Characterization Modeling and Remediation Method Selection to Support Remedial Design Solution Development for the Hanford 618-10 and 618-11 Burial Grounds

L.M. Nolan, J.N. Winters, N.C. Little, S.E. Parnell
Washington Closure Hanford, LLC
2620 Fermi Avenue, Richland, WA 99301 USA

ABSTRACT

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 565 square kilometers (218 square miles) of the Hanford Site along the Columbia River, in the State of Washington.

The regulatory framework to achieve the Hanford Site remediation is established in the Hanford Federal Facility Agreement and Consent Order [1], commonly known as the Tri-Party Agreement, entered into by the DOE, U.S. Environmental Protection Agency Region 10 (EPA), and the Washington State Department of Ecology.

This paper describes the significant challenges associated with the planned remediation of the Hanford 618-10 and 618-11 Burial Grounds. It discusses the process used to identify remediation options, and the process and analysis used to determine the preferred remediation methods that will be included in the Project’s design solution document. Additionally, this paper discusses the preferred retrieval methods and how they allow flexibility for change in remediation approach and disposal based on conditions encountered in the field and as waste characterization understanding increases during field characterization, pre-retrieval, and retrieval activities. Finally, this paper discusses the challenges in development of a characterization model, given that little or no records were available to start the project.

INTRODUCTION

The remediation of two large Hanford waste burial grounds present unique and unparalleled challenges with respect to waste characterization, retrieval, and packaging for disposal. The 618-10 and 618-11 burial grounds operated from 1954 to 1967 and contain 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 contamination wastes. This waste was placed at the 618-10 and 618-11 Burial Grounds for the purpose of non-retrievable disposal.

These burial grounds are located directly upwind and only a few hundred feet from either Hanford's main highway access (618-10), or an operating commercial nuclear power plant (618-11).

Washington Closure Hanford, LLC (WCH) is developing a design solution for the remediation of these burial grounds. The design solution includes innovative solutions to address the significant waste characterization and waste retrieval challenges to enable WCH to safely complete the remediation ahead of schedule.

Burial Grounds Description

The 618-10 Burial Ground is located approximately 6.4 kilometers (four miles) north of the Hanford 300 Area (Fig. 1.), and approximately 400 meters (1300 feet) 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 (75 ft) wide and 92 meters (300 ft) long by up to 7.6 meters (25 feet) deep. It also contains 94 vertical pipe units (VPUs), which are bottomless 208 liter (55 gallon) drums that were welded together and buried vertically. The burial ground received a broad spectrum of low- to high-activity radioactive waste. The waste was primarily fission products and some plutonium-contaminated waste from the 300 Area. The trenches received low to high activity 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. In 1959, the 327 Radiometallurgy Building began using a cask truck to transport hot cell waste in aluminum "milk pails," which were remotely dropped into the unit. These "milk pails" were sealed with gelatin and had no lids. Another cask, known as the "Gattling gun," deposited l-liter "juice" cans of high-activity waste from a rotating chamber into the pipe units [2]. Few records documenting solid waste burial activities were kept until 1960.

The 618-11 Burial Ground is located approximately 12 kilometers (7.5 miles) northwest of the Hanford 300 Area (Fig. 1.) just upwind and within the controlled area of an operating commercial nuclear power plant. The 618-11 burial ground was operational from October 1962 through December 1967. The site is 114 meters (375 ft) wide by 305 meters (1,000 ft) long, appearing as a long rectangular area that is oriented east to west. The burial ground consists of three trenches, fifty VPUs (similar in design to 618-10), and five 2.4 meter (8 ft) diameter 3.1 meter (10 ft) tall caissons, which are buried 4.6 meters (15 feet) deep and connected to the surface by an offset 0.9 meter (three foot) diameter corrugated pipe chute designed to reduce radiation dose rates at grade level. Trenches are 275 meters (900 ft) long, 15.3 meters (50 ft) wide, 7.6 meters (25 ft) deep, and are V-shaped with a 1:1 sides slope.

Based on process knowledge, the 618-10 and 618-11 Burial Grounds contain a vast spectrum of low radionuclide concentration to high radionuclide wastes. Contaminants that may be present include technetium, zirconium, uranium, americium, cesium, curium, Sr ^{90}, C ^{14}, plutonium metals, and plutonium nitrates. Other contaminants may include thorium, beryllium, aluminum-lithium, and carbon tetrachloride. The waste would also have included laboratory equipment. In the early 1960s, the Atomic Energy Commission (now Department of Energy) determined that

