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SEGREGATION PRACTICES IN THE MANAGEMENT OF LOW-LEVEL RADIOACTIVE WASTES

D.E. Clark and P. Colombo

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NUCLEAR WASTE RESEARCH GROUP
DEPARTMENT OF NUCLEAR ENERGY
BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.
UPTON, LONG ISLAND, NEW YORK 11973

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ABSTRACT

A scoping study has been undertaken to determine the state-of-the-art of waste segregation technology as applied to the management of low-level waste (LLW). Present-day waste segregation practices were surveyed through a review of the recent literature and by means of personal interviews with personnel at selected facilities. Among the nuclear establishments surveyed were Department of Energy (DOE) laboratories and plants, nuclear fuel cycle plants, public and private laboratories, institutions, industrial plants, and DOE and commercially operated shallow land burial sites. These survey data were used to analyze the relationship between waste segregation practices and waste treatment/disposal processes, to assess the developmental needs for improved segregation technology, and to evaluate the costs and benefits associated with the implementation of waste segregation controls.

For improved processing and disposal of LLW, it is recommended that waste segregation be practiced wherever it is technically feasible and cost-effective to do so. It is noted that LLW management practices are now undergoing rapid change such that the technology and requirements for waste segregation in the near future may differ significantly from those of the present day.

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1. INTRODUCTION

The intended purpose of this report is to provide an overview of waste segregation technology as currently applied to the management of low-level radioactive wastes in the U.S.A. In this study, which was undertaken for the National Low-Level Waste Management Program (NLLWP), information has been obtained on radioactive waste management practices and the associated segregation technologies at selected private and government facilities. Among the facilities surveyed were Department of Energy (DOE) laboratories and plants, representative fuel cycle and nonfuel cycle facilities, and low-level waste (LLW) disposal sites. Due to the paucity of published information on waste segregation technology, most of the available data had to be gathered through personal contacts and site visits. It is hoped that this report will serve both to publicize current segregation practices to a large cross section of the LLW management field, and to generate interest in the further development and transfer of waste segregation technology.

1.1 Potential Benefits of Waste Segregation.

There are many potential benefits that may be derived from greater use of waste segregation technology at the LLW generating facilities and disposal sites. These include reductions in cost and radiation exposures to personnel, as well as an enhanced ability to adopt volume reduction and other advanced waste treatment options.

The segregation or separating out of radioactive waste streams by the LLW generator can produce a number of direct benefits. Segregation of nonradioactive waste from radioactive wastes at the source can drastically reduce the volume of waste requiring costly waste treatment and disposal. Segregation of wastes can also lead to more efficient waste processing by which, for example, personnel exposures can be reduced and solidification can be specifically directed towards certain "problem" wastes. Another potential benefit is the reduction in waste volumes resulting from improved packaging and utilization of space.

LLW disposal practices can also be improved through proper application of waste segregation technology. At the present time in the U.S.A., LLWs are disposed of as packaged liquids, solids, or gases in shallow land burial sites.

There are eight (8) DOE and three (3) commercial burial sites currently in operation. Although little waste segregation has been practiced at LLW burial sites in the past, it is now recognized that many of the problems connected with this disposal mode are directly attributable to or aggravated by the indiscriminate mixing of various waste types in the burial trenches. For example, organic chelating materials have been buried in the same trenches as solidified wastes, providing a mode for radionuclide migration while also effecting a large decrease in the radionuclide sorption capacity (K_d) of the disposal site geology. Corrosive compounds, frequently present, promote a rapid loss of integrity of metallic waste containers and enhance radioactivity release from the waste forms. Other chemical interactions may also occur when diverse waste types are buried in close proximity without regard to segregation. Furthermore, some wastes in shallow land burial may be primarily chemical or toxic hazards (rather than radioactive hazards) and, as such, benefits may result from more waste-specific disposal practices. Subsidence and trench cap deterioration may be minimized by segregation of organic solid wastes susceptible to microbial decomposition and compaction under the weight of the overburden.

1.2 Mandatory Requirements for Waste Segregation.

At the present time, and as will be discussed in following sections of this report, there are only a few mandatory requirements for segregation of LLW. However, this situation is rapidly changing, and there appears to be little doubt that more segregation controls will be mandated for LLW in the future.

In 1981, the Nuclear Regulatory Commission (NRC) published draft regulations regarding acceptable disposal practices for burial of commercially generated LLW in the future [1]. It may be anticipated that disposal site segregation controls will be imposed in the future to permit the application of specific disposal methods or use of specific site locations for LLW based upon waste characteristics such as type, form, chemical composition, and radionuclide content. Segregation technology can provide the capability of discriminating among wastes based on their physical, chemical and radiological properties, thus permitting selection of a disposal method related to the relative hazard of the waste. At the shallow land burial sites, waste segregation must necessarily be limited to the proper placement of separate LLW units (containers) in the trenches. Therefore, in the management of LLW, it is the responsibility of the LLW generators and processors to segregate wastes within each of the containerized units, and to provide the necessary assemblages of appropriately segregated waste packages for disposal.

For the purposes of this report, LLWs are considered to be those radioactive wastes which are not spent fuel or high-level waste and which contain less than 10 nanocuries of certain alpha-emitting radionuclides per gram of material (thus differentiating LLWs from so-called transuranic or TRU wastes) [2]. By definition, TRU wastes contain more than 10 nanocuries/gram (10 microcuries/kilogram) of alpha activity from ^{233}U or the transuranic radionuclides (except for ^{238}Pu and ^{241}Pu) [3]. Some alpha-contaminated-waste producing facilities (mostly DOE) will generate both LLWs and TRU wastes, and thus may apply segregation techology for the separation of these waste streams. While LLWs are disposed of by shallow land burial, the final disposition for TRU wastes is not yet available. Earlier, as is done with LLW, TRU wastes were disposed of by shallow land burial. However, in 1970 the Atomic Energy Commission (now DOE) initiated a policy requiring that all newly generated TRU wastes be segregated and placed in 20-year retreivable storage prior to disposal. It is now planned that TRU wastes will be permanently disposed of in suitable geologic repositories. The first such repository to be made available for this purpose will be the Waste Isolation Pilot Plant (WIPP) located in southeastern New Mexico. The tentative disposal strategy and proposed WIPP acceptance criteria for TRU wastes have been published in DOE reports [4-6]. At the present time, generators are required to segregate their wastes into TRU/non-TRU (usually LLW), combustible/noncombustible fractions. Additional segregation requirements may become mandatory for these wastes when both the acceptance criteria for disposal and the operational plans for this disposal option are finalized.

1.3 Objectives and Methodology of This Study.

The objectives of this scoping study have been as follows: (1) determine the current state of LLW segregation technology, (2) ascertain the waste segregation practices at existing shallow land burial sites, and the practices of waste producers, and compare these practices with established procedures (regulatory, standards group, facility), (3) analyze the relationship between waste segregation practices and waste treatment and disposal processes, (4) suggest changes and development needs for improved segregation technology, and (5) assess the costs and benefits associated with significantly improved waste segregation practices.

The methodology used for this study included a survey of the pertinent literature, personal interviews with waste managers, and site visits to selected facilities. The literature survey proved to be generally nonproductive due to the fact that little has been published on LLW segregation practices. Telephone interviews ranged from very productive to nearly useless, and were generally very time-consuming. Many persons involved in LLW management had been contacted repeatedly for information by different survey groups, and there were both positive and negative reactions to the multiple informational requests. The site visits proved to be most productive; however, since these tend to be relatively costly and time-consuming, only a minimal number could be made. In nearly all cases, the site personnel were highly cooperative and understanding of the needs of this study, and many useful suggestions and comments have been received through these interviews.

Survey information that was requested and received from LLW generators during the interviews included data on the generation rates and characteristics of LLW at each facility, waste collection and handling practices, current or anticipated use of waste segregation technology, available cost information, on-site treatment and packaging of the wastes, and final disposition of the packaged LLW. During the interviews, any planned changes in the management of LLW or requirements for waste segregation were also discussed. Waste brokers or intermediate handlers of LLW were also queried as to their waste segregation practices, both current and anticipated, and any waste classification schemes that are being used to determine transportation and handling practices. Information was sought from burial site personnel concerning any waste classification used for determining the subsequent disposal technique or area, the current disposal and segregation practices at the site, along with rationale for these practices, any available cost information, and the types and extent of burial inventory records.

Included among the sites surveyed for their waste segregation practices were selected DOE laboratories and plants; fuel fabrication plants; research and commercial power reactors; institutions such as universities, hospitals, and medical research centers; industrial concerns such as radioisotope and radiopharmaceutical producers; waste brokers and processors, and LLW disposal sites, both DOE and commercial.

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2. CURRENT STATUS OF WASTE SEGREGATION

Many LLW waste generators practice some degree of segregation of their various waste streams (although the terminology "waste segregation" is not in common usage).* Because of the rapidly increasing costs of LLW disposal and the restrictions which have been imposed over the past two years at commercially operated shallow land burial sites, there has been an increasing interest in technologies to reduce the volumes of LLW which must be shipped for disposal. Volume reduction treatments are specific to certain waste types, and consequently require segregation as a pretreatment. Thus, the technology and requirements for waste segregation are now undergoing rapid change.

It is now recognized that waste segregation is an essential element of the LLW management system if the problems attendant to shallow land burial are to be either solved or alleviated. As they are currently being proposed for application to commercial sites, it is expected that future regulations will mandate the implementation of disposal site segregation controls permitting the application of specific disposal methods or use of specific site locations for LLW on the basis of its type, form, chemical composition and radionuclide content.

Waste segregation can be utilized for the exercise of different disposal options. The recent NRC changes in 10 CFR Parts 20.301, 20.303, 20.305 and 20.306 (Federal Register/Vol. 46, No. 47, March 11, 1981, pp. 16230-16234), which allow for the disposal of certain biomedical waste "without regard to its radioactivity" have already resulted in a significant reduction in the volumes of LLW shipped from several institutions. While alternate disposition of these wastes is in some cases uncertain, this deregulation by the NRC is generally considered to have resulted in a significant improvement in the management of LLW.

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*It should be noted that in the proposed 10 CFR Part 61 recently issued, the Nuclear Regulatory Commission uses the term "segregation" in a different context.

The management of LLW involves a series of unit operations as shown in Figure 2.1. To a varying degree, waste segregation may be applied at any of the stages indicated in Figure 2.1. However, segregation is best accomplished early on and as close to the point of generation as is technically feasible. It then will serve as a key determinant of all subsequent operations (i.e., waste treatment and processing, interim storage, transportation and final disposition of LLW). For the improved processing and disposal of LLW, waste segregation should be practiced wherever it is feasible and cost-effective to do so.

As will be further discussed below, because of their inherently different properties, the segregation considerations for gaseous and liquid wastes differ from those for solid wastes.

Gaseous and liquid LLW streams naturally arise in uncombined (segregated) states such that the continued segregation of these wastes is rather straightforward.

At the LLW generating facility, gaseous wastes may be diluted and released as low-risk effluents. Alternatively, they may be processed and converted to nongaseous waste forms (e.g., as with the use of getters), or in some cases may be disposed of in appropriately containerized, low-pressure (near atmospheric pressure) waste forms. Segregation of gaseous waste streams should be employed to assure that incompatible forms do not come into contact with one another.

