Intrusive Characterization of the Hanford 618-10 Burial Ground Trenches - 11044

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ABSTRACT

Intrusive characterization was conducted to obtain data and information needed for planning remediation strategies for the Hanford Site's 618-10 burial ground trenches, which contain very high dose rate and very highly alpha contaminated items. The term "intrusive" is used to distinguish these activities from previously conducted "non-intrusive" characterization, which was performed without exposing personnel or the environment to waste material. Planning for remediation requires better understanding of the type, quantity, and condition of the materials deposited into the trenches than has been obtained through record searches and previous non-intrusive characterization activities. Intrusive characterization is defined as characterization activities that will remove materials for sampling and analysis from within selected 618-10 Burial Ground trenches. Exploratory test pitting was performed with excavations up to 6 meters deep and approximately 2 meters wide (at the base) and cross cut existing engineered burial ground trenches. Test pitting was used to expose a cross section of materials deposited in a burial ground trench to gain information regarding trench contents while minimizing the inventory of hazardous material exposed to personnel and the environment. Initial locations of intrusive characterization test pits were based on surface geophysical surveys and existing data obtained from the previously conducted nonintrusive sampling and characterization of radionuclides within the trenches. As intrusive characterization progressed, information gathered led to modifications and efficiencies in test pitting.

INTRODUCTION

Washington Closure Hanford, LLC, under contract to the U.S. Department of Energy (DOE), Richland Operations Office, is currently conducting deactivation, decontamination, decommissioning, and demolition of excess facilities; placing former production reactors in an interim, safe, and stable condition; and remediating waste sites and burial grounds in support of the closure of the Hanford Site River Corridor. The Hanford Site River Corridor consists of approximately 210 square miles of the Hanford Site along the Columbia River, in the State of Washington.

The remediation of the Hanford 618-10 burial ground presents unique and unparalleled challenges with respect to waste characterization, retrieval, and packaging for disposal. The 618-10 burial ground operated from 1954 to 1963 and contains waste generated primarily from Hanford's 300 Area, where fuel metallurgical analysis was performed and new methods were developed to separate plutonium from nuclear fuel. These wastes consisted of metallurgical sample residues, samples from experiments, and other very high dose rate, high alpha contaminated wastes. This waste was placed at the 618-10 burial ground for the purpose of non-retrievable disposal.

Washington Closure Hanford (WCH) submitted a Remediation Design Solution for the 618-10 Burial Ground to the Department of Energy, Richland Operations Office (DOE/RL) in 2007. DOE/RL reviewed the design solution and determined that the approach was reasonable, but had some recommendations and concerns that needed to be addressed prior to authorizing design and remediation of these burial grounds. The recommendations included:

- Perform characterization of the trenches in terms of further record searches, non-intrusive sampling, and intrusive sampling.
- Based on the characterization results, refine the remediation approach to provide a detailed design that would include environment, safety, and health controls; radiological controls; confinement strategy; and development of any new instrumentation that will be required.
- Provide a more defensible life-cycle cost for transuranic (TRU) waste, which should include the extent of TRU waste processing that will be required after it arrives at interim storage facility to meet waste acceptance criteria for disposal and include the appropriate escalation and contingency costs
- Reexamine the assumption that no discrete, separable, and identifiable spent nuclear fuel (SNF) will be exhumed from the burial grounds and provide life-cycle costs and disposition of spent nuclear fuel as appropriate

Intrusive characterization is required to respond to the recommendations associated with further record searches, non-intrusive sampling, and development of a potential confinement strategy.

Burial Ground Description

The 618-10 Burial Ground is located approximately 9.6 kilometers north of the city of Richland and approximately 400 meters upwind of the primary Hanford highway. It was activated in March 1954 and closed in September 1963.

The burial ground includes 12 trenches of various sizes which are up to 23 meters wide and 92 meters long by up to 7.6 meters deep. It also contains 94 vertical pipe units (VPUs), which are bottomless 108 liter drums that were welded together and buried vertically The VPUs are not included in this characterization activity, but were included in the previously conducted nonintrusive characterization project. The burial ground received a broad spectrum of low- to high-activity, dry, radioactive waste. The waste was primarily fission products and some plutonium-contaminated waste from the 300 Area. The trenches received low level waste in cardboard boxes; concreted drums containing higher activity waste, including some liquids; and large miscellaneous items (i.e., laboratory hoods, vent filters, and glove box trays). Non-radioactive beryllium was also disposed in the trenches. Few records documenting solid waste burial activities were kept until 1960.

