WASTE REDUCTION BY CHARACTERIZATION AND SEPARATION OF CONTAMINATED SOILS DURING ENVIRONMENTAL RESTORATION

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ABSTRACT

During cleanup of contaminated sites, environmental restoration activities frequently encounter soils with low-level radioactive contamination as well as metals and volatile/semi-volatile organic compounds. Standard protocol is to excavate the soil within the boundary of the contamination, resulting in the commingling and disposal of clean and contaminated material. To reduce the amount of waste generated, Sandia National Laboratories/New Mexico (SNL/NM) Environmental Restoration (ER) Project is pursuing an aggressive waste minimization effort.

Cleanup activities described are for completed remediations at ER Sites 1, 16, and 12B and 228A combination and an ongoing remediation at ER Site 2. Two separation technologies, for radioactively contaminated soils, used at these sites are being evaluated.

The first, the Segmented Gate System (SGS), locates and removes gamma-ray-emitting radionuclides from soil. The soil is transported to an analyzer/separation system, which segregates the clean and contaminated material, based on radionuclide activity level.

A second technology, the Large Area Gamma-Spec System (LAGS), utilizes a gamma spec analyzer suspended over a soil batch volume of about 7 ½ cubic meters. A full-spectrum analysis for the isotopes of interest is obtained. The LAGS has been tested on soil excavated from the Classified Waste Landfill, ER Site 2, located in Technical Area II (TA-II).

The ER Project at SNL/NM utilized the SGS on soil from excavations at: 1) The Radioactive Waste Landfill (RWL), ER Site 1; 2) The Open Dumps (Arroyo del Coyote), ER Site 16; and 3) The Burial Site/Open Dump (Lurance Canyon), ER Site 12B and Centrifuge Dump Site, ER Site 228A combination. Initially, 971, 506, and 846 cubic meters, respectively of soil would have required off-site disposal at a life cycle cost of $1,292 per cubic meter (Reference 1). With SGS processing, soil volume was reduced to 278.6, 0.24, and 27 cubic meters, respectively, for a cost avoidance of $884K, $653K, and $1,058K.

This evaluation is being conducted as part of the Pollution Prevention Tools for Environmental Restoration project. Results of the field tests using the SGS and the LAGS will be presented.

INTRODUCTION

During cleanup of contaminated sites, Sandia National Laboratories, New Mexico (SNL/NM) frequently encounters soils with low-level radioactive contamination. The contamination is not uniformly distributed, but occurs within areas of clean soil. Because it is difficult to characterize heterogeneously contaminated soils in detail, and to excavate such soils precisely using heavy equipment, it is common for large quantities of uncontaminated soil to be removed during excavation of contaminated sites. This practice results in the commingling and disposal of clean and contaminated material as low-level waste (LLW), or possibly low-level mixed waste (LLMW). Until recently, volume reduction of radioactively contaminated soil depended on manual screening and analysis of samples, which is a costly and impractical approach and does not uphold As Low As Reasonably Achievable (ALARA) principles. To reduce the amount of LLW and LLMW generated during the excavation process, SNL/NM is evaluating two alternative technologies. These technologies are the Segmented Gate System (SGS) and the Large Area Gamma-Spec System (LAGS). The SGS has been used at the Radioactive Waste Landfill (RWL), ER Site 1, the Open Dump (Arroyo del Coyote), ER Site 16, and the Burial Site/Open Dump (Lurance Canyon), ER Site 12B and Centrifuge Dump Site, ER Site 228A combination. The LAGS has been used at the Classified Waste Landfill (CWL), ER Site 2.

Acknowledgement
Acknowledgement of the following individuals must be made for their remediation efforts at the various ER sites and contribution of data discussed in this paper: Bob Galloway, Paula Slavin, Joe Fritts, Sue Collins, Anh Lai, Mike McVey, John Copland, Paul Freshour, and Erne Vinsant.

