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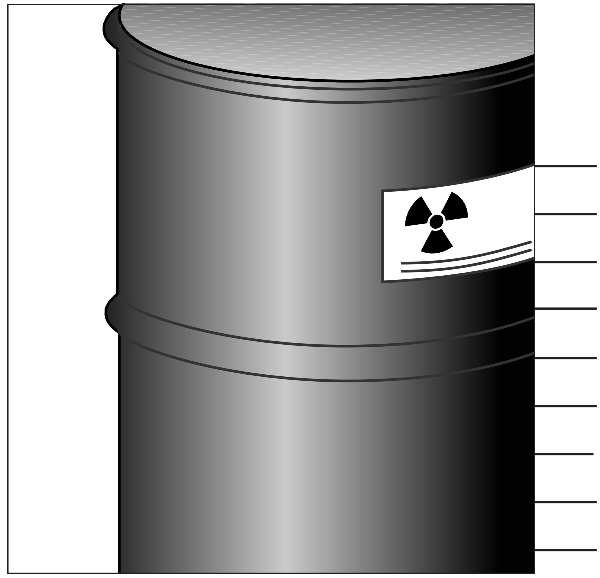

Low-Level Radioactive Waste BASICS

U.S. Department of Energy
Office of Environmental Management

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U.S. Department of Energy
Office of Nuclear Energy,
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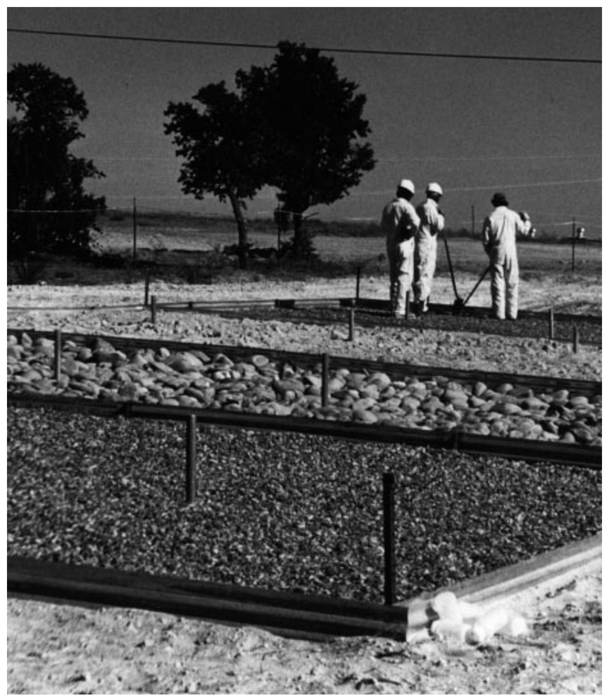
U.S. Department of Energy

Foreword...

Today, more than 20,000 organizations in the United States are licensed to handle radioactive material—material that is routinely a part of many medical, agricultural, and industrial processes. These processes include producing electricity, diagnosing and treating a variety of illnesses, tracing the paths of fertilizers in plants, and monitoring and controlling thicknesses in the manufacture of plastics, paper, and photographic film.

Almost every process that uses radioactive material produces some radioactive waste. The largest volume of this waste has low levels of radioactivity and is called low-level radioactive waste. For purposes of this brochure, low-level radioactive waste will hereinafter be designated by the abbreviation LLW. Most LLW resembles normal



Cover Systems Research for Low-Level Waste Disposal Facilities.

industrial and research waste and includes items slightly contaminated with radioactivity, such as paper, gloves, filters, cleaning rags, and obsolete equipment. Because the levels of radioactivity are low, most LLW requires little or no shielding and has historically been disposed in shallow trenches in moisture-resistant clay soils. Small amounts of the waste (< 3%) contain higher concentrations of radionuclides and are subject to more stringent requirements for waste form, packaging, biological shielding, and disposal. Management and disposal of LLW designated a State responsibility is regulated by the U.S. Nuclear Regulatory Commission.

