COST AND PERFORMANCE REPORT

Thermo NUtech's Segmented Gate System

Tonapah Test Range, Clean Slate 2
Tonapah, Nevada

Accelerated Site
Technology Deployment

U.S. Department of Energy

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This report was prepared for the U.S. Department of Energy by:

Sandia National Laboratories; Albuquerque, New Mexico

For More information, please contact:
Tom Burford, Sandia National Laboratories, (505) 845-9893
or
Mike Hightower, Sandia National Laboratories, (505) 844-5499

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LIST OF ACRONYMS

ASTD	Accelerated Site Technology Deployment Program
BN	Bechtel Nevada
CEARP	Comprehensive Environmental Assessment and Response Program
DOE	Department of Energy
DOE/NV	Department of Energy, Nevada Operations Office
EPA	Environmental Protection Agency
ER	Environmental Restoration
ES&H	Environment, Safety and Health
FS-5	Firing Site Five
HE	High Explosive
HSWA	Hazardous and Solid Waste Amendments
ITRD	Innovative Treatment Remediation Demonstration
NTS	Nevada Test Site
PPE	Personal Protective Equipment
PRG	Preliminary Remediation Goal
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
SGS	Segmented Gate System
SVOC	Semi-volatile Organic Compound
SWMU	Solid Waste Management Unit
VOC	Volatile Organic Compound
WBS	Work Breakdown Structure

FOREWORD

The Department of Energy (DOE) is working to accelerate the acceptance and application of innovative technologies that improve the way the nation manages its environmental remediation challenges. The DOE Office of Science and Technology established the Accelerated Site Technology Deployment Program (ASTD) to help accelerate the acceptance and implementation of new and innovative soil and ground water remediation technologies. Coordinated by the Department of Energy's Idaho Office, the ASTD Program reduces many of the classic barriers to the deployment of new technologies by involving government, industry, and regulatory agencies in the assessment, implementation, and validation of innovative technologies.

Funding is provided through the ASTD Program to assist participating site managers in implementing innovative technologies. The program provides technical assistance to the participating DOE sites by coordinating DOE, industry, and regulatory participation in each project; providing funds for optimizing full-scale operating parameters; coordinating technology performance monitoring; and by developing cost and performance reports on the technology applications.

In 1995, the DOE's Innovative Treatment Remediation Demonstration (ITRD) Program initiated a joint project with DOE Plants in Ohio to investigate the use of innovative technologies for the remediation of heavy-metal contaminated soils. Preliminary technology assessments indicated that processing radionuclide-contaminated soils through physical separation using advanced sensors was cost-effective and could significantly reduce the volume of soil requiring either further treatment or off-site disposal. The ITRD program sponsored a study using the Segmented Gate System (SGS) for separating uranium and plutonium contaminated soil from clean soil. Based on these results, Sandia National Laboratories' Environmental Restoration Project and the ITRD Program sponsored a soil remediation effort at Sandia's Technical Area II in August and September 1997 using the SGS. The system was used to cost effectively clean and separate contaminated soil for four different contaminants; plutonium, uranium, thorium, and cesium. Based on those results, the DOE's Ohio Field Office submitted an ASTD proposal to use the SGS at seven other DOE sites across the country.

The purpose of this Cost and Performance Report is to document the project activities, project data, and provide evaluation results of the operational cost and performance of the ASTD deployment of the SGS at the Nevada Operations Office (DOE/NV), Tonopah Test Range, Clean Slate-2 soil remediation site.

1. SUMMARY

On May 4,1998, the ASTD Program in cooperation with Bechtel Nevada deployed Thermo NUtech's Segmented Gate System (SGS) for a radioactive material volume reduction project. The deployment took place at the U.S. Department of Energy, Nevada Operations Office (DOE/NV), Clean Slate-2 soil remediation site. The site is located 130 miles northwest of Las Vegas and 40 miles southeast of Tonopah Nevada in the central portion of the Tonopah Test Range. The test range is in the northwest portion of Nellis Air Force Base and north of the Nevada Test Site.

The DOE/NV Environmental Restoration Program includes sites with large quantities of soil contaminated with finely dispersed plutonium. The contamination resulted from safety shot experiments conducted in 1963. Interim corrective actions have been completed at Double Tracks and Clean Slate 1. Corrective actions are scheduled for three additional sites; Clean Slate 2, Clean Slate 3, and Project 57.

Field activities using Thermo NUtech's SGS took place between May 4**,** 1998 and June 12, 1998. The initial work involved the mobilization of the Bechtel Nevada (BN) support equipment and facilities, and the receipt and setup of the Thermo NUtech equipment. Following equipment setup, the SGS was checked and calibrated. The purpose of this mobilization was to assess the performance of the system in reducing the quantity of plutonium contaminated soil.

Soil processing began on May 18, 1998, and continued through June 3, 1998. A total of 333 cubic yards of soil was processed through the SGS. Mobilization, system setup and calibration were accomplished during the allotted time. Demobilization went as expected, and there were no problems decontaminating the SGS equipment prior to it leaving the Clean Slate 2 site.

The soil volume reduction ranged from 4 percent to 99 percent and was dependent on the activity in the processed soil compared to the set-point value used to activate the sorting gates. Because a corrective action level had not been established, different set points were tested relative to the soil activity level in order to maximize data points for comparison.

Total cost of the SGS treatability study at Clean Slate-2 was $138,126, detailed costs are outlined in Table 4.

2. SITE INFORMATION

Identifying Information

Facility:	Tonapah Test Range
Location:	Tonapah, Nevada
OU/SWMU:	Clean Slate-2
Regulatory Driver:	RCRA
Type of Action:	Corrective Measure – Site Remediation
Technology:	Thermo NUtech's Segmented Gate System
Period of operation:	May 18th to June 3rd 1998
Treatment volume:	333 yd^3

Site Background

Tonapah Test Range is a DOE and DOD weapons testing range. The Clean Slate-2 site is situated within the boundaries of the Tonopah Test Range in an area called Cactus Flat. Operation Roller Coaster was a series of four nuclear weapons, component, explosive vulnerability destruction experiments conducted in 1963. These experiments left varying levels of finely dispersed plutonium at the site. The clean up of that plutonium is the subject of this report. Interim corrective measures have been completed at two of the sites, Double Tracks and Clean Slate-1.

Release Characteristics

Characterization of the site indicated that finely dispersed plutonium was the only contaminant present at the site. There is a large volume of surface contaminated soil from the explosive tests. Only a small volume of soil was a part of this assessment. The deposition mechanism caused the plutonium concentrations to vary widely across the area designated for soil processing.

Site Contacts

Funding for the project was provided under the Accelerated Site Technology Deployment Initiative under the direction of Tom Burford [(505) 845-9893]. The technical contact for the Clean Slate-2 SGS project is Mike Hightower, of Sandia National Laboratories [(505)-844-5499]. The project manager for Thermo NUtech is Scott Rogers [(505) 471-3232 ext. 651].