Similarly, liquid wastes (if of sufficiently low specific activity) may be diluted and released as low-risk effluents. Alternatively, liquid LLW streams may be processed and converted to granular or monolithic solids, or they may be immobilized through mixing with excess quantities of sorbent material. When properly packaged, liquid vials and traces of free liquid may also be disposed of at LLW burial sites, but the specific disposal criteria vary from site to site. Frequently, liquid waste streams are segregated and then combined for processing purposes with liquids of a similar nature. For example, at nuclear power plants, high conductivity waste streams are usually combined (this being cost-effective) for common processing by evaporation, and low conductivity waste

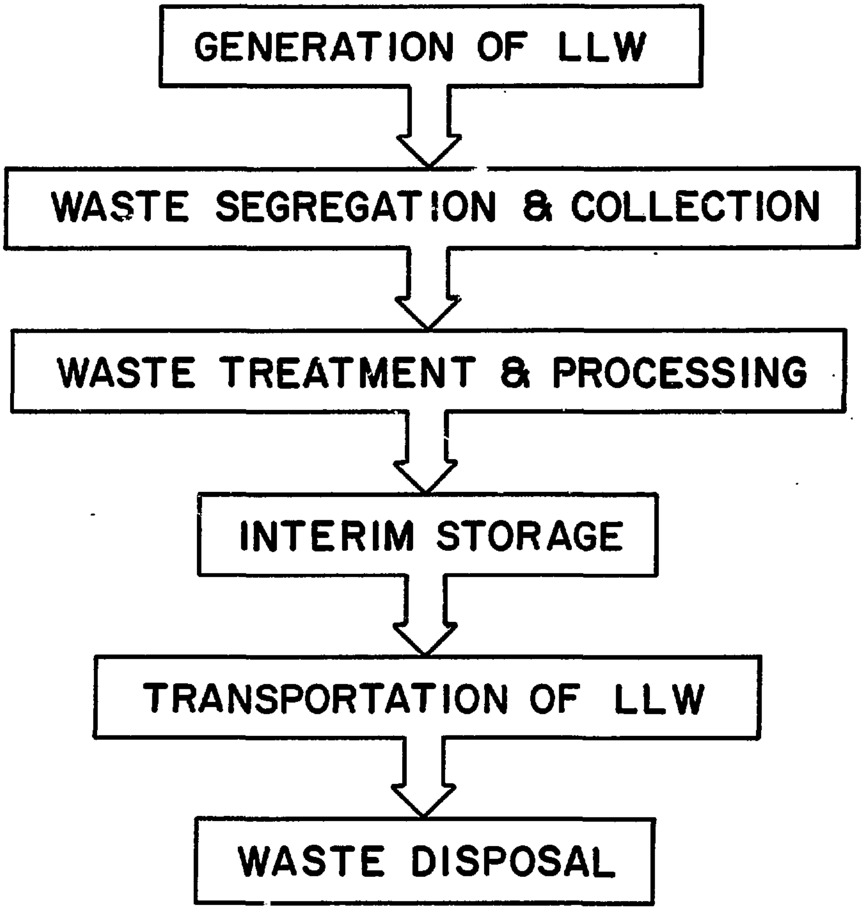

FIGURE 2.1. Unit Operations Involved in the Management of LLW.

streams are likewise combined for treatment by ion exchange. In general, wet organic and aqueous LLWs are segregated wherever possible (special solidification techniques are normally required for organic liquids). Low-activity and high-activity liquid waste streams are usually processed separately. Non-TRU-bearing liquid streams are nearly always segregated from TRU-bearing waste streams.

Because of their heterogeneous nature, solid LLW streams may present a formidable challenge to successful segregation within the framework of acceptable cost (both economic and radiologic). However, solidified LLW streams arising from the processing of liquid or gaseous wastes are normally produced as distinct (segregated) waste packages. If required, the continued segregation of these packaged waste forms on the basis of radiation levels, half-lives, etc. should be a reasonably straightforward operation, provided that this would not involve excessive handling with associated incremental radiation exposures, etc. Trigilio [7] has discussed methods used to segregate solid wastes into constitutents amenable to further treatment, including hand sorting, shredding, and air classification systems.

3. LOW-LEVEL WASTE (LLW) MANAGEMENT AND SEGREGATION PRACTICES IN THE U.S.A.

A wide variety of low-level radioactive waste types are produced by activities in both government and commercial facilities. Summary discussions of the production and characteristics of LLW at DOE sites have been given in several recent reports [2, 8-10]. Federal operations that generate LLW include defense activities as well as basic research and development (R&D) activities. Over the past 40 years or so, these activities (fuel fabrication, reactor operation, spent fuel storage and chemical processing, and various kinds of R&D and other operations) have generated up to as much as 10^8 ft^3 ($3x10^6$ m^3) of LLW. Most of these government wastes have been disposed of by shallow land burial at what are now DOE sites. Lesser amounts of these wastes have been disposed of by ocean dumping (during the period of 1946-1970) and by shallow land burial at commercial sites. Since 1979, the small percentage of DOE waste that formerly was disposed of at commercial facilities has been shipped to DOE burial sites. However, a small percentage of LLW from government sources, (e.g., Department of Defense wastes from the Navy and from veterans' hospitals) continues to be disposed of at commercial burial sites.

Commercially generated LLWs arise from fuel cycle operations (nuclear power plants, fuel production and fabrication plants, and storage-reprocessing facilities) [11-14] and non-fuel cycle operations (institutional R&D, pharmaceutical and other industrial uses of radioisotopes, and diagnostic and therapeutic practices in radiomedicine) [14-16]. Over the past 20 years or so, approximately $3x10^7$ ft^3 ($8x10^5$ m^3) of commercial LLW has been buried at commercial sites [17].

The estimated annual generation rates of LLW in the U.S.A. [17] are given in Table 3.1. It is seen that approximately 46% of the domestically produced LLW volume is from government sources, and 54% is commercially generated.

Table 3.1. Estimated 1980 Annual LLW Generation Rates in the U.S.A.[a]

Source	Estimated Annual Generation Rate		Percentage Total
	m^3	ft^3	
DOE	73,600	2,600,000	44.
OTHER GOVERNMENT OR UNCLASSIFIED[b]	6,500	229,000	4.
COMMERCIAL (Fuel Cycle + Non-Fuel Cycle)	85,900	3,020,000	52.
			100.
Fuel Cycle (58% of Commercial LLW)			
UF_6 Production	1,600	56,500	3.
Enrichment	200[c]	7,060[c]	-
Fuel Fabrication	4,700	166,000	10.
Reactor Operations	43,200	1,520,000	87.
Total Fuel Cycle	49,500	1,740,000	100.
Non-Fuel Cycle (42% of Commercial LLW)			
Institutional	18,200[d]	642,000[d]	50.
Industrial	18,200[d]	642,000[d]	50.
Total Non-Fuel Cycle	36,400	∿1,280,000	100.
TOTAL OF ALL LLW	166,000	∿5,850,000	

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[a] Data taken from Reference 17.

[b] For example, waste from fuel fabrication for foreign reactors or waste generated by government agencies but shipped for commercial burial.

[c] Included in DOE waste total given above.

[d] Non-fuel cycle wastes are estimated to be 50% institutional and 50% industrial.

DOE wastes contain radioactive contamination from all known radionuclides, but the activities of most general concern are ^{90}Sr (pure beta emitter) and ^{137}Cs (energetic gamma emitter), both of which are fission products, with half-lives of 28 and 30 years, respectively; ^{60}Co (energetic gamma emitter), an activation product with a half-life of 5.3 years; ^{3}H (pure beta emitter which readily exchanges with hydrogen atoms in water), with a half-life of 12.6 years; and certain long-lived alpha emitters. While the concentrations of radioactivity and the radiation levels for these wastes will vary over wide ranges, most are so-called contact-handled with surface dose rates of less than 200 mrem/hr. Based on data reported by Dieckhoner [10], the overall mean concentration of radioactivity for LLW sent to burial by DOE is estimated to be approximately 0.4 Ci/ft^{3} (15 Ci/m^{3}).

Commercial LLWs, consisting of institutional, industrial, and nuclear power production wastes, contain many of the same radioactive contaminants which are common to DOE wastes, but in generally different proportions. Institutional LLWs sent to burial are largely contaminated with ^{35}S (pure beta emitter with a half-life of 88 days); ^{45}Ca (pure beta emitter with a half-life of 165 days); ^{14}C (pure beta emitter with a half-life of 5700 years); ^{125}I (which decays by electron capture with a half-life of 60 days); and ^{3}H; or, in the case of sealed source and accelator target wastes, with ^{137}Cs, ^{90}Sr, etc. Industrial LLW contains a similar sampling of radioactivities, along with ^{170}Tm (half-life of 127 days) and ^{192}Ir (half-life of 75 days), which are used in doubly-encapsulated form as gamma emitters, and ^{226}Ra (alpha emitter with a half-life of 1620 years). Nuclear power production wastes contain fission and activation products (principally ^{58}Co, a gamma emitter with a half-life of 71 days; ^{60}Co; ^{59}Fe, an energetic gamma emitter with a half-life of 45 days; ^{54}Mn, an energetic gamma emitter with a half-life of 280 days; ^{137}Cs; ^{90}Sr; ^{144}Ce, a beta-gamma emitter with a half-life of 290 days; ^{89}Sr, a beta emitter with a half-life of 53 days; ^{55}Fe, which decays by electron capture with a half-life of 2.6 years; ^{134}Cs, a gamma emitter with a half-life of 2.1 years; and ^{3}H), naturally occurring, long-lived alpha emitters, and occasional traces of transuranic elements (less than 10 nanocuries/gram).

Disposal of LLWs arising from DOE operations occurs at eight (8) DOE burial sites, of which the six major ones are located at Hanford, Washington; Idaho National Engineering Laboratory (INEL); Nevada Test Site (NTS); Los Alamos National Laboratory (LANL); Oak Ridge National Laboratory (ORNL); and the Savannah River Plant (SRP). These burial sites operate under equivalent rules to those established by the NRC for commercial LLW burial sites, although the NRC has no regulatory authority over the sites operated by the DOE. The disposal capacity at these sites appears to be sufficient for the near future since they are located on large controlled-access DOE reservations. Nevertheless, conservation of burial space is practiced to a great extent at the DOE sites.

Three (3) commercial sites for LLW are currently in operation. These include the U.S. Ecology, Inc. sites at Richland, Washington (established in 1965) and Beatty, Nevada (established in 1963), and the Chem-Nuclear Systems, Inc. site at Barnwell, South Carolina (established in 1971). Previously operated sites were the Nuclear Engineering Co., Inc. (now U.S. Ecology, Inc.) sites at Sheffield, Illinois (1967-1978), and Maxey Flats (located near Morehead, Kentucky, 1963-1975), and the Nuclear Fuel Services, Inc. site at West Valley, New York (1963-1975).

Recently, severe restrictions have been placed on the LLW volumes accepted at the Barnwell site. This has been of special significance to the nuclear waste generating community, since Barnwell is the only operating eastern burial site for commercial LLW (most of which is produced in the eastern part of the country). In addition to this constraint, within the last two years, operations at the Beatty site have been significantly reduced by intermittent closings and the establishment of a third party inspection requirement by the State of Nevada [18]. Intermittent closings, along with the passage in 1980 of a state referendum to restrict acceptance of non-Washington State LLW to "medical wastes" only (the validity of which is being tested in the courts), have also created uncertainty as to the continued availability of the Richland site for many generators of LLW who have previously relied upon this site for disposal purposes. Thus, at the present time, there is considerable concern over the sufficiency of LLW disposal space in the future, and pressure is building to develop urgently needed new LLW disposal sites.

In 1980, the developing consensus among state governments was that each state should have responsibility for disposal of commercial LLW generated within its boundaries, but that the states should be encouraged to join together to carry out this responsibility. This view was endorsed by the State-Federal Assembly of the National Conference of State Legislatures (NCSL) in July of 1980, and was formalized as shown in Attachment A of Appendix A. In December of 1980, the U.S. Congress passed legislation incorporating the key recommendation received from the various states (a copy of this legislation is included in Appendix A as Attachment B). Clearly, the opening of additional LLW disposal sites in the future will have to depend largely on initiatives taken by the States, and there are indications that this is indeed occurring to a varying degree in different parts of the country. Meanwhile, for many commercial LLW generators, the waste management and disposal options available to them in the near future appear to be uncertain, and the situation is even now changing rapidly.

