Nevada Test Site (NTS) Radioactive Waste Acceptance Program (RWAP) and the Disposal of Unique Waste Streams - 10332

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ABSTRACT

The Nevada Test Site (NTS) is one of two U.S. Department of Energy (DOE) regional facilities used for the permanent disposal of low-level radioactive waste (LLW) and mixed low-level radioactive waste (MLLW) generated throughout the DOE Complex. The DOE, National Nuclear Security Administration Nevada Site Office Radioactive Waste Acceptance Program (RWAP) controls the acceptance of LLW and MLLW for disposal at the NTS. The RWAP process by which waste generators are granted approval to ship LLW and MLLW to the NTS includes considerations for unique waste streams. This paper will provide an overview on the types of LLW and MLLW that have been accepted for disposal at the NTS. The use of innovative approaches for the safe acceptance and disposal of MLLW (e.g., macroencapsulation, amalgamation, stabilization, thermal desorption, plasma gasification, physical extraction) and unique wastes will also be discussed to include waste characterization, treatment, certification, packaging (e.g., grouted, stainless-steel, and high-integrity containers; poly liners in carbon steel; low-density polyethylene [LDPE]/polyethylene), transportation, and off-loading for burial. Several high-profile waste stream examples will be highlighted, including high-activity, fissile, oversized/overweight shipments, and special transportation and handling issues.

INTRODUCTION

The U.S. Department of Energy (DOE), National Nuclear Security Administration Nevada Site Office (NNSA/NSO) directs the management and operation of the Nevada Test Site (NTS), which is located in Nye County in south-central Nevada (Figure 1). The base camp for the NTS is Mercury, Nevada, which is located approximately 105 kilometers (km) northwest of Las Vegas, Nevada. The NTS encompasses approximately 3,561 square kilometers (km^2). It is bordered on the southwest corner by the Yucca Mountain Project area, on the west and north by the Nevada Test and Training Range (NTTR), on the east by an area used by both the NTTR and the Desert National Wildlife Range, and on the south by Bureau of Land Management lands. The combination of the NTTR and NTS represents one of the largest unpopulated and restricted access areas in the United States, comprising some 14,200 km^2.

Among the major responsibilities of NNSA/NSO are the continued stewardship of the nation's nuclear weapons stockpile and the maintenance of a testing capability. Historically, the primary mission of the NTS was to conduct nuclear weapons tests. Since the current moratorium on full-scale nuclear testing began in October 1992, this mission changed to maintaining a readiness to resume full-scale tests, if so directed in the future, and to supporting vital national security programs. Because of its favorable environment and infrastructure, NTS also supports DOE environmental management (environmental restoration, waste management, and environmental compliance); national security response (e.g., emergency response to weapons of mass destruction); and defense and civil technologies (e.g., conventional explosives testing, characterization of hazardous material spills, and emergency response training).

