Soil Segregation Methods for Reducing Transportation and Disposal Costs - 13544

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ABSTRACT

At Formerly Utilized Sites Remedial Action Program (FUSRAP) sites where the selected alternative for contaminated soil is excavation and off-site disposal, the most significant budget items of the remedial action are the costs for transportation and disposal of soil at an off-site facility. At these sites, the objective is to excavate and dispose of only those soils that exceed derived concentration guideline levels. In situ soil segregation using gross gamma detectors to guide the excavation is often challenging at sites where the soil contamination is overlain by clean soil or where the contaminated soil is located in isolated, subsurface pockets. In addition, data gaps are often identified during the alternative evaluation and selection process, resulting in increased uncertainty in the extent of subsurface contamination. In response, the U.S. Army Corps of Engineers, Buffalo District is implementing ex situ soil segregation methods. At the remediated Painesville Site, soils were excavated and fed through a conveyor-belt system, which automatically segregated them into above- and below-cleanup criteria discharge piles utilizing gamma spectroscopy. At the Linde Site and the Shallow Land Disposal Area (SLDA) Site, which are both in the remediation phase, soils are initially segregated during the excavation process using gross gamma detectors and then transported to a pad for confirmatory manual surveying and sampling. At the Linde Site, the ex situ soils are analyzed on the basis of a site-specific method, to establish compliance with beneficial reuse criteria that were developed for the Linde remediation.

At the SLDA Site, the ex situ soils are surveyed and sampled based on Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) final status survey guidance to demonstrate compliance with the derived concentration guideline levels. At all three sites, the ex situ soils that meet the site- specific DCGLs are retained on-site and used as backfill material. This paper describes the ex situ soil segregation methods, the considerations of each method, and the estimated cost savings from minimizing the volume of soil requiring transportation and off-site disposal.

INTRODUCTION

Radiologically contaminated Formerly Utilized Sites Remedial Action Program (FUSRAP) sites are being remediated by the U.S. Army Corps of Engineers. Generally, the greatest cost component of the radiological soils remediation of FUSRAP sites is the cost to transport and dispose of the excavated soils, typically contaminated with naturally occurring isotopes of uranium, thorium, and radium, at an appropriately permitted off-site disposal facility. The objective is to excavate and dispose of only those soils that exceed the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)-based derived concentration guideline levels (DCGLs) [1]. The heterogeneous nature of the contamination encountered makes it difficult to accurately delineate the extent of contaminated soil using the often limited discrete sampling data collected during the investigation phases. In situ soil segregation using gross gamma detectors to guide the excavation is often challenging at sites where contaminated soil is overlain by clean soil or where the contaminated soil is located in isolated, subsurface pockets. To address this issue, the U.S. Army Corps of Engineers, Buffalo District employed ex situ soil segregation methods to reduce the potential for transportation and disposal of soils that meet the cleanup limits.

The use of the soil segregation methods resulted in cost savings through reduction of the volume of excavated soil that required off-site transportation and disposal, as well as reduction of the amount of imported clean backfill required as place-back material to restore the completed excavations. This paper describes the soil segregation methods implemented by the Buffalo District at three different sites.

SITE DISCRIPTIONS AND METHODS

Painesville Site Description

The Painesville FUSRAP Site is an approximately 12-hectare (ha) (30-acre [ac]) former industrial facility located in the Township of Painesville in Lake County, Ohio. The site was operated as a magnesium production facility from 1942 to 1953 under contract to the Federal Government. While there is no known history of processing or production of radioactive materials at the site,

site soils were contaminated through the receipt, storage, and use of radiologically contaminated scrap steel, from Atomic Energy Commission inventories, in the magnesium production process. In 1963, the site was sold by the General Services Administration to a commercial chemical production company, which reconfigured the site for their own uses and conducted operations until 1999. The property is not currently in active use, and all but one of the former buildings have been torn down [2].

The following four radionuclides comprised the radiological DCGLs for the Painesville Site: radium-226 (Ra-226), thorium-232 (Th-232), thorium-230 (Th-230), and total uranium (Total U). Ra-226 and Th-232 are easily and directly measurable by strong, characteristic gamma emissions. Ra-226 served as an appropriate surrogate for constituents of concern (COCs) in the U-238 decay series, including Th-230 and Total U. Based on previous site characterization, remediation, and final status survey activities, conservative relative activity factors were determined and applied to the Ra-226 value to attribute appropriate concentrations to Th-230 and Total U [2].