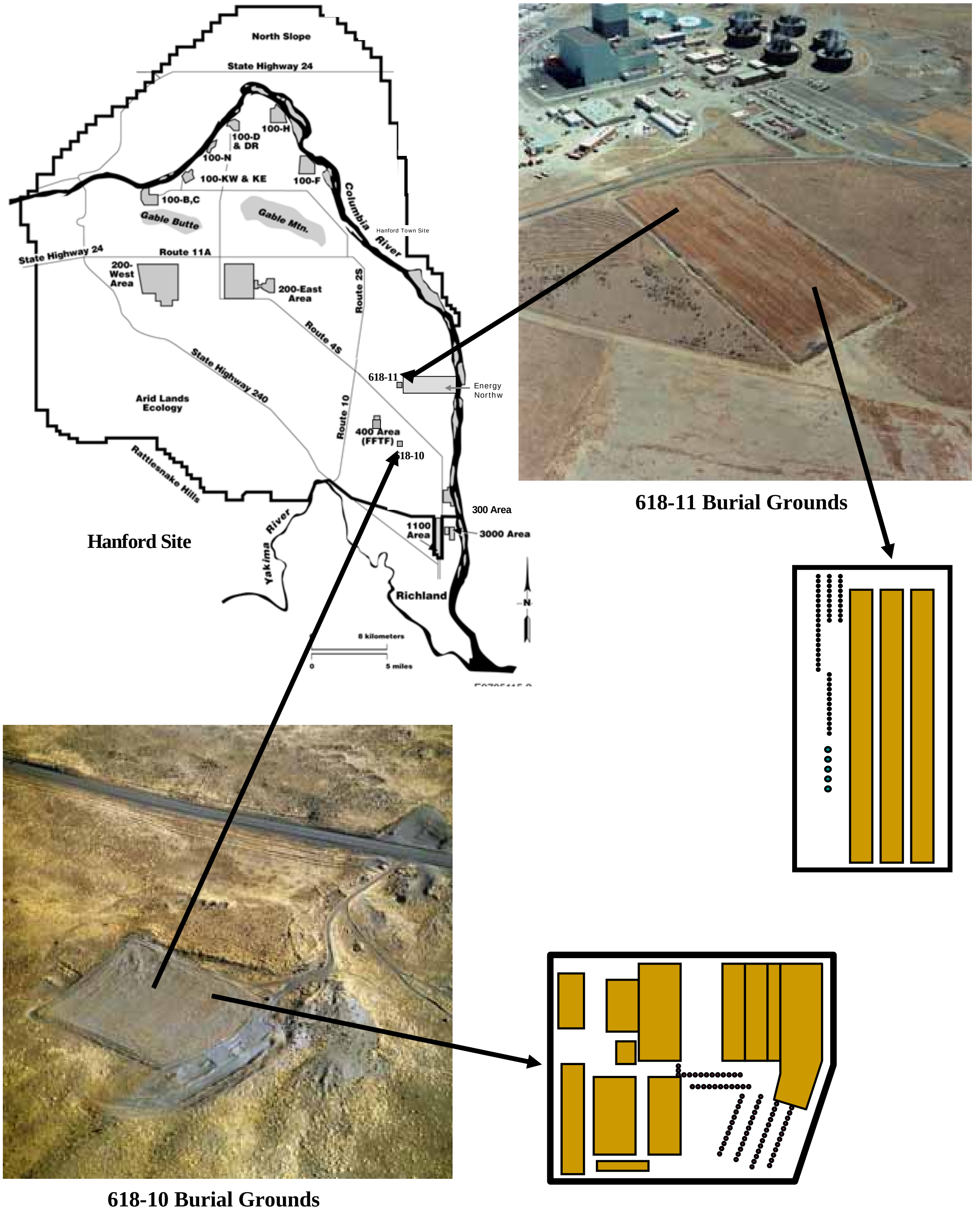

Fig. 1. Location and aerial view of the 618-10 and 618-11 Burial Grounds

high dose rate, high plutonium concentration wastes should not be disposed near the Columbia River and, confirmed by radiological surveys, waste disposal practices changed in the mid 1960s resulting in disposal of 300 Area high dose rate, high plutonium concentration wastes in the 200 Area burial grounds located within Hanford’s Central Plateau.

REMEDIATION METHOD SELECTION

A systematic approach was used to determine retrieval methods that WCH recommends for use at the 618-10 and 618-11 Burial Grounds [7, 8, 9, 10, 11, 12, 13, 14]. The analysis and selection process had four main steps. First, the selection criteria were established for the waste retrieval process. The selection criteria focused on the functional requirements for remediation of the burial grounds. Second, retrieval technologies that are commercially available were identified along with information on how they might be used in retrieving waste. The third step was to evaluate the available retrieval options and rank how well each could meet the selection criteria. Based on that ranking, a short list of feasible options was identified. In the fourth and final step, each feasible option was developed in greater detail as to how it could be used for waste retrieval. With an additional understanding of how each feasible retrieval option could be used, they were re-ranked against the selection criteria. The highest ranked alternative was selected as the preferred alternative for waste retrieval from the burial ground disposal units.

Selection Criteria

The basis for the criteria selection is the team’s understanding of the physical configuration of the waste disposal units, waste characteristics and the *Interim Action Record of Decision for the 300-FF-2 Operable Unit* (300-FF-2 ROD) [3] requirements to remove, treat, and dispose of the burial ground waste. The project team identified the key remediation functions to be characterization, development of screening criteria, excavation, sorting, packaging/shipment, and waste transportation/disposal.

In addition to functional selection criteria, the retrieval options were ranked against four other criteria that are commonly used when evaluating alternatives or options in feasibility studies. Those criteria are safety/health considerations, cost, schedule, and administrative issues.