The distribution of LLW disposed of at commercial burial sites in 1979 is shown in Figure 3.1 [19]. Except for the wastes from nuclear power plants, fuel cycle LLWs from fuel fabrication, etc. are included in the industry classification. With the continued growth of nuclear power, an increasing percentage of LLW will be attributable to nuclear power plants in the future.

While contributing significant volume to the disposal of LLW (19% by volume of the commercially disposed of LLW in 1979), institutional wastes generally contain very low levels of radioactivity (typically of the order of $4\text{x}10^{-4}$ Ci/ft^3, or $1.6\text{x}10^{-2}$ Ci/m^3) [14]. Industrial wastes (representing 22% by volume of the commercially disposed of LLW in 1979) generally have higher activity levels than institutional wastes, but the

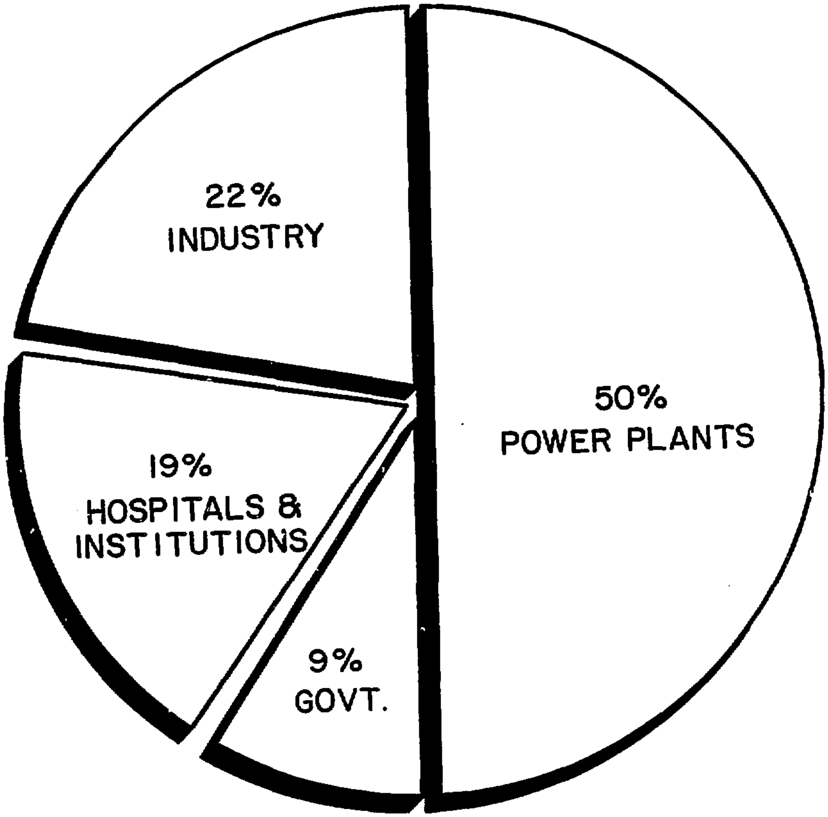

FIGURE 3.1. Distribution of LLW Disposed of at Commercial Burial Sites in 1979.

nature of this radioactivity has not been well-established. Radionuclide concentrations in reactor wastes vary from about 6×10^{-4} Ci/ft^3 to 6×10^{-1} Ci/ft^3 (2×10^{-2} to 20 Ci/m^3) [14].

3.1 DOE Laboratories and Plants.

Waste-producing activities at various DOE laboratories and plants include nuclear fuel preparation; development, testing and irradiation of nuclear fuels and advanced reactor components; examination of irradiated materials; the operation of nuclear reactors and charged-particle accelerators; facility decontamination and decomissioning (D&D); radioactive waste management operations; plus a wide assortment of nuclear-related R&D activities.

The DOE-generated LLWs arise as gases, liquids, and wet or dry solids, and may receive further treatment or processing as appropriate prior to disposal. Details concerning the generation, treatment, handling, packaging and disposition of DOE-generated LLWs at different sites have been published previously [8,10,20-36].

A data system called SWIMS (the acronym for Solid Waste Information Management System) has been established for storing detailed information concerning all DOE solid LLW and TRU waste generation, retrievable storage, and shallow land burial activities [10]. The most recently available SWIMS data are for DOE waste inventories through FY 1980 [37]. The radionuclide content of DOE wastes is reported in SWIMS by categories given in Table 3.2. In SWIMS, the waste generator must report the quantities produced in each of the following six classifications:

- Biological waste (sewage, animal carcasses, excreta, etc.)

- Contaminated equipment (components, maintenance wastes, etc.)

TABLE 3.2. Categories Used for Reporting the Radionuclide Content of DOE Wastes in SWIMS

1. TRU - Waste materials contaminated with ^{233}U (and its daughter products), plutonium, or transplutonium nuclides at levels greater than 10 nCi/g. (Note that ^{238}Pu and ^{241}Pu waste should be handled as transuranium-contaminated waste when so indicated by ^{239}Pu impurities or when required by local burial criteria).

2. Uranium/Thorium - Waste materials in which the principal hazard results from naturally occurring uranium and thorium isotopes. The hazard from all other radioactive contaminants should be insignificant. Examples of these wastes include depleted uranium, natural uranium ore and slightly enriched uranium.

3. Fission Product - Waste materials contaminated with beta-gamma emitting radionuclides which originate as a result of fission processes. Primary examples are ^{137}Cs and ^{90}Sr.

4. Induced Activity - Waste materials contaminated with beta-gamma emitting radioisotopes which are generated through neutron activation. Of major concern is ^{60}Co.

5. Tritium - Waste materials in which the principal hazard results from tritium.

6. Beta-Gamma TRU - Waste materials contaminated with quantities of transuranium nuclides, as well as beta-gamma emitting radionuclides. These wastes require retrievable storage as well as special handling due to their gamma background. An example is the hulls from reprocessing of commercial fuels.

7. Alpha - Waste materials contaminated with alpha-emitting radionuclides not listed under categories 1 or 2, or low levels (< 10 nCi/g) of TRU isotopes.

8. Other - Not defined.

- Decontamination debris (wastes resulting from D&D efforts, construction debris, etc.)

- Dry solids (normal plant wastes, blotting paper, combustible materials, etc.)

- Solidified sludge (any wastes solidified from a process sludge, such as evaporator bottoms solidification, solidification of precipitated salts, etc.), or

- Not classified (materials which are outside of the above categories).

The waste generator is further required to indicate what percentage of these waste classifications is combustible. As an optional feature of SWIMS, data may also be reported on any volume reduction treatments applied to the waste along with an estimate of the volume reduction factor.

3.1.1 Argonne National Laboratory (ANL).

The LLW management practices at ANL are probably typical of those at many DOE sites. At ANL, the waste producers have primary responsibility for the waste they produce. The individual waste producer performs segregation and packaging of LLW as directed by the laboratory waste management group (at ANL, this is Reclamation) and provides required information about the waste characteristics. Health Physics personnel monitor all radioactive waste packages prior to pickup by Reclamation for subsequent delivery to an interim treatment/holding area. The wastes are then further treated as necessary (e.g., liquid wastes are immobilized), segregated by type, and loaded into off-site shipping containers (ANL M-III bins) for disposal or, in the case of TRU wastes, retrievable storage at INEL.

The waste generators segregate solid wastes into combustible and noncombustible, TRU and non-TRU categories by placement in appropriate solid waste collection units (so-called "Blickman" cans). The containers are stainless steel throughout and consist of an inner open-top can, the outer shell, and a top containing a sliding section. A one cubic foot fiberboard drum can be placed in the inner can, or the latter can be lined with a plastic bag. This doubly-contained LLW is transferred from the point of generation to the interim treatment/holding area where it is placed in large steel bins or sealed into heavy cardboard boxes. If high gamma fields are present, the LLW may be placed in a 55-gallon drum with concrete used as shielding.

Generators of LLW at ANL are instructed to separate out single high-level sources and nonactive trash. Short-lived materials are collected separately and allowed to decay to "nonradioactive" levels. Liquids are kept separated to the maximum practicable extent and are respectively treated by Reclamation.

3.1.2 Los Alamos National Laboratory (LANL).

At LANL, the adherence to standard operating procedures is required for all operations involving the generation and handling of radioactive wastes. These procedures must detail the methodology used for proper segregation, packaging, and handling of the wastes, and must be approved by the Laboratory waste management group (H-7). Supervisors of waste generating locations are responsible for familiarizing operating personnel with waste management requirements, for minimizing the quantities of waste generated, and for properly segregating, packaging, and documenting wastes for disposal.

Waste segregation at LANL involves the initial separation into three types, as follows:

Type 1 Waste - is noncontaminated, and originates from non-radioactive work areas. This waste is disposed of by ordinary landfill.

Type 2 Waste - is essentially non-TRU waste (LLW).

Type 3 Waste - is transuranic contaminated (TRU waste).

Type 2 waste must be segregated into routine compactible, routine noncompactible, and special categories. The routine compactible and noncompactible wastes are placed in separate dumpsters for eventual separate treatment and burial. The special wastes require special pickup and may contain unusual levels or types of radioactive and/or chemical contaminants, which could pose a greater hazard than that associated with the usual packaging, handling, and disposal methods used for routine wastes. Such materials may include liquids, oils, pyrophoric substances and spray cans, as well as tritium wastes contaminated in excess of 20 mCi/m^3 (1 mCi/2-ft^3 box).

Compactible waste consists of trash-type materials such as paper, plastic, rubber, and small items of glassware up to approximately one-gallon size. Small items such as short lengths of pipe or conduit, small pieces of wood or sheet metal, are acceptable for inclusion with compactibles, but larger items are excluded. Also excluded are any waste chemicals, free or absorbed liquids, biological waste, pressurized containers, or any other particularly hazardous materials.

Noncompactible waste includes all large or bulky items exceeding the maximum dimensions 16" x 19" x 36", or other obvious noncompactibles such as heavy pipe, angle iron, equipment, lumber, building rubble, soil, etc.

The historical record for radioactive waste buried at LANL for the period of 1971 to 1978 is shown in Table 3.3. The total waste volume for this period was approximately 1.9×10^6 ft^3 (5×10^4 m^3). This list indicates the diverse character of wastes produced at a multidisciplinary DOE laboratory such as LANL.

TABLE 3.3 Historical Record of Wastes Buried at LANL for the Period 1971-78[a]

Waste Category		Volume-%
Laboratory trash		25.8
Failed equipment		5.0
Building rubble		19.7
Sludge		2.3
Cement paste		5.1
Soil		35.5
Oil		.2
Uranium and residues		.5
Filter media		.2
Hot cell waste		.1
Graphite		1.0
Animal tissue		.1
Chemical wastes		.4
Other		4.1
	Total	100.0

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[a] Data taken from Reference 32.

3.1.3 Oak Ridge National Laboratory (ORNL).

At ORNL, a comprehensive waste segregation program has been implemented [38]. This program has been quite successful due largely to dedicated efforts for increasing worker awareness of the need to segregate all solid wastes and to reduce as much as practicable the volume of LLW requiring costly treatment and burial. The ORNL effort has included the coordinated use of seminars and training sessions, publications of articles in the laboratory paper, and dissemination of attractive and effective posters throughout the laboratory. At ORNL, wastes are segregated into the following categories:

- noncontaminated biodegradable compactible waste
- noncontaminated noncompactible waste not for recycle
- noncontaminated scrap metal for public sale
- noncontaminated waste glass
- noncontaminated waste (paper, tires, acid and mercury batteries, metal drums, etc.) for recycle
- special or other hazardous noncontaminated waste
- general high-level radioactive waste
- general low-level radioactive compactible waste
- general low-level radioactive noncompactible waste
- uranium-233/transuranic waste
- uranium-235 waste
- mixed radioactive wastes, and
- low-hazard contaminated waste.