For the 2010 through 2011 Painesville Site remediation effort, the U.S. Army Corps of Engineers, Buffalo District employed the use of automatic soil segregation to minimize waste requiring transportation and off-site disposal [3].

Painesville Site Method

During the 2010 and 2011 remediation effort all soils and buried materials that were impacted or potentially impacted above DCGLs, based on prior characterization data and in-field surveys, were excavated and placed into stockpiles. Once large debris was removed from the materials, all soil and soil-like material were assayed by gamma spectroscopy to determine if the material met the Record of Decision (ROD) acceptance criteria. The 100% assay of all excavated material was accomplished using the automatic soil segregation system [3].

To begin excavation of an impacted area, a gross gamma survey was conducted, using a 7.6-centimeter (cm) by 7.6-cm (3-inch [in.] by 3-in.) sodium iodide detector coupled to a global positioning system. The threshold value was the gross count rate above which the soil was likely to be greater than the ROD acceptance criteria. After the initial excavation of impacted areas, the remediation was guided by field gross gamma surveys and biased sampling based on the results of the field scan data. All of the excavated soil was then stockpiled in a soil pre-segregation area designed to stockpile approximately 27,000,000 kilograms (kg) (30,000 tons) of soil materials for processing by the automatic soil segregation system [4].

The automatic soil segregation system is a radiological monitoring and processing system designed to perform real-time segregation of soil into two distinct groups based on its radiological properties. The system is capable of processing and segregating large volumes of soil with relatively high throughput rates. The material is sorted into two distinct groups (piles), commonly referred to as the "Below Criteria" and "Above Criteria" (or "Diverted") groups. The soil material is sorted and segregated into distinct volumes on the basis of diversion control setpoint(s) (DCSs) that are established to automatically trigger the diverting mechanism, which sorts the material into the appropriate group. The DCSs are established based on DCGLs with sum of ratios applied, the site-specific DCGL derivation assumptions (i.e., DCGL area and contamination layer thickness), and an appropriate dose consequence for the COCs. Please see the 2012 Waste Management Symposium proceedings, *Successful Implementation of Soil Segregation Technology at the Painesville FUSRAP Site*, for additional information regarding the operation of the automatic soil segregation system [3].

Painesville Site Costs

In 2010 and 2011, a total of 43,500,000 kg (47,950 tons) of suspect contaminated soils and debris was excavated as part of the Painesville Site remediation effort. Of that total, 42,600,000 kg (46,932 tons) of soil and soil-like material were processed through the automatic soil segregation system. The soil segregation system segregated 41,800,000 kg (46,095 tons) of material to the "Below Criteria" stockpile for reuse at the site to fill the excavations, and 760,000 kg (837 tons) of material to the "Above Criteria" stockpile for eventual shipment for off-site disposal. The cost to design, mobilize, calibrate, operate, and demobilize the automatic soil segregation system was approximately $2.15 million. In addition, confirmatory soil samples from the "Below Criteria" stockpile were collected for off-site laboratory radiological/chemical analyses; soil handling/moving activities in combination with these sampling costs increased the soil segregation costs to a total of $2.7 million. Dividing that cost by the total amount of soil and soil-like material processed at the site yields a cost per ton processed of approximately $58 for the Painesville Site. To transport and dispose of material from the site, the cost per ton was $170, yielding a cost per ton savings of $112 for use of the soil segregator versus transportation and disposal.

Linde Site Description

The Linde Site comprises approximately 55 ha (135 ac) and is located in the Town of Tonawanda in Erie County, New York. The site consists of various office buildings, fabrication facilities, warehouse storage areas, material laydown areas, and parking lots. The site is currently owned by Praxair, Inc. As a result of historic Manhattan Engineer District ore-handling activities on site, soils and some of the buildings were contaminated with radionuclides. While radiologically contaminated soil was likely deposited on or near the soil surface, subsequent earthmoving activities associated with infrastructure, utility, and building construction have resulted in subsurface contamination overlain by clean backfill throughout the site. As a result, traditional surficial gamma scans were relatively ineffective in identifying areas of potential concern. In addition, it was learned during remediation that areas of radiologically contaminated buried infrastructure were overlain by un-impacted soil. At the Linde Site, the objective was to develop an ex situ soil segregation method to demonstrate that potentially un-impacted soil could be retained on site and used for backfill material.