Retrieval Technology Identification and Assessment

Information was collected on waste retrieval technologies that may be applicable to remediation of the 618-10 and 618-11 Burial Grounds. The sources of information on retrieval methods included 1) evaluations completed by other U.S. Department of Energy (DOE) projects on available retrieval methods [8, 13, 14], 2) progress reports for technical demonstration projects involving burial ground waste retrieval, 3) interviews with key project personnel on waste retrieval projects at Hanford, Idaho National Engineering and Environmental Laboratory (INEEL), and Rocky Flats remediation projects, 4) site visits to Hanford and INEEL projects to learn from their remediation experience, and 5) review of equipment methods considered for other projects where the work is done remotely such as waste retrieval from tanks and decommissioning/demolition projects. Equipment vendors were also contacted to better understand how their equipment could be used to support waste retrieval at 618-10 and 618-11 Burial Grounds.

A list of available retrieval technologies was prepared based on the findings of those information sources. From the list, the project team selected retrieval methods based on the team's experience and understanding of the burial grounds, that could be applicable for waste retrieval.

Waste Retrieval Options Development and Selection

The project team used the information from the technology identification and assessment step and developed a set of waste retrieval methods that incorporated one or more of the retrieval technologies. These methods are called the available options for waste retrieval. The retrieval methods developed include several variations of trench waste retrieval using an excavator. During retrieval method development, the team also added several excavation methods that had not been included in the initial retrieval technologies list. A written description for each of the available options was prepared. The descriptions included an overview of how the retrieval options would be used and a discussion of the pros/cons and risks. The write-ups were prepared to support comparison and ranking of the available options.

Ranking Waste Retrieval Options

Using the information developed, the available retrieval options were ranked against the selection criteria. The ranking process was conducted in two workshops. At the first workshop, participants ranked available retrieval options. During the second workshop, the higher ranked retrieval options from the first workshop were evaluated using additional information.

In April 2006, the first ranking workshop was held. The project team and invited specialists reviewed the available options and ranked them on how well they met the selection criteria. Workshop participant backgrounds included expertise in nuclear facilities design/startup/operation, criticality safety, waste characterization/transportation, nuclear safety, health and safety, and waste remediation methods. From the first workshop effort, the higher scoring available options for the three disposal units (trenches, VPUs, and caissons) were identified. These options were designated as the feasible retrieval options.

For remediation of waste located in trenches, three excavator-based methods scored the highest. The use of an excavator for waste retrieval from burial grounds has been used successfully at the Hanford Site and many other DOE sites. Using this retrieval method, waste items and contaminated soil will be removed from the trenches with an excavator working from above the dig face. The workshop team determined that the excavation of trench waste will be conducted in a weather enclosure, which would support remediation operations during inclement weather.

For remediation of the waste in the VPUs, the three highest scoring available options were an overcasing method, vitrification, and piece by piece removal of the waste.

For the waste contained in the caissons, retrieval using a piece by piece approach and vitrification were the highest ranked methods. A method that would inject stabilizing material into the caisson, remove it as a monolith and dismantle the monolith elsewhere, was a distant third and was dropped from further consideration.

To further evaluate the feasible options, additional information was developed and reviewed. That information included development of process flow sheets, review of radiological survey records of waste disposed at the burial grounds, waste and soil excavation volume estimates, site plan/facilities layout, electrical power source review and preliminary site layout, contacts made to weather enclosure manufacturers, preliminary review of fire protection requirements, and development of conceptual level cost estimates.

Using that information, a second retrieval method ranking workshop was held in July 2006 to finalize the rankings. Only the feasible options for VPUs and caissons were evaluated. The trench waste retrieval method was identified already by the scoring during the first workshop. An excavator-based approach, working inside a weather enclosure, is the final/preferred option for trench waste retrieval.

From the second workshop, the final/preferred retrieval options for waste retrieval from the VPUs and caisson were identified as the over-casing method and the piece by piece method, respectively.

The same ranking system and criteria scoring guide was used in the second workshop for re-ranking the feasible options for VPU and caissons. Workshop participants included the same group as the first ranking workshop attendees except for the criticality engineer, who did not participate. No changes were made to the criticality sub-criterion rankings.

FINAL/PREFERRED RETRIEVAL METHODS

Using a thorough method to identify candidate retrieval methods, selection criteria, and evaluation of retrieval options, a set of final/preferred options were identified. Following are descriptions of the final/preferred options for the remediation of the 618-10 and 618-11 burial grounds.

The information provided below on final/preferred retrieval methods being developed by WCH is current as of November 2006. The 618-10 and 618-11 design solution document will not be submitted to Department of Energy and response received in time to be reflected in this paper. The final preferred options are reflective of the ranking and evaluation system developed by the WCH 618-10 and 618-11 team.

Trench Waste – Retrieval by Excavator Inside Weather Enclosure

For this retrieval method, a weather enclosure (treated-fabric covered, self-supporting movable building) [14] will be placed over a portion of burial ground trenches to be excavated. The enclosure will be approximately 37 meters (120 feet) wide by 43 meters (140 feet) long with sufficient height (approximately 8.5 meters [28 feet] at side wall) for excavator operation inside. The weather enclosures and associated support equipment (e.g., HEPA filtration units, power, lighting, and concrete blocks to secure the enclosure) are designed to be moved as waste is removed. The excavators and other equipment inside the enclosure will be provided with HEPA filtration on their cab breathing air supply system as well as having a compressed air supply available to the operator. Excavators that operate inside the enclosure will be equipped with exhaust scrubber systems. Water and fixatives will be applied prior to and during waste excavation to control dust and contamination movement.