In response to the need for sharing the burden of hosting LLW disposal facilities more equitably throughout the country, Congress passed legislation giving States the responsibility for safely managing the majority of LLW generated within their borders. This pamphlet describes the Government role regarding LLW, the characteristics of LLW, who produces it, and the technologies available for handling and disposing of LLW.

Radioactive materials are routinely a part of many medical, agricultural, and industrial processes. Above: A medical specialist examines a bone scan made using radioisotopes.

Milestones and Deadlines for New Disposal Sites

July 1986	States were to enact compact legislation or certify their intent to develop their own disposal sites.
January 1988	Nonsited compact regions were to designate a disposal facility host State and develop a siting plan. States not belonging to a compact (nonmember States) were to develop a siting plan.
January 1990	Nonsited compact regions and nonmember States were to file facility operating license applications or certify their capability to manage their low-level waste beginning in 1993.
January 1992	Nonsited compact regions and nonmember States were to file facility operating license applications.
January 1993	Nonsited compact regions and nonmember States were to have provided for disposal of all low-level waste generated within their borders or forfeit financial incentives under the Act.
January 1996	The Act's final target date to establish a national LLW disposal system.

Afterword...

Radioactive material is routinely used as a "tool" in medicine, agriculture, and industry. But for every process that uses radioactive material, some waste is produced. Although the levels of radioactivity are generally low, safely managing this waste is a high national priority. Federal regulations govern and ensure the long-term, safe management of LLW, providing guidance and rules for its handling, treatment, transportation, and disposal. Experience at the currently operating facilities over the past 20 years has shown that low-level waste can be disposed safely.

There are several options for disposal of LLW, all of which provide the necessary isolation from the environment. The U.S. Government is providing technical assistance to the States in discharging their responsibilities to arrange and dispose of their LLW. A thorough understanding of LLW, combined with modern management and disposal technologies, will ensure the safe and productive use of radioactive material now and in the future.

Defining Low-Level Radioactive Waste

Radioactive waste is categorized as either "high-level" or "low-level." Federal law defines low-level waste as radioactive waste that is not spent nuclear fuel or by- product material from weapons production processes, and radioactive waste that is not specifically defined as high-level waste in other laws. Federal regulations (10CFR61) classify low-level waste into subcategories (classes A, B, C, greater-than-Class C) on the basis of concentrations of contained radionuclides. Most low-level waste contains a small amount of radioactive material. It includes items such as radioactively contaminated paper, protective clothing, cleaning materials, tools, and equipment. Examples of low-level waste with higher concentrations of radioactivity include metal parts and filters from nuclear powerplants and sealed radioactive sources used in industry and medicine, some of which may not qualify for disposal in a near-surface (shallow land) facility. Low-level waste is commonly measured in three ways: by volume, by the amount of radioactivity, and by the half-lives of the radioactivity present.

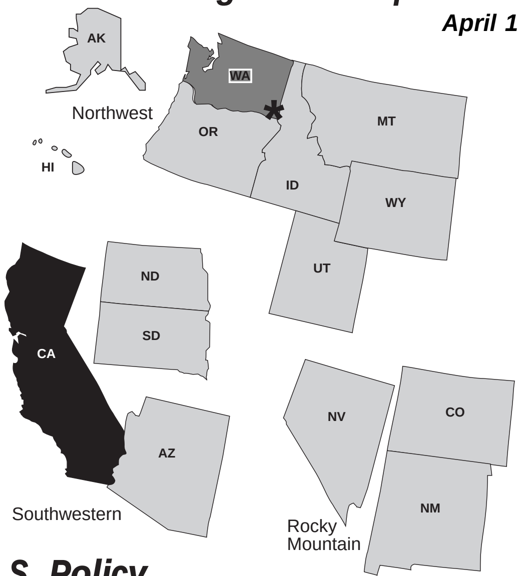
The volume of the waste containing radioactive material is measured in cubic meters or cubic feet. *The actual amount of radioactivity is generally very small in relation to the overall volume of the waste.*

Radioactivity is measured in units called curies, which are a count of the number of atoms undergoing radioactive decay per second. Because the activity of most low-level waste is slight, it is often measured in millionths of a curie (microcuries).