SITE HISTORIES

The Radioactive Waste Landfill

The RWL, ER Site 1, located in the eastern portion of TA-II, was identified in the Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA) as Solid Waste Management Units (SWMUs) 32 through 37. The RWL consisted of three pits and three trenches where low-level radioactive waste was disposed of from 1949 to 1959. The waste was not containerized before disposal, and the unlined pits and trenches did not contain leachate detection or collection systems. During their use, the active pits and trenches were temporarily covered with plywood. The pits and trenches were filled, and then covered with native soil and capped with approximately one meter of concrete. Metal pipes were originally installed to mark the corners of the concrete caps. The excavated pits and trenches were estimated to be 450 cubic meters and 600 cubic meters, respectively. No detailed records of waste material disposed in the RWL are available. However, Department of Energy (DOE) Solid Waste Information Management System (SWIMS) records show that an estimated 315 cubic meters of radioactive waste was buried in the landfill, with an estimated total activity of 2,847 curies (Ci).

Excavation of the RWL was completed in late 1996. Waste materials were removed, containerized and disposed as LLW. Radioisotopes consisted of uranium-238, tritium, radium, cobalt-60, nickel-63, cesium-137, strontium-90, and plutonium. The excavated soil was segregated for separate processing.

The Open Dumps (Arroyo del Coyote)

The Open Dumps (Arroyo del Coyote), ER Site 16, covers an area of approximately 113,000 square meters and is located along Arroyo del Coyote northeast of the access road to Technical Areas III/V (TA-III/V). Dumping and quarrying began between 1959 and 1967. The site is no longer active, and access is uncontrolled. Process knowledge indicated that the following were dumped on the site:

- Construction demolition debris from facilities known to have used depleted uranium, such as Building 9939 and the TA-III sled tracks;
- Concrete laser targets;
- Large concrete crucibles used to test concrete-sodium reactions (Building 9939);
- A concrete septic tank;
- Piles of fire bricks (2 piles contained asbestos);
- A pile of oil shale and slag dumped between 1983 and 1985;
- Numerous piles of soil apparently from the large excavation to build the TA-V facilities deposited between 1959 and 1967;
- Rocket debris, foam insulation, cans, wood, and rebar.

In January 1994, a visual surface inspection found no unexploded ordinance or high explosives. In February 1994 and June 1996, radiological surveys located 23 anomalies consisting of debris piles and depleted uranium fragments. In November 1994, a photographic interpretation was completed. In May 1995, soil vapor and geophysical surveys were completed with no significant findings. In November 1995, soil samples were taken and analyzed for metals and volatile organics. In March 1995, June, October, and November of 1996 and October 1997 through April 1998, voluntary corrective measures removed all the surface radiation anomalies except two which were determined to be naturally-occurring geologic material.

The Centrifuge Dump Site

The dump area is an inactive site covering approximately 6500 square meters located east of ER Site 50 (Old Centrifuge Site) along the Tijeras Arroyo floodplain and TA-II embankment. Dumping at the west end of the site was associated with operating the old centrifuge. In general, dumping at this site was uncontrolled and undocumented. Visible debris appears to be construction materials and various metal objects.

In 1994, a gamma-beta surface radiological survey detected three radiation anomalies along the end of an embankment in some construction debris. One anomaly was a small electrical component with no associated uranium oxide; it was removed. The partial remediation of the other two anomalies generated thirteen 55-gallon drums of depleted uranium contaminated soil and depleted uranium fragments.

In November 1994, an enhanced aerial photograph interpretation report was completed for ER Site 228. This identified soil disturbances at the site from 1951 through 1988. A 1968 photograph was the last record of dumping and excavation. Subsequent photographs reveal no significant additional dumping or excavation. By 1989 most of the site had been covered with fill material. Fill material was either pushed from the higher reaches of the site (generally northeast to southwest) or imported.

In May 1995, passive soil vapor samples were collected at 41 locations; these samples were analyzed for volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs). Many of the samples indicated ion counts in excess of 1,500,000 counts. The highest soil gas response level was 2,842,120 ion counts for per-chloro ethylene (PCE). Soil vapor responses are semi-quantitative and cannot be directly correlated to soil concentrations. However, readings in the millions-range of PCE generally relate to parts-per-billion soil concentrations. The two soil vapor samples in the vicinity of the radiological anomalies did not indicate any VOCs or SVOCs there.

In June 1995, a surface geophysical survey was conducted across the entire site. The investigation revealed five potentially significant burials.