Existing Baseline Remediation Technology Description

The baseline technology for this site remediation has been:

- Excavating contaminated soil with activity exceeding the corrective action level.
- Assaying the soil for transportation and disposal using a sodium iodide (NaI) belt detector system.
- Loading the soil into "burrito wrap" lined trailers.
- Hauling the soil to the Nevada Test Site (NTS) for disposal, and
- Disposing the soil in the Area 3 Radioactive Waste Management Site (RWMS).

Reducing the volume of contaminated soil requiring disposal could help reduce the overall life-cycle cost of soil remediation projects at this site. The potential savings are in the volume reduction of contaminated soil loaded into trucks, hauled to the NTS, and disposed.

3. MATRIX AND CONTAMINANT DESCRIPTION

The type of matrix treated by the SGS at Clean Slate-2 was radionuclide-contaminated surface soil mixed with small amounts of gravel. The processed material contained no significant debris.

Nature and Extent of Contamination

The only contaminant of concern found in the characterization of Clean Slate-2 was finely dispersed plutonium (Pu). Contamination ranged from background to greater than 1100 pCi/g. The plutonium contamination is estimated to affect an area of sixty acres. This includes approximately 26,000 cubic yards of soil to depths of two to sixty inches. The site is still undergoing characterization. With expansion due to excavation, the total volume of contaminated soil at Clean Slate-2 is estimated to be approximately 32,000 cubic yards.

Matrix Characteristics Affecting Treatment Cost or Performance

Soil type was primarily desert alluvium consisting of sand and silt with some gravel and cobbles. Due to the desert climate soil moisture content was very low. The soil type and moisture content were optimal for operation of the SGS.

4. TECHNOLOGY DESCRIPTION

Purpose of Technology

Due to depositional mechanisms, contaminated soil is often heterogeneously distributed. The SGS is used to separate radionuclide contaminated soil from clean soil. The goal is to separate the contaminated soil to a predetermined acceptable level, reduce the volume of contaminated soil requiring disposal and reduce soil disposal costs.

Segmented Gate System Description

The Thermo NUtech 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 arrays of sodium iodide (NaI) detectors applicable to radionuclides that emit low and high energy gamma rays. This mobile unit includes a material feed conveyor, a sorting conveyor coupled to a sophisticated motor control unit to assure constant belt speed, a contaminated material conveyor, and a below criteria material conveyor.

The sorting conveyor, detector arrays, segmented gates, and all downstream conveyors and subsystems are controlled through the use of an on-board computer that is operated from a mobile van. The computer makes soil-processing decisions based on operating parameters entered by the control room technician. The operating display on the computer shows real-time status of the conveyor monitor system and will automatically shut down all components when abnormal conditions are detected.

In addition to the components of the sorting system itself, several support components are needed for operation of the system. A transportable air compressor provides air pressure for the pneumatic cylinders. A separate van houses the computer and also provides operating space for the control room technician. A portable generator may be used if commercial power is not available. The equipment weighs 40,000 lbs. so a 35 to 50 ton crane is needed for loading and unloading equipment in addition to a forklift. A front-end loader with a 2 to 5 yard bucket no greater than 8.5' in width is needed to move soil to and from the SGS plant. Site requirements for SGS staging and soil processing are listed in Table 1. The SGS footprint is depicted in Figure 1.

Table 1. SGS Staging and Processing Area Requirements

Provision	Requirement
Staging Area	Level area, 100 feet x 130 feet
Power	250 Amp, 208 Volt, 3 phase power 115 Volt power for overnight and weekend detector chamber environmental control
Water	Water supply for dust suppression (100 to 200 gallons per day)
Ancillary Equipment	35 to 50 ton crane, loader with 2 to 5 yard bucket no wider than 8.5 feet, forklift

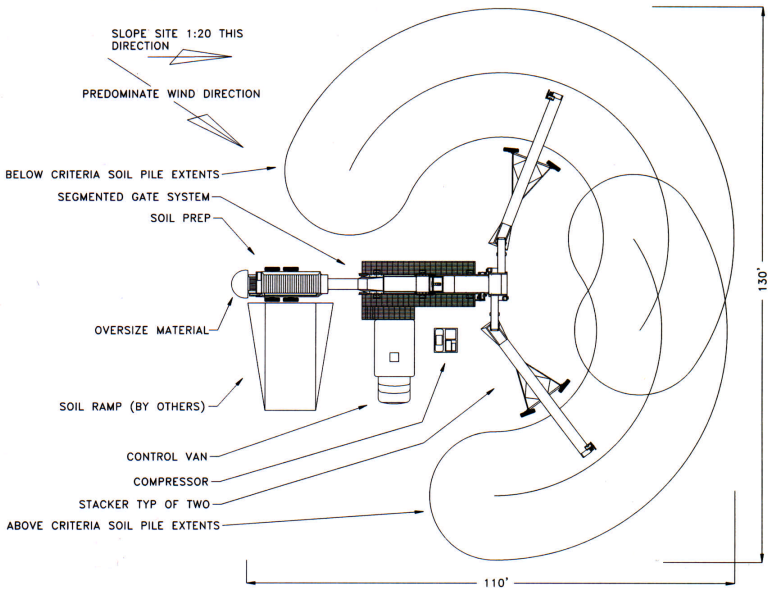

Figure 1. Segmented Gate System Footprint

Technology Advantages

The treatment of radionuclide-contaminated soils using the SGS offers the following advantages:

- The system physically surveys the entire volume of soil during processing,
- The system typically reduces volumes of soil needing treatment or disposal,
- No chemicals or other additives are used, and
- The generation of secondary waste is limited to PPE and decontamination rinse water.

Technology Limitations

The SGS has the following limitations:

- The two detector arrays provide the ability to analyze a maximum of two radionuclides with different gamma energies simultaneously,
- The SGS is primarily limited to gamma emitting radionuclides, although it can be modified to detect beta particle emitting radionuclides,
- Prior knowledge of the primary radioactive contaminants is required and soil cannot be properly sorted for unknown radioactive contaminants,
- Soil may contain levels of radioactivity above the criteria if it is sorted based on the wrong radionuclides, and
- Material greater than 1-2 inches in diameter cannot be processed by the SGS without pre-crushing.