A *half-life* is the time in which a quantity of a radioactive substance loses one-half of its radioactivity. In two half-lives, for example, a substance would retain one half of one half of its radioactivity, and therefore would be one-fourth as radioactive as when it began. Because of this natural law, radioactive materials have a finite lifetime.

Regional Compact Status

April 1994



U.S. Policy for Disposal Of Low-Level Radioactive Waste

During the 1970s, the disposal of LLW generated by licensees became a national concern. The term licensee refers to those persons or organizations that must obtain a license from the U.S. Nuclear Regulatory Commission or its authorized Agreement States in order to have possession of radioactive materials. By 1978, three of the six LLW disposal sites stopped accepting waste, leaving the disposal responsibility to the three remaining disposal facilities cited in Nevada, South Carolina, and Washington. In 1980, Congress passed the Low-Level Radioactive Waste Policy Act, which made LLW disposal the responsibility of each State. In addition, it encouraged States to form interstate compacts, or agreements, to manage and dispose of LLW on a regional basis. In an effort to facilitate the development of new disposal sites, Congress passed the Low-Level Radioactive Waste Policy Amendments Act of 1985. The Amendments Act ensured the availability of the remaining disposal facilities through 1992 after which they could close. In addition, the Act required States and compact

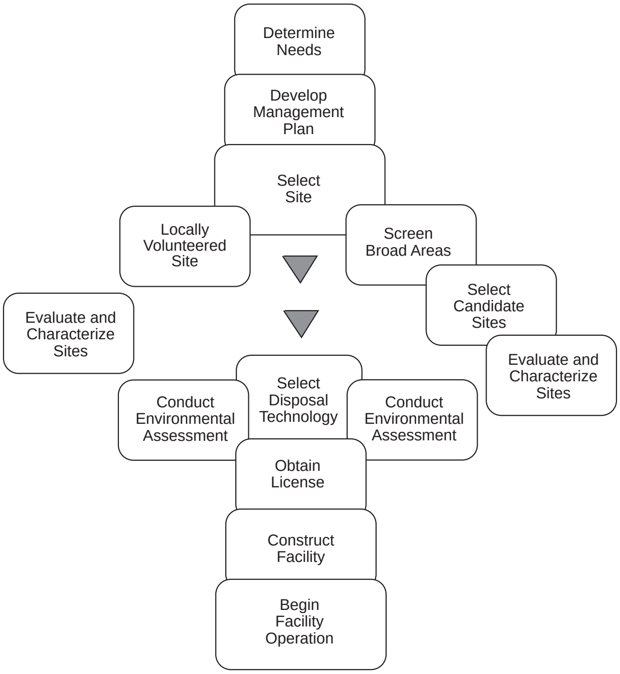
(radioactive material to be disposed), one can evaluate the long-term performance of the system for isolating the waste in terms of compliance with the regulations and licensing requirements. After the NRC or the State regulatory body issues a license, site construction can begin. Operation of the disposal sites will be typically managed by private sector companies under Government regulations.

Disposal Economics

The factors that affect the cost of LLW disposal are varied and complex. The disposal costs are affected by the kind of waste and the type of disposal technology chosen. Today, the base cost to dispose of low-level waste ranges from $ 50-$235 per cubic foot. In the most extreme case, such as certain Class C wastes that have greater levels of radioactivity and require special handling, disposal can cost thousands of dollars per cubic foot.