In July 1995, a scoping investigation was conducted. Fourteen boreholes to depths of 6.1 meters were installed and samples were collected every 1.5 meters. Samples were collected where soil vapor samples indicated the presence of PCE and tri-chloro ethylene (TCE). Each sample was analyzed by in-house laboratories for gamma radiation, VOCs, and RCRA metals. The gamma spectroscopic results indicated no radiation above background. There were no VOCs detected in the soil samples as well.

A Voluntary Corrective Measure (VCM) plan to remove depleted uranium (DU) was completed in June 1998.

The Burial Site/Open Dump (Lurance Canyon)

The Burial Site/Open Dump (Lurance Canyon) is comprised of two subunits: Site 12A and Site 12B. Site 12B is approximately 170 meters long and 6 to 9 meters wide. The site is within a former arroyo channel in the canyon floor alluvium in the closed upper reaches of the Lurance Canyon drainage. Moderately steep canyon walls surround the site, and the immediate topographic relief is over 150 meters.

Activity at Site 12B is probably associated with the historical operation of Site 65, the Lurance Canyon Explosives Test Site. The site was listed as a radioactive materials management area (RMMA) because of documented depleted uranium contamination from explosives testing at Site 65. It was delisted in January 2000. A review of available historical aerial photographs verified that the site was undeveloped prior to 1971.

By 1975, site-grading activities had buried a small portion of the arroyo. These activities continued until approximately 1983, when the central and southern portions of the graded area at Site 65 covered the arroyo. Various tests, including general explosives tests, fuel-fire burn tests of test units containing explosives, and rocket propellant burn tests, were conducted at Site 65 from 1967 to 1993.

Comprehensive records on the material buried at Site 12B were not located. Interview records state that solid debris such as cables, wire, and insulation material from past burn tests may be present in the buried portion of the arroyo channel. Additional debris may include wood, sandbags, weapons casings, camera stands, mirrors, and high explosive residue.

During remediation efforts at Site 12B, approximately 4 cubic meters of soil was segregated and the contamination was judged to be similar to that at Site 228A. This soil was then transported to Site 228A to be processed with soil from Site 228A.

The Classified Waste Landfill

The CWL, ER Site 2, located in the eastern portion of TA-II and covering approximately 10,000 square meters, is part of a locked, controlled-access, fenced area. Classified waste, defined as surplus material that by shape or content contains information important to national security, was buried in the landfill from the early 1950s through 1990; however, classified material may have been disposed of in the CWL as early as 1947. The majority of classified waste in the CWL is composed of metal, plastic, and paper. Until 1958, no records were maintained for material disposed of in the landfill. An inventory of the classified material buried prior to June 1972 was apparently destroyed during file purging following a DOE paperwork reduction initiative.

At the CWL, waste material was buried in unlined trenches with no leachate containment or monitoring devices. During disposal operations, the trenches were backfilled one section at a time after waste emplacement, and each section was covered with at least 1.8 meters of native soil. Steel pipes, placed at the end of each section as it was filled, were labeled with reference to their location.

Historical information suggests that some tubes (possibly glass) containing nickel and strontium radioisotopes may have been buried in the landfill, as well as other components that may have contained tritium. Lead, poly-chlorinated biphenyls (PCBs), DU, beryllium, and chlorinated solvents such as TCE, are among the potential contaminants. Other items buried in the landfill include weapon cases, shells, and related components, lasers, furnace parts, radar equipment, aluminum parts, and test panels. Radioactive calibration sources were also buried in the CWL. Some classified material contained gold plating, silver, and platinum; it was often buried if it was associated with classified parts or material. Most items in the CWL are labeled as security containers, hoppers, missiles, skids, and wooden boxes.

TECHNOLOGY DESCRIPTIONS

Segmented Gate System

The SGS is a transportable gamma radiation detector system with motorized conveyor belts, a variable belt speed motor controller, air actuated segmented gates, a radionuclide assay computer system, and two sets of radiation detector systems applicable to radionuclides that emit low and high energy gamma rays (Reference 2). The mobile unit includes a material feed conveyor, a sorting conveyor coupled to a motor control unit and material conveyors for below criteria (clean) and above criteria (contaminated) material (See Figure 1).