An excavator will typically work from the top of the excavation slope where there is a better view of the slope being worked and is a safer position for the excavator operator. The excavator operator will take the necessary steps to make sure that excavator is working from a clean soil working surface. Based on the physical reach limitations of the excavator used at a burial ground excavation and the depth of the trench, some trenches will require waste removal in two lifts. In those cases, once the first lift of waste is removed, a layer of clean fill will be placed over the excavated area to provide a clean working surface for the excavator to begin work on removal of the second (lower portion) lift of the trench contents.

At the excavation dig face, initial sorting of the waste will occur. The mixing/initial sorting steps allow the operator to identify waste that should be separated from the debris and handled separately such as unusual/anomalous items that require further identification and/or sampling. Additionally, dose rate instrumentation will be installed near the excavator bucket to support initial radiological screening, and industrial hygiene monitoring equipment will be mounted near the excavator bucket. As the mixing/initial sort activity occurs, the air quality will be monitored and data gathered will be used for radiological safety purposes. During the initial mixing and sorting activities, the excavator operator and staff working near the area of the excavation may need to use a fresh air supply and anti-contamination clothing.

Drums and other unearthed items failing initial sorting criterion will be segregated by type, placed in approved containers and taken to an established waste staging area. Large debris will be staged outside of the enclosure for characterization and future size reduction.

The soil and waste excavated from the dig face will be cast up to a second excavator that will be used to transport it to a secondary sorting area located within the weather enclosure. There the waste and soil will be spread out into a layer approximately 0.3-m (1-ft) thick in a sorting trench. A radiological survey and sort of the waste will be completed at the sorting area to identify high dose rate and additional anomalous wastes. Items identified during radiological screening will be removed from the enclosure for characterization and sampling in accordance with the sampling and analysis plan. In addition, samples will be taken and analyzed for hazardous constituents to support waste disposition decisions.

When confirmed by review of sample results, the soil and remaining scanned waste that meet the Environmental Restoration Disposal Facility (ERDF)[1] waste acceptance criteria [4] will be loaded into a large roll-off container and subsequently transported to ERDF.

Waste that has been segregated out for further sampling/analysis, including anomalous and high-dose-rate wastes, will be placed in drums and/or overpacks as necessary to support its transfer

[1] The ERDF is a Hanford on-site CERCLA and low-level radioactive waste disposal facility.

out of the weather enclosure and storage in a secure staging area. Characterization results for this waste will be used to determine its disposal path. Shielded or unmanned excavators may be required for handling high-dose items. Video cameras will also be used to support identification of segregated items.

Waste items may be treated if necessary to meet the waste acceptance criteria for either the Central Waste Complex (CWC)[2] or ERDF [3, 4]. As stated in the 300-FF-2 Record of Decision (ROD), waste treatment will typically be performed in the 300 Area (at 618-10 or 618-11) or at ERDF prior to disposal. Treatment technologies envisioned for these waste materials are macroencapsulation and microencapsulation, although other options may also be appropriate. TRU waste will be packaged in 208 liter (55 gallon) drums or standard waste boxes and transported to the CWC awaiting additional characterization and eventual shipment to the Waste Isolation Pilot Plant. Anomalous items will be managed in accordance with alternate treatment plans or recovery plans.

Soil beneath the trench will be sampled in accordance with the sampling and analysis plan. If the soil meets the cleanup requirements of the Record of Decision (ROD), a cleanup verification package will be prepared for submittal to U.S. Environmental Protection Agency (EPA) for approval. If the underlying soil does not meet the cleanup requirements of the ROD, a ROD-supported path forward will be developed with RL and EPA. Sampling and characterization activities for waste retrieval will be supported by a mobile analytical laboratory (radiological and hazardous constituents) and a nondestructive assay facility located at the project site.

Vertical Pipe Units – Over-case Vertical Pipe Units, Inject Grout and Remove as One Piece

For this retrieval method, a 1.3 centimeter (0.5 inch) wall thickness, 8.5 meter (28 foot) long, 1.2 meter (4 foot) diameter steel pipe will be installed to over-case each VPU (Fig 2). Geophysical surveys will be used to locate the top of each VPU. Four cone penetrometer pipes will be installed around the perimeter of each VPU. A radiation detection instrument string [3] will be lowered into the cone penetrometer pipes to vertically log the dose rate and identify and quantify key radionuclides at 0.3-m (1-ft) intervals along the length of the VPU to support waste characterization. If the over-cased VPU is determined to be TRU waste, it may be retrieved and placed in an interim storage facility awaiting the availability of a