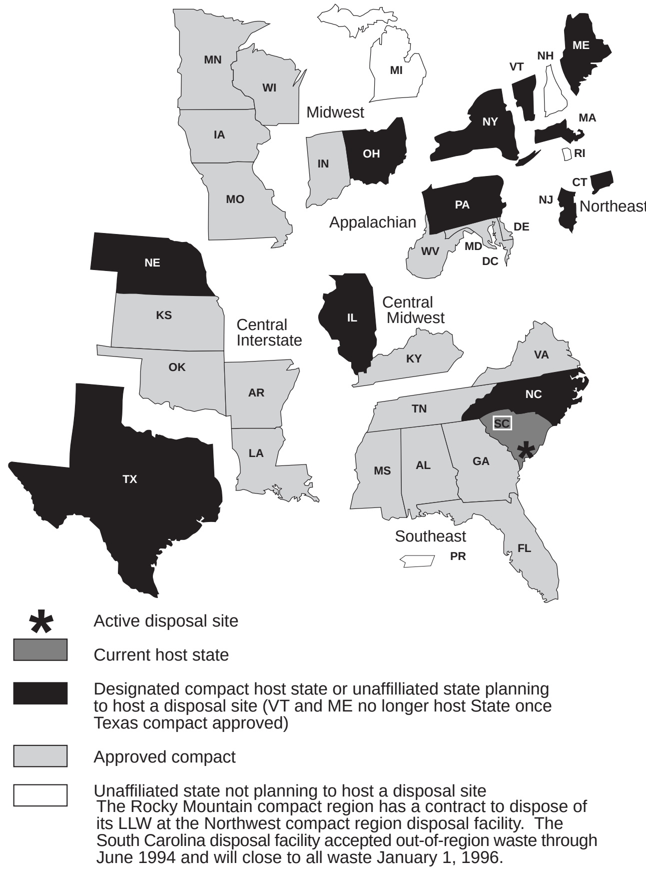
Another factor that will affect the cost of LLW disposal is the number of disposal sites to be operated. Currently, two disposal sites handle the Nation's commercial LLW. Developing more disposal facilities could increase disposal costs because each facility will have to recover its fixed construction and operating cost while handling a smaller share of the waste. At the same time, improved technologies and procedures are reducing the amounts of low-level waste produced each year.

State and interstate compact officials are examining the economic impact of high disposal costs on site operations and waste management practices. Ultimately, the utilities, industries, hospitals, and their customers must pay these costs.



Selection of a site generally involves three steps: site screening, candidate-site selection, and site evaluation and characterization. Volunteered site or site screening identifies land areas that may be suitable for a low-level waste disposal site. Studies of the potentially suitable areas can lead to the selection of one or more candidate disposal sites. Field studies examine the geology, hydrology, seismology, climate, population densities, natural resources, and potential uses for the land.

One or more candidate sites are then chosen. A detailed environmental assessment of the potential sites is conducted, including studies of the soil chemistry, surface and ground water, weather patterns, and the potential socioeconomic impacts of developing the site. Armed with the site characteristics, the features of the preferred disposal technology, and the projected source term inventory



regions to establish the necessary disposal capabilities for the Nation's LLW disposal needs by January 1, 1993, or forfeit financial incentives also provided by the Act. On December 31, 1992, the Nevada facility closed and the Washington facility stopped accepting out-of-region waste. The South Carolina facility stopped accepting out-of-region waste on June 30, 1994.

Some States, commonly referred to as unaffiliated States, have chosen to develop their own disposal facilities. Most States, however, have chosen to form compact regions. To date, ten compact regions have been formed, nine of which have been approved by Congress. They are the Appalachian, Northeast, Rocky Mountain, Central, Midwest, Central-Midwest, Southeast, Southwestern, and Northwest. Legislation for Congressional approval of the Texas compact region, consisting of Texas, Maine, and Vermont, has been introduced. In some of the compact regions, the States will take turns hosting a disposal facility.

Who Creates this Waste?

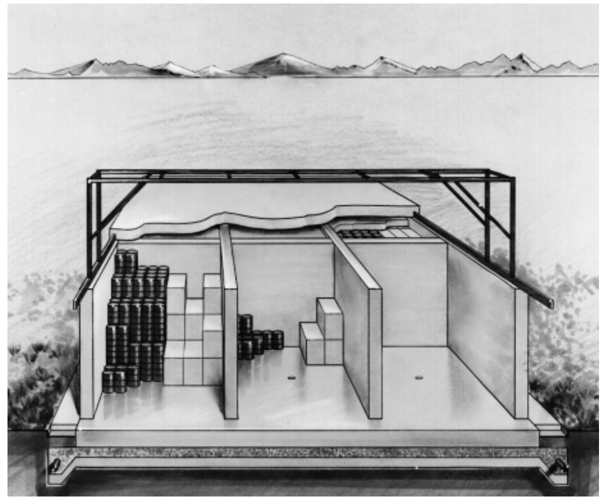
Of the 350 billion cubic feet of all waste products produced in the United States each year, only 1 million to 2 million cubic feet is LLW. Compared to other waste sources, LLW contributes very little to the total annual waste volume. Certain U.S. Government research, development, and defense programs also generate LLW, but these wastes are handled and disposed separately from commercial wastes.