Treatment System Schematic and Operation

Figure 2 shows the process flow of the SGS under typical operating conditions. During system operation, contaminated soil is excavated with standard heavy equipment and relocated to the feed point of the mobile SGS processing plant. The soil is first pre-sorted into piles using a vertical bar field grizzly, which removes material larger than 6 inches in diameter. The soil is then sent through the SGS screen plant and hammer mill where all rocks and debris greater than 1 to 2 inches in diameter are removed. The remaining soil is deposited in the feed surge bin. The surge bin deposits soil on the SGS conveyor belt using a screed to control the thickness and width of the soil layer. The SGS screed is adjusted to spread the material across the conveyor belt to a depth appropriate for the radioisotope of interest and the soil characteristics. The soil passes under two sets of gamma radiation detector arrays housed in shielded enclosures. The first, the thin array, is designed for 0.16 inch-thick sodium iodide (NaI) detectors, which are generally used to detect gamma radiation from 15 keV to 200 keV. The second, the thick array, is designed for 2 inch- thick NaI detectors, which are generally used to detect gamma radiation from 150 keV to 1 MeV. Either set of NaI detectors may be replaced by a beta detector system that uses 100 cm^2 gas proportional detectors. These detectors may be used to monitor beta-emitting radionuclides in the top 0.25 inches of the soil layer on the conveyor belt. This measurement may then be used to infer the beta emitting contamination in the remaining thickness of the soil layer on the conveyor belt.

The process material is conveyed underneath the detector arrays at a pre-selected speed, based on the separation criteria, contaminant, and soil type. The 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 separation criteria for radioactivity is diverted to the contaminated material conveyor, where it is transferred to a stacking conveyor on one side of the SGS. The below criteria material falls onto the below criteria conveyor that transports it to a second stacking conveyor on the opposite side of the SGS.

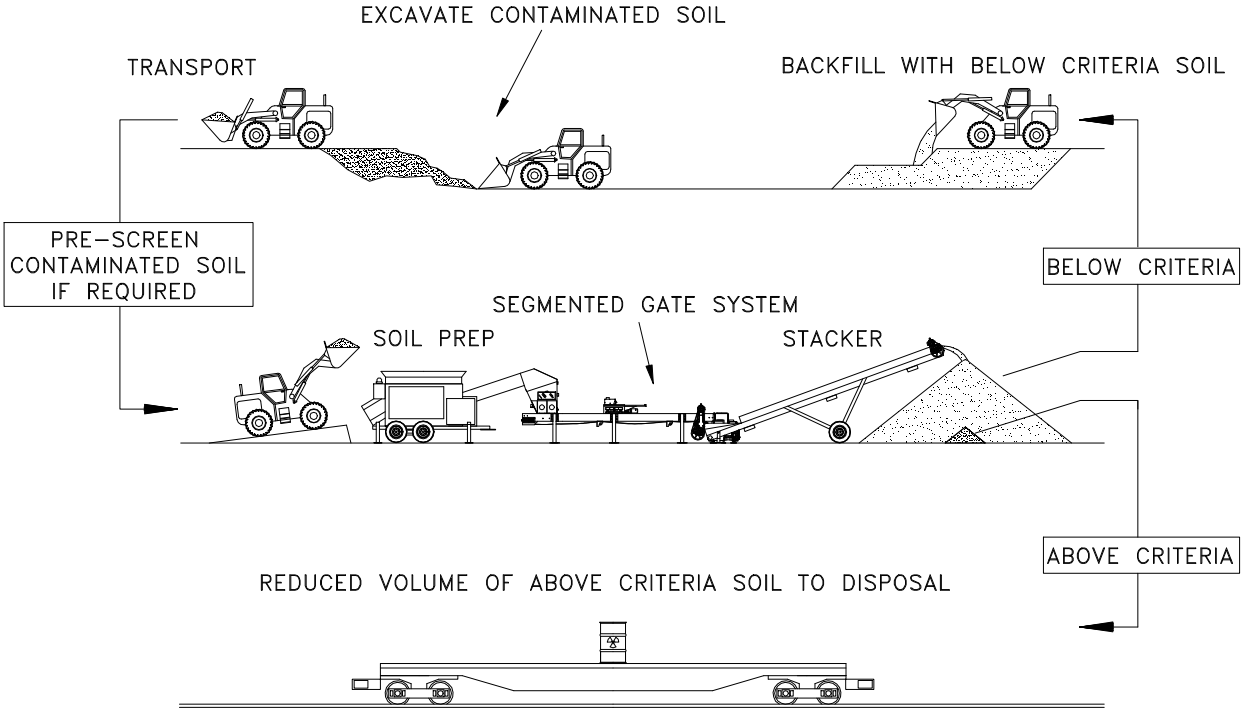

Figure 2. SGS Process Flow Diagram

Key Design Criteria

The application and utility of the SGS is affected by several site-specific factors. The primary factors are the gamma energies of the radioactive isotopes of interest, the attenuation of the soil for the energies of interest, and the density of the soil. Depending on these factors, soil may be processed in layers varying between 0.5 and 2.0 inches thick. The SGS is capable of operating at belt speeds between 20 and 40 feet per minute. The belt speed selection depends upon the sensitivity of the radiation detectors to the radioisotope of interest, the background levels, and the volume processing requirements. Minimum belt speeds allow each fraction of the soil to be counted for a longer time, increasing the sensitivity by collecting an increased number of counts for the same volume of soil. If the sensitivity is sufficient, the belt speed can be increased to enhance production levels. This results in a minimum throughput of 8.5 yd^3/hr and a maximum throughput of 28.5 yd^3/hr per sorting conveyor assuming a nominal soil density of 1.2 g/cm^3.

Since the detector arrays can be operated simultaneously, the SGS can monitor a second radioactive contaminant while looking for the primary radionuclide of concern. A separate calibration is required for each contaminant.

Operating Parameters

The operating parameters for the SGS at Clean Slate-2 were varied to provide a large number of data points to help determine the acceptable level of contaminant reduction. The belt speed and soil layer thickness was varied to assess production for various separation criteria. The operating parameters are summarized in Table 2 below and the detector settings are listed in the Appendix.

Table 2. Operating Parameters Affecting Treatment Cost or Performance

Parameter	Value or Specification
Processing speed	30 fpm (sorting conveyor belt speed)
Belt length from detectors to conveyor end	Thin array: 16.0 ft (4.88 m) Thick array: 18.0 ft (5.5 m)
Soil layer thickness	1 to 2 inches (2.54 to 5.08cm)
Soil layer width	30.75 inches (78.1 cm)
Soil density (on the conveyor belt)	1.0 g/cm^3
Detector type	Sodium iodide (NaI) 1/16 inch thick crystal
Separation Criteria Set Point	50 pCi/g to 1500 pCi/g

5. SEGMENTED GATE SYSTEM PERFORMANCE

SGS Operational Capability

The overall impression was that SGS operated as expected and had very good reliability. Downtime was minimal and was limited to excessive wind, snow and to check or reset detector calibration. Mobilization, system assembly and calibration were accomplished during the allotted time. Demobilization went as expected and there were no problems decontaminating the SGS equipment prior to it leaving the site.

Project Objectives and Approach

The primary objectives of the Clean Slate-2 SGS ASTD project were:

- Assess various operational parameters and determine their influence on:
- The volume of soil requiring off-site disposal.
- The volume of plutonium that could be removed using different set-points.