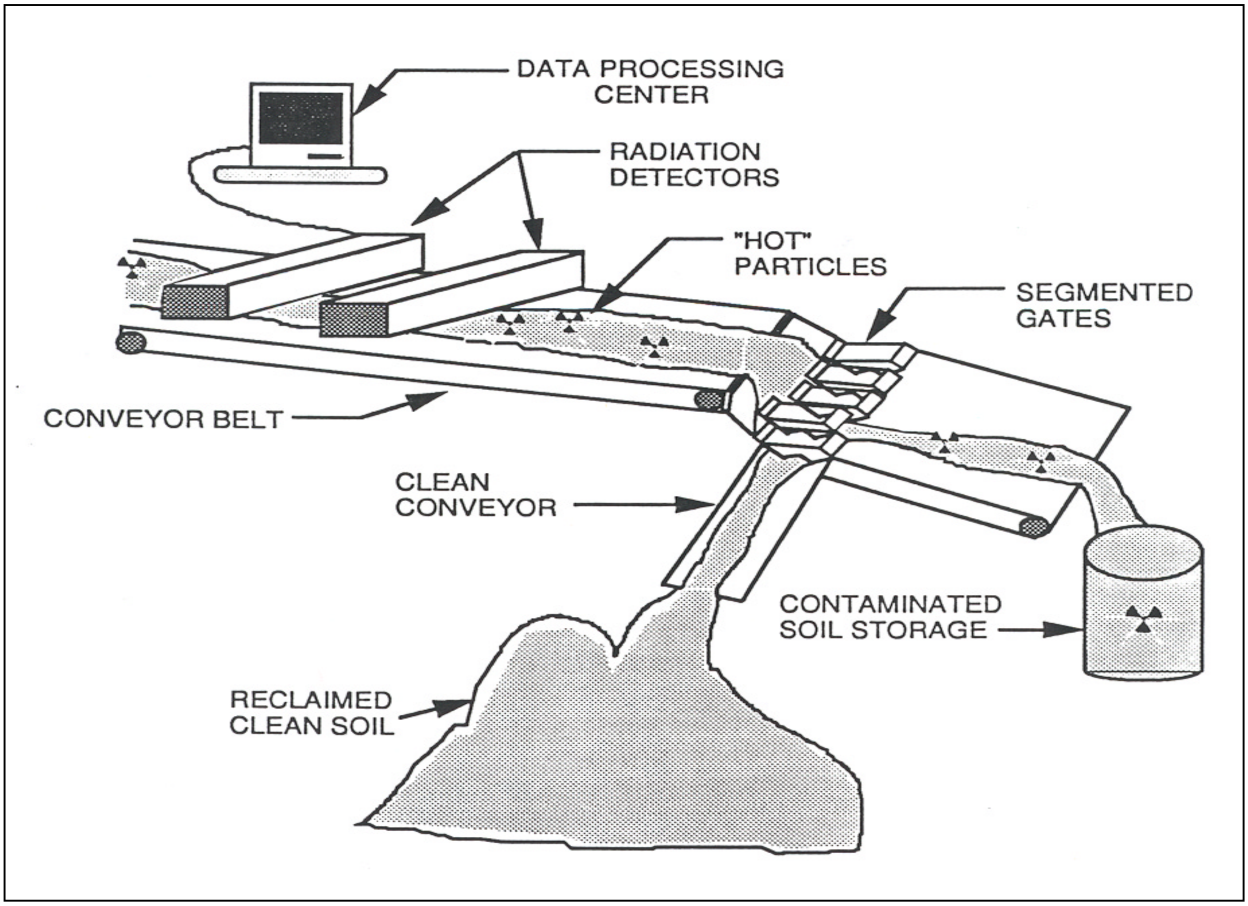

Figure 1. Component Schematic of the Segmented Gate System.

Process material is screened through a separation plant to remove rocks and debris then conveyed underneath the detector arrays at a speed selected for the specific radioisotope of interest and the soil characteristics. These arrays are linked to a control computer, which toggles pneumatic diversion gates located at the end of the sorting conveyor. Contaminated material that exceeds the criteria for radioactive materials is diverted to the contaminated material conveyor, where it is transferred to one of two stacking conveyors. Below criteria material falls directly onto the clean material conveyor (See Figure 1), which transports it to the other stacking conveyor (See Figure 2).