LLW comes from such sources as commercial nuclear powerplants, industrial facilities, government agencies, and hospitals and universities.

The commercial nuclear powerplants licensed to operate in the United States generate approximately 35 percent of the total volume of LLW. They also produce about 85 percent of the radioactivity, which is measured in curies.

Industry creates about 50 percent of the LLW and about 10 percent of the curies. Industrial waste products include machinery parts, plastics, and materials used in manufacturing pharmaceuticals and consumer goods such as smoke alarms, emergency exit signs, and luminous watch dials.

- *Above-ground (above-grade) vault disposal* differs from other methods because it does not use an earthen cover. A concrete vault is constructed above the natural grade of the site, the packaged waste is placed inside, and the spaces between the containers are filled. A concrete roof is poured in place over the vault to close the unit.



Above-Ground (Above-Grade) Vault Disposal

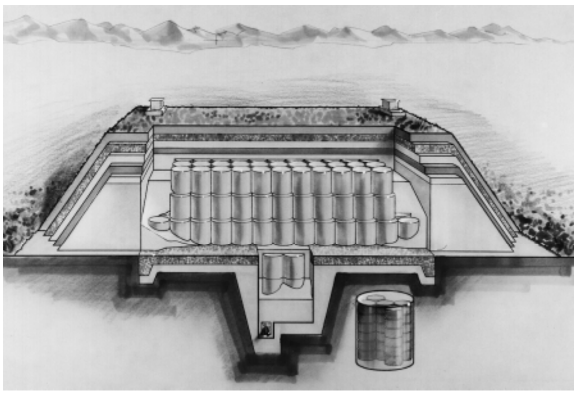
Disposal Sites

The disposal of LLW is the responsibility of each State. Establishing a LLW disposal facility requires participation by the public, private industries, local governments, State governments, and Federal agencies. The regulations for siting, operating, and maintaining all new LLW disposal sites are contained in Title 10, Part 61, of the Code of Federal Regulations.

Above-Ground (Above-Grade) Disposal

Two above-ground (above-grade) disposal concepts are currently being considered.

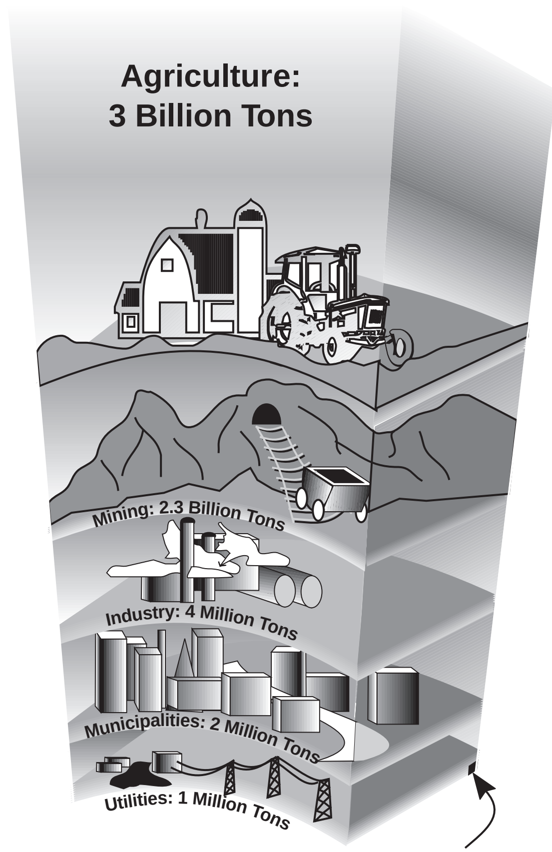
- *Earth-mounded concrete bunker (EMCB) disposal* concept for low-level radioactive waste combines the use of two disposal concepts in the same disposal unit: the belowground vault and modular concrete canister concepts.