The SGS was used to sort 333 cubic yards of plutonium contaminated soil excavated from Clean Slate-2. The results from this effort were then used to define optimum operating parameters and costs for a possible follow-on effort at this and the remaining sites at the Tonapah Test Range. To accomplish this, the data from the various operating parameters were evaluated for volume reduction and contaminant removal. Based on this data, optimum operating criteria were established for the soil processing at the site. When an acceptable criteria is established using this data, the expected overall system performance and remediation costs for operations at the sites can be developed.

Performance Summary

Field activities at Clean Slate 2 took place between May 4**,** 1998 and June 12, 1998. The initial work involved the mobilization of the Bechtel Nevada (BN) support equipment and facilities, and the receipt and setup of the Thermo NUtech equipment. Following equipment setup, the SGS was checked and calibrated. Soil excavation included use of a motor grader to scrape a 2” deep swath of soil into windrows. The windrows were then moved by Front-end loader to the SGS. Though this excavation method significantly mixes the soil, homogenizing high concentration areas, this is the excavation technique preferred by Bechtel-Nevada for shallow soil contamination. Because of the large areas of soil contamination at these sites, that technique is expected to be the most cost effective for soil removal.

Soil processing began on May 18, 1998, and continued through June 3, 1998. A total of 333 cubic yards of soil was processed through the SGS. Table 3 summarizes the daily activity during the period of time the soil was being processed. Seventy-nine separate periods of operation or “runs” occurred, each characterized by different soil activity levels, equipment operating parameters and set points, or depth of soil on the belt. A summary of SGS performance for all runs, numbered from 1 to 78, is contained in the Appendix. Soil volume reduction, contaminant removal and the average activity of the processed and below separation criteria soil are summarized in Figures 3 through 8.

TABLE 3. SUMMARY OF DAILY OPERATIONS

Date	Activities	Soil Activity Levels Processed (pCi/g)[1]
5/18/98	Excavated ground zero soil (> 800 pCi/g); processed soil; stockpiled clean soil; discharged contaminated soil to first trailer; prepared 200-400 pCi/g area for excavation.	> 800
5/19/98	Excavated 200-400 pCi/g soil; processed soil; stockpiled clean soil; discharged contaminated soil to second trailer. Thermo NUtech rechecked detector calibration.	200-400
5/20/98	Processed soil; stopped processing because of high winds; separately stockpiled clean and contaminated soil.	200-400
5/21/98	Excavated 50-100, 100-200 and 200-400 (second cut) pCi/g soil; processed soil; stockpiled clean soil; discharged 200-400 contaminated soil into first trailer; discharged 100-200 contaminated soil into second trailer.	100-200, 200-400,
5/22/98	Excavated 200-400 pCi/g soil; processed soil; stockpiled clean soil; discharged contaminated soil into trailer.	50-100 “salted” with hot soil, 200-400
5/26/98	Prepared 400-800 pCi/g area for excavation; snow and very wet soil conditions curtailed operations.	
5/27/98	Excavated 400-800 pCi/g; processed soil; stockpiled clean soil; discharged contaminated soil into trailer. Thermo NUtech installed revised SGS software (see page 16); resumed processing.	400-800
5/28/98	Prepared another 400-800 pCi/g area for excavation; processed soil; stockpiled clean soil; discharged clean and contaminated soil to separate stockpiles. Validated revised SGS software for Radioactive Waste Acceptance Program.	200-400
5/29/98	Excavated new 400-800 pCi/g area; processed soil; discharged contaminated soil into trailer. Thermo NUtech repaired equipment.	200-400, 400-800
6/1/98	Processed soil; stockpiled clean soil; discharged contaminated soil into trailer. Thermo NUtech re-calibrated SGS to 2-inch soil depth on belt.	200-400, 400-800
6/2/98	Thermo NUtech revalidated software for 2-inch bed depth; processed soil at 2-inch bed depth; stockpiled clean soil; discharged contaminated soil into trailer.	400-800
6/3/98	Processed soil at 2-inch bed depth; stockpiled clean soil; discharged contaminated soil into trailer. Began equipment decontamination.	200-400, 400-800

Notes:

[1]Expected activity range based on prior site characterization.