Two sets of gamma radiation detector arrays are housed in shielded enclosures that can be adjusted vertically above the flat assay conveyor belt allowing for various soil thicknesses. The detector systems microprocessor obtains a net count from each detector at the end of every count period and sends it to the control computer. The control computer analyzes the shape of the activity peak generated by the signal and actuates the appropriate gate(s).

The control computer records the date, time, activity, gates used, and mass of each contaminated soil diversion. This information is tabulated by the control computer and stored on the internal hard disk for data archiving and report generation. Data are also backed up daily on removable storage media. Upon command the control room computer can generate production reports.

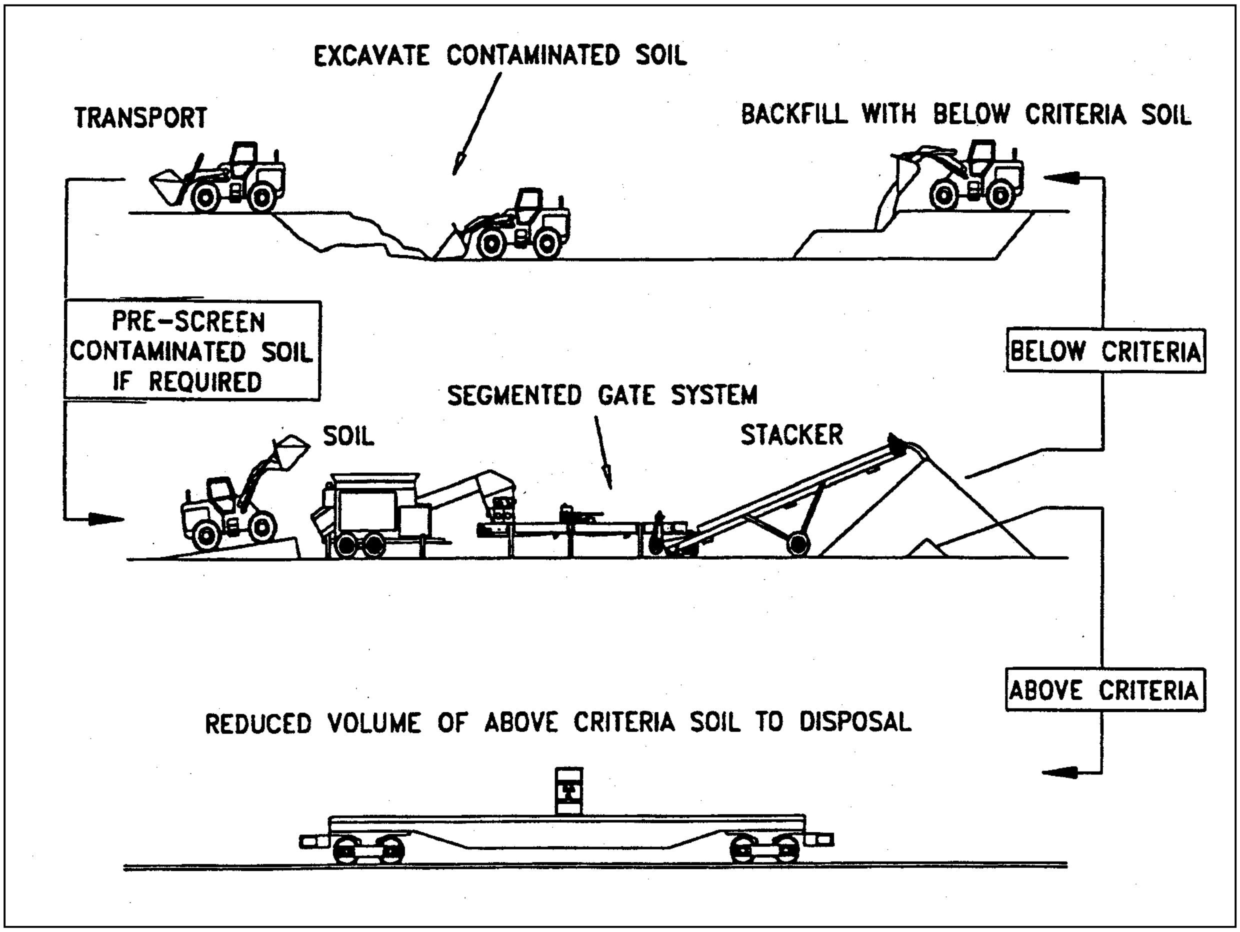

Figure 2. Process Flow for Segmented Gate System.