Earth-Mounded Concrete Bunker Disposal

A belowground vault is used to dispose of Classes B and C waste below the natural grade of the disposal site. The waste is backfilled with concrete and a concrete roof is poured to form a concrete "monolith" upon closure. Modular concrete canisters containing Class A waste are stacked on top of the belowground vault. The canisters are backfilled and covered with an engineered earthen cover.

Solid Waste Produced in the United States



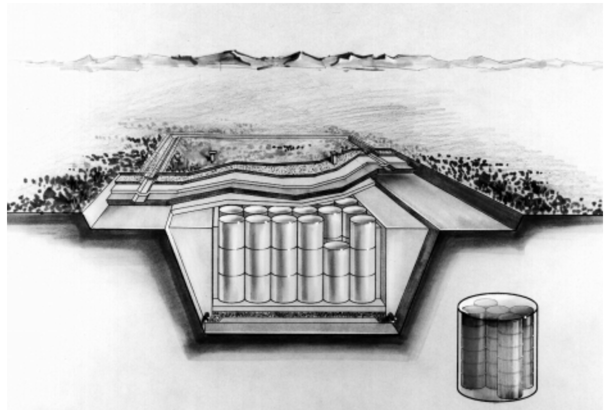
Of the 6 billion tons (350 billion cubic feet) of waste produced in the United States each year, only 0.0004 percent is low-level radioactive waste.

Commercial nuclear powerplants generate about 35 percent of the LLW in the United States.

Government agencies produce approximately 10 percent of the volume of LLW that is disposed at the commercial disposal sites and 5 percent of the total curies. This waste originates in such facilities and programs as Veterans Administration and military hospitals, national laboratories, and Federally sponsored research projects.

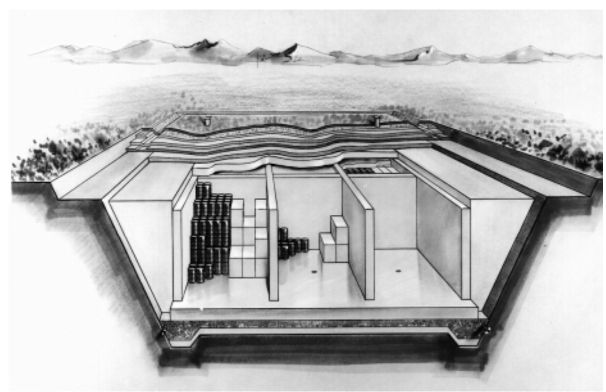
Agencies and programs of the U.S. Government contribute about 10 percent of the LLW disposed at commercial facilities.

- *Modular-concrete canister disposal* places the LLW below the natural grade of the site but uses specially constructed concrete canisters to house the packaged waste. The concrete canisters are positioned in the trench, which is then backfilled and capped.



Modular-Concrete Canister Disposal

- *Below-ground vault disposal* involves constructing a concrete vault below the natural grade of the site. Waste is placed in the vault, which is then sealed and capped.

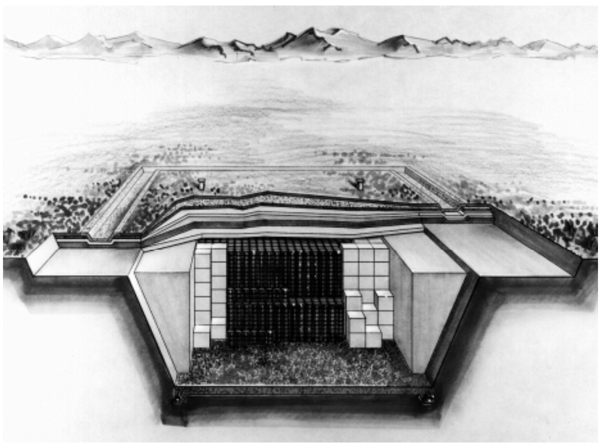


Below-Ground Vault Disposal

Below-Ground Disposal

Below-ground disposal concepts include four different trench-backfill systems:

- *Shallow land disposal* consists of placing waste containers in an engineered system consisting of excavated trenches for waste packages with any voids being filled with sand or other suitable material, a drainage collection system, a monitoring system, a closure cap consisting of a mound of multiple layers of earth and rock to prevent infiltration of water, to divert rainfall away from the disposal area and to prevent erosion.