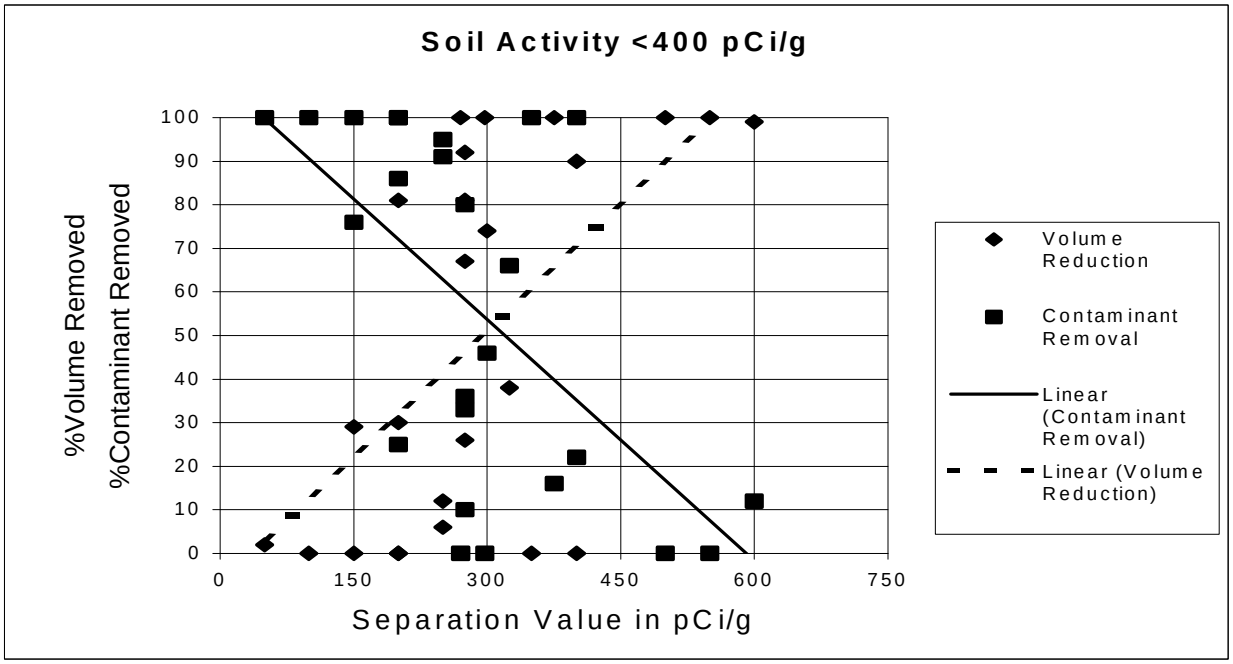

Figure 3. **Contaminant and Volume Reduction (Soil Activity <400pCi/g)**

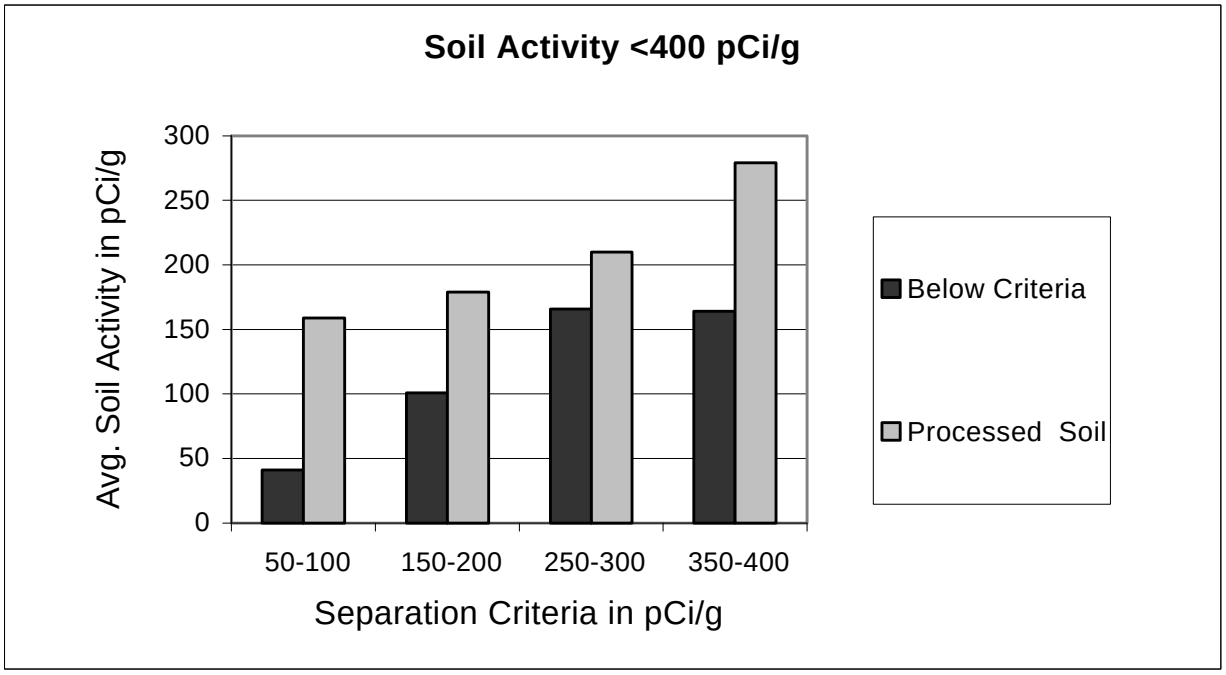

Figure 4. **Clean Soil Activity vs. Separation Criteria (Soil Activity <400pCi/g)**

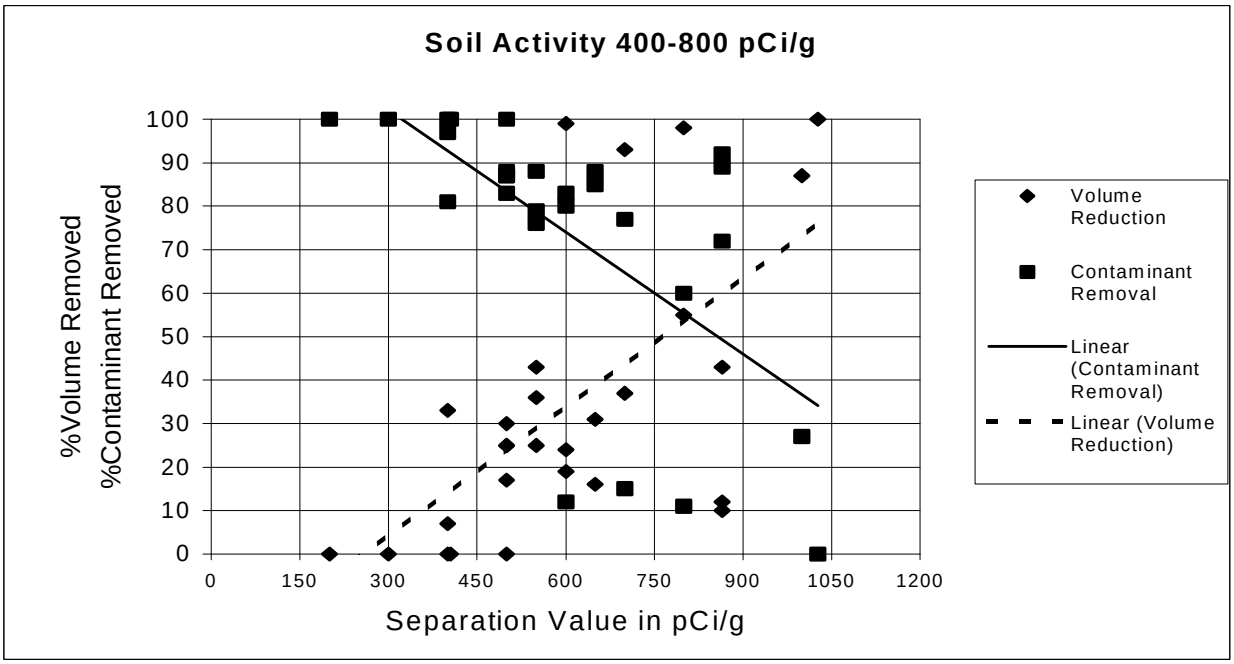

Figure 5. Contaminant and Volume Reduction (Soil Activity 400-800 pCi/g)