When waste was disposed, higher dose rate items were generally transported to the 618-10 burial ground in bottom-opening shielded casks and placed in vertical pipe units. Remaining waste was disposed in trenches. Some high-dose-rate waste was disposed in trenches by either loading cardboard boxes of waste into shielded load luggers or centering small quantities of waste in a drum and pouring either concrete or a combination of concrete and lead around the waste. While use of the concreted/lead-shielded drums resulted in a significant dose rate reduction for personnel disposing of the waste, they present characterization and handling challenges when the waste is exhumed.

SUMMARY OF NON-INTRUSIVE CHARACTERIZATION

In 2009 and 2010, the 618-10 trenches and VPUs were evaluated using an *in situ* radiological multi-detector probe (MDP) through sealed, metal-cased probe points located just outside each of the VPUs and within the boundaries of each trench structure. Geophysics data from surveys previously performed at the site was used be used to locate the approximate centerlines of the trenches so that probe points could be installed approximately every 7.6 meters.

The main phases of work related to burial ground trenches were:

- Delineate burial ground structures using geophysical methods to locate *in situ* measurement and soil sampling points
- Install cased probe points near or within subsurface burial ground structures
- Collect *in situ* radiological measurements from within the installed probe points using a MDP assembly

Trench Geophysical Surveys

Extensive geophysical survey data were collected during previous mapping activities at 618-10. The earlier geophysical work detailed ground penetrating radar and magnetometer surveys. The results of these activities were documented onsite maps using global positioning system (GPS) -generated coordinates.

These data were used to determine the approximate centerlines of the trenches and to identify any areas that may be of special interest (Figure 1).

Probe Point Installation for Multidetector Probe Logging

Based on the geophysical delineation of the trenches, probe points were positioned along the entire length of each trench at the approximate centerline. These probe points were spaced at approximately 7.6 m intervals. Each of the probe points were be driven to a total depth of approximately 9.2 m below the existing ground surface.

Multidetector Probe Measurements

Each of the direct-push locations were logged using an MDP instrument configured with two gamma-ray detectors that were used as spectrometers, two neutron detectors, and a gross gamma detector. The detectors are configured to measure a broad range of radiation sources and activities through the wall of a steel direct push rod. These detectors are incorporated into a single assembly with integral shielding to restrict the field of view of some of the detectors, improve efficiency, and locate the vertical position of radiation sources within the material being logged.

618-10 Trench Multidetector Data Evaluation

The comprehensive review of the source test and sampling data collected during the 618-10 project characterization indicates the MDP detectors functioned with the designed parameters. The detectors were calibrated and source tested, and functioned to produce reliable data for the estimation of TRU contents within the VPUs.

The goal of the MDP characterization activities was to provide data and information needed for planning future intrusive characterization activities and remediation strategies for the VPUs and trenches located in the 618-10 Burial Ground. The MDP concept is based on a suite of detectors with differing operational ranges. The detectors were specified to measure a broad range of possible waste radiation types and activity levels through the wall of the steel penetrometer casing.

The results indicated that a large percentage of VPUs would be classified as TRU, depending on waste source assumptions. Further analysis of the data indicates there could be approximately 44 m3 of TRU material in the VPUs.

The results of the trench sampling were valuable to note “hot spots”, but without knowledge of densities and potential interferences, the data does little else. These data indicate almost no potential TRU measurement locations and very little 137-Cs activity. No transuranic material was directly measured and there appears to be little activity in the trenches, at least in the immediate vicinities of the installed cone penetrometers. Beyond a radius of approximately 1 meter, even high activity waste would be difficult to detect.

10 soil samples below and adjacent to the VPUs were collected and analyzed for chemicals and radionuclide activity. No radiation levels above background and no chemical constituents of interest were found in any of the samples.