The following three radionuclides comprised the soil DCGLs for the Linde Site: Ra-226, Th-230, and Total U [5]. Similar to the Painesville Site, Ra-226 served as an appropriate surrogate for COCs in the U-238 decay series, including Th-230 and Total U.

For the current Linde Site remediation effort the U.S. Army Corps of Engineers, Buffalo District, implemented the following ex situ soil segregation methodology using gamma walkover surveys (GWSs) and soil sampling and analysis to minimize waste requiring transportation and off-site disposal.

Linde Site Method

Prior to the start of the excavation, three threshold values were developed for a 5.1-cm by 5.1-cm (2-in. by 2-in.) sodium iodide detector to guide the excavation activities. GWSs were conducted in the excavation areas using a sodium iodide detector coupled to a Trimble Global Positioning System and the soil was removed in 30-cm (1-foot [ft]) lifts. On the basis of the field scan measurements, excavated soil and soil-like material were sorted into one of the three following possible classifications, with corresponding actions: (1) soils with a gamma threshold that exceeded 22,000 counts per minute (cpm) were classified as exceeding the Linde ROD criteria and shipped off-site for disposal; (2) soils with a gamma threshold up to 18,000 cpm were classified and evaluated as “clean soil”; and (3) soils with a gamma threshold between 18,000 and 22,000 cpm were classified and evaluated as “gray” soils. The “clean” and “gray” soils were excavated and transported to an evaluation area/pad for additional surveys and sampling. Two different procedures were implemented depending on whether the excavated soils are classified as “clean” or “gray.”

Soils meeting the “clean” gamma threshold criteria were staged in windrows of up to 380 cubic meters (m^3) (500 cubic yards [yd^3]). Each windrow was composite sampled and staged until the radiological results were received. The results were compared to the surface ROD criteria of 5 pCi/g for Ra-226, 14 pCi/g for Th-230, and 554 pCi/g for Total U and the as low as reasonably achievable (ALARA) goals from the New York State Department of Environmental Conservation of 2 pCi/g for Ra-226, 2 pCi/g for Th-230, and 5 pCi/g for U-238.

The “gray” soils were divided into 15-m^3 (20-yd^3) piles, which were spread into 30-cm (1-ft) lifts in segregation bins on the pad. A 100% GWS was then conducted to confirm these soils were below the sodium iodide detector threshold value of 22,000 cpm. If the soils were below the GWS threshold value, then a composite sample was collected from six bins, or 92 m^3 (120 yd^3) of soil, for radiological analysis. The soil was staged into windrows until the radiological results were received. The results were compared to the surface ROD criteria and the ALARA goals. If soils exceeded the 22,000 cpm threshold value, then they were removed from the pad and transported to the off-site disposal facility. Periodically the gamma thresholds were compared to off-site laboratory data, so that the thresholds could be adjusted if necessary based on the more definitive off-site laboratory analyses.

If the sample results met the ALARA goals, then the clean or gray soils were relocated to a final staging pile of up to 3,800 m^3 (5,000 yd^3), at which point a 10-point composite sample was collected for chemical laboratory analysis. The chemical results were compared to chemical quality requirements or hazardous waste standards as defined by the New York State Department of Environmental Conservation. On the basis of the laboratory results, the following four potential outcomes were possible: (1) soils meeting the ALARA goal and the chemical quality requirements were used on-site as excavation backfill; (2) soils meeting the ROD surface criteria and chemical quality requirements but exceeding the ALARA goal were evaluated for appropriateness as on-site subsurface backfill material; (3) soils failing to meet the ROD surface radiological criteria were disposed of at the off-site disposal facility; and (4) soils meeting the ROD surface criteria but failing to meet the chemical criteria or hazardous waste standards were turned over to the site owner for final disposition.

Linde Site Costs

From August 2010 through October 2012, 28,600,000 kg (31,560 tons) of soil have been analyzed for on-site reuse at the Linde Site. Of these soils, 27,200,000 kg (30,030 tons) met the ALARA goals and chemical requirements while 1,400,000 kg (1,530 tons) failed to meet the ROD surface criteria. The decision was made to dispose of the failing soil at the off-site waste disposal facility. The total estimated cost at the Linde Site for managing the segregated soil stockpiles (i.e., staging, surveying, moving, soil sampling, and laboratory analysis) was $4.9 million. Dividing that cost by the total amount of soil sampled and surveyed for beneficial reuse yields an approximate cost per ton of $155. The cost per ton to transport and dispose of soil from the Linde Site was $264, yielding an estimated cost per ton savings of $109 for managing the segregated soil versus transportation and disposal. To conduct the cost comparison, a 1.5 conversion factor from ex situ cubic yards to tons was used on the basis of site-specific conditions at the Linde Site.