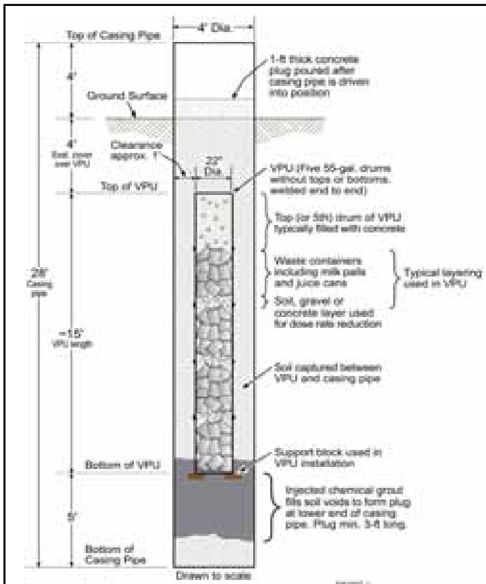

Fig. 2. Over-Cased Vertical Pipe Unit

---

[2] The Central Waste Complex, operated by Fluor Hanford, manages potential TRU wastes at Hanford.
[3] The instrument string consists of a GM tube (dose rates), NaI and CZT detectors (gamma isotopic), and BF_3 and He^3 tubes (neutrons for Pu determination).

remote-handled waste treatment and repackaging facility, to be constructed at Hanford's Central Plateau. Subsequently, the over-casing pipe will be driven into place with a vibratory hammer, suspended by a large crane as the overcasing pipe is advanced into the ground. The over-casing pipe is sized to extend from approximately 1.5 meters (5 feet) below the bottom elevation of the VPU up to approximately 2.4 meters (8 feet) above the VPU. Similar to the cold testing of VPU overcasing method that was recently completed as part of a technical demonstration project funded by DOE headquarters, the over-casing pipes will include grout pipes mounted axially along the inside wall of the overcasing pipe.

Once the over-casing pipe has been driven into place, the driving head equipment will be removed and the grouting system used to inject a chemical grout below the VPU to form a lower plug. The plug will be within the overcasing pipe and below the bottom of the VPU. As a second step for those VPUs characterized as a low-level waste and acceptable for disposal at the ERDF, grout will be injected between the VPU and over-casing to fill voids in the soil captured between the casing and VPU to macroencapsulate the waste debris present within the VPU. This grouting step will not be completed for those VPUs characterized as TRU to support future repackaging of the waste. As a final grouting step for all VPUs, a layer of cementatious grout or concrete will be placed inside the overcasing pipe to close the top end of the pipe. The bottom and top grout plugs are installed to assure that the VPU contents stay within the casing as it is being removed from the ground. These same overcasing and grouting steps will continue until all VPUs in a burial ground have been addressed in this manner.

After the grout reaches its design strength, the activity to remove each overcased VPU from the ground can begin. As with the overcasing step, removal of the overcased VPU will be completed in an open air condition using the same techniques for dust and contamination control. A crane or other piece of equipment will be used to stabilize an overcased VPU while an excavator removes the soil from one side of the overcasing pipe. With the backfill removed, the overcased VPU will be laid down in the excavation. Temporary bracing and equipment will be used to secure the tops of adjacent overcased VPUs as this excavation progresses.

With the encased VPU positioned horizontally, the grouted bottom plug inside the overcasing pipe will be inspected to verify the plug covers the entire lower cross section of the pipe. Concurrently, a radiological assessment is performed adjacent to the VPU to determine if radioactive contaminants are present in the area surrounding the VPU. Waste items or contaminated soil identified during the assessment will be removed from the area and set aside for future characterization and/or disposal preparation. A radiological survey of the encased VPU will also be conducted to confirm that the radiological conditions are acceptable for transport.

Once these surveys have been completed and any radiological concerns are satisfactorily addressed, the lifting attachment to the overcasing pipe will be repositioned and a lifting harness installed. The harness will allow the crane to lift the overcased VPU out of the excavation and load it in a horizontal position. Bagging or wrapping of the overcased VPU to facilitate its shipment will be completed during this survey, extraction and loading process. It may be required that an external cap be installed on each end of the VPU for transportation. The VPU will then be lowered into a 12.2 m (40 ft) sea-land container and transported per the requirements of the package-specific safety document, developed per the *Hanford Sitewide Transportation Safety Documen*t [6].

Contaminated soil from around the VPUs will be removed and disposed at the ERDF, provided sample results meet the appropriate waste acceptance criteria. Soil beneath each VPU will be sampled and, if contamination is found above cleanup levels, this soil will be addressed with the same process used for soil beneath the burial ground trenches.

Caissons – Removal of Waste Piece by Piece While Working Inside a Containment

As part of pre-characterization activities for the five caissons at 618-11 (Fig. 3), the angled corrugated pipe chute will be examined to determine if they are filled with waste, concrete, or soil. If the chutes are accessible, pre-characterization activities will be conducted through the chute. If the inspection determines the chute is full or obstructed, additional inspection means will be implemented to conduct the caisson inspection. Pre-characterization includes:

- Use of cameras and boroscopes to visually inspect the degree of fill, degree of solidification/soil addition, and the form and condition of waste packages
- Insertion of radiological instrumentation, similar to that used for VPU characterization, to determine general area dose rate and radionuclide inventory
- Chemical screening for volatiles, lower explosive limit, etc.