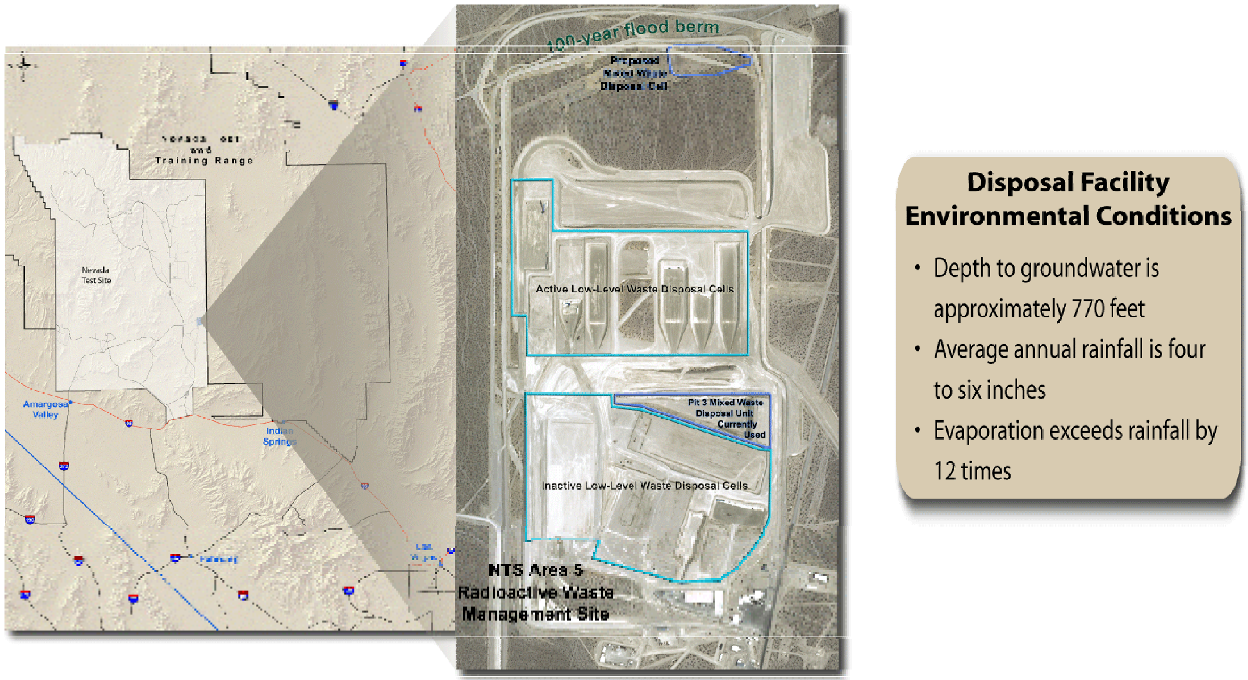

Fig. 1. NTS and Area 5 Radioactive Waste Management Site location relative to Southern Nevada.

LOW-LEVEL AND MIXED LOW-LEVEL RADIOACTIVE WASTE MANAGEMENT

The NTS is a designated regional disposal facility for low-level radioactive waste (LLW) and mixed low-level radioactive waste (MLLW) for the DOE Complex. The NTS currently accepts waste from 24 generators with approved programs that certify waste to the NTS Waste Acceptance Criteria (NTSWAC) [1]. These generators include DOE sites (Environmental Management, National Nuclear Security Administration, Science, and Nuclear Energy Programs) as well as the Aberdeen Proving Ground (representing U.S. Department of Defense locations) and commercial firms (Nuclear Fuel Services, Perma-Fix, Duratek/EnergySolutions, Boeing and General Atomics). The NNSA/NSO provides a comprehensive waste acceptance review and oversight function through the Radioactive Waste Acceptance Program (RWAP) and waste generator technical assistance support for both new and current generators. The NTS Management & Operating contractor, National Security Technologies, LLC, also has a Waste Generator Services organization that provides waste characterization and certification support to both onsite NTS generators and offsite locations.

Facilities that support the NTS Waste Management Program include the Area 5 Radioactive Waste Management Complex (RWMC) and the Area 3 Radioactive Waste Management Site (RWMS). The current Environmental Management Baseline reflects planned closure in 2027; however, the life of the Area 5 RWMC could be extended beyond that time to accommodate the disposal needs of the DOE Complex.

AREA 5 RWMC

The Area 5 RWMC is located approximately 19 km north of Mercury, Nevada, and covers 300 hectares. Historical disposal at the Area 5 RWMC has occurred in a 37-hectare portion of the site since the early 1960s. The current active and inactive disposal area includes 81 hectares with approximately 220 hectares of land available for future radioactive waste disposal cells. The site is currently used for disposal of onsite- and offsite-generated LLW and MLLW packaged in drums, soft-sided containers, large cargo containers, or boxes placed in excavated pits and trenches (disposal cells). Classified transuranic waste has also been placed in the Area 5 RWMC in trenches and Greater Confinement Disposal boreholes. Less than 20 percent of the total available land capacity is currently used at the Area 5 RWMC. At the current rate of cell use, the facility can be expected to provide a nominal disposal capacity of 42,475 cubic meters (m^3) per year for more than 50 years. The historical 37-hectare disposal area is expected to be filled and closed by 2011. New disposal cells are typically constructed to the north and west as needed to maintain an available capacity of approximately 140,000 m^3. Although the RWMC is currently planned to close after 2027, LLW and MLLW disposal services are expected to continue at the Area 5 RWMC until the needs of the DOE Complex are met.

Disposal of onsite- and offsite-generated MLLW is ongoing in the *Resource Conservation and Recovery Act* (RCRA) permitted [2] Pit 3 Mixed Waste Disposal Unit until November 30, 2010, or until 20,000 m^3 is reached, whichever comes first. Any LLW containing regulated polychlorinated biphenyls (PCBs) in concentrations exceeding 50 parts per million is also disposed in Pit 3 [3]. Current plans are to obtain approval to construct and operate a new fully RCRA-compliant and permitted MLLW disposal cell by February 2011 [4].