Large Area Gamma Spec System

The LAGS utilizes a high purity lithium doped germanium (GeLi) gamma spectroscopy analyzer system that can be used for either routine laboratory sample analysis or environmental in-situ analysis of field soil. At SNL/NM, an artificial field setup was designed and built adjacent to the remediation excavation of Site 2, the CWL. This design included suspending the GeLi detector over a concrete slab (10 meters by 10 meters) upon which soil from the excavation is spread out to a uniform depth of about 7 ½ centimeters (total batch volume of about 7 ½ cubic meters). Soil is counted for a period of approximately 30 minutes to obtain a full-spectrum analysis for the isotopes of interest. The entire setup is enclosed by a sprung structure enclosure.

Using the Canberra Genie-PC software, batch procedures automate environmental in-situ gamma spectroscopy analysis. Current batch procedures allow for spectrum acquisition, saving of an acquired spectrum, viewing the spectrum collected or acquired on the detector, and analysis of a saved spectrum. During environmental in-situ spectrum analysis, the user is prompted for the number of files to be analyzed, the name of the first file to be analyzed, and the sample information for each file to be analyzed. Next, assuming a uniform source distribution, the program locates spectral peaks, quantifies the associated area, matches each peak against a user defined library identifying the candidate isotope(s), and converts peak count rate to radionuclide concentration from activity per unit mass to exposure rate in μR/hr. A detailed summary report is printed which includes sample information, exposure rate, radionuclide concentration, the 2-sigma concentration error associated with the isotopes found, and a MDA value for all nuclides in the library.

In addition, portable GeLi systems have been calibrated for environmental in-situ spectroscopy using the DOE Environmental Measurements Laboratory (EML) HASL-258 method. The technique is particularly well suited for quickly determining the level of contamination over a large area, screening for establishment of soil sampling locations, monitoring the progress of cleanup activities, and establishing that acceptable activity levels have been met. Currently, systems are calibrated assuming a uniform depth distribution for the quantification of natural gamma emitters and associated external radiation exposure. During in-situ analysis in a non-standard counting geometry, the user is prompted whether or not to perform a disc source-solid angle correction. For a measurement where the sample approximates a disc source, and is counted at a known distance from the detector face, this correction is used to estimate the absolute efficiency of the system, which yields more accurate activity results.

RESULTS

SGS and the RWL

Initially, a total of 26 individual soil piles (numbers 1 through 26) were generated from the excavation of the RWL. Soils suspected of plutonium and americium contamination were excavated and placed directly in 1.5 cubic meter sacks for storage and to prevent spread of airborne contaminants. In preparation for SGS processing, the 1.5 cubic meter sacks were emptied to form Pile 27. Pile numbers 4, 15, 20, 25, and 27 representing a total volume of 971 cubic meters, were sorted using the SGS. Release limits were based on the DOE Residual Radioactivity (RESRAD) soil Radiological Risk Based Preliminary Remediation Goals (PRG) for volume reduction.

Before SGS sorting began, sampling of the soil piles indicated the contaminants that the system should be "tuned" to look for were uranium, plutonium, and cesium. Pile 4 was sorted by the SGS for U-238, and achieved a 99 plus percent cleanup efficiency (CE). Pile 15 was sorted for Cs-137 with a 98.8 percent CE. Pile 25 was sorted for Cs-137 with a 55.8 percent CE. Piles 20 and 27 were sorted for Pu-239 with a 25.8 percent and 82.8 percent CE, respectively.

SGS and the Open Dumps (Arroyo del Coyote)

At the Open Dumps (Arroyo del Coyote), Site 16, a total of 506 cubic meters were processed through the SGS. An additional volume of oversize material, estimated at 25 percent of total volume, was not sorted through the SGS. Total volume reduction reported by the SGS was in excess of 99 percent. Actual volume reduction for the first pass was closer to 97.5 percent after accounting for soil that was sent to the above criteria path due to unscheduled operational halts. Total soil volume that was sent to the above criteria path due to unscheduled halts was 12 cubic meters.

The 12 cubic meters in the above criteria pile was processed again to remove the soil generated from operation halts. A total of 0.24 cubic meters (slightly more than one 55-gallon drum) of above criteria soil required off-site disposal.