SLDA Site Description

The Shallow Land Disposal Area (SLDA) Site is located in Parks Township in Armstrong County, Pennsylvania, about 37 km (23 miles) east-northeast of Pittsburgh, Pennsylvania. The 18-ha (44-ac) site is largely undeveloped and was used for disposal of radioactive wastes generated by Nuclear Materials and Equipment Company (NUMEC) between 1961 and 1970.

Based on examination of historical records, previous investigations, and discussions with individuals familiar with disposal operations at the SLDA Site, the waste materials were reportedly placed into a linear series of pits constructed adjacent to one another and resembling trenches. The Atomic Energy Commission regulation (i.e., Title 10 of the Code of Federal Regulations, Part 20, Section 20.304) in effect at the time these disposals took place required that individual burials be separated by a minimum of 1.8 m (6 ft). The disposals at the SLDA Site were reportedly conducted in accordance with this regulation, which also limited disposal quantity and frequency. Following placement in the pits, the waste materials were to be covered with approximately 1.2 m (4 ft) of clean soil. The depths of placement of disposed materials within the "pits" are reported to have ranged from 1.2 m (4 ft) to 4.3 m (14 ft) below ground surface (bgs) [6]. In summary, the majority of waste material was placed into nine trenches and one backfilled settling pit (referred to as trench 3), as confirmed by historical and current geophysical surveys of the site. The radioactive contamination is generally confined to the immediate vicinity of the trench areas, and to a few localized pockets of contaminated surface soils outside these areas [7].

The following radionuclides comprised the DCGLs for the SLDA Site: plutonium-241 (Pu-241), plutonium-239 (Pu-239), americium-241 (Am-241), Th-232, uranium-234 (U-234), uranium-235 (U-235), uranium (U-238), and radium-228 (Ra-228). It was expected that the majority of the upper 1 m (3 ft) of trench cover/overburden soils and the bench/side slope soils (to be removed to ensure excavation stability) would be below the DCGLs [8]. In addition, it was also expected that these soils would meet the Pennsylvania Department of Environmental Protection (DEP) *Management of Fill Policy* clean fill requirements for chemicals [9].

On the basis of historical records and previous investigations, trench cover and bench/side slope soils potentially could be below the DCGLs. The U.S. Army Corps of Engineers implemented an ex situ soil segregation methodology using GWSs and soil sampling and analysis to survey and sample overburden soils from two trenches to determine whether they met the DCGL requirements. The goal was to survey and sample these soils to demonstrate compliance with the DCGLs, retain them on-site to be used as backfill material, and minimize the volume of the soils requiring transportation and off-site disposal.

SLDA Site Method

From August 2011 through September 2011, the 1 m (3 ft) of overburden cover was excavated from two trenches and transported to a pad for final status survey samples to demonstrate MARSSIM compliance with DCGL requirements.

The ex situ overburden soils were sampled at a density equivalent to a MARSSIM Class 1 unit. For in situ Class 1 units at the SLDA Site, the sample density was a minimum of one sample per 100 square meters (m^2) (1,076 square feet [ft^2]); this is equivalent to 20 samples per a 2,000-m^2 (21,528-ft^2) area Class 1 unit. In situ samples are typically collected from the surface to a depth of 15 cm (6 in.). For a 2,000-m^2 (1,076-ft^2) final status survey unit, the volume of soil is 306 m^3 (400 yd^3). For consistency with in situ Class 1 units, 20 soil samples were collected from an ex situ Class 1 306-m^3 (400-yd^3) volume of soil (equivalent to collecting samples from the top 15 cm [6 in.] of surface soil from a 2,000-m^2 [21,528-ft^2] area in situ Class 1 survey unit). The volume of soil represented by each sample was 15 m^3 (20 yd^3); this is equivalent to one sample per 100 m^2 (1,076 ft^2) in situ, which corresponds to the derivation of the DCGL - elevated measurement comparison ($DCGL_{emc}$).