Shallow Land Disposal

- *Intermediate-depth disposal* closely resembles the near-surface concept, but the trench is deeper and the earthen and/or engineered cover thicker.

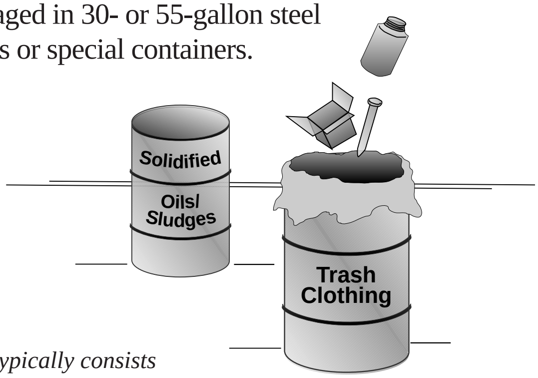
Hospitals and universities produce about 5 percent of the LLW in the treatment, diagnosis, and therapy of patients and from the research and development of radioactive products.

Hospitals and universities generate about 5 percent of the LLW and less than 1 percent of the curies. During routine treatment, diagnosis, and therapy of patients, a variety of materials can become contaminated with radioactivity. These items may include scintillation fluids (detector liquids used in diagnosis), organic liquids (alcohols, ethers, and glycerine), and laboratory equipment (test tubes, microscopes, slides, and protective clothing).

Classifying Low-Level Radioactive Waste

Low-level waste is classified according to how concentrated its radioactivity is and the amount of time needed for the radioactivity to decay to insignificant levels. Three classifications of LLW have been established: Classes A, B, and C. All classes of waste are required to be in a dry, solid form for disposal. There must be no explosives or flammable materials, and medical waste must be treated to reduce any chance of it being infectious. All three classes of LLW are disposed in solid form and in near-surface disposal facilities.

Class A waste has lower concentrations of radioactivity than Classes B and C waste. Class A waste consists mostly of trash, discarded clothing, oils, sludges, and biomedical waste. It makes up more than 90 percent of all LLW. Plywood boxes can be used to contain this waste, but it is usually packaged in 30- or 55-gallon steel drums or special containers.



LLW typically consists of discarded clothing, used equipment, filters, and sludges. It is classified according to its radioactivity.

Class B waste is largely composed of equipment and materials from nuclear powerplants and includes such items as used hardware, filters, and water purification resins. This waste contains

A truck carrying LLW is inspected to make sure it meets Federal and State regulations set by the Department of Transportation and the Nuclear Regulatory Commission.

Disposing of the Waste

The purpose of LLW disposal is to isolate the waste from the environment long enough for it to decay to safe levels. Depending on its form, volume, and type, the waste is stabilized into a form that will reduce the likelihood of radioactivity escaping from the disposal units. Disposal units are monitored for many years after the site is closed, while the waste undergoes radioactive decay. Licensed disposal sites today use near-surface land disposal facilities often referred to as engineered shallow-land disposal facilities. Other disposal technologies being considered include intermediate-depth disposal, below-ground vaults, modular-concrete canisters, earth-mounded concrete bunkers, and above-ground vaults. Regardless of the technology used, the overall disposal system must meet technical specifications and performance standards set by the NRC.

Packaging The Waste

Once the LLW is classified and treated, it must be packaged to protect the workers and the public during shipping and to meet acceptance criteria at the receiving facility. The shipping package is often the same package that is used to dispose of LLW. Packaging requirements are set according to (1) the type of radioactive materials, (2) the amount of the radioactivity, and (3) the form of the radioactive material.