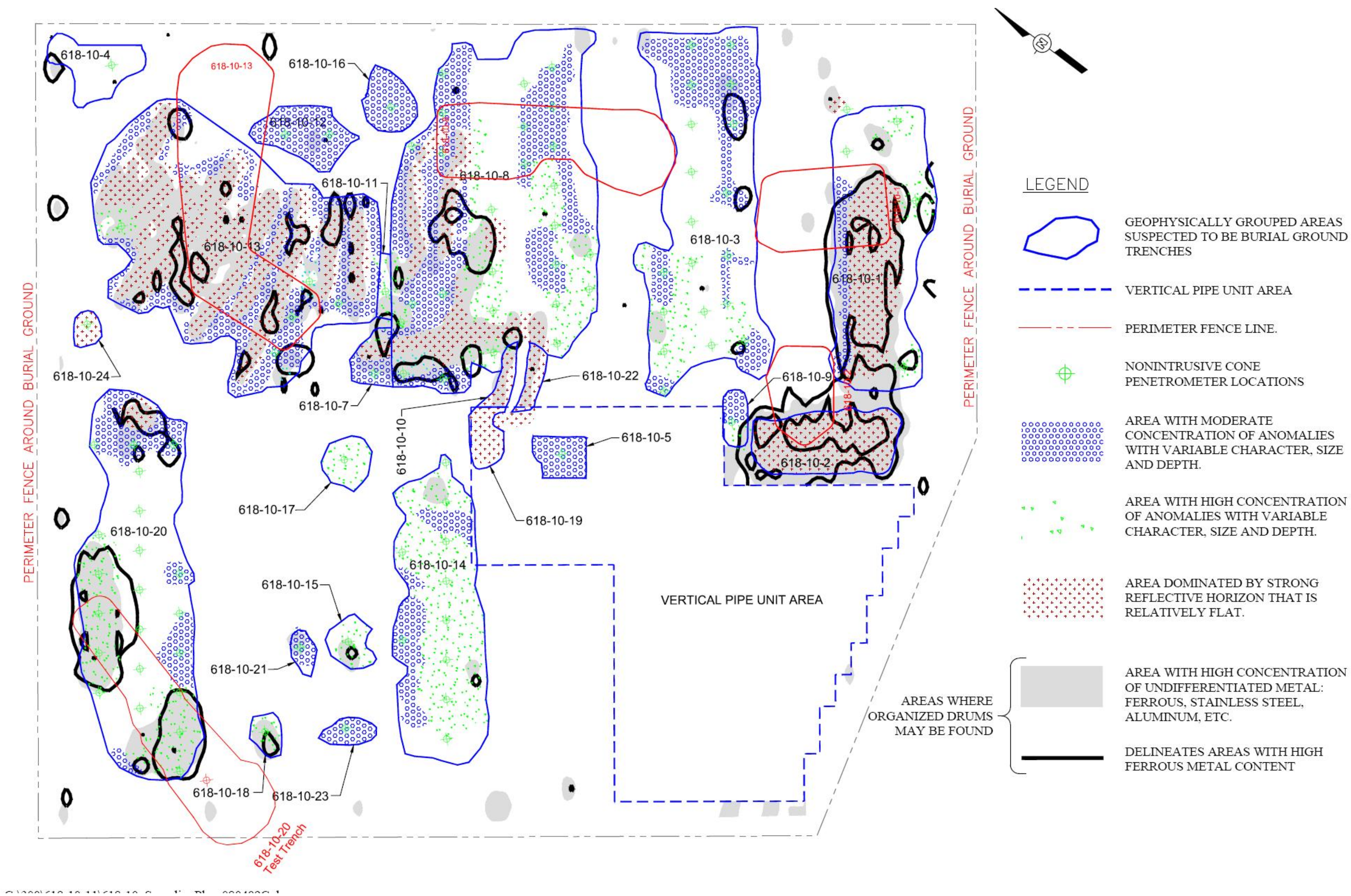

Figure 1. Map of the 618-10 Burial Ground Geophysical Analyses

INTRUSIVE CHARACTERIZATION DESIGN

Because the total number of buried drums and the nature/variability of their contents remain unknown, a nonstatistical design was used for the intrusive characterization of the 618-10 burial ground trenches. Excavation locations were focused in the 618-10 Burial Ground areas that were most likely to have buried drums present based on historical records and geophysical survey results.

The intrusive characterization activities for the 618-10 burial ground trenches included the following:

- Cross-trench or pothole select trenches based on previous geophysical studies and readings from the nonintrusive MDP characterization.

- Analyze soil samples on a grid across and at depth for each cross-trench.

- Collect samples of waste material and catalog waste types, distribution, and quantity from within the trenches selected.

- Analyze samples to the extent possible using real-time field analytical techniques. Determine the presence of free liquids in waste materials. Send remaining samples to appropriate laboratories for analysis.

- Determine if geophysical studies and *in situ* radionuclide characterization information, coupled with information collected during intrusive characterization, are sufficient to support design solutions and remediation of 618-10 burial ground trenches.

- Determine if sampling methods, field analytical techniques, laboratory techniques, and soil fixatives are adequate to support remediation.