Area 3 RWMS

The Area 3 RWMS occupies an area of approximately 50 hectares and is situated about 38 km north of Mercury, Nevada. Subsidence craters created from historical underground nuclear weapons tests, conducted at depths well above the groundwater table, are used as waste disposal cells. Additional excavation/earthwork of these craters has been completed to allow for the disposal of bulk and unpackaged wastes.

Disposal operations at the Area 3 RWMS began in the late 1960s. The Area 3 RWMS consists of seven subsidence craters configured into five disposal cells. This site was used historically for the bulk disposal of onsite- and offsite-generated LLW and MLLW, such as soils or debris, in cargo containers, concrete monoliths, burrito wraps, and supersacks. On July 1, 2006, the site was placed into inactive status due to reduced overall shipment volumes arriving at the NTS.

NTS disposal operations

During fiscal year 2009, the actual volumes of waste arriving at the NTS varied considerably from month to month and did not always compare favorably with the volumes forecasted by the generator sites. The NTS disposal operations activity was budgeted and planned at an annual capacity of 42,475 m^3 for the fiscal year, which equates to an average expected monthly volume of 3,540 m^3. Actual volumes received have sometimes exceeded this nominal capacity – a result of efficiency achieved through forward planning and frequent contact with the generating sites, including voluntary rescheduling of shipments from selected sites in order to avoid congestion on dates where high volumes had been projected in advance.

With the exception of wastes treated at the Area 11 Explosive Ordnance Disposal Unit and selected onsite-generated MLLW, NTS is not currently permitted to treat hazardous (RCRA) waste from offsite waste generators.

The NTS is considering submitting a RCRA Part B Permit Application for the storage and treatment of MLLW. If approved, this would allow offsite-generated MLLW to be stored and/or treated at the NTS.

The DOE is preparing a Greater Than Class C Environmental Impact Statement (GTCC EIS) to address disposal of GTCC low-level radioactive waste and GTCC-like DOE waste [5]. The NTS is being considered as one of eight candidate DOE sites for disposal of such waste, along with generic commercial disposal facility options in arid and humid environments. If the NTS alternative is selected as part of the GTCC EIS Record of Decision, this could result in changes to facilities and operations at NTS.

To provide NTS-approved generators with additional cost-effective waste transportation options, NTS staff has encouraged the establishment of rail-to-truck transloading alternatives. Per DOE agreement with the State of Nevada, there is currently no transloading of LLW or MLLW allowed within Nevada. However, there are transloading options outside Nevada, including one currently operating within Arizona.

The NTS has resolved all legacy transuranic and mixed transuranic waste concerns at NTS through repackaging, characterizing, and shipping the stored waste to the Waste Isolation Pilot Project (WIPP) or Idaho National Laboratory (INL). The NNSA/NSO research operations on the Joint Actinide Shock Physics Experimental Research (JASPER) Project annually result in about 23 m^3 of newly generated transuranic waste that will also be sent offsite for disposition.

Receipt of higher-activity and unique waste streams

As additional DOE sites have closed and the waste footprint at others has been significantly reduced, the NTS has disposed of more higher-activity and unique LLW and MLW streams. During fiscal years 2008 and 2009, this trend was particularly noticeable, as evidenced by receipt and burial the following waste streams:

- Twenty shipments of un-irradiated light-water breeder reactor fuel rods from INL, which required special cask extraction fixtures and segregation at the time of burial
- Multiple shipments of more than 30 former U.S. Department of Defense-utilized radioisotope thermal generators (RTGs) with a total activity of more than 637,000 curies from several field locations, which required certification by Lawrence Livermore National Laboratory and segregation at the time of burial
- Sixty-five shipments of calorimeter assemblies containing depleted uranium that were recovered from the Hadron-Electron Ring Accelerator facility near Hamburg, Germany, which required certification upon entry to the United States at the Port of Houston and special crane off-loading at the NTS
- Disposal of high-activity DOE-owned reactor base plates irradiated at the Tennessee Valley Authority Watts Bar reactor near Spring City, Tennessee, which required special handling due to potential personnel exposure
- Burial of four World War II-era Patton battle tanks used for target practice at the Nellis Air Force Base Test and Training Range, which required special packaging and transportation requirements before disposal
- Burial of more than 375 cobalt-60-sealed sources recovered from multiple locations and shipped by Lawrence Livermore National Laboratory in Type B casks

Depleted uranium calorimeters were certified and shipped by Brookhaven National Laboratory to the NTS (Figure 2). This waste was shipped to the United States from a research facility in Germany in SeaLand or Cargo type containers. Area 5 Disposal Operations unloaded the calorimeters from the SeaLand containers, and the empty containers were then sent back to Germany through a transload facility out of the Port of Houston, Texas.