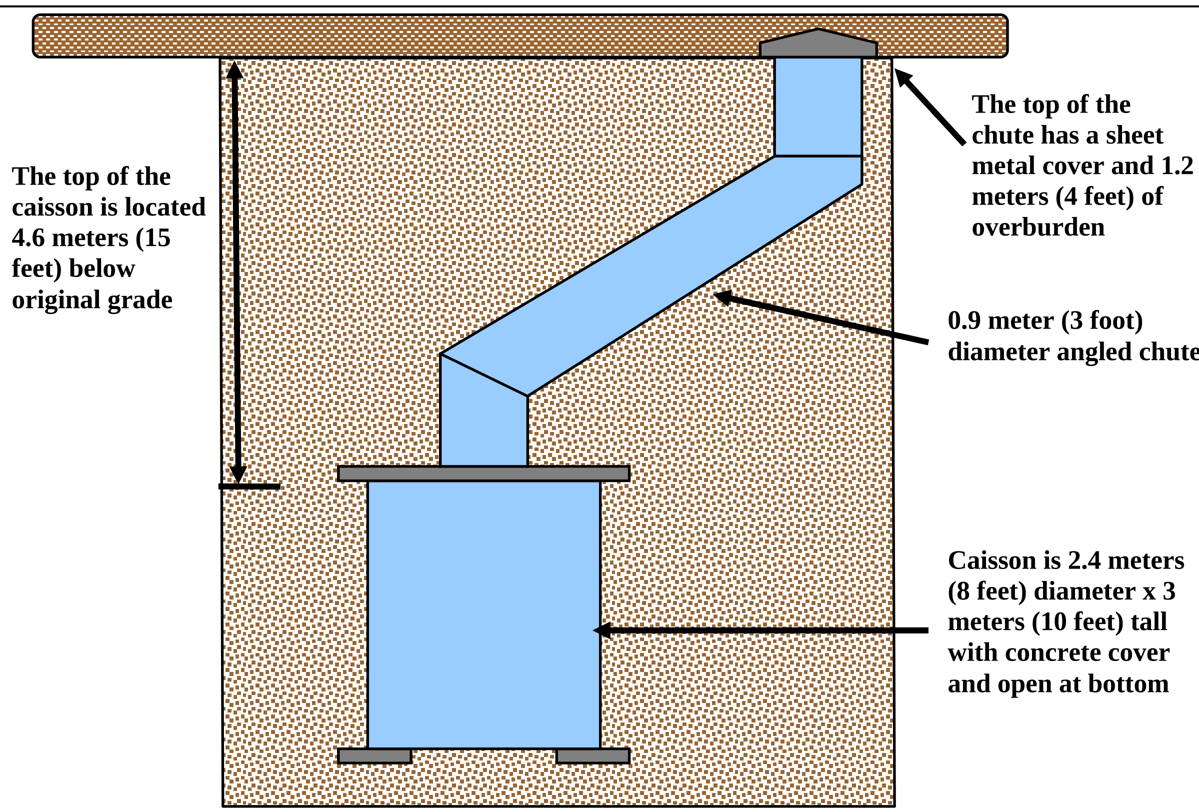

Fig. 3. 618-11 Burial Ground Caisson

For waste retrieval from the caissons, the first step is to conduct geophysical surveys to locate the position of the caisson chutes. Before excavating to remove the chute, a weather enclosure (same enclosure type and size as used for waste retrieval from the trenches) will be positioned to encompass the area needed for excavation of the caissons.

For caissons with waste in their delivery chutes, a containment tent will be erected within the weather enclosure and centered over the chute to be removed. The tent (approximately 9.2 meters [30 feet] wide by 23 meters [75 feet] long by 7.6 meters [25 feet] high) will have two chambers (main work chamber and antechamber) and will be self-supporting rigid frame covered with plastic or vinyl sheeting. Working inside the tent, a small excavator with interchangeable end effectors will be used to dismantle the chute and remove and package its contents piece by piece. With the delivery chute and waste items removed, the cover soil above the caisson would then be removed and the containment tent moved to allow excavation down to the caisson roof level. This removed soil will be stockpiled and used as backfill material or disposed as LLW at the ERDF, depending on contamination levels.

If there is no waste located in the delivery chute, an excavator will remove the cover soil above the caisson until it creates a working bench at the same level as the top of the caisson cover slab. This excavation will be completed within the weather enclosure. The excavated soil will be staged for subsequent sampling and, if acceptable, used for backfill. As the soil is removed, radiation detectors mounted on the bucket end of the excavator boom (or a separate piece of equipment) will transmit information to a central location to monitor dose rates. Both manned and remote-operated excavators will be available to support this waste retrieval method. A temporary cover plate will be placed on the caisson's roof slab opening for contamination control and shielding. With this working level reached, the containment tent will be installed. Working inside the containment tent, the remote-controlled excavator will remove the caisson cover slab. The concrete will be broken up and the waste containers exposed using an excavator bucket or ram-head end effector to the excavator. HEPA air handlers will be used to exhaust air from within the containment tent to the outside atmosphere to effectively control any airborne contamination that could be generated within the tent during removal activities.

Identified waste items removed from the caisson (intact as well as breached containers) will be placed in 208 liter (55 gallon) drums. This packaging method will allow the waste to be transferred from the containment and weather enclosure in support of waste characterization efforts. The containerized waste will be removed from the containment and weather enclosure and staged awaiting characterization. Characterization methods include a check for liquids present and hazardous constituents in the discrete items being inspected and a determination as to whether the waste is TRU or LLW.