Excavation, removal, inspection, and characterization of 10 to 20 drums was planned from different areas of the burial ground. General observations of the depth, orientation, layering, and condition of unearthed drums were recorded. Excavated were to be selected for characterization based on a preference to obtain information from drums with dissimilar exterior features (e.g., size, type, and markings). It was recognized that the degree to which these objectives could be met might be affected by project schedule constraints and actual number of drums encountered.

During all phases of the field investigation, industrial hygiene (IH) and radiological surveys were conducted to collect chemical and radiochemical information from the breathing zone, work areas, and drum contents. As part of the sample design, each drum was to be inspected and opened to identify the physical inventory of the contents and sampled to determine the chemical and radiochemical properties of the waste. Samples of surrounding soil from beneath the drums were to be collected and submitted to a contract laboratory for analysis to determine the chemical and radiochemical properties of the soil.

Exploratory Trenching

Drums were expected to be located within burial trenches showing a strong reflective surface as detected during the geophysical surveys (see Figure 1). The planned test pitting is depicted in Figure 2.

618-10-20: This location was proposed as the first test pit site because it appeared to be free of debris and drums that could provide an initial starting point for test pitting operations.

618-10-1: Test pitting was planned to cut through the middle of the burial trench on the edge of an area with a strong reflective horizon shown in the geophysical surveys. The reflective area from the geophysical survey indicated it was highly metallic consisting of ferrous material. This was suspected to be stacked drums.

618-10-13: Test pitting was planned to cut through the eastern portion of the burial trench. This area showed geophysical character unlike any other burial ground characterized to date along the river corridor. Individual anomalous features were shown to be quasi-linear, 1.5 to 3 m wide, flat topped, and variable in length but on the order of 30 meters long. It was not clear if the individual linear anomalies were a single feature or closely spaced smaller individual features.

618-10-8: Test pitting was planned to cut through the middle portion on the burial trench. The burial trench showed two interpreted separate area, a 15.2-m by 58-m trench in the southern half, and a group of anomalous features approximately 3 m by 30 m in the northern half within a single trench related to the anomalies in 618-10-13. In the southern half the apparent greater burial depth (approximately 3 m bgs) reduced the reliability of the geophysical interpretation. The northern portion appeared flat topped, organized, and highly metallic with variable ferrous content.

618-10-14: Test pitting was planned to cut through the middle portion of the burial trench. The geophysical interpretations showed variable concentrations of debris, with potential quantities of nonmetallic debris. The metallic debris appeared scattered, but slightly more concentrated at the ends of the trench.

618-10-2: Test pitting was planned to cut through the longitudinal direction of the burial trench (north-south). Geophysical surveys showed the contents of the trench to be highly metallic, including ferrous material. A well-defined or organized boundary with a relatively flat top indicated the potential for stacked drums.