SGS and the Burial Site/Open Dump (Lurance Canyon) and Centrifuge Dump Site Combination

Characterization of the Centrifuge Dump Site, Site 228A, indicated that DU was the only contaminant present at the site. The volume of possibly contaminated soil was initially estimated at around 1400 cubic meters, including an estimated 20 percent of oversize material. Manual removal of visible DU fragments was done after localized heavy rains eroded a portion of the DU burial spreading DU mixed with soil and some debris down the slope in a deposit that extended as far as 90 meters from its original source. This manual removal of exposed DU and debris along with more accurate definition of the extent of the contaminated soil finally resulted in a total processed soil volume of 846 cubic meters. This includes the 4 cubic meters of soil that was transported and processed from the Burial Site/Open Dump (Lurance Canyon), Site 12B.

The SGS processing of the 846 cubic meters of soil from this site combination resulted in a reduction of the soil to be disposed of by 819 cubic meters. The volume of soil shipped offsite for disposal was 27 cubic meters.

SGS Cost-Benefit Analysis

Table I summarizes the economic benefit realized from using the SGS at the two SNL/NM sites. Two different scenarios are presented. The DOE model uses the DOE Life Cycle Waste Disposal Costs, Source: Avoidable Waste Management Costs, INEL-94/0250, January 1995 (Reference 1). The Sandia model uses disposal and shipping costs that the SNL/NM ER project incurs. These costs are nearly three times less than the estimated DOE life-cycle costs. The DOE model should be used to estimate true life-cycle costs, and to standardize savings to compare similar projects at different sites. However, it should be noted that these are estimated savings to DOE, and not to the project. A project manager considering remediation alternatives must be able to justify up-front implementation costs based on the project budget alone.

Table I. SGS Economic Benefit Summary

	Site 1, Radioactive Waste Landfill	Site 228A and 12B	Site 16, Open Dump (Arroyo del Coyote)
Volume Processed (cubic meters)	971	846	506
Volume Reduction (cubic meters)	684	819	505.8
Implementation Costs	$200K	$190.6K	$160.5K
COST AVOIDANCE			
DOE @ $1292/cubic meter	$884K	$1,058K	$653K
SNL/NM @ $445/ cubic meter	$304K	$364K	$225K
COST SAVINGS			
DOE @ $1292/ cubic meter	$684K	$867.4K	$492.5K
SNL/NM @ $445/ cubic meter	$104K	$173.4K	$64.5K
PROCESSING COST (imp. cost / vol. processed)	$206/cubic meter	$225/cubic meter	$317/cubic meter

A key determining factor in deciding whether or not to use the SGS is the contaminated soil volume. Despite some operational problems (see below), processing costs were less at the RWL (Site 1) with the Centrifuge Dump Site and the Burial Site/Open Dump (Lurance Canyon) (Site 228A and 12B) combination ranking second. In general, processing cost is lower when the soil volume to be processed is greater.

SGS Separation Limitations

The SGS has a proven track record in separating above criteria material from below criteria material. However, it works best in a situation where the contaminant radionuclides are well defined and their energy spectra are compatible with the calibration constraints of the system.

A positive example is the experience with the SGS at the Open Dumps (Arroyo del Coyote). The only known radionuclide in the contaminated soils was depleted uranium (U-238). The SGS was calibrated for the spectrum of U-238 and processing began and was completed with no major problem. Examination of the above criteria and below criteria fractions showed a successful operation.

A negative example occurred during the SGS operation on the soils from the Radioactive Waste Landfill (TA-II). It was anticipated that a specific pile of soil was contaminated with radionuclide "A". The SGS was calibrated to detect "A". Processing began and "A" was not being seen. However, using a portable gamma-spec system, the soil was scanned and it was determined that radionuclide "Z" was the main contaminant. The SGS was recalibrated to detect

"Z" and processing continued. When processing was completed, the below criteria fraction and the above criteria fraction were scanned and it was found that "A" was indeed in the soil and could be found in relative abundance in the below criteria (clean) fraction. The SGS was then recalibrated for "A" and the below criteria (clean) fraction was reprocessed.