The contents of each caisson will be exposed and dismantled as described above. The caisson wall (corrugated metal pipe) will be cut into sections for disposal using an excavator with a shear end-effector. The side slope of the excavation around each caisson will be controlled so as not to impact remediation work on adjacent caissons. As each caisson is removed, the surrounding soil will be surveyed to determine if radioactive contamination is present. Contaminated soil, if found, will be removed with an excavator as necessary to meet project cleanup levels. The contaminated soil removal will not require the use of a containment tent. Instead, the contaminated soil will be excavated within the weather enclosure. Soil beneath the caissons will be sampled and if found contamination will be addressed with the same process used for soil beneath the burial ground trenches.

CHARACTERIZATION MODELING

At the start of the project, it was known that specific documentation of 618-10 and 618-11 waste disposal activities had been destroyed in the early 1990s. Accordingly, other methods for characterization needed to be developed. A document search identified over 3000 radiological surveys from facilities that generated and disposed waste at the 618-10 and 618-11 burial grounds. These surveys were used for a number of purposes, including identification of the primary facility contributors of waste disposed to the two burial grounds. Because the surveys frequently identified the method of conveyance and type of containers prepared for disposal, they were used to identify if the wastes were disposed in the VPUs, caissons, or trenches. Per radiological surveys, two buildings, the 325 building (radiochemistry building) and 327 building (radioactive metallurgy building), were identified as generating a majority of waste disposed to 618-10 and 618-11. Because these two facilities analyzed single-pass reactor fuels during the time the 618-10 and 618-11 Burial Grounds were in operation, a single pass reactor radionuclide distribution was used as the basis for characterization modeling. The ORIGEN2™ computer code was used to provide this representative radionuclide distribution for 618-10 and 618-11. The combination of radiological surveys and single-pass reactor radionuclide distribution was then used to develop a characterization model to estimate the radionuclide inventory in the vertical pipe units and caissons and development of a dose rate to curie relationship for trench and caisson waste screening.

Piece-by-piece removal of waste from the caissons and trenches is planned, which allows for sampling and analysis to determine waste inventory. Because the VPUs will be removed individually using an over-casing method, waste characterization will be more of a challenge and is described below.

618-10 VPU Characterization Model

Per the radiological survey review, most of the waste disposed to VPUs originated from the 327 building. Characterization modeling was completed by applying single-pass reactor ORIGEN2 radionuclide distribution at one year after removal of the fuel from the reactor (to decay short-lived radionuclides), decay corrected from 1959, corresponding to the year 618-10 operated that had the most waste disposed, to 2006. A mass of waste was then calculated based upon maximum waste loading of a milk pail and the average number of milk pails disposed per VPU drum (10 milk pails per drum, 40 milk pails per VPU, as the top drum was assumed to be filled with concrete to reduce personnel dose rates at grade). Milk pails were selected as the waste population because over 90 percent of the waste disposed to VPUs was milk pails. Additional mass is added because, when the waste was disposed, intermediate backfill was added (site soil, gravel, and concrete) to reduce dose rates at grade. The total amount of activity per VPU drum

™ The ORIGEN2 computer code was developed by Oak Ridge National Laboratory was calculated assuming a TRU concentration of 37 kBq/gm (1000 ηCi/gm) per drum. To determine if 37 kBq/gm (1000 ηCi/gm) was bounding, one tenth of the activity in a VPU drum was placed in a single milk pail and a contact dose rate was calculated using MicroShield, which yielded a year 1959 dose rate of 0.37 Sv/hr (36.6 Rem/hr). This was compared to an average dose rate, as documented on radiological surveys, of 0.18 Sv/hr (17.9 Rem/hr) and, absent field characterization data, is bounding and conservative.

Using a 37 kBq/gm (1000 ηCi/gm) concentration for each individual item in a given VPU, when averaging the corresponding radioactivity across the entire mass of the VPU after treatment (using a vibratory hammer to insert a pipe over the VPU and use of a chemical grout to seal the ends), this corresponds to an average TRU concentrations and dose rates of the following:

Table 1. Projected 618-10 VPU TRU Concentrations and Dose Rates for Different Over-Casing Configurations

	VPU Prior to Over Casing	48" Over-cased VPU
TRU Concentration kBq/gm (ηCi/gm)	12.7 (343)	1.3 (36.6)
2006 Dose Rate mSv/hr (mRem/hr)	91.6 (9,160)	0.45 (45)

618-11 VPU Characterization Model

The waste is modeled similar to 618-10 above, except that the single pass reactor ORIGEN2 radionuclide distribution is decayed from 1964, not 1959, as 1964 represents the year the highest percentage of waste was disposed in the 618-11 burial grounds. Note: As the radiological VPU inventory is calculated based upon a one year decay of the ORIGEN2 radionuclide distribution, the dose rates and inventory is the same for 618-10 in 1959 as it is for 618-11 in 1964.

The total amount of activity per VPU was calculated similar to 618-10, and assumes a TRU concentration of 37 kBq/gm (1000 ηCi/gm) per drum. To determine if 37 kBq/gm (1000 ηCi/gm) was bounding, one tenth of the activity in a VPU drum was placed in a single milk pail and a contact dose rate was calculated using MicroShield, which yielded a 1964 dose rate of 0.37 Sv/hr (36.6 Rem/hr). This was compared to an average dose rate, as documented on radiological surveys, of 0.06 Sv/hr (6.2 Rem/hr) and, absent field characterization data, is bounding.