Very little is required in the way of segregation for liquid wastes at ORNL. These wastes are collected in holding tanks and are disposed of on a regular batch basis by hydrofracture injection into the underlying shale structures located hundreds of meters below ORNL [36].

It is the responsibility of the individual LLW generator at ORNL to assure that solid wastes are properly segregated, decontaminated or contained, monitored and labeled for disposal in accordance with the laboratory rules. Health Physics personnel provide consultation, surveying and monitoring, and other services as needed for proper management of the LLW, including periodic, unscheduled on-site team inspection of waste to ensure proper segregation (e.g., contaminated wastes segregated from noncontaminated wastes). Health Physics personnel also control all of the keys to the locked dumpsters for LLW and perform individual spot checks as necessary.

The waste segregation practices adopted at ORNL have been shown to be cost-effective and have resulted in significant reductions in the volume of LLW requiring disposal [38]. To a varying degree, similar practices have been adopted at other DOE facilities. However, because of the great success of the ORNL program, it is spotlighted as a worthy model for all other similar sites.

3.1.4 Idaho National Engineering Laboratory (INEL).

At INEL, aqueous LLWs are collected, evaporated, and then combined with high-level waste streams for treatment in the INEL Calciner Facility. Liquid organic LLWs are likewise kept separate until combined with solvent wastes from the fuel extraction operations for treatment in the INEL Solvent Burner Facility. Thus, there is no solidification of liquid LLWs at INEL. The solid LLWs are segregated into compactible and noncompactible fractions. If the radiation levels of solid LLW are greater than 500 mrem/hr, the waste is automatically treated as noncompactible in order to avoid undue radiation exposure to the operating personnel. An operational change is being made at INEL which will require locking of waste dumpsters and regular monitoring of LLW placed in the dumpsters on the part of Health Physics personnel.

3.1.5 Hanford Site.

At Hanford, substantial quantities of both LLW and TRU wastes are produced in connection with diverse site activities, and these waste types are also received from other sites. All LLW buried at Hanford has been at least partially segregated as required of the generator (e.g., separation of incompatible materials, exclusion of certain materials, case-by-case consideration of certain radioactive toxic wastes, etc.). Volume reduction, except for continuing decontamination efforts, has received relatively little attention at Hanford due to the large tracts of land available for burial of the wastes.

3.1.6 Lawrence Livermore National Laboratory (LLNL).

At LLNL, both toxic chemical and radioactive wastes are controlled by the same operational group (Toxic Waste Control). As is occurring elsewhere, increasing attention is being paid to the need for segregating and tracking the various radioactive waste streams at LLNL. Radioactive liquid wastes are segregated at the point of generation according to their chemical and radiological properties, and are volume reduced and solidified prior to off-site shipment for disposal. Problem wastes are segregated and receive special treatment; these may include wet organic wastes such as chlorinated solvents, ketones, oils, and vacuum pump oils. Solid wastes are segregated on the basis of their radionuclide content, compatibility and compressibility. Expanded D&D activities may be expected to generate large quantities of waste that will pose new requirements or challenges for LLW management and segregation technology in the future.

3.1.7 Mound Facility.

Mound Facility wastes are contaminated principally with tritium or ^{238}Pu, the latter being TRU wastes. The LLWs from Mound are shipped to NTS for burial, while the TRU wastes are shipped to INEL for interim storage. Major D&D projects are currently underway at Mound, including the decommissioning of a plutonium production facility and a radiochemical research building. At this laboratory, TRU wastes are segregated by waste code, similar to management practices at other DOE sites, and the LLWs are separated into combustible and noncombustible fractions.

3.1.8 Rocky Flats Plant.

At the Rocky Flats Plant, LLW, TRU, and suspect-TRU wastes are generated in connection with defense-related activities. Segregation is practiced to a very high degree for all of the wastes and, wherever possible, suspect-TRU wastes are assayed/decontaminated for possible reclassification as LLW. The LLW from Rocky Flats is disposed of at the NTS, whereas the TRU wastes are shipped to INEL for interim retrievable storage. Because of the considerable cost differential between these two disposal modes, there is real incentive to segregate TRU from nonTRU, and to reduce the TRU waste volumes to the maximum extent possible.

Liquid waste streams arising at the plant consist of laundry wastes, very low or nonradioactive plant wastes, radioactive plant wastes (including acid wastes), and the various recovery wastes (acid, caustic and fluoride wastes). The radioactive plant and recovery wastes are concentrated to a sludge product by evaporation and drying. The purified liquid stream along with low-activity plant waste is dried to a fine powdery salt of fairly uniform chemical composition. This packaged salt, in combination with other LLW produced at the plant, is shipped to NTS for disposal.

3.1.9 Special LLW Treatment Facilities at DOE Laboratories.

As alternate treatment technologies for LLW at DOE facilities are adopted, the implementation of additional segregation controls may be required. For example, the planned installation of a smelter facility at INEL for the treatment of metallic LLW, plus an incinerator for combustible LLW, will require segregation of metallic from nonmetallic, and combustible from noncombustible wastes. At ORNL, another option (with implications for segregation) for processing solid LLW is under study [36]. This treatment would involve the production of waste pellets of 1/8-inch diameter, 1/2-inch maximum length for injection by hydrofracture along with liquid wastes produced at ORNL. The preconceptual design for this processing facility includes a step for the mechanical sorting out (i.e., segregation) of metals and nonpelletizable material from the waste feed stream.

3.2 Fuel Cycle Facilities.

The generation of LLW occurs as a necessary by-product of all phases of the nuclear fuel cycle. The management and segregation practices applied to these wastes at nuclear fuel fabrication plants, nuclear power plants, and fuel reprocessing plants are discussed below.

3.2.1 Fuel Fabrication Plants.

Nuclear fuel fabrication plants use enriched UF_6 or UO_2 powder or UO_2 pellets as feed material to fabricate light-water reactor fuel assemblies. For plants which receive UF_6 as feed material, a conversion process is used to convert this feed material to UO_2. Two conversion processes are used: the ammonium diuranate process (ADU) and the direct dry conversion process (DDC).

In the currently predominant ADU process, the UF_6 is dissolved in deionized water to which ammonium hydroxide is added. The uranium then precipitates as ADU. The ADU slurry is dewatered by either filtration or centrifugation, dried and calcined to UO_2 powder in a reducing atmosphere. The liquids from the precipitation operation contain ammonium fluoride or ammonium nitrate, ammonium hydroxide, and approximately 10 to 15 parts-per-million residual uranium.

In the alternate DDC process, UF_6 is processed through a series of retorts which results in formation of UO_4. This is then reacted with hydrogen gas to form UO_2 powder and water vapor.

The UF_6-UO_2 conversion processes do not directly result in solid wastes. Most of the liquid wastes generated by these operations are pumped to a settling pond, or lagoon, or are recycled for reuse.

After obtaining the UO_2 powder, the following major steps are carried out: pellets of UO_2 are formed and sintered to the desired density, the pellets are loaded into Zircaloy tubes (fuel elements), the tubes are fitted with end caps which are then welded into place, and the tubes (fuel elements) are assembled into fixed arrays to be handled as fuel assemblies.

The unit operations in the pellet manufacture area commonly consist of the following [13]:

- Powder transfer
- Blending and precompaction
- Granulation
- Pressing
- Green pellet vacuum cleaning and tray transfer
- Oxidizing
- Sintering furnace (entrance and exit)
- Sampling hoods
- Centerless grinding

As with the UF_6-UO_2 conversion process, the pelletizing and fuel assembly fabrication process does not produce solid wastes directly, other than recoverable UO_2. The primary sources of solid waste are noncombustible and combustible trash, filters from ventilation systems, and filter cakes from some liquid waste treatment systems. If the uranium concentration of filter cakes and sludges is too low for economic recovery, the sludge is packaged for burial. If sufficient uranium is present, the sludge is processed through scrap recovery prior to disposal. Several facilities incinerate their combustible trash in order to concentrate any uranium contamination. Once it is concentrated, the subsequent recovery of uranium becomes economically feasible. However, much of the waste contains uranium that is not economically recoverable, and these wastes are shipped off-site for disposal.

As a result of rotary press operation, oil is produced as a waste accompanying the manufacture of UO_2 pellets. The general practice is to segregate oil wastes for special disposition.

The principal steps of a scrap recovery system are as follows:

- Dissolution of the uranium in nitric acid, forming uranyl nitrate
- Purification of the uranium through solvent extraction
- Precipitation of a hydrated uranium oxide with ammonium hydroxide and hydrogen peroxide
- Conversion to U_3O_8 by drying, and
- Reduction to UO_2 powder

The recovered uranium is returned to the main powder-pellet production system.

LLWs are produced by cleanup of both liquid and gaseous waste streams, scrap recovery operations, and general plant operations including fabrication of absorber elements. In contrast to wastes from light-water reactors, fuel fabrication plant wastes include little in the way of concentrated liquid wastes other than those that are pumped into evaporation ponds on site. The liquid wastes are sometimes segregated by activity and placed in different ponds. Solid wastes are segregated into radioactive and nonradioactive fractions, and further into economically recoverable or non-economically recoverable uranium fractions.

Some fuel fabrication plants plan to eventually recycle all waste materials so that no off-site shipments would be required. Such plans call for extensive decontamination and scrap recovery operations to be instituted at the plants. Waste streams would be segregated by enrichment bands (differing by 1% enrichment or so) and by phase or form (e.g., fluoride sludges would be segregated from nitrate sludges, etc.) for inplant processing.

3.2.2 Nuclear Power Plants.

Nearly all of the nuclear power plants operated in the U.S.A. are of the light-water reactor type, either pressurized water reactors (PWRs) or boiling water reactors (BWRs). The general sources of radioactive wastes produced at these plants are shown in Figure 3.2.

The radioactive wastes from reactors (known as "radwastes") contain activated structural, moderator, and coolant materials; corrosion products; and fission products contamination arising from the fuel. Gaseous radioactivity appears in the off-gas streams of the reactor and the ventilation systems. Soluble radioactivity appears in the primary coolant of water-cooled reactors or in the fuel storage pool. Minor amounts of these liquids can contact other fluids and, as a result, radioactivity appears in various other streams of the reactor plant. Additional liquid waste arises during the decontamination procedures which follow refueling and maintenance of reactor facilities. The handling, treatment, and processing of liquid and gaseous wastes result in the production of considerable quantities of solid wastes at reactors. These radwastes include filters, ion exchange resins, evaporator bottoms, and other residues and sludges. Another source of solid radwaste is the accumulation of miscellaneous paper, rags, clothing, plastics, etc. used during the operation and maintenance of the facility, discarded equipment, and D&D wastes, etc. The production of these wastes is highly variable and will be related to the specific plant design of each site.

A general listing of typical radwaste characteristics for PWRs is given in Table 3.4, and for BWRs in Table 3.5. Much more detailed information concerning reactor wastes and their management has been presented in References 7, 8, 11, 13, and 40-43.

