additional driving was observed. Resistance or drive refusal was assumed to occur at the boundary between the pit fill material and the original undisturbed soil material at the bottom and sloping sides of the pit because of the expected higher bulk density of the undisturbed material. As a result of the in-situ penetration techniques supported additionally by the radionuclide distribution data discussed below, Pit 1 dimensions were found to be 90 ft long by 20 to 25 ft wide with relatively steep-sloped sides. An unexpected, but very important finding from this activity was that the actual pit depth was 25-27 ft below the asphalt pad rather than the expected 15 ft. This increased depth has been attributed to the addition of at least 8-10 ft of fill material to the Pit 1 site during the 1981 capping activity.

**Pit 1 Radionuclide Inventory and Distribution**

In order to characterize the spatial distribution of radioactivity within Pit 1 without producing significant quantities of radioactive sample material, in situ beta/gamma logging was employed. The AQ rods and pipes already emplaced in the pit were used in obtaining details about the quantity and distribution of radioactivity within the pit. Typically, a Geiger-Mueller probe connected to a scaler was lowered down one of the AQ rods (or pipes) and measurements in counts per minute (cpm) were taken at one-half to one-foot intervals. Background counts and a $^{137}$Cs source check were also measured inside a short section of AQ rod and recorded before and after each logging session. Results of the logging confirmed the depth determinations discussed above and indicated that nearly all of the contamination was concentrated in a narrow layer (2-4 inches thick) at the bottom of the pit. In addition, readings along the northern and western sides of the pit were markedly elevated, though much lower than the source contamination at the pit bottom, suggesting that the contents of the pit overflowed during its operation. Figure 2 is a plot of in situ logging data superimposed upon a cross section of the central north-south transect. The dotted line represents the bottom of the pit as determined by drive refusal of the AQ rods. Note that the layer of maximal contamination resides slightly above the refusal depths. Hence, the target depth for ISV operations was determined to be at least to the refusal depth in order to incorporate the source contamination into the melt.

Soil core samples were taken using 1-inch diameter core tube at 14 locations in and around pit 1 including three in the deepest area of the pit along the central north-south transect. Each core was sub-divided into discrete three-inch sections that were weighed and oven dried at 70 C in order to determine dry weight, moisture content and bulk densities. Afterwards, radionuclide assays were performed on each section to determine $^{137}$Cs, $^{90}$Sr, and $^{60}$Co activities. In addition, selected sections were subsampled for determination of additional physical and chemical properties. After core sample collection, AQ rod was driven into six of the existing coreholes including the three deep holes, and the holes were logged in situ as discussed above. The $^{137}$Cs activity (dpm/g) from the radionuclide assays of the six soil cores was correlated, using depth distribution, with the logging data (cpm) for these six coreholes. This correlation or ratio of counts per minute logged with activity (dpm/g) measured was applied to the logging data for all other AQ rods and pipes, enabling a determination of total radionuclide inventory and distribution from the collection of a small number of cores. While the $^{90}$Sr and other
radionuclide analyses are incomplete, the $^{137}$Cs inventory in Pit 1 has been calculated to be 39 curies based upon this characterization effort. Other properties determined for the core samples, including bulk densities, elemental composition, and leach properties, will be used to predict such parameters as melt temperature and product durability.

Pit 1 Groundwater Sampling and Monitoring
Screened Geoprobe$^\text{TM}$ groundwater wells (1 inch o.d.) were also installed to depths of 25 ft. along the central north-south transect of Pit 1 in order to monitor and sample any groundwater present within the pit fill material. Presence of water was determined using Solinst$^\text{TM}$ water level meters (0.01 ft accuracy). Groundwater elevations within Pit 1 and the surrounding area have been measured at least weekly since February 1994. Typical water level data for Pit 1 is presented in Figure 3. The "tracking" of the three wells indicates that the groundwater in Pit 1 is interconnected without possible areas of perched water. While variable with seasonal changes, storm events, etc. groundwater is always present within the pit fill material. During the period studied, the water depth has averaged approximately 8.5 ft below the surface of the asphalt cap, which is at an average ground elevation of 825 ft. Due to correlation of water level rises with rainfall events, it is assumed that Pit 1 is connected to the local groundwater system. Slug tests were also performed using the Geoprobe screened wells. Preliminary data indicates the hydraulic conductivity of the Pit 1 fill material to be $1.9 \times 10^{-4}$ cm/sec. (An estimate of the permeability of Pit 1 material is essential in planning the ISV process since the quantity of water and its recharge into the pit will affect ISV processing rates and cost.) Groundwater samples were also collected from these Geoprobe wells and analyzed for a variety of properties including pH, alkalinity, suspended solids, volatile and semi-volatile organics, and radionuclide composition. These analyses also verified that Pit 1 contained no chemical (RCRA hazardous) contamination.

REFERENCES


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.
Figure 1. Location of points in and around ORNL Pit 1 for penetration tests, AQ rod insertions, water monitoring and sampling wells, and soil core sampling.

Figure 2. AQ rod refusal depths and gross beta/gamma activity versus hole depth within and along the length of ORNL Pit 1.
Figure 3. Elevation of groundwater within ORNL Pit 1 and relation to precipitation.