An additional factor inherent in the operation of the SGS in any situation is the mobilization/demobilization cost. This cost may be in the neighborhood of $100,000.

LAGS and the Classified Waste Landfill (TA-II)

In developing the remediation plan for the CWL, it was anticipated, from the review of records, that there would be no significant radioactive contamination of the soil. Also, it was anticipated that if there was soil contamination, the potential for multiple radionuclides (U, Th, Pu, Ra, …) could be high. With this in mind, the LAGS was selected as a means for reducing the amount of clean fill material being disposed of as LLW.

In general, all the material that has been removed from the landfill has been in the form of discrete artifacts. As excavation proceeds artifacts are separated and removed from the soil, which is then sent to the LAGS. The LAGS is used as a means to screen, one batch at a time, about 7 ½ cubic meters of this separated soil. If analysis shows above background activity, the batch of soil is then screened by hand to find associated hot spot(s). Hot spot(s) are then removed and remaining soil is moved to an area reserved for clean excavation backfill material.

Additionally, the LAGS is being proposed as a means of performing artifact characterization. Correct geometry and counting parameters are being studied to establish the feasibility of determining radionuclides and their quantities to provide definitive waste characterization data. Remediation activities at the CWL are ongoing and have yet to show any radioactive soil contamination above relevant criteria.

Since the remediation activities at the CWL are ongoing, a cost analysis cannot be completed. However, the following system costs should be noted. The LAGS consists essentially of a high purity GeLi detector at a cost of $40K, a multi-channel analyzer at a cost of $20K, and a computer with software to run the system at a cost of $5K. Total cost for the gamma-spec system, excluding the cost for the concrete slab used to spread out soil, is approximately $65K. Additional costs include labor both for technicians to run the system and heavy equipment operators to move soil.

LAGS Separation Limitations

Experience with LAGS at the CWL (TA-II) to date has shown the system to be simple and relatively flexible in its operation. The LAGS is well adapted to materials contaminated with multiple radionuclides with gamma emission energies varying over the spectrum. Its potential to be used as a waste characterization system for excavated artifacts is showing promise.
A drawback that may be experienced with the system is the batch operation mode that must be used. At the CWL a batch of 7 ½ cubic meters of soil is counted for 30 minutes. Additionally, labor is involved in transporting the soil to the counting pad and spreading it to the required thickness for the counting parameters involved. Once counting is completed, the soil must then

be removed and a new batch of soil prepared on the pad. This batch mode is time-consuming and could relay a higher operating cost due to its labor intensity.

CONCLUSIONS

Although sufficient data has not yet been developed from remediation activities at the CWL to support a complete cost analysis for LAGS, general conclusions can still be drawn.

First, both systems work well but work best for different situations. The SGS works best when soils are contaminated with radionuclides of similar emission energy spectra. The SGS has a clear cost benefit analysis when a large amount of contaminated soil is present. The LAGS works best when multiple radionuclides are present. Use of the LAGS is warranted when a small amount of contaminated soil requires processing.

The professional judgment of SNL/NM ER personnel who have performed rough calculations indicate that roughly 1,150 cubic meters of process soil is required to present a clear cost savings benefit by utilizing the SGS. Lesser amounts require a thorough cost benefit analysis to be performed before a decision to implement SGS is made.

Both SGS operations (Radioactive Waste Landfill and Open Dumps) benefited from external funding that subsidized the use of the SGS. Funding ($60K) was obtained from the DOE high Return on Investment (ROI) program to support the use of SGS at the Radioactive Waste Landfill. Use of the SGS at the Open Dumps was proposed and predominantly supported by the Environmental Restoration Technology Department 6131 at SNL/NM. Of the $160.5K used for the SGS, the Environmental Restoration Technology, Department 6131, provided approximately $140K and the Environmental Restoration for Technical Areas and Miscellaneous Sites, Department 6133, (the SNL/NM organization responsible for the remediation of the Open Dumps) provided the balance. The LAGS operation at the CWL benefited from the free use of the system provided by the Personnel Monitoring and Lab Services Department at SNL/NM.

REFERENCES

1. Avoidable Waste Management Costs, INEL-94/0205, January 1995.

2. Segmented Gate System TA-II Remediation Project, Sandia National Laboratories, Final Report, September 1997.

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under Contract DE-AC04-94AL85000.