Fig. 2. Calorimeter disposal at the NTS Area 5 Radioactive Waste Management Site.

Area 5 Operations experienced some difficulty unloading the calorimeters in the beginning of the campaign because metric tools and equipment were required. Metric tools were not readily available in Area 5 at the time but were located elsewhere on the NTS. Another hurdle Area 5 needed to overcome was building a Lift Plan for crane offloading, because all of the specifications and lifting certifications were provided in German. Area 5 personnel worked with the Brookhaven National Laboratory (waste generator) staff and were able to develop a Lift Plan to safely offload the calorimeters.

The NTS received un-irradiated fuel canisters from INL. These un-irradiated fuel canisters were from the Light-Water Breeder Reactor, and disposal required Area 5 Operations to update the Documented Safety Analysis due to the plutonium-equivalent gram (PEg) loading in each canister. A total of 40 canisters were shipped in a Type B container (SuperTiger), which looked like a typical SeaLand from the outside but inside was mostly foam surrounding an inner area that held anywhere from one to four canisters. The canisters were often shipped two at a time due to the PEg limits for the total shipment. A formal Lift Plan and "as-low-as-reasonably-achievable" (ALARA) review were required. The INL provided a special "lift table" that was used to extract the canisters from the SuperTiger as they had been loaded horizontally for transport. After removal in the horizontal position, Operations then lifted them upright to the vertical position to be able to swing into dedicated trenches and immediately cover with soil.

Area 5 Operations were held to special package spacing and criticality configuration requirements for the as-buried containers, so offloading in any of the current active disposal cells was not possible. Operations identified a location suitable to comply with the spacing requirements. The canisters were placed in individual "mini-trenches" that were approximately 4 feet in depth and about 12 feet in length. Once all

40 canisters were received and placed in their respective “trenches,” a 4-foot cover of additional soil was placed over the area to ensure no other waste was placed over the buried canisters.

National Aeronautics and Space Administration (NASA) Plum Brook Station research reactor control rods were another unique waste stream received by the NTS. The materials disposed of were activated stainless-steel-clad cadmium control rods that had been stored by NASA in a Model OP-246 liner, which is a 246-gallon OverPack high-integrity container. The control rods were contained in two inserts inside the high-integrity container. The on-contact dose rates ranged from 10 Roentgens per hour (R/hr) at the top to 450 R/hr at the bottom. Area 5 Operations prepared a formal ALARA job review before offloading this waste in addition to a formal Lift Plan for crane offloading. Once the outer lid of the cask was removed, no one was allowed to break the plane of the open container with any body part. Instead, personnel used a shepherd’s hook and a mirror to locate the rigging on the inside of the outer container. Under normal operations, the rigging would be detached and sent back to the waste generator; however, due to the elevated dose rates, the rigging became sacrificial and was buried along with the inner disposal container. Area 5 built a “nest” using other waste containers already disposed and placed the waste package inside them for additional shielding. It was immediately covered with soil until the dose rates were within those for a “radiation area.”

Radioisotope thermal generators are unique as they are heat-generating electricity sources used in extremely remote conditions, such as for military applications or space travel. Area 5 Operations had to find a disposal location where the RTGs could be separated from each other as well as from other waste and also have room enough for adequate cover soil.

- Profile approval was limited to a total of four sources (three Model MW3000 RTGs with activity less than 8,500 curies each, and one Model LCG-25B RTG with activity greater than 142,000 curies).
- The RTGs were disposed in a single layer of the cell.
- A minimum separation of 4 meters was maintained with all other non-RTG waste.
- A minimum separation of 0.5 meters between RTGs was maintained.

West Valley Environmental Services, LLC, had a large volume waste stream (drum cell waste) that was shipped via rail to a facility in Arizona and then transloaded on flatbed trailers for transportation to the NTS. Four-drum assemblies were mounted on pallets and loaded into supersacks. Area 5 had to use a special lifting frame fixture that attached to the crane; approximately 20 hooks on this fixture needed to be attached to the lifting loops on the supersacks. This waste stream filled one entire tier of waste in a disposal cell, and the only issue was the cumulative dose rate associated with the whole waste stream, as it started to add up. Area 5 Operations monitored the disposal crew personnel closely to ensure they did not reach their allowable dose for the year.