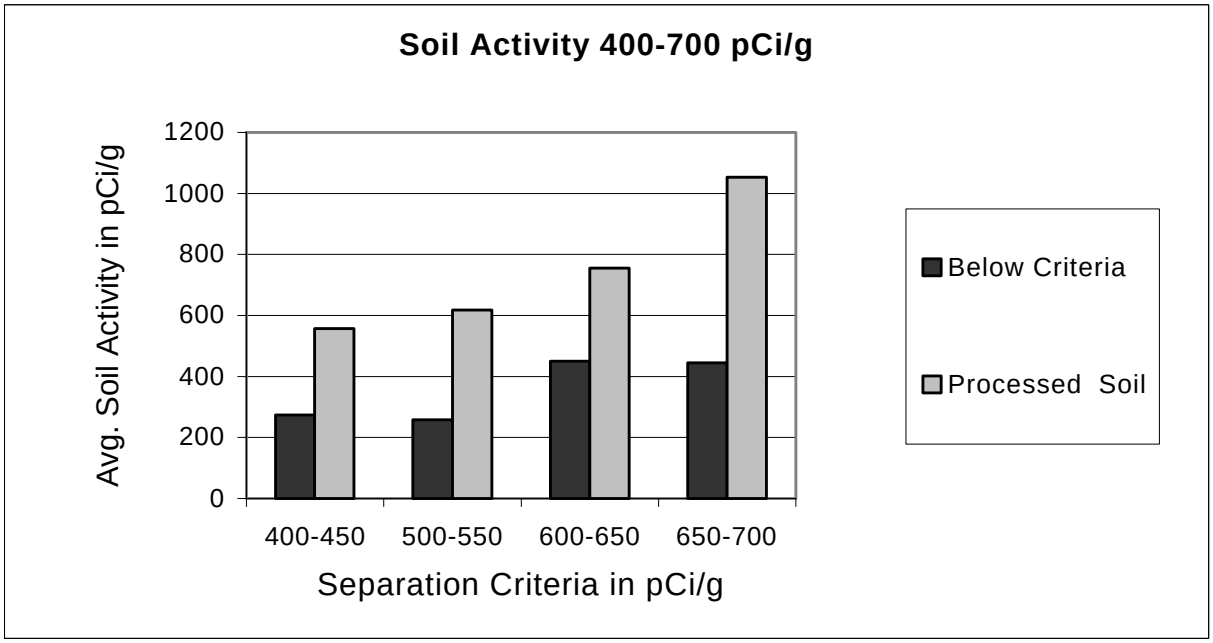

Figure 6. Clean Soil Activity vs. Separation Criteria (400-800pCi/g)

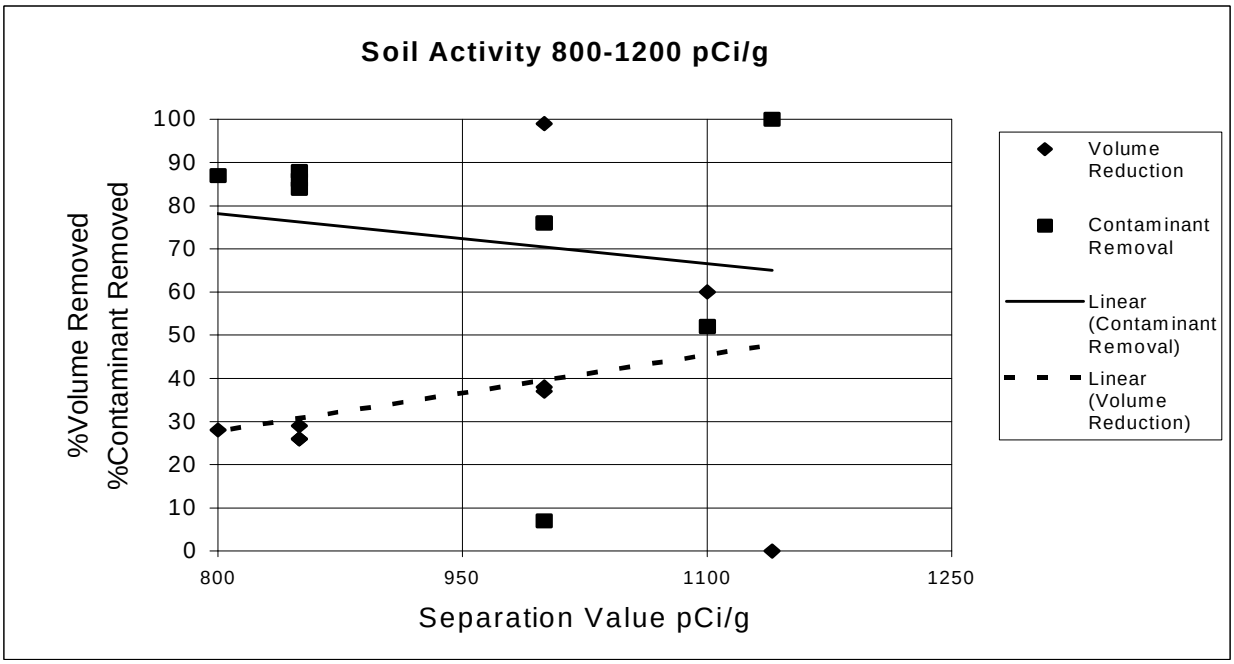

Figure 7. Contaminant and Volume Reduction (Soil Activity 800-1220pCi/g)

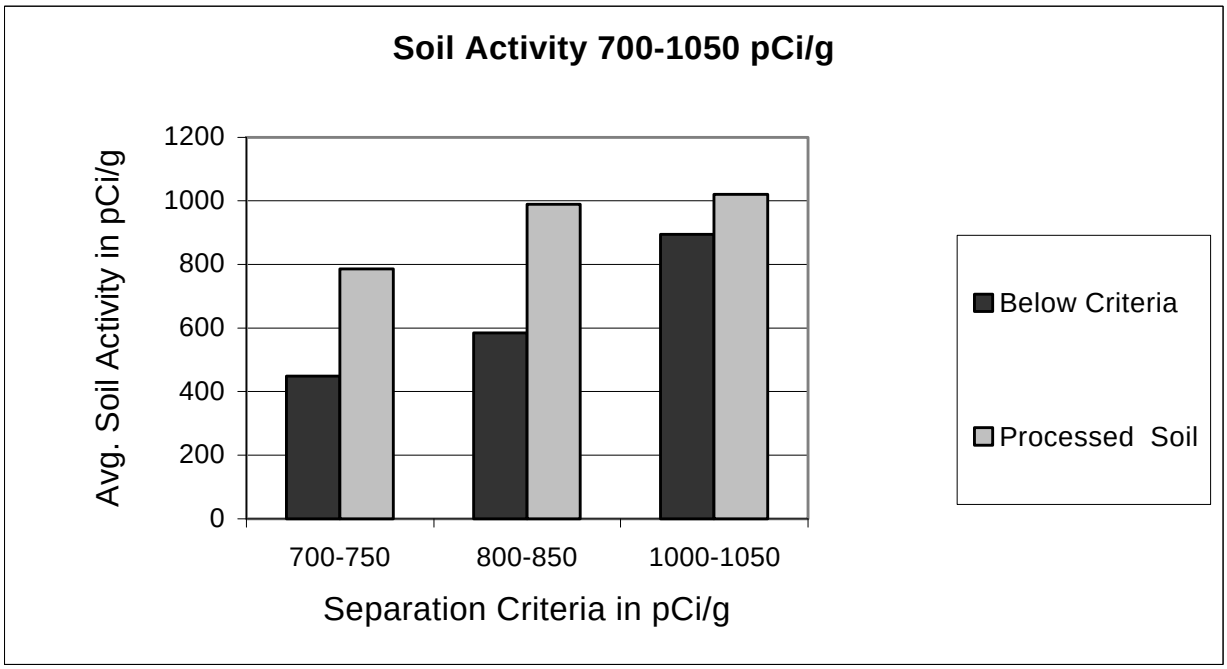

Figure 8. Clean Soil vs. Separation Criteria (Soil Activity 800-1200pCi/g)

Based on the results shown in Figures 3 through 8, several general conclusions can be drawn.