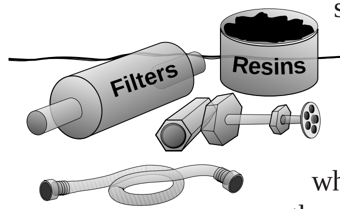
A graded approach to safety is taken in packaging LLW, and three types of packages are used. The first, called strong, tight packaging, consists of wood or metal boxes, steel drums and bins. The second, called Type A packaging, is progressively stronger, consistent with the higher hazard of the material. The third, called Type B packaging, requires approval by either the Department of Transportation (DOT) or the NRC. This type packaging must provide biological shielding and contain the radioactive material after a severe transportation accident. Type B packaging is loaded and unloaded pursuant to established strict procedures.

Transporting the Waste

The transportation of radioactive material is regulated by DOT and NRC. The standard for labeling and packaging radioactive shipments is set by DOT. Vehicle safety and maintenance requirements are also a DOT responsibility.

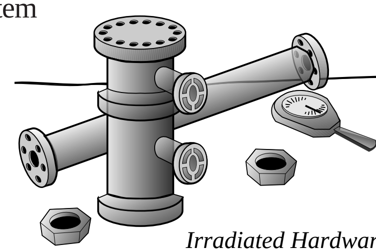
Typically, tractor-trailer trucks are used to transport LLW. The NRC requires shippers to certify that the LLW is properly packaged and labeled. Special highway routing may be required for some shipments.

higher concentrations of radioactivity than Class A waste and must be solidified and packaged in durable containers that will retain their structural stability and prevent failure of the disposal unit.



Equipment

Class C waste, which represents less than 1 percent of all LLW, is produced from a variety of nuclear powerplant, research, and industrial activities. This waste includes irradiated reactor parts and sealed radiation sources. Waste in this category has higher concentrations of radioactivity and requires engineering barriers designed to protect against inadvertent intrusion for at least 500 years. Class C waste requires high-integrity canisters to ensure waste package stability and the integrity of the disposal system to comply with the regulatory performance requirements. Specially engineered barriers such as concrete caps are placed over the area to prevent the waste site from being accidentally disturbed.


Irradiated Hardware

Radioactive waste that is not classified by law as high-level waste, yet exceeds the limits of Class C low-level waste, is called "greater-than-Class-C low-level waste." By law, the Federal Government is responsible for disposal of this kind of waste. However, this class of LLW is currently stored where it is generated until applicable disposal technologies and regulatory standards are determined.

This cutaway view of barrels of LLW shows how clothing, equipment, and solidified sludge are packaged in a dry, solid form.

Reducing the Volume of Solid Waste

Today, the volume of LLW produced by industry and research is being greatly reduced. Disposal cost and growing environmental concern have led to more efficient processing and new ways of avoiding unnecessary contamination of equipment and clothing.

Volume reduction can be achieved with super-compactors, which use hydraulic force to squeeze drums of LLW down to less than one-fourth of their original size.

Compaction and thermal treatment technologies, including incineration, also reduce the LLW for disposal.

Much like a large version of a home trash compactor, a hydraulic or mechanical compactor flattens drums filled with dry, low-level waste. Some compactors make dense bales of assorted wastes, reducing the volume by as much as 85 percent. This method is relatively inexpensive and is widely available to waste producers.

Incineration is effective in reducing the volume of LLW in the form of dry trash, biological matter, and can also be used for some contaminated liquids. During incineration, exhaust filters capture the radioactive particles which, with the ash, are disposed as LLW.

Treating Liquid Waste

Three principal techniques are used for reducing the volume of LLW liquids: filtration, ion exchange, and evaporation.

- Filtration involves passing a liquid containing radioactive matter through a filtering material to remove the radioactivity. The filter and recovered solids are then classified as LLW.
- Ion exchange uses small resin beads to remove dissolved radioactive material from water. The beads can be discarded as LLW or cleaned and reused.
- Evaporation removes water from a liquid waste by heating. The solid radioactive residue is then treated as LLW.

The Nuclear Regulatory Commission (NRC) requires that all LLW be in a solid, immobile form before it is shipped. Some common materials such as cement, ceramic resin materials, and bitumen (asphalt) are used to convert liquids into a solid form.