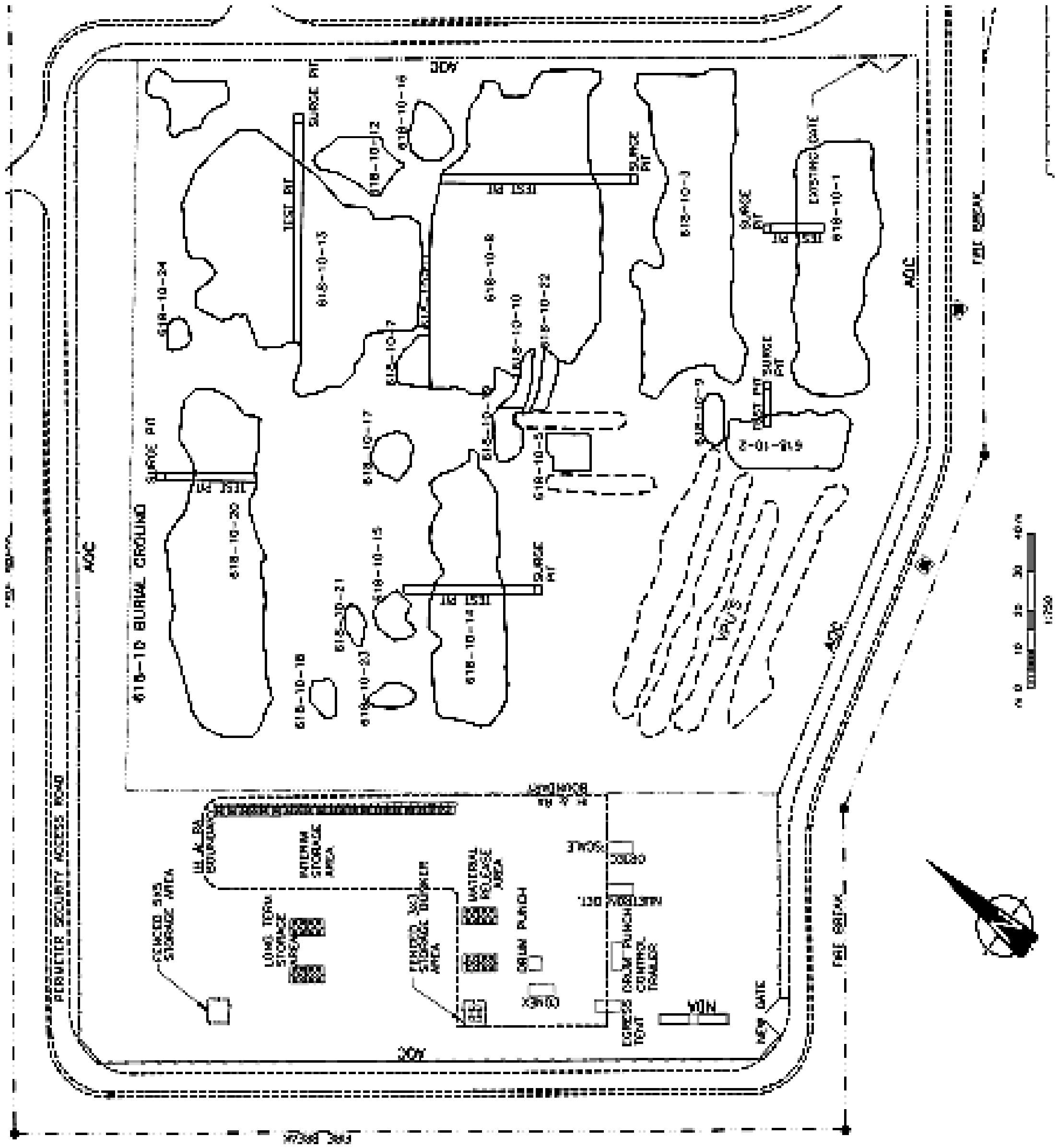

Figure 2.   Planned 618-10 Test Pit Locations

Excavation Techniques

At each location where intrusive activities were conducted, excavation was performed in accordance with approved means and methods that reflect the design elements and the following general earthwork objectives:

- Minimize the potential to inadvertently pierce a drum (e.g., toothless bucket)
- Minimize disturbance to surrounding drums during the excavation process

- Prevent dispersion of dust from the site during operations with the use of dust-suppression agents such as magnesium chloride or calcium chloride.

A primary excavator, equipped with an enclosed cab and blast shield, was used to cross-trench and to remove drums from the excavation face. The excavator was equipped with a gamma radiation rate meter, an infrared sensor (to detect thermal changes in drums), and a photo ionization detector. The primary excavator was also be equipped with a camera to be used by the operator in recording and relaying images to the support staff when an anomaly or item of interest was located during excavation. A second excavator, with a Compton Ratio Analysis Testing for Environmental Radioactivity (CRATER®) detector, was initially used to sort small-sized material looking for spent nuclear fuel. The first track-hoe excavated a "surge pit" in clean undisturbed material adjacent to the trench to be excavated. The operator then initiated trenching toward the burial ground trench. An example of the excavation process is presented in Figure 3. During trenching activities fixatives were used to negate airborne contamination. At the end of characterization, the cross-trench was covered with clean backfill.