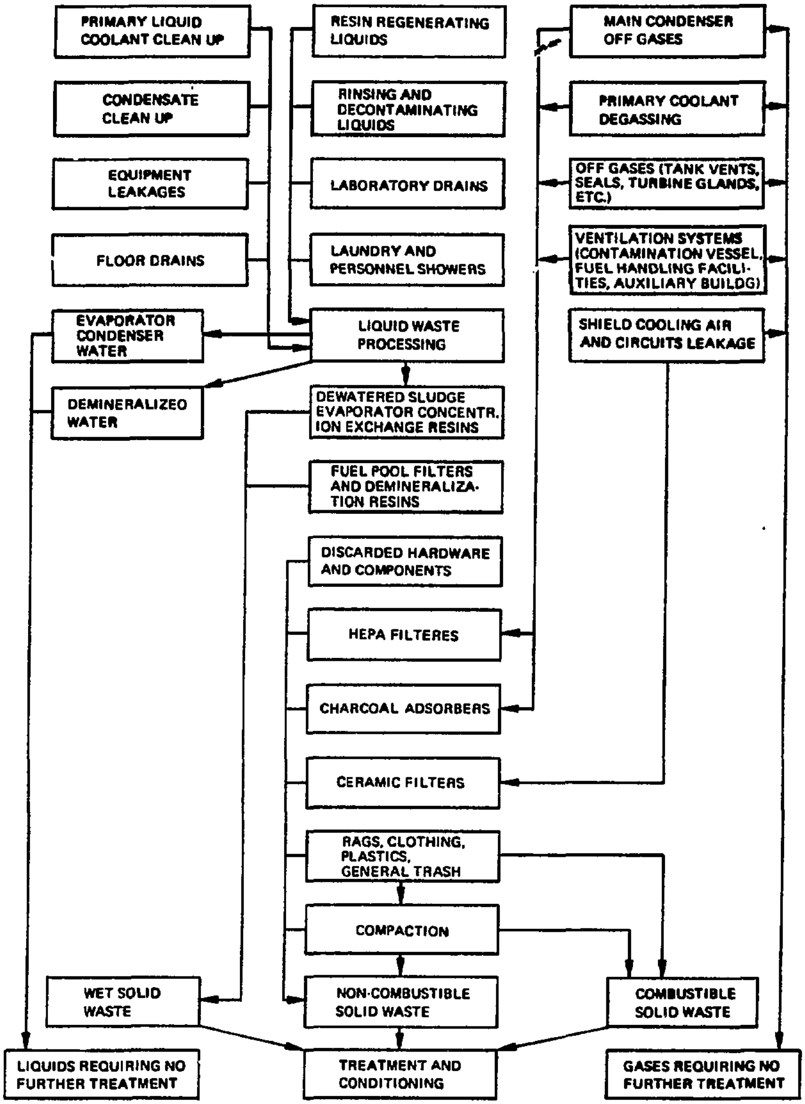

FIGURE 3.2. General Sources of Radioactive Wastes from Light-Water Reactor Plants (from Reference 39).

TABLE 3.4. Typical Waste Characteristics of PWRs[a]

System	Nature of Waste	Specific Activity (Ci/m^3)
Primary coolant cleanup	Wet ion exchange resins	1-5 x 10^2
	Filter cartridges	5 x 10^1 - 5 x 10^2
Liquid waste processing	Evaporator concentrates, sludges, resins	10^{-2} - 10^0
Off-gas and ventilation	HEPA filters	10^{-2} - 10^0
	Charcoal filters	10^{-2} - 10^0
General power plant operation	Paper, rags, clothing	2 x 10^{-3} - 2 x 10^{-2}
	Discarded hardware components	10^{-1} - 10^1
	Control rods; startup neutron sources; fuel element components and spacers	3 x 10^3

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[a] Assumed reactor output of 1,300 MWe; data taken from Reference 39.

TABLE 3.5. Typical Waste Characteristics of BWRs[a]

System	Nature of Waste	Specific Activity (Ci/m^3)
Primary coolant cleanup	Wet ion exchange resins	$2 \times 10^{-2} - 10^{-1}$
	Filter cartridges	$10^0 - 10^1$
Liquid waste processing	Evaporator concentrates, sludges	$3 \times 10^{-2} - 5 \times 10^{-1}$
Off-gas and ventilation	HEPA filters	3
	Charcoal filters	15
General power plant operation	Paper, rags, clothing, little wear components	2×10^{-1}
	Control rods	6×10^4
	Components from repair	10^1

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[a] Assumed reactor output of 1,300 MWe; data taken from Reference 39.

Most of the nuclear power plants included in our survey report that they have had few requirements for waste segregation in the past but that this situation is changing because of steadily increasing disposal costs and decreasing disposal quotas. Segregation of solid wastes into radioactive and nonradioactive fractions has been reasonably successful at most plants, but only when done with use of single check points that can be continuously monitored. The general experience with sorting mixed batches of waste into radioactive and nonradioactive fractions appears to have been that too much cross-contamination occurs. Improved housekeeping and employee training are receiving increased attention at all of the plants which were surveyed.

Quaka has reported on the importance of segregating incoming water streams according to activity and conductivity at the Dresden Station liquid radwaste process facility [44]. It was noted that all input flow paths to the various radwaste collection tanks should provide for monitoring and identification. This can have great impact on the liquid processing operations. For example, with a relief valve discharge -- this could be an intermittent leak caused by pump startup or a slow leak due to improper seating of the valve; without means of detecting and monitoring such a leak, a great deal of extra water might have to be needlessly processed. This same principle can be applied to all parts of the plant where there are collection points with a number of sources.

At nuclear power plants, the concept of on-site storage of all LLW is now being seriously considered. TVA, for example, has constructed an on-site storage facility and is hopeful of eventually receiving approval for indefinite storage of its LLW [45]. It may be that the deployment of properly engineered on-site treatment/storage facilities will be acceptable as an option for nuclear-based utilities in the future. If so, it may be presumed that the on-site treatment and storage of the wastes generated at nuclear power plants will require the adoption of advanced methods for collecting, handling, processing and packaging radwastes. Associated with these developments will be increasing demands for the segregation of radwastes for both treatment and storage purposes.

Meaningful efforts are being made to reduce radwaste generation and to improve waste management practices at the nuclear power plants which were surveyed. Extensive studies on methods to reduce volumes and minimize processing/transportation costs have suggested proceeding along two major lines:

1. Improvements in Operating Modes of Existing Equipment, and
2. Administrative Controls.

Some examples of successful approaches for reducing costs are highlighted below:

1. Improvements in Operating Modes

These improvements tend to be reactor-specific since there is wide variation in the types of equipment from plant to plant.

a. Plant A (BWR): It was found to be cost-effective to discontinue the practice of regenerating the ion exchange resin beds. A bed is now used until loaded and then is removed for disposal; this is cost-effective as long as the resin can be sent to disposal in dewatered condition (no solidification). The savings have been substantial since the total volumes have been cut in half (which more than makes up for the extra cost of the resin).

b. Plant B (BWR): Leakage in the turbine condensor introduces seawater into the steam condensate which must be removed by ion exchange before condensate is returned to the primary coolant input. By using an epoxy coating inside the first third of a meter or so of the condensor tubes, the seawater intrusion has been greatly reduced (thus substantially reducing the replacement rate of the condensate cleanup resin beds).

c. Plant C (PWR): Process cycle for floor drains and other contaminated water was formerly: demineralize-evaporate-demineralize. The first demineralizing stage has been eliminated without loss of overall system capability but with large volume savings.

d. Plant D (BWR): A new volume reduction and solidification facility is being installed. The new facility will permit incineration of resins and combustible trash (approximately 90% of the trash currently generated at this plant). Incineration of combustible trash is expected to result in a volume reduction factor of greater than 95% for these wastes, while incineration of dewatered resins should reduce that waste volume by at least 85%. The incinerated LLW ashes will be solidified and disposed of at a commercial burial site.

In addition to these examples, many other system-specific operating changes are being implemented by the nuclear power industry.

2. Administrative Controls

The following is a list of actions reported to be successful at various plants:

a. An employee awareness program aimed at trash minimization.

b. Formulate trash minimization control procedures for outside contractors. Many outside contractors are used for refueling, repairs, etc. Radwaste minimization specifications are included in vendor construction contracts.

c. Assign more personnel who are dedicated full-time to radwaste processing, thus raising the level of employee proficiency.

d. Eliminate paper protective clothing, return to washable protective clothing.

e. Create a centralized tool distribution and decontamination facility along with appropriate administrative control program.

f. Use metal planking instead of wood for refueling and maintenance jobs. Metal planking can be decontaminated and reused; alternatively, surface contamination may also be removed from wood planks by planing.

g. Institute better controls for usage of decon solutions which decrease the life of ion exchange resins.

h. Replace precoat filters with back-wash filters.

i. Change procedures so that a filter must be changed instead of bypassed, thus increasing the life of the downstream ion exchange resin.

j. Investigate bypassing ion exchangers upstream of waste evaporator.

k. Investigate increasing the boron discharge limits so that the evaporator is used less often.

l. Investigate alternate disposal forms for filter cartridges (e.g., place them in resin liners).

m. Improve density measurement techniques for the evaporator to assure maximum volume reduction.

n. Investigate methods to dewater filter sludge prior to solidification.

o. Investigate alternate schemes for combining liquid radwaste streams.

p. Collect all new ion exchange resin bags in special wire mesh baskets in the condensate demineralizer area. These are collected separately by Health Physics personnel and carefully surveyed for possible disposal as nonradioactive waste.

q. In Radwaste Building, empty bags and boxes are placed in a designated wire mesh container. As these are filled, they are surveyed by Health Physics personnel for possible disposal as nonradioactive waste.

r. Place color-coded trash cans in regulated zones for monitoring by Health Physics personnel of nonradioactive trash.

s. Future purchases of cleaning mops will be of the type with detachable heads. Before initial use of these mops, the handles should be painted for ease of decontamination.

t. New supplies and equipment issued from stores will be removed from their original containers before issuance.

u. Waste metal collected in the service shop will be surveyed by Health Physics personnel to determine if it is contaminated or noncontaminated. Contaminated waste metal is sent to radwaste for disposal or decontamination. Noncontaminated waste metal is placed in the salvage box.

These are simply examples of successful approaches that have been used in some nuclear power plants in an attempt to better segregate and/or reduce the volume of LLW requiring treatment and disposal.

3.2.3 Fuel Reprocessing Plants.

The reprocessing of irradiated nuclear fuel accomplishes the separation of uranium, plutonium and fission products produced while in the reactor. Streams containing plutonium and uranium are segregated to recover their fissile values for reuse in the nuclear fuel cycle, or to isolate for long-term confinement.

The production of radioactive wastes at reprocessing plants has been reviewed elsewhere [40]. In normal practice, the liquid LLWs produced at a reprocessing plant are added to the high-level waste (HLW) stream. The solid LLWs arising from the various operations are classified as wet solid (e.g., sludges), combustible and noncombustible trash, discarded equipment, and ventilation filters. The bulk of the CaF_2 sludge from the conversion process scrubbers at reprocessing plants is nonradioactive. The same segregation and waste management practices should apply to the solid LLWs from reprocessing plants as for similar wastes at other facilities.

3.3 Non-Fuel Cycle Facilities.

A significant fraction of the commercially generated LLW volume can be attributed to non-fuel cycle activities, as previously discussed in Section 3. These wastes arise at nuclear research centers; institutions such as universities, hospitals and medical research centers; and at industrial facilities such as associated with the production of radioisotopes and labeled compounds. These industrial and institutional LLWs are produced in all 50 states and the District of Columbia. The distribution of these wastes by states is given in Reference 14. A recent count of licensees indicated there were 6,415 institutions (medical facilities and universities) and 10,961 industrial concerns licensed to use radioisotopes (and therefore potential generators of LLW).

A study of non-fuel cycle wastes generated in the late 1970's indicated that on a volume basis these wastes are 8% from academic sources, 65% from medical sources, and 27% from industrial sources on a volume basis [46]. The academic sources include universities, colleges, vocational, and secondary schools where radionuclides are used in biological or physical research and classroom demonstrations. The medical sources include clinical and teaching hospitals, medical laboratories, and private clinics and physicians. Medical users generate LLWs in connection with diagnostic and therapeutic procedures, *in vitro* assays, and biological research. The industrial LLWs arise from use of radioisotopes for radiography, electronic instruments, thickness gauges, radiopharmaceuticals, luminous dials, measurement devices, smoke alarms, and physical or biological research, as well as the production of these radioisotopes in nuclear reactors or charged-particle accelerators.