After the overburden soil was transported to the stockpile area, up to 306 m^3 (400 yd^3) of soil was spread into a 0.3-m (1-ft) layer on a pad for scanning and sampling. The soil layers were scanned by conducting 100% GWS surface scans using a Field Instrument for Detection of Low Energy Radiation (FIDLER) detector. Surface gamma scan results were compared to a derived investigation level, defined as a contamination level that was not equivalent or consistent to background rate measurements. If anomalous areas were identified, the anomalous soils were removed for off-site disposal and/or biased sampling was conducted at these locations to determine $DCGL_{emc}$ compliance or exceedance. If the $DCGL_{emc}$ was exceeded, soils in the elevated area were flagged for off-site disposal. The GWSs were used (in addition to the soil sample results) to demonstrate $DCGL_{emc}$ compliance.

Systematic sampling locations were laid out on random start triangular grids, where possible. Samples were collected from a depth interval of 0 to 0.3 m (0 to 1 ft), the entire vertical layer, to obtain representative samples from a final status survey unit up to 306 m^3 (400 yd^3) in volume. The resulting sum of ratios (SOR) scores were first compared to 100-m^2 (1,076-ft^2) $DCGL_{emc}$ requirement. If a sample result was greater than a $DCGL_{emc}$, the contaminated soil within the elevated area was segregated and removed for off-site disposal. If all of the SOR values were less than the 100-m^2 (1,076-ft^2) $DCGL_{emc,}$ the results were then used to calculate DCGL - wide area average ($DCGL_w$) SOR values. $DCGL_w$ compliance was demonstrated using the Wilicoxon Rank Sum (WRS) test. If the 400-yd^3 (306-m^2) unit failed the WRS test, the soil layer was removed and packaged for off-site disposal.

If a survey unit satisfied all DCGL requirements, soil samples from the stockpile layer survey unit were analyzed for chemicals required to meet the Pennsylvania DEP clean fill requirements [8]. If the samples also met the Pennsylvania DEP criteria, the soils were released and stockpiled to be reused as backfill soils at the site. If the soils failed to meet the Pennsylvania DEP backfill criteria, the soils were turned over to the site owner for final disposition.

SLDA Site Costs

From August 2011 through November 2011, 28,600,000 kg (5,525 tons) of soil were analyzed following MARSSIM guidance for on-site reuse at the SLDA Site. Of these soils, 27,200,000 kg (5,200 tons) met the DCGL requirements, while 1,400,000 kg (325 tons) failed to meet the DCGL requirements and were transported and disposed of at the off-site waste disposal facility. The total estimated cost at the SLDA Site for surveying, conducting soil sampling and laboratory analysis, and soil handling was $1.1 million. Dividing that cost by the total amount of soil sampled and surveyed for beneficial reuse yields an approximate cost per ton of $200. The cost per ton to transport and dispose of soil from the SLDA Site was $1,027, a much higher disposal cost relative to the Painesville and Linde sites because of the types of contaminants present in the trenches. The estimated cost per ton savings is $827 for managing the segregated soil versus transportation and off-site disposal. To conduct the cost comparison at the SLDA Site a 1.3 conversion factor from ex situ cubic yards to tons was used on the basis of site-specific conditions at the SLDA Site

CONCLUSIONS

Cost savings were achieved by the U.S. Army Corps of Engineers at each of the three FUSRAP sites implementing different on-site soil segregation methods. For each site, the cost of on-site soil handling, soil surveying, and soil sampling and analysis resulted in a cost savings when compared to off-site transportation and disposal costs. Though not evaluated in this paper, additional overall project cost savings were realized from the reduction in the amount of clean off-site backfill necessary to be procured, due to the reuse of segregated soils as backfill material. All three sites required an area (or pad) of adequate size for the soil segregation activities (specifically, the stockpiling, surveying, and sampling) to occur. The three sites are located in different states, Ohio (Painesville Site), New York (Linde Site), and Pennsylvania (SLDA Site). Each of the state environmental agencies was provided plans describing the soil segregation methods; all three state agencies provided acceptance of the segregation processes before and during the remediation. In addition to the cost savings, implementing a segregation method as part of the remediation process promoted environmental stewardship and sustainability by reducing the unnecessary transportation and disposal of soil below the site-specific criteria.

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