Naval reactors waste in casks from Portsmouth Naval Shipyard (Duratek) was compliantly disposed of at the NTS. This shipment involved a shipping cask that was non-standard because the Generator requested that Area 5 Operations supply the hoisting and rigging from onsite rather than the Generator supplying the rigging. Area 5 Operations was able to supply the rigging without having to special order any slings, and the high-activity package was disposed without incident.

Sift-proof containers were received from Savannah River Site. These sift-proof containers (Figure 3) looked just like SeaLand containers but were designed and constructed to be completely airtight and prevent release of any waste (fine-powder consistency and packaged in drums). The container design used a steel bulkhead with wide gasketed surfaces to seal the back door of the SeaLand, and Savannah River shipped 174 sift-proof containers to Area 5 without incident. Savannah River chose these specially constructed containers to ensure no release of waste from a large population of drums containing depleted uranium oxide; many these drums were not in pristine condition following long periods of storage onsite.

Fig. 3. Sift-proof containers from Savannah River Site.

Oversize box sources were buried below grade on site at the NTS. These sources were not acceptable to be sent off site from NTS to WIPP. Area 5 Operations loaded the sources that were packaged into drums into a SeaLand container, secured the drums inside the container, and lowered the container into a hole that was excavated just a little larger than the SeaLand container. To achieve full macroencapsulation, a concrete mixture was pumped through two holes that were cut previously into the top of the SeaLand container.

Future waste streams

The NTS-approved generators provide annual forecasts of LLW and MLLW that are planned for NTS disposal. Other potential LLW and MLLW streams have been identified that are not forecasted at this time but may be considered for NTS disposal. The actual generation of these waste streams is uncertain, and there may be options for their disposition at locations other than the NTS. These waste streams are listed below; however, this is not an inclusive list, as new waste streams may be identified in the future:

- U.S. Department of Defense and DOE strontium-90 radioisotope thermoelectric generators recovered from field sites throughout the world
- Depleted uranium waste generated at the planned Portsmouth and Paducah depleted uranium hexafluoride (DUF6) conversion facilities
- U.S. Department of Defense cleanup of facilities or sites containing depleted uranium armor, projectiles, or targets
- Site cleanups at former Manhattan Project and supporting facilities
- Former research reactor site cleanups at facilities where fuel was supplied by the Atomic Energy Commission (AEC) or successor agencies
- Disposition of uranium-233 waste from site cleanup at Oak Ridge National Laboratory
- DOE Naval Reactors Program waste resulting from naval vessel decommissioning
- Waste from environmental restoration at Los Alamos National Laboratory
- Large vitrification process components from West Valley determined to be Waste Incidental to Reprocessing
- Wastes containing enriched uranium from historical Nuclear Engine for Rocket Vehicle Application (NERVA) (AEC-NASA) nuclear rocket engine project support sites
- Transuranic wastes not acceptable for disposal at the WIPP
- Decontamination & decommissioning (D&D) wastes from former DOE gaseous diffusion plants in Oak Ridge, Portsmouth, and Paducah
- LLW generated by U.S. commercial uranium enrichment projects – per requirements in Title 42 *United States Code* Section 2297h-11 [6]
- Classified legacy transuranic waste currently stored at the NTS that is not shippable to WIPP due to current size and fissile gram content limits for WIPP-approved transport containers
- Reactor pressure vessel from the D&D of the former NS Savannah nuclear-powered ship
- Wastes covered by DOE memorandums of understanding with private firms performing cleanups at commercial sites
- Sealed sources and other high-risk radiological items recovered by the DOE Global Threat Reduction Initiative through the Los Alamos Offsite Source Recovery Program
- Wastes resulting from the down-blending of highly-enriched uranium by DOE contractors
- Irradiated concrete shield blocks from DOE Science research project sites

Treatment and disposal of MLLW

The RWAP ensures that requirements governing disposal of LLW and MLLW (as mandated by NNSA/NSO and other regulatory agencies) are fully satisfied. The NTS serves as one of two approved DOE regional disposal facilities. The NTSWAC [1] is the guiding document providing the requirements, terms, and conditions under which the NTS will accept LLW and MLLW for disposal. The NTSWAC contains the requirements for waste certification programs, characterization, traceability, prohibited items, waste profiling, waste form, packaging and shipment of waste.