Benda [46] reported that over 58% of the non-fuel cycle waste licensees do not use commercial disposal facilities as the primary disposal route (the principal disposition being decay to nonradioactive levels, incineration, or on-site burial which was reportedly used by 7% of the waste generators at the time of his study).

3.3.1 Institutional Generators of LLW.

The institutional generators of LLW are not only large in number, but they also vary greatly in size and type. A thorough study of institutional wastes was performed by Beck, Cooley and McCampbell of the University of Maryland, as reported in Reference 16. It was determined that a very large proportion of non-fuel cycle licensees (including many institutions) use radioactive materials primarily in sealed source form as an integral part of an analytical instrument or irradiator. Other than the occasional disposal of such sources or of instruments containing sources, these licensees contribute little in the way of LLW.

Beck et al. [16] considered institutional wastes as belonging to one of seven (7) categories, as follows:

- Liquid scintillation wastes
- Organic liquids
- Aqueous Liquids
- Biological wastes (predominantly animal carcasses and tissues, and including animal bedding excreta and labeled culture media)
- Patient excreta (LLWs from patients undergoing diagnostic or therapeutic procedures which require the administration of radioactivity)

- Gaseous wastes (predominantly ^{133}Xe, used for ventilation studies and trapped on charcoal or other filters)
- Dry solid wastes

For these seven waste categories, eight (8) waste disposal alternatives were considered, as follows:

- Sewer disposal
- Common refuse
- Incineration
- Shipment for commercial burial
- Burial on site
- Transfer to another institution
- Evaporation or distillation (for liquid wastes)
- Venting to atmosphere (for gaseous wastes)

Survey data based on these considerations were obtained, along with radionuclide content of the wastes and other information, from a large number of institutions. This study provides a good illumination of the variety and characteristics of LLWs being generated at institutions in this country.

Several authors [47-49] have discussed disposal problems posed by biomedical wastes which largely contain low levels of short-lived radionuclides. Briner [49] has proposed the use of segregation controls, where suitable, for alternate disposal options such as on-site holding for decay. In NRC regulated states, special license approval under 10 CFR 20.302 is required in order to hold radioactive materials for decay prior to disposal as ordinary trash. For burial of small quantities of radioactive materials on a licensee's site, a license amendment may be sought under provisions of a new rule effective February 1981 in 10 CFR 20.302. Disposal of radioactive liquids in sanitary sewage is governed under 10 CFR 20.303, and volume reduction such as by compaction or incineration is covered under 10 CFR 20.305. The recently adopted section 10 CFR 20.306 permits disposal as nonradioactive certain animal and liquid scintillation wastes containing ^{3}H and ^{14}C.

LLWs shipped from some of the larger academic institutions may also include wastes from hospitals and medical treatment facilities that are either part of the institution or serviced by its radiological safety office. It is not unusual for larger institutions to have several hundred users of radioisotopes and full-time personnel are required to service the individual LLW generators. For such large-sized operations, it may not be particularly difficult to segregate wastes by container according to radionuclide type, etc. Advanced waste treatment systems (e.g., compactors, incinerators) which would require some degree of segregation as a pretreatment, could be cost-efficient for larger institutions, although perhaps not at all justifiable for the low volume generator.

The most widely practiced segregation treatment at institutions is to separate the wastes according to half-life of the radioactive contaminants. Most of the institutions surveyed do require users to segregate LLWs into the categories: biological, liquid scintillation, dry solid, aqueous liquid, or organic liquid. Segregation is also maintained for incompatible wastes and for those with special hazards (e.g., carcinogens).

As an alternative disposal option for institutional and other nonfuel cycle LLWs, there appears to be growing interest in incineration. Cooley and co-workers [50] have recently reviewed current practices of incineration for institutional LLWs. NRC regulations permit this option under 10 CFR 20.305 provided that the effluent concentrations are in accordance with the requirements of 10 CFR 20.106 and that all state and local regulations are met. Many institutions are highly sensitive to local opposition to radioactive waste incineration and have opted not to incinerate in deference to opponents of this option. However, incineration is expected to become more attractive as the technology has improved markedly in recent years and the option is becoming more cost-effective.

Pretreatment requirements for efficient incineration include segregation of wastes by BTU content (e.g., dry solids separated from aqueous liquids, carcasses, etc.) and by radionuclide content. While some radioisotopes are good candidates for incineration (e.g. ,^{3}H, ^{14}C, ^{51}Cr, ^{55}Fe, ^{57}Co, etc.), others are better held for decay (e.g., those with half-lives of less than 30 days or so), and still others probably should not be incinerated (e.g., radioiodine). A demonstration incinerator facility is under development at the University of Maryland; it is expected that approximately 80% of the LLW generated there would qualify for incineration [51].

Most institutions report that they have had few problems in managing their LLW other than the steadily increasing cost of disposal and the widespread concern that due to minor infraction of the rules (or the gross miscalculation of an individual) they could be excluded from the LLW burial sites. This fear appears to be a pervasive one throughout the entire LLW community, but is particularly prevalent among smaller institutions and individual users who may sense that they would have fewer options available to them should they be so excluded than would larger generators of LLW. In any case, the driving force for adopting waste segregation or other conservative management practices beyond what is required by regulations is largely economic. Current disposal costs for institutional wastes appear to be averaging approximately $175 for a 55-gallon (208-liter) drum. For the small LLW generator, there is little if any incentive for practicing waste segregation, however, since he may produce only an occasional drum of waste.

3.3.2 Industrial Generators of LLW.

The LLWs generated by industrial uses of radioactive materials have not been well-characterized. Pharmaceutical wastes are believed to be a major component of industrial LLWs, but data on their characteristics are often considered proprietary. Radiopharmaceutical wastes can be expected to be primarily organic compounds labeled with relatively long-lived radionuclides such as ^{35}S, ^{3}H, ^{135}I, and ^{14}C. Many of the same wastes arising from institutional use of labeled compounds are also generated by the industrial facilities that produce these labeled compounds. For many of the organic labeling reactions that are run at industrial plants, the radiochemical yields are quite low and significant fractions of the initial radioactivities appear in the resultant LLWs.

Some of the industrial LLWs may pose particular disposal problems. For example, tritium gas and tritiated compounds of high specific activity have particularly severe containment requirements due to the potential for migration at the burial sites. Many of the labeled compounds used for medical treatments or biomedical research are organic and can present a particular challenge to pretreatment for disposal (e.g., these are difficult to solidify, etc.). So-called "problem" wastes also arise from the production of radioisotopes in commercial nuclear reactors, etc. These "problem" wastes include organic solvents, vacuum pump oils, chelating agents, highly contaminated metals (targets, etc.), and high-specific activity and other wastes considered to be especially hazardous because of the radiotoxicity of certain isotopes such as ^{235}U, ^{239}Pu, ^{90}Sr, and other fission products.

Waste segregation practices vary greatly among different industrial generators of LLW, but appear to be similar in nature for industrial concerns of the same type. Thus, high-specific activity wastes are nearly always segregated at those facilities which produce LLWs having a wide range of radioactivity concentrations. Producers of radioisotopes, labeled compounds, assay kits, and similar products for biomedical and physial research purposes generally will also produce a wide assortment of LLWs as inevitable by-products. At such facilities, waste segregation becomes very important as a basis for radioactive waste processing. A study was made of the segregation practices at a large company representative of this type (New England Nuclear) which could serve as a model for other facilities.

At New England Nuclear, segregation of radioactive wastes is practiced to a high degree. This has been accomplished largely through the implementation of institutional controls and increasing employee awareness of the need for waste segregation. For the most part, segregation occurs at the point of generation and is the responsibility of the waste generator. Radioactive wastes are separated into seven (7) distinct categories, as follows:

Category A	Dry-solid radioactive waste
Category B	Absorbed liquid radioactive waste
Category C	Liquid radioactive waste
Category D	Noncompactible radioactive waste
Category E	Animal and biological radioactive waste
Category F	Radioactive material requiring special handling and/or packaging
Category G	Short-lived materials to be held for decay

Within these categories, the wastes are further segregated according to activity and radioisotopic contamination, and organics are separated as organic acids, oil, liquid scintillation mixtures, and solvents (all others).

An important feature of the waste management plan at New England Nuclear is the careful documentation of the nature and orgin of all radioactive waste generated by laboratory personnel. A cradle-to-grave system of documentation is used in which it is possible to trace the origin of a particular radioactive waste unit back to a particular laboratory and employee.

A special procedure is in use at New England Nuclear for inspecting laboratory wastes before they are compacted. These wastes contain predominantly ^{3}H, ^{14}C, or ^{35}S and present very little radiation hazard when packaged as bagged LLW in 55-gallon (208-liter) drums collected from the laboratories. Using a mechanical drum tilting device and a sorting table, the contents of each drum are handled and inspected under controlled radiological conditions by personnel familiar with LLW acceptance criteria for the burial site. If acceptable, the inspected wastes are then placed in another drum and are compacted.

Each year at New England Nuclear approximately 1,000 drums (55-gallon/208-liter size) of LLW are placed in storge for decay for a minimum of 10 half-lives. These wastes, segregated at the points of origin, are contaminated with radionuclides from one of the following groups: ^{201}Tl, ^{67}Ga, ^{99}Mo, ^{99m}Tc; or ^{32}P, ^{131}I; or ^{133}Xe.

3.4 Waste Brokers and Shippers.

Many of the small institutional and industrial generators of LLW rely upon waste brokers for the routine pickup of packaged wastes for ultimate delivery to a LLW shallow land burial site. Waste brokers vary widely in size and frequently may service generators of toxic chemical waste as well as LLW. The waste brokerage business varies from region to region, depending on the need for this service. In the state of California, for instance, five waste broker companies have been identified, two of which together account for an estimated 80-90% of the LLW brokerage business.

Typically, waste brokers service many clients and make pickups of the packaged LLW upon arrangement with the generating facility. Often the packaged LLWs are then placed in interim storage in a warehouse facility, which may be owned or leased by the waste broker, until sufficient numbers have been accumulated for shipment to a burial site. The brokers are generally well-informed as to the waste preparation and packaging requirements which apply to their LLW generator customers, and often provide them with consulting services as well as supplying waste containers, and so on.

Across the country there are many commercial organizations that provide various LLW management services to the private sector, including brokerage and consulting services, radiological protection services, waste processing and equipment rental, decontamination and laundry services, packaging and ultimate disposal of LLW. In general, these organizations apply little in the way of waste segregation in their handling and treatment of LLWs.

Currently, all commercial LLWs are shipped by truck. Several companies specialize in handling services, including transport of the wastes and the design, fabrication and rental of trucks equipped with shield casks. The shield casks or overpacks are required for certain categories of LLW in order to reduce public exposure from radiation and to provide some degree of protection in the event of an accident.

3.5 LLW Disposal Sites.

In general, two types of shallow land burial sites have been used for the disposal of LLW: arid sites and humid sites. Of the six major DOE burial sites, four are classified as arid (INEL, Hanford, NTS and LANL), and two are humid (ORNL and SRP). Of the three currently operating commercial sites, two are classified as arid (Beatty and Richland) and one is humid (Barnwell). The distinguishing feature between these two types of burial sites is the annual precipitation, which becomes important in terms of potential contact of water with the buried wastes.

3.5.1 Arid Shallow Land Burial Sites.

The arid shallow land burial sites are located in the western part of the country in areas of low precipitation and sparse population. The distance to the water table below the waste is large for arid sites, and the distance from the burial site to points of groundwater discharge is also large. These features are generally considered to be advantageous since water contact with the waste and migration of radioactivity will be minimal at arid sites. A disadvantage of arid sites for disposal of LLW is the potential for rapid wind erosion and the long transportation distances between these sites and most of the LLW-generating sites.