Using a 37 kBq/gm (1000 ηCi/gm) concentration for each individual item in a given VPU, when averaging the corresponding radioactivity across the entire mass of the VPU (or over-cased VPU, this corresponds to an average TRU concentration and dose rates of the following:

Table 2. Projected 618-11 VPU TRU Concentrations and Dose Rates for Different Over-Casing Configurations

	VPU Prior to Over Casing	48” Over-cased VPU
TRU Concentration kBq/gm (ηCi/gm)	12.7 (343)	1.3 (36.6)
2006 Dose Rate mSv/hr (mRem/hr)	103.2 (10,320)	0.51 (51)

VPU Pre-Retrieval Characterization

Prior to retrieval the VPUs will be surveyed by installing cone penetrometers and detection tubes and performing radiological surveys, 90 degrees apart, in one foot increments along the length of each VPU, at a distance of four inches from the VPU. The results of this survey will provide an average gamma dose rate, gamma radionuclides and their activities, and Pu-238 concentration. The radionuclides identified and their concentrations will be compared to the ORIGEN2 and MicroShield® calculations to determine the accuracy of characterization modeling and whether corrections are required. Subsequently, dose rate to curie conversion and the radionuclide distribution and percent contribution will be developed and used to identify transuranic and other hard to detect radionuclides.

The radionuclide information gathered above will then be averaged across each VPU to determine whether the waste is acceptable for disposal at the Environmental Remediation Disposal Facility as low-level mixed waste or must be prepared for storage at the Hanford Central Waste Complex (CWC) awaiting additional characterization.

Dose rates will be verified once each over-cased VPU is extracted to support transport to the waste disposition facility.

Additionally, a small percentage of the VPUs may be core sampled to confirm no spent fuel or liquid is present.

Trench and Caisson Wastes

Screening criteria will be developed based upon VPU characterization (radionuclide distribution and concentrations), as described above, to provide an indication whether trench and caisson waste is low-level or transuranic. Samples will be taken and analyzed as required to confirm the radioactive waste classification (low-level or TRU) and to determine if the waste is hazardous and may require treatment prior to shipment to the ERDF or CWC.

® MicroShield is a trademark of Grove Software, Inc., 147 Mill Ridge Rd., Lynchburg, VA 24502

REFERENCES

1. *Hanford Federal Facility Agreement and Consent Order*, 89-10, Rev. 3, Fourth Amendment, Washington State Department of Ecology, Olympia, Washington; United States Environmental Protection Agency, Region 10; and U.S. Department of Energy, Richland, Washington (1994)
2. M. S. Gerber, *Past Practices Characterization Study – 300 Area – Hanford Site*, WHC-MR-0388, Westinghouse Hanford Company (1993)
3. *Interim Action Record of Decision for the 300-FF-2 Operable Unit, Benton County, Washington*, U.S. Environmental Protection Agency, Region 10, Seattle, Washington (2001)
4. *Environmental Restoration Disposal Facility Waste Acceptance Criteria*, BHI-00139, Rev. 4, Bechtel Hanford, Inc., Richland, Washington (2002)
5. *Hanford Site Solid Waste Acceptance Criteria*, HNF-EP-0063, Rev. 12, Fluor Hanford, Inc., Richland, WA (2005)
6. *Hanford Site-wide Transportation Safety Documen*t, DOE/RL-2001-36, Rev. 1, U.S. Department of Energy, Richland, Washington (2006)
7. *Technology Alternatives Baseline Report for the 618-10 and 618-11 Burial Grounds, 300-FF-2 Operable Unit*, Bechtel Hanford, Inc., Richland, WA (2001)
8. *Evaluation of Soil and Buried Transuranic Waste Retrieval Technologies for Operable Unit 7-13/14*, Idaho Environmental Engineering Laboratory, Idaho Falls, Idaho (2002)
9. *618-10 and 618-11 Burial Ground Remedial Design Technical Workshop Summary Report*, Fluor Hanford, Inc., Richland, WA (2003)
10. *Phase I Topical Report: In-Situ and Ex-Situ Waste Characterization and Source Term Retrieval of the Hanford Burial Grounds*, Weston Solutions, Inc., Albuquerque, NM (2004)
11. *In-Situ TRU Waste Delineation and Waste Removal at Hanford 618-10 and 618-11 Burial Grounds, Draft Phase II Topical Report*, North Wind, Inc., Idaho Falls, ID (2005)
12. *Interim Demonstration Report In-Situ TRU Waste Delineation Removal Project, Phase II*, AMEC Earth and Environmental, Inc, Richland, WA (2005)
13. *Conceptual Design of a Deep Repository for Low and Intermediate Level Waste at Ontario Power Generation's Western Waste Management Facility*, Parsons Infrastructure Tech Group, Inc. Pasedena, CA and MMM Design Group, Inc., Norfolk, VA (2004)
14. *Fact Sheet on the Melton Valley Projects*, Oak Ridge National Laboratory, Oak Ridge, TN (2004)