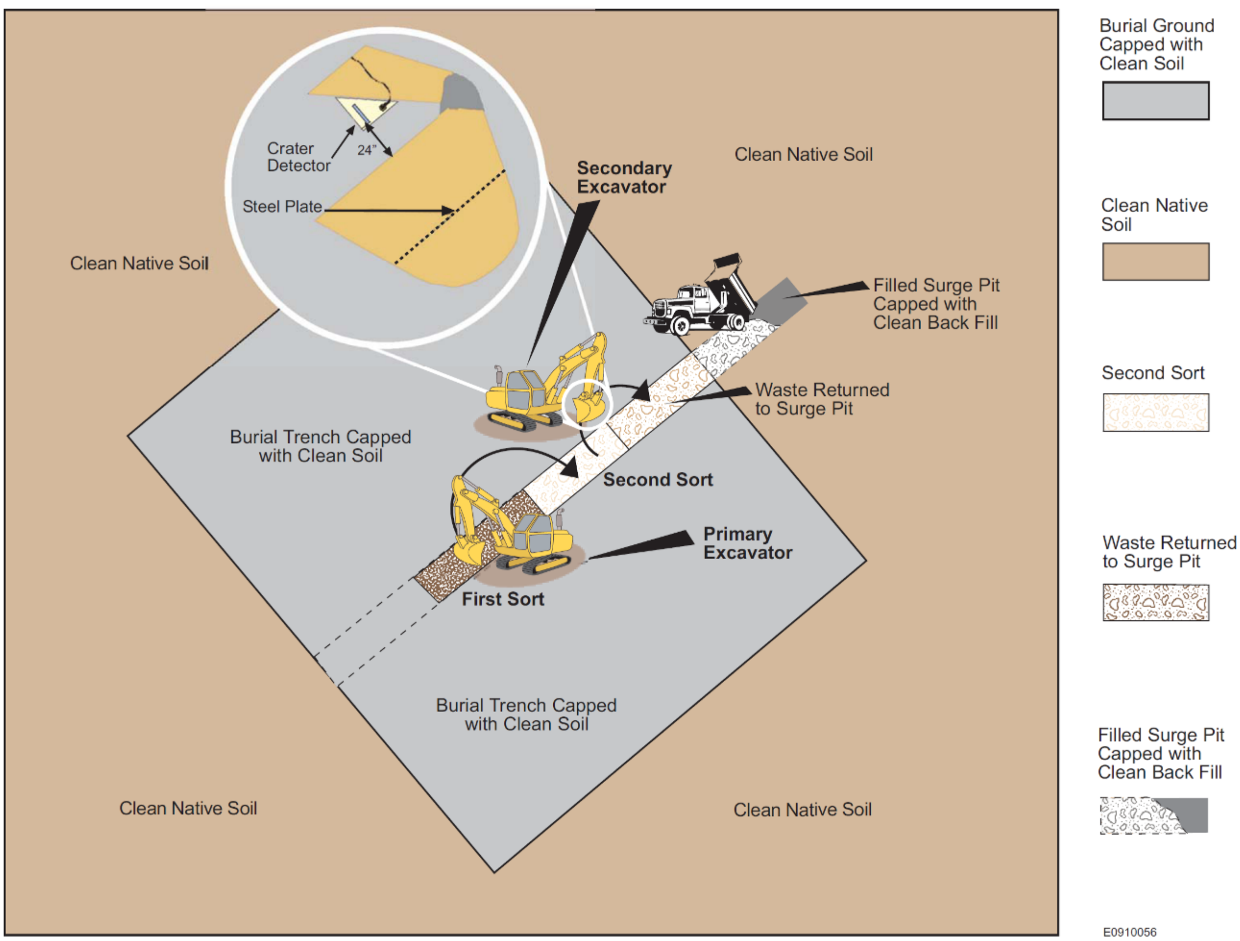

Figure 3. Test Pit Excavation Process

As each bucket of material was excavated from the cross-trench it was monitored for gross radiation, temperature, and volatile organic compounds. Radiological control technicians and IH technicians conducted further monitoring. The project resident engineer determined the material that would be further analyzed or sampled. Typical material sampled included discolored soil, free liquids, intact drums, debris with anomalous radiological readings. After sampling and analysis and cataloging and mapping, the second track-hoe inspected the debris for spent fuel and returned the material into the adjacent area (surge pit).

Dust-suppression water and fixatives were applied with use of remotely controlled nozzles to prevent visible dust from being suspended or dispersed from the excavation site.

Sampling and Characterization

Soils

Soil and bulk materials were screened and moved from their original location to a second location as part of the test pitting sorting and screening process as described previously. Soil samples were collected within the test pits in a grid pattern. At least six soil matrix samples were planned to be collected from each test pit.

Drums

The primary objective of the drum collection activity was to collect intact drums of debris and a subset of concreted drums for the testing of characterization methods used to determine the presence of alpha-emitting radionuclides and subsequent designation of TRU waste. Drums were expected to be found in differing stages of degradation and fall into one of three categories: (1) drums of loose debris, (2) drums of uranium/zircaloy chips in mineral oil, and (3) concreted drums (drums with concrete and possibly lead shielding surrounding a central cylindrical volume of waste materials). Approximately 10 to 20 intact drums were planned to be removed during intrusive characterization activities.

Before being removed from the excavation face, drums were observed for crystallized material around the drum opening/joints or bulging/disfiguration (which may indicate pressurization), IH surveys were conducted, and radiological surveys with the aid of excavator mounted instrumentation were conducted. The temperature of the drums was also checked using an infrared thermometer and recorded. Once the exposed drums were allowed to equilibrate and cleared the survey/temperature checks, the drum was removed from the excavation face and put into the designated inspection area. Drums were placed into overpacks as needed prior to movement.