- The optimum separation criteria for soils with <400 pCi/g is about 300 pCi/g. With this value a volume reduction of about 60% can be obtained and the amount of contaminant removal will also be about 55%. The average clean soil activity at this separation criteria would be about 160 pCi/g.
- For soils between 400 –800 pCi/g there does not appear to be a definitive optimum separation criteria. All values will give a volume reduction of about 30-40% and remove about 70-80% of the contaminant. Use of separation criteria of about 500-550 pCi/g provides an average clean soil activity of about 250 pCi/g, significantly lower than the use of higher separation criteria.
- For soils of >800pCi/g there does not appear to be an optimum separation criteria. All values give similar results, about 30% volume reduction and 85% contaminant removal. Unfortunately, all the below criteria soil activities exceed approximately 500 pCi/g. This is over twice the generally accepted level. This suggests that processing any soil above 800 pCi/g is probably not appropriate.

Potential Treatment Scenarios

Based on these results, two potential treatment scenarios exist for using the SGS at Clean Slate-2 and similarly contaminated sites at Tonopah Test Range.

- The first option would be to use a separation criteria of 300 pCi/g for soils with activities between 0 – 400 pCi/g and a separation criteria of 550 pCi/g for soils with activities between 400 – 800 pCi/g. Soil activitiy greater than 800 pCi/g would not be processed through the SGS. The expected clean soil activity would depend on the ratio of the different soil concentrations, but a volume reduction of about 55% might be expected. The amount of contaminant left on-site would be less than 25%.
- The second option would be to use the SGS to only process soil with activities less than 400 pCi/g. This would help maintain a below criteria soil activity less than 200 pCi/g. The benefits of these two options will depend on the relative volumes of each of the contaminated soil activity ranges, the relative costs for soil processing using the SGS and soil transportation and disposal costs.

6. SEGMENTED GATE SYSTEM COSTS

CONTRACTING METHOD

Sandia National Laboratories, for the ASTD program, contracted the SGS on a daily operational rate, with separate line items for non-labor mobilization and demobilization costs. Total invoiced cost for this project was $138,126.

COST BREAKDOWN

Mobilization costs included trucking and crane costs to deliver the SGS and delivery charges for heavy equipment, mobile office space, toilet facilities, etc. Demobilization charges included pickup charges for the various equipment and facilities, crane services to load the SGS onto the trucks, and funding for preparation of the final report. Mobilization costs for transportation of the crew to the work site were invoiced at cost plus G&A and were not included in the defined mobilization costs.

Daily operational costs included crew wages, per diem, equipment rentals, PPE and daily operating supplies. Operational days included equipment unloading, assembly and calibration, site excavation, operation during soil processing, and disassembly, decontamination and loading of the equipment for shipment to the next job site. For the ASTD program, trucking charges for transportation to the next site were considered part of the mobilization charges for the next client. In cases where the SGS is not scheduled for another project, trucking charges would be considered part of the demobilization.

Table 4. Cost Breakdown

Cost element	Description	Costs	Subtotals
Regulatory Compliance Issues	Air permit exemption application, site specific health and safety plan, operating procedures	8,203	$8,203
Mobilization	Labor	18,052	
	Travel and per diem	4,754	
	Equipment, materials, and other direct costs	6,808	$29,614
Physical Treatment	Labor	46,059	
	Travel and per diem	12,654	
	Equipment, materials, and other direct costs	1,292	
	Depreciation*	18,540	$78,545
Demobilization	Labor	15,340	
	Travel and per diem	3,799	
	Final report	2,625	$21,764
Total			$138,126

* The depreciation schedule is calculated on a per deployment basis Unit treatment and processing costs for SGS operations provided by Thermo NUtech were about $236 per cubic yard. The treatment costs reflect the low volume processed, weather and administrative delays and the time associated with addressing the approximately eighty different separation criteria settings used at this site.

7. REGULATORY/ INSTITUTIONAL ISSUES

A Federal Facility Agreement and Consent Order (FFACO) regulates the Clean Slate-2 site. The FFACO took effect on May 10, 1996 and establishes a framework for identifying, prioritizing, investigating, remediating and monitoring Nevada sites contaminated by the DOE and DOD.

Final remediation criteria have not been established for this site. This treatability study is useful in identifying what levels of volume reduction could be achieved at varying set-point criteria. Once cleanup criteria are determined and characterization is complete, a cost analysis of potential savings can be projected.

8. SCHEDULE

Field Activities at Clean Slate-2 took place between May 4, 1998 and June 12, 1998. The initial work involved the mobilization of the Bechtel Nevada (BN) support equipment, facilities and receipt and setup of the Thermo NUtech equipment. Following equipment setup, the SGS was calibrated and checked.

Soil processing began on May 18, 1998, and continued through June 3, 1998. A total of 333 cubic yards of soil (at a density of 1 gram per cubic centimeter on the SGS belt) was processed.

Mobilization, system setup and calibration were accomplished during the allotted time. Demobilization went as expected and there were no problems decontaminating the SGS equipment prior to leaving the Clean Slate-2 site.

Delay Due To Software Change

The SGS detectors and computer control equipment measure “hot” particle and distributed activity using appropriate mathematical algorithms. The computer analyzes the data and sends commands to open the appropriate diversion gates.

The distributed activity algorithm totals the net counts of activity from an array of 80 segments of soil on the belt (each segment is 4 inches x 12 inches of surface area and 1 or 2 inches thick. depending on the soil thickness on the belt). If the net activity exceeds the predetermined set- point, a signal is sent to divert increments of soil from the array. Some averaging of adjacent segments occurs in this algorithm. The original software algorithm was designed for very low activity soil. If more than 50 percent of a batch of 80 soil segments on the belt were being diverted to the contaminated side (e.g., the activity was greater than the set-point value), the computer made the decision to divert the entire 80 segment batch.

The “hot” particle algorithm looks at individual segments of the belt and diverts these segments if they exceed a predetermined threshold (the multi-particle value), regardless of the activity of surrounding segments. In effect, these segments are not averaged. The multi-particle value is typically 3 to 30 times the distributed set-point value. This is the typical software configuration used at previous sites including Johnston Atoll, Sandia, and Pantex.

For the first 47 runs at Clean Slate 2, the distributed set-point varied from 50 pCi/g to 1,027 pCi/g and the multi-particle factor was generally set at 3 to 4 times the distributed set-point value. The SGS only sorted soil when the distributed set- point was set near the average concentration of the soil being processed. When sorting did occur, all eight gates would divert soil to the “hot” side. Individual gates were not opening to divert regions of “hot” soil on the belt. This occurred because there were not hot particles within the soil mixture, only finely dispersed activity that had been homogenized within the soil.