At arid burial sites, LLW with very high radiation levels is frequently segregated from other wastes and disposed of by placement in deep shafts. This normally presents no particular problems since the trenches are well above groundwater levels.

The operations at a DOE arid site for burial of LLW are exemplified by Figure 3.3, which shows the unloading of crated wastes at the NTS. These wastes have relatively low radiation levels at the container surfaces such that handling does not pose a severe problem. At this site, TRU wastes are stored retrievably at a nearby surface storage pad. NTS requires that combustible TRU wastes are segregated from non-combustible TRU wastes and packaged separately. These categories are further separated into compactible, noncompactible, and bulk waste. Both LLW and TRU wastes must be free of pyrophoric or explosive materials and free liquids. The LLW is disposed of by placement as shown in open trenches, which are then covered with a minimum of four feet of soil on top. The LLW packages consist of drums or boxes, and these are segregated in the trenches only by type for improved packing efficiency; however, each waste package is identified as to its contents, and records are kept as to placement location.

At the Hanford site, both on-site and off-site generated waste are disposed of by shallow land burial (or, in case of TRU wastes, are placed in retrievable storage). LLW is disposed of in cardboard boxes, barrels, concrete boxes, fiberglass-impregnated boxes, etc. that are emplaced in trenches. Final coverage of earth over the waste-filled trenches is to a minimum of eight feet. The following specifications apply to LLW disposed of at the Hanford DOE site [52]:

A. <u>Incompatible Materials - Must Not be Packaged Together</u>: Materials which are incompatible (e.g., those which could react spontaneously, vigorously, possibly explode or react in combination with the container, such as certain organics and HNO_3) shall not be packaged in

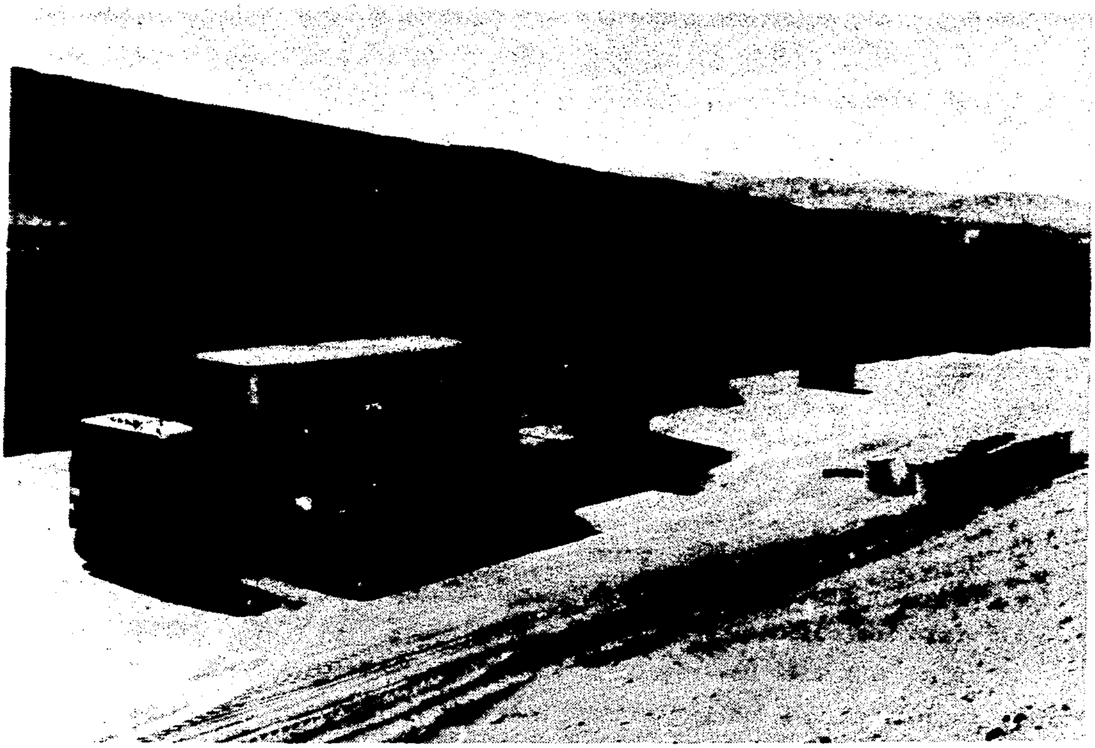

FIGURE 3.3. Unloading and Handling Operations for Packaged LLW at the NTS.

the same container. Oxidizing materials shall be packaged with combustible wastes or in combustible containers.

B. Class B Poisons Such as Beryllium and Mercury - Must be Packaged in Double Containment: Compounds of beryllium and mercury, including oxides, are Department of Transportation (DOT) Class B poisons. Therefore, solid radioactive waste containing these materials must be packaged in double containment which also meets DOT requirements, sealed, and labeled for each material.

C. Unreacted Alkali Metals - These Materials are Prohibited: Solid waste for disposal or storage shall not contain unreacted alkali metals.

D. Solid Waste: Solid waste shall be essentially dry - no free liquids. Damp waste must be packaged in an inner liquid-tight container so that the moisture is contained and the integrity of the outer container is not jeopardized during transit, storage and/or burial operations.

E. Liquids - Must be Absorbed in Inert Material: Liquids in waste for disposal by burial shall be mixed with inert absorbent materials which will not result in gas generation, spontaneous combustion, or explosion, and the liquid must not flow if the container is broken. Exceptions: contaminated liquid organic waste and animal carcasses (see I,J).

F. Flammable Liquids, Pyrophorics, Explosives - Prohibited: Flammable liquids (free or absorbed) whose flash point is below 150°F, pyrophorics, and explosives are prohibited.

G. Contamination - Must be Contained: Waste associated with loose contamination must be stabilized or contained in the package so the outer surface of the container remains free of detectable loose contamination during transport and placement into burial or storage sites.

H. Radioactive Contaminated Toxic Waste: The acceptance of hazardous or toxic waste in combination with radioactive waste must receive prior approval. Containers of toxic waste shall be labeled as to contents and container inventory.

I. Liquid Organic Waste: Contaminated liquid organic waste (flash-point > 150°F) is acceptable if properly packaged and labeled. Liquid organics (flashpoint $\leq$ 150°F) require special approval.

J. Animal Carcasses: Animal carcasses are acceptable waste when properly packaged and labeled.

Similar waste specifications apply for disposal of LLW at other DOE arid sites.

Except for decontamination efforts, volume reduction has received relatively little attention at Hanford due to the large tracts of land available for burial of the waste. As with other arid sites, the burial trenches are well above the top of the zone of saturation and studies have shown that precipitation does not percolate to the water table (i.e., the evaporation potential exceeds the precipitation) [53].

At INEL, shallow trenches (12 feet deep) are used for the disposal of compactible solid LLW such as paper, rags, etc., and also for noncompactible wastes originating at the laboratory. A bale-type compactor unit at the burial site is used to compact waste into 600-pound bales [54]. The baled wastes are placed in specially designed fiberboard boxes with plastic liners and are then stacked in the trenches. Larger noncompactible wastes arrive in wooden boxes and are stacked in the trenches along with the compacted bales. When the trenches are full, they are covered with a minimum of three feet of soil. LLW with higher levels of radiation is disposed of in steel liners equipped with concrete shields or in soil vaults. The soil vaults are large holes bored to depths as great as 30 feet. These vaults are filled with LLW and covered with several feet of soil. Barreled LLW (30- and 55-gallon steel drums), coming mostly from off-site shippers, is also disposed of at INEL.

The LANL burial site is considered to have a semi-arid continental mountain climate. This site is on a mesa covered by a clay-like soil and underlain by volcanic tuff. Both trenches and shafts are excavated in the tuff for disposal purposes. Most of the LANL wastes are buried in trenches ranging in depth to about 40 feet, depending on the stability of the pit walls. The LLW is buried in layers, with a minimum of about 6 inches of backfill compacted between layers. A waste compactor-baler is used to reduce the volume of trash-type wastes prior to burial. Waste packaging serves to meet requirements of safe on-site handling and transport, and typically includes plastic wrap and bags, cardboard boxes, metal or fiber drums, and wooden crates. Large equipment items and many of the D&D wastes are not packaged, but are delivered to the burial site in covered or enclosed transport vehicles. Following burial, the arid site environment contains the LLW and its radioactivity. The trenches are covered with excavated tuff to a thickness of about six feet.

To provide for better isolation following burial and/or to increase worker safety, certain LLWs are buried in deep shafts at the LANL site. These wastes, and the specific reasons for shaft burial (as described by Warren [32]) are listed in Table 3.6.

The two commercial shallow land burial sites of the arid type are both operated by U.S. Ecology, Inc. (formerly the Nuclear Engineering Company, Inc.). The Beatty site is located on land owned by the State of Nevada and leased to the operating company. It is situated within about 100 miles of the NTS site and has a similar climate and geology. Annual rainfall in this region is normally about 3 to 5 inches per year and is greatly exceeded by the evapotranspiration potential. Groundwater in this region migrates slowly and lies deep (hundreds of feet) below the surface. Furthermore, most of the groundwater flow paths lead to hydrologically isolated desert basins.

At the Beatty site, only a few segregation procedures have been mandated, the general practice being a random placement of waste containers

TABLE 3.6. Burial Shaft Usage for Burial of LLW at LANL.

LLW Type	Rationale for Use of Special Burial Shaft
High activity ^3H (> mCi quantities)	Greater protection of packaging; ease of monitoring.
Beta-gamma hot cell waste (intermediate level)	Direct disposal from bottom-loading, truck-mounted cask; personnel protection.
High-activity accelerator waste	Personnel protection.
Contaminated chemical wastes	Greater protection of packaging; improved isolation from other reactive wastes.
Animal tissue	Isolation from meat-eating animals.
Cement paste	Ease of operation; paste is pumped directly into shaft from adjacent liquid waste treatment facility.

in the trenches to be covered by random placement of other waste containers or by backfilling with a minimum of three feet of dirt. Liquid scintillation wastes are segregated by placement in the bottom of the trenches and are covered by backfilling on the day of receipt. Wastes containing special nuclear material (SNM) are segregated by location in the trench according to the quantity in each waste package. Sealed sources containing up to the equivalent of 50 curies of ^{60}Co are segregated by placement in special burial wells. Additional segregation requirements may be delineated in the new license when it is issued. From an operational point of view, the principal reasons for segregating wastes at this burial site appear to be (1) physical segregation by container for more efficient utilization of disposal trench volume, and (2) segregation by hazard classes other than radioactivity for safety reasons (e.g., flammable solvents, chelating agents, acid/caustic, etc.).

Chemical or toxic wastes are also disposed of at the Beatty site, but these are placed in separate trenches from those used for disposal of radioactive wastes. Approximately 46 acres of the 80-acre site are allocated for radioactive disposal, 16 acres are for chemical disposal, and an 18-acre area serves as a buffer zone. For improved utilization of existing disposal areas, the recent trend has been to much larger trench size. Thus, the most recently excavated trench measures 50 feet deep, 300 feet wide, and about 800 feet long. Future trench depths may go to as much as 100 feet.

As of April 1, 1981, the State of Nevada has instituted a new requirement for all users of the Beatty disposal site, the third party prequalification requirement [18]. This certification, which is subject to renewal each year, is obtained through application to and subsequent inspection by the Nevada Inspection Service, a subsidiary of Quadrex Corporation, located in Campbell, California. The annual qualification permit is $1,000 per generator, plus a charge of $3.50 per cubic foot of waste buried at the Beatty site in excess of 100 cubic feet. Presumably, any preshipment segregation or other requirements that would be specific for the Beatty site could be enforced through this interactive mode with the LLW generators. Since the establishment of this requirement by the State of Nevada, LLW volumes disposed of at Beatty have declined significantly, while at the Richland site a sharp increase in the volume of incoming waste has been reported.