The project sampling technician performed a nonintrusive, physical inspection of each drum after it was removed from the dig face and moved to the drum inspection area. Information gathered/recorded during the physical inspection included the following:

- General observations of the drum condition
- Drum size
- Weight
- Any markings present on the drum exterior
- Temperature
- IH survey readings
- Radiological survey readings

Radiological surveys were performed on drums in the drum inspection area with a stationary gamma spectrometer. Drums determined to not contain alpha-emitting nuclides were processed through a drum punch facility. In the drum punch facility, individual overpack drums could be remotely pierced to obtain access to the drum contents. Each drum was visually surveyed and cleared prior to being pierced. Radiological surveys and headspace/ breathing zone surveys were conducted once the inner drum had been pierced, and the temperature of the drum was checked.

The project sampling technician observed and recorded the physical contents of the drum including the estimated volume/amount, phase (e.g., liquid, solid, and multi-phase), color, pH, and any other observations noted during the inspection.

If the drums contained metal chips and/or sludge that were not immersed in fluid, water or mineral oil would be added to the inner container to ensure that the solid/sludge material would be fully immersed and in a stable configuration.

Mobile non-destructive assay (NDA) was used to generate assay results for identification of potentially TRU materials.

Presence of SNF was determined with the CRATER® system.

Backfill and Characterization Completion

Soil and debris removed during the field investigation was used to backfill the open investigation areas. Overpacked/stabilized drums that were removed during the investigation activities were staged for storage until they can be processed at a later time during remediation. To ensure a stable configuration between the field investigation and the start of remedial actions at the site, a minimum fill depth of 1 m was used at locations where drums or anomalous items were not removed from the trenches were encountered and/or remain exposed. Remediation activities are planned to begin in the spring of 2011.

DATA EVALUATION

Field Observations

During the intrusive field operations five test trenches were excavated through burial trenches 618-10-1, 618-10-2, 618-10-8, 618-10-13 and 618-10-20. These areas can be seen in Figure 1 outlined in red. Several anomalies were uncovered during the excavation process including drums containing depleted uranium, an oil filled drum, concreted drums, various laboratory bottles and debris, metal debris, and metal pipes. Six soil samples were collected from each trench for the purpose of determining the chemical and radionuclide concentrations in the trench soil matrix.

During the intrusive characterization activities drums were found in three of the five test trenches (618-10-1, 618-10-20, and 618-10-2). A total of five drums were retrieved from the trenches: one depleted uranium drum from 618-10-1, three concreted drums from 618-10-20, and one oil filled drum from 618-10-20. Several depleted uranium drums were located in 618-10-1, and one uranium drum was unearthed in 618-10-2.

Only the one uranium containing drum was retrieved from the trench because it was determined that the fire risk outweighed the benefit of characterizing the drum contents. Based on previous burial ground remedial activities sufficient knowledge is available for drums containing depleted uranium and uranium oxide. The total number of retrieved drums was limited by the types and location of drums uncovered during the intrusive activities. Only a few location were found with multiple drums (e.g. concreted drums in 618-10-20 and depleted uranium drums in 618-10-1) and it was determined that only a select representative few should be retrieved from each location, resulting in a fewer number retrieved than the approximately 10 – 20 planned.

After a time of using the secondary excavator and CRATER® system to sort through excavated material in search of high-dose items and SNF, it became evident that the gamma radiation rate meter on the primary excavator was sufficient for screening. After an item of interest was identified with the gamma rate meter, the CRATER® system could used to further screen and characterize the item. No SNF was identified during intrusive characterization activities.

618-10-1

In this trench a cache of scattered 113 liter drums were encountered, as expected, at about 1.5 m below ground surface (bgs). One leaking depleted uranium drum was exhumed, placed into an overpack container, and sampled. Also, several bottles were seen below the drum cache at about 4.5 m bgs. Other bottles were found at various locations in the trench.

618-10-8

In this trench various anomalous items were found. Of particular interest was a stainless steel transportation cask or “pig” at 4.5 m bgs. The cask was monitored in place, and then removed from the trench for analysis. No radiation above background was detected and the cask was returned to the trench to be dispositioned during the forthcoming remediation activities. Also a 0.6 meter long box was encountered. The contents of the box could not be determined visually and since the project was not equipped to handle this type of material, it was left in place. Also, several bottles were found throughout the trench.