On May 27, 1998, a revised version of the SGS software, valid for set-points ≥400 pCi/g, was installed which allowed the SGS to evaluate individual segments on the belt without averaging. This change resulted in individual gates operating to remove 4- inch x 12- inch segments on the belt when the activity exceeded the established set-point value. Unfortunately, much of the validation period had already been expended, so it became necessary to operate the SGS a few extra days in order to collect sufficient data.

9. OBSERVATIONS AND LESSONS LEARNED

Cost Observations and Lessons Learned

SGS performs best in heterogeneously contaminated soil conditions. SGS limitations and benefits are well documented in this report. The soil that was processed at Clean Slate-2 was often homogeneous, containing finely dispersed plutonium fallout with few hot spots. An accurate pre-characterization of the site is imperative in making a determination as to which remediation technology should be used. The NTS Clean Slate-2 site is still being characterized well after the deployment of the SGS. An accurate characterization of the site will help provide a better estimate of the SGS cost benefits to the applications at Tonapah Test Range.

Performance Observations and Lessons Learned

An accurate estimate of system throughput cannot be extrapolated from test runs when the set point criteria are changed so frequently. A total of 333 cubic yards of soil were processed with 79 different runs. A large number of set points were tested relative to the soil activity level in an effort to maximize data points for comparison of separation efficiencies. Better, more accurate site characterization data would have eliminated the need for as many set point changes. This would have, in turn, yielded better equipment reliability testing and throughput results.

Soil excavation using a motor grader to scrape soil into windrows significantly mixes the soil, homogenizing potential high concentration areas and rendering the SGS less effective. Some type of marking system to identify hot areas within the windrow would tell the loader operator which section of the windrow to send to the SGS and which section should not be processed for volume reduction.

10. REFERENCES

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3. *Avoidable Waste Management Costs, Idaho National Engineering and Environmental Laboratory, January 1995*.

4. *Segmented Gate System Validation at Clean Slate-2, Revision 0, Bechtel Nevada, Las Vegas Nevada, August 1988*

5. *Letter on Data and Conclusions for Tonapah Test Range, Thermo NUtech, Scott Rodgers, August 21st, 1998.*

6. *Final Report, Segmented Gate System Validation At Clean Slate-2, Bechtel Nevada Environmental Development, August 10, 1998*

11. VALIDATION

"This analysis accurately reflects the performance and costs of the remediation."

Original Signed by Tom Burford

Tom Burford, Project Manager
Accelerated Site Deployment Program
Sandia National Laboratories; Albuquerque, New Mexico

Original Signed by Mike Hightower

Mike Hightower, Technical Coordinator
Accelerated Site Deployment Program
Sandia National Laboratories; Albuquerque, New Mexico

APPENDIX

SGS SOIL VOLUME REDUCTION PREFORMANCE

SGS Set-Point Activity (pCi/g)	Avg. Activity of Soil Processed (pCi/g)	Soil Volume Reduction (%)	Soil Thickness on Belt in Inches	Run Number
400	269	97	1	66
400	489	33	1	49
400	641	7	1	50
500	441	17	1	54
500	581	30	1	51
500	684	25	1	52
500	691	25	1	64
550	671	43	1	65
550	723	25	2	73
550	583	36	2	78
600	176	4	1	55
650	730	31	2	74
650	877	26	2	75
650	1151	17	2	72a
650	1100	60	2	77
650	1018	15	1	62
650	1022	19	2	76
650	1119	9	1	63
700	442	93	1	53
700	782	37	1	56
700	1136	20	1	57
800	725	55	2	70
800	854	98	2	68
800	922	28	2	69
850	1044	29	1	61
850	1082	26	2	71
850	1105	26	1	58
865	933	43	1	48
1000	1092	38	1	59
1000	1116	37	1	60
1000	749	87	2	72b

SOIL ACTIVITY REMOVAL PERFORMANCE

SGS Set-Point Activity (pCi/g)	Avg. Activity of Soil Processed (pCi/g)	Soil Activity Removal (%)	Soil Thickness on Belt in Inches	Run Number
400	269	10	1	66
400	489	81	1	49
400	641	97	1	50
500	441	87	1	54
500	581	83	1	51
500	684	87	1	52
500	691	88	1	64
550	671	76	1	65
550	723	88	2	73
550	583	79	2	78
600	176	90	1	55
650	730	85	2	74
650	877	88	2	75
650	1151	94	2	72a
650	1100	52	2	77
650	1018	93	1	62
650	1022	92	2	76
650	1119	96	1	63
700	442	15	1	53
700	782	77	1	56
700	1136	92	1	57
800	725	60	2	70
800	854	11	2	68
800	922	87	2	69
850	1044	84	1	61
850	1082	88	2	71
850	1105	86	1	58
986	933	72	1	48
1000	852	76	1	59
1000	1090	7	2	67
1000	1116	76	1	60
1000	749	27	2	72b

CLEAN SOIL ACTIVITY PERFORMANCE

SGS Set-Point Activity (pCi/g)	Avg. Activity of Soil Processed (pCi/g)	Clean Soil Avg. Activity (pCi/g)	Soil Thickness on Belt in Inches	Run Number
400	269	250	1	66
400	489	276	1	49
400	641	270	1	50
500	441	341	1	54
500	581	322	1	51
500	684	345	1	52
500	691	341	1	64
550	671	381	1	65
550	723	335	2	73
550	583	341	2	78
600	176	414	1	55
650	730	341	2	74
650	877	415	2	75
650	1151	436	2	72a
650	1100	763	2	77
650	1018	468	1	62
650	1022	457	2	76
650	1119	448	1	63
700	442	407	1	53
700	782	491	1	56
700	1136	322	1	57
800	725	521	2	70
800	854	771	2	68
800	922	428	2	69
850	1044	593	1	61
850	1082	519	2	71
850	1105	588	1	58
865	933	611	1	48
1000	1092	706	1	59
1000	1090	1026	2	67
1000	1116	707	1	60
1000	749	629	2	72b

Notes:

[1] Soil thickness is depth of soil on belt passing under detectors.
[2] For the first 47 runs at Clean Slate-2, the distributed set-point varied from 50 pCi/g to 1,027 pCi/g and the multi-particle factor was generally set at 3 to 4 times the distributed set-point value. The SGS only sorted soil when the distributed set point was set near the average concentration of the soil being processed. When sorting did occur, all eight gates would divert soil to the “hot” side. Individual gates were not opening to divert regions of “hot” soil on the belt. This occurred because there were not hot particles within the soil mixture, only finely dispersed activity that had been homogenized within the soil.

On May 27, 1998, a revised version of the SGS software, valid for set-points 400 pCi/g, was installed which allowed the SGS to evaluate individual segments on the belt without averaging. This change resulted in individual gates operating to remove 4-inch x 12-inch segments on the belt when the activity exceeded the established set-point value. Unfortunately, much of the validation period had already been expended, so it became necessary to operate the SGS a for additional days to allow for the collection of sufficient data.