A RCRA Part B Permit [2] was approved for NNSA/NSO activities on NTS which allows for the disposal of onsite- and offsite-generated MLLW in the Mixed Waste Disposal Unit (Pit 3) under the interim status provisions of 40 Code of Federal Regulations 270.10(e) [7]. The interim approval status for disposal of offsite MLLW became effective in December 2005 and will remain in effect through November 30, 2010, or until a total of 20,000 m^3 of mixed waste is received, whichever comes first, with closure to take place thereafter

In addition to the NTSWAC, MLLW profiled and disposed at the NTS must also meet the requirements of the RWAP Waste Analysis Plan [8]. This plan details how wastes received for disposal are adequately characterized, and details the physical and chemical screening requirements to ensure the MLLW meets applicable regulatory requirements.

Currently, RWAP has approved 11 DOE waste generators for shipment and disposal of MLLW in Pit 3 at the NTS. From December 2005 through September 30, 2009, 4,048 m^3 of mixed waste has been disposed in Pit 3. This represents 284 shipments and 1,646 waste containers. In addition, 3,866 m^3 of regulated PCB remediation waste has been disposed in Pit 3 within the same time frame. In total, 7,914 m^3 of waste has been disposed of in Pit 3 through September 30, 2009. This represents only 40 percent of the total capacity allowed in Pit 3 before closure in December 2010. Preliminary MLLW forecasts for fiscal year 2010 indicate that an additional 4,066 m^3 may be received, bringing the total MLLW received before closure up to approximately 60 percent of the permitted limit.

A number of acceptable MLLW treatment processes have been accepted for disposal at the NTS, with macroencapsulation being the most prevalent. Macroencapsulation is primarily used to treat hazardous debris. Five macroencapsulation treatment processes have been accepted for MLLW disposal at the NTS. These are grouting in carbon-steel boxes or drums, welded stainless-steel containers, UltraTech heat-sealed containers, high-integrity containers, and low-density polyethylene (LDPE)/polyethylene containers.

Macroencapsulation with grout meets the treatment standard expressed as a specified technology (MACRO in 40 CFR 268.42 [7]) that is acceptable for use with radioactive lead solids and other non-debris waste. Grout macroencapsulation also meets the Alternative Treatment Standard for Hazardous Debris (40 CFR 268.45) [7].

The use of a continuous welded stainless-steel container has also been accepted. The stainless-steel container meets the requirements of 40 CFR 268.45 [7], macroencapsulation immobilization technology, a technology-based treatment standard.

UltraTech containers consist of a high-density polyethylene (HDPE) liner that fits snugly into U.S. Department of Transportation-compliant carbon-steel containers. The HDPE liner is the jacket of inert material that will completely surround the waste. This is also an approved macroencapsulation immobilization technology. Figure 4 shows an example of this waste package.

High-integrity containers and LDPE/polyethylene have also been used to create a jacket of inert inorganic material to reduce surface exposure to potential leaching media. This technique also meets the macroencapsulation immobilization technology.

In addition to macroencapsulation, four other treatment processes have also been accepted. These are amalgamation, stabilization, thermal desorption, and physical extraction. Amalgamation is performed by placing elemental mercury into the amalgamation vessel; a chemical mixture is then added to the mercury, and the mixture is heated and mixed. The final waste form meets the 40 CFR 268.42 standard for amalgamation [7].

Fig. 4. Oversize box lowered into an UltraTech container before macroencapsulation.

Stabilization technology includes the addition of reagents such as Portland cement or lime/pozzolans (e.g. fly ash and cement kiln dust) that is added to the waste matrix to reduce the leachability of the contaminant in the waste mixture. Reagents (e.g., iron salts, silicates, and clays) may also be added to enhance the set/cure time and/or compressive strength, or to reduce the leachability of the hazardous constituents.

Vacuum thermal desorption is a separation technology that separates organics and other volatiles from the waste matrix. The process volatilizes organic compounds by indirectly heating the feed material in a vacuum dryer and condensing the organics separately from the remaining solids.

Physical extraction and chemical extraction technologies are used to remove hazardous contaminants from debris surfaces or remove contaminated debris surface layers. These technologies include the use of high- pressure steam and water sprays or baths of sufficient temperature, pressure, residence time, agitation, surfactants, acids, bases, and detergents to remove the contaminants from the debris surface.

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DOE/NV--1338