618-10-13

This geophysics for this trench showed a geophysical character unlike any other burial ground characterized to date along the river corridor. Individual anomalous features were shown to be quasi-linear, 1.5 to 3 m wide, flat topped, and variable in length but on the order of 30 meters long. It was not clear if the individual linear anomalies were a single feature or closely spaced smaller individual features.

This area was found to be full of “Hog Wire” fencing with wooden fence posts (Figure 4). There were also various bottles and open metal cons found. No items were removed from this trench for analysis.

Figure 5. “Hog Wire” Fencing in 618-10-13

618-10-20

This trench was thought to be free from debris and drums. This turned out to be a false assumption. Several drums were found and analyzed:

- 208 L concreted drum with picking eye - marked “Prestone Anti-Freeze”
- Rusty damaged concreted drum with a picking eye
- 208 L concreted drum with picking eye - marked “CHEMICAL” and “PITSBURGH”
- Damaged drum leaking purple oil. This drum was overpacked and a sampled for chemical/radiological analysis. No radiation above background was detected at the container surface.

All radiological analyses were near or below detection limits.

Also found in this trench were several steel pipes and metal debris. None of these items were removed.

618-10-2

This trench was presumed to contain a cache of drums. Again, wooden fence posts with wire (not “hog wire” were found here. A few drums were encountered including an open 208 L drum filled with soil and a closed 208 L drum. Neither of these was removed.

Soil Sampling

Six soil samples were collected from each test trench for the purpose of determining the chemical and radionuclide concentrations in the trench soil matrix. Most radionuclide results were found below cleanup levels and no chemical contaminants of concern were detected. This does not mean that the burial ground soils are expected to be at these levels during remediation. The highest radionuclide results from each trench are listed in Figure 5.

	618-1-1	618-1-2	618-1-8	618-1-13	618-1-20	Cleanup Levels*	
Analyte	High result (Bq/g)	High result (Bq/g)	High result (Bq/g)	High result (Bq/g)	High result (Bq/g)	Unrestricted Direct Exposure (Bq/g)	Unrestricted Groundwater Protection (Bq/g)
Gross Alpha	0.4625					NA	NA
Gross Beta	0.8066					NA	NA
C-14	6.549	0.05698	0.05402	0.03552	0.13468	0.3219	NA
U-233/234	0.0222	0.03293	0.03145	0.04403	0.02701	1.0064	0.6623
U-238	0.06549	0.02331	0.03515	0.03885	0.02479	0.9694	0.6401
Pu-239/240	0.07104		0.01332		0.11433	1.2987	0
K-40	0.444	0.5032	0.4588	0.4551	0.4588	NA	NA
Cs-137	0.0037	0.002183	0.01517			0.2294	NA
Ra-226	0.01628	0.01591	0.01369	0.01591	0.01443	NA	NA
Ra-228	0.02627	0.02775	0.02368	0.02442	0.02405	NA	NA
Th-228		0.02331	0.02183	0.02109	0.02183	0.0851	NA
Th-232	0.02479	0.02775	0.02368	0.02257	0.02405	0.037	NA
Am-241	0.00703					1.1877	NA
*Remedial Design Report/ Remedial Action Work Plan for the 300 Area (DOE/RL-2001-47, rev. 3)							

Figure 5. Radionuclide Results in 618-11 Soils

CONCLUSION

Intrusive characterization, as a follow-on activity to nonintrusive characterization, provided needed data and information on the various waste types, quantity, level of contamination, condition and retrievability of the waste materials in the 618-10 burial ground trenches. The characterization information is being used to support design for the upcoming remediation of the 618-10 waste disposal trenches. The activity was also valuable to validate the geophysical investigations performed at an earlier time. In some cases, the presumed contents and actual contents of individual trenches varied widely. In other cases, the actual trench contents were similar to what was presumed. Some of the lessons learned include:

- Although some of the expected waste streams were identified, the diminished level of contamination observed in the soil laboratory results and the lower dose rates identified in the concreted drum NDA results are surprising. No contamination levels above the RDR/RAWP cleanup levels were identified in the soils, and no transuranic (plutonium) radionuclides were identified in the concreted drums.

- The magnetic signature from the geophysical surveys was the best indication for determining areas where drums and metal anomalies might be located. The geophysical data proved to be a poor indicator of drum locations and yielded minimal results. The hog wire fencing is likely manifested in the magnetic patterns shown over 618-10-13 and other places.

- The use of the CRATER™ system did not provide and efficient method for searching for high-dose items and use will be diminished during remediation activities. The CRATER™ system will not be used to screen through bulk materials and soil, and will be used to screen/monitor discrete items at the discretion of the project engineer or resident engineer.

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