The U.S. Ecology burial site for LLW at Richland, Washington is situated in close proximity to the DOE burial site on the Hanford reservation. This commercial site is on property deeded to the State of Washington by the federal government. Washington, being an Agreement State (as are Nevada and South Carolina, the other two states having active commercial LLW burial sites), has jurisdiction over activities at the Richland site. At present, little waste segregation is practiced at this site, although more stringent requirements are expected to be applicable in the future. The waste containers are placed randomly in large trenches as they are received. Boxed or cartoned wastes are arranged in stacked rows across the trenches, with the placement of drums between the rows. Tritium gas cylinders are disposed of separately, and Type B or > 10 rem/hr contact wastes are segregated out and buried at greater depths.

3.5.2 Humid Shallow Land Burial Sites.

The humid shallow land burial sites are located in the southeastern part of the country in areas of high precipitation and not far (within a few hundred miles) from many of the major generators of LLW. These include the two DOE sites (ORNL and SRP) and the Chem-Nuclear site at Barnwell, South Carolina. These humid sites have an advantage over the western sites in that they are located closer to where the wastes are generated and local disposal avoids the added costs and risks of long-distance transport of the waste.

A common disadvantage of humid sites is that of increased potential for leaching of the waste forms and subsequent radionuclide transport in the ground and surface water. At humid sites, the distance between the buried waste and the water table is relatively small, and the distance to points of groundwater discharge to the surface water is relatively short.

However, the large volumes of surface-water flow do provide a considerable measure of dilution once contamination has reached the surface-water system. In contrast to arid sites, erosion control normally can be maintained at humid sites with a minimal surface maintenance effort. Because of the greater potential for contact of buried wastes with water at humid sites, the segregation of incompatible wastes is much more important than at arid sites.

The burial site in current use at ORNL for disposal of LLW has a gentle relief for ease of operations and freedom from flooding. The surface of this site is essentially free of erosion by runoff of rainwater. The soil is easily excavated by heavy equipment and the walls of deep cut will remain freestanding. Trenches range from 8 to 14 feet deep, with the bottom of the trench being at least three feet above the highest observed elevation of the groundwater table. Waste is placed in the trenches to within three feet of the surface and backfilled immediately with the excavated material (shale). The backfill material is normally graded to the original ground surface level. After backfilling, the cover is fertilized and limed, then seeded with grass. After the initial seeding, natural vegetation may take over, but the area is mowed to prevent growth of scrubs and trees.

Since 1965 (when ORNL ceased to be the Southern Regional Burial Ground), only small amounts of LLW have been received at the ORNL site from other facilities. Compactible LLW at ORNL is collected in plastic bags and placed in yellow walk-in dumpsters. When full, the dumpsters are transported to the compactor-baler facility which is located near the burial site. This facility produces bales of waste in rectangular cardboard boxes (15 ft^3 in volume, and weighing approximately 670 pounds) which are bound with four metal straps to prevent springback. The ORNL baler will compact small hardware items such as tubing, small bottles and cans, in addition to the usual wastes as paper and clothing. A compaction ratio of approximately 9 to 1 has been experienced for this facility. Noncompactible LLW at ORNL is collected in yellow dempsey dumpsters (top loading). LLW with high radiation readings (surface > 200 mrem/hr) is collected in lead-shielded dempsey dumpsters. When full, the dempsey dumpsters are transported to the burial site and the contents placed in the burial trenches. Waste which might be suspected of being contaminated but having no measurable radiation is collected in green dumpsters and used as landfill.

Fissile waste (non-TRU, predominantly ^{235}U waste at concentrations of less than one gram per cubic foot) is buried, unpackaged, in burial trenches at ORNL. For those fissile wastes having greater than one gram of fissile material per cubic foot (but still non-TRU), the disposition is burial in a suitable container in an unlined auger hole (42 inch diameter, 20 feet deep). After placement in the auger hole, the waste package is covered with soil until the surface reading is less than 200 mrem/hr. The hole is then capped with a metal plug which is not removed until another container has been received for burial. At a minimum filling of two feet below the surface, the hole is topped off with bentonite and soil.

The buried wastes in some parts of the ORNL disposal site are often in contact with groundwater; furthermore, the distance from these trenches to surface waters is relatively short [55]. Therefore, the only significant impediment to radionuclide migration at this site is the retardation of radionuclides through interactions with the geomedia.

The SRP burial site is situated in a region where the climate is mild and humid. The absence of extremes in temperature and precipitation prevents frost wedging, rapid erosion, excessive drying of sediments, etc. Weathering occurs at a uniform slow rate due to the moderate climate. However, the amount of rainfall at this site (the annual mean precipitation is 47 inches) does require that care be taken in the preparation, backfilling, and surface finishing of the burial trenches in order to prevent perched water conditions. The burial trenches are excavated to a depth of about 18 feet, with the bottom of the trench being at least 10 feet above the water table. The topography is level and surface water runoff is well-controlled.

LLW generated on-site at SRP is not required to be packaged, except that usual practice is to drum high beta-gamma wastes in 55-gallon containers. LLW is unloaded manually or emptied directly from transport containers into trenches in a random manner. Remote handling operations are employed for LLW having high radiation levels, including the use of a shielded crane for handling waste with the highest exposure rates.

At SRP, waste in the trenches is covered with soil soon after emplacement to reduce the radiation levels and possibilities for contamination or fire. The usual soil cover is four feet, but it must be sufficient to reduce the surface radiation exposure to less than 6 mrem/hr. Fires have occurred in the trenches at SRP, and since 1973 combustible waste has been separated from noncombustible waste [55]. About 85% of the total buried LLW volume at SRP contains ^{3}H, and its on-site migration has been documented. Off-site generated LLW is normally segregated from the on-site generated wastes.

Examples of LLW materials which have been disposed of at the SRP burial site are the following:

- Contaminated equipment: obsolete or failed tanks, pipes, deionizers containing spent resin, and other process equipment.

- Reactor and fuel hardware: fuel components and housings not containing fuel or products.

- Spent lithium-aluminum targets: the waste target alloy after tritium was extracted by melting the alloy.

- Contaminated nonrecoverable mercury: wastes from the mercury recovery unit, packaged as solid wastes in sealed containers.

- Oil from gas displacement pumps in the tritium facilities: prior to burial, the oil is placed in drums containing an absorbent material.

- Laboratory and operating wastes: small equipment, clothing, analytical waste, decontamination residues, plastic sheeting, gloves, etc.

- Special shipments from off-site: tritiated wastes from Mound Facility, ^{238}Pu process waste from LANL and Mound Facility, and debris from two U.S. military airplane accidents in foreign countries.

- Spent deionizer resins: from reactor purification systems.

This list simply indicates again the great variety of LLW types that are being disposed of at major burial sites.

The Chem-Nuclear Barnwell commercial burial site is located within a few miles of the SRP site and thus has a similar climate and geology. The Barnwell site has a clay layer under the burial trenches; this feature limits the trench depth to approximately 25 feet since it is desirable not to disturb the clay layer. The emplaced LLW is covered daily at the Barnwell site; the trench caps at this site consist of three feet of clay covered by three feet of seeded topsoil.

Relatively little waste segregation is practiced at the Barnwell site. High activity wastes are disposed of in split trenches where personnel radiation exposures can be minimized by use of remote handling techniques. Organic medical wastes and some chemical wastes (CaF_2) are segregated in individual trenches. Wastes contaminated with ^{235}U may require separation spacing in the trenches due to criticality considerations. Fuel cycle and non-fuel cycle LLWs are also segregated by placement into different trenches.

The Barnwell site no longer accepts wastes containing toluene, xylene, dioxane, scintillation liquids, or other organic liquids with similar chemical properties, nor will the site accept any containers which have at any time contained any of these liquids.

The generic problems of disposing of LLW in humid shallow land burial sites have been reviewed by Meyer [56], who has concluded that past problems of radioactivity migration at these sites are correctable but will require great cost and the application of certain specific design and waste management criteria in the future.

3.6 Other LLW-Generating Operations.

Some LLWs are also produced in the U.S.A. by other than DOE, fuel cycle and non-fuel cycle operations. The principal source of such wastes is the Department of Defense (DOD), in particular, nuclear operations of the U.S. Navy. All of the U.S. Navy reactors are PWRs and are similar in operation to commercial PWRs in many respects, although the fuel is much more highly enriched. Because they use a highly enriched fuel, the Navy reactors may have to be refueled only once every 5 to 15 years, depending on the type of vessel and percent power level at which they are operated.

LLWs produced during operation of Navy reactor-powered vessels are normally transferred to a tender for processing and packaging. Radioactive liquid wastes are collected in stainless steel vessels and processed through filters, carbon beds, and ion exchange resin beds. Maintenance and overhaul operations also produce liquid and solid LLWs. The transfer of these materials from nuclear-powered vessels to support facilities is strictly controlled in accordance with Navy accountability procedures. These procedures include serialized tagging and marking and signatures by Health Physics personnel.

Navy wastes are primarily contaminated with activited corrosion products, the principal radionuclide being ^{60}Co. Data on the wastes transferred from ships at California facilities or produced at Navy support facilities in California are given in Reference 42.

Little has been published concerning waste segregation and management practices for Navy wastes. It is common practice to use compaction and other methods to minimize solid waste volumes. It is suspected that waste segregation is rather extensively practiced at Navy facilities.

4. ASSESSMENT OF THE COSTS AND BENEFITS OF SEGREGATION

In general, the establishment of waste segregation controls by generators and handlers of LLW should involve fairly minimal expenditures. It is expected that little additional expense would be required for radiation survey and monitoring instrumentation beyond what would already be available at the facility. Large-sized instrumentation (e.g., drum assay systems) would only be added to a facility if justified on the basis of the quantity of waste handled or the economic value of recoverable materials such as radionuclides for recycle. The redesign of a waste management system would perhaps involve the acquisition of waste containers and handling/processing systems of varying complexity. However, this should require only a modest outlay in comparison with the overall LLW management budget. Most of the technology for waste segregation is relatively inexpensive and its adoption should not be greatly burdensome.

Very little cost information was obtained in this survey of LLW segregation practices. It is frequently the case that waste segregation has been accomplished largely through the establishment of institutional controls and dedication on the part of the concerned parties. Waste segregation may primarily involve visual-manual type operations on the part of LLW generators and other workers. Thus, the assignment of economic cost to the adoption of waste segregation practices is understandably imprecise. Likewise, the assignment of radiologic costs arising from increased handling operations and consequent exposure to ionizing radiation is imprecise, and a proper evaluation would require considerable study of each situation.

Many facilities have reported considerable cost savings resulting from adoption of segregation practices, in particular where radioactive waste volumes have been reduced through segregation of nonradioactive from radioactive wastes. The costs of LLW disposal have risen sharply over the past three or four years, more so than the rate of inflation. At the present time, it may cost several hundred dollars to dispose of a single 55-gallon drum of LLW. The actual disposal cost consists of management, labor, and materials costs at the facility, plus transportation to the burial site, plus burial costs including cask handling surcharges, etc. An example of the disposal costs for LLW from a nuclear-based utility in late 1980 is given in Table 4.1. It is seen that disposal costs increase rapidly if radiation levels are over 200 mrem/hr. Reduction of LLW volumes through segregation can effect significant savings in cost, the more so as disposal costs continue to increase.

TABLE 4.1. An Example of LLW Disposal Costs as Reported by a Nuclear Utility in Late 1980

	Disposal Cost/Drum[a] ($)	
Contact Dose (rem/hr)	Burial Site A	Burial Site B
0.2	100	130
0.2 - 1	180	290
1 - 5	220	350 - 440
5 - 10	270	510
10 - 25	330	660
25 - 50	410	830 - 880
50 - 75	510	920
75 - 100	560	930

[a] 55-gallon (208-liter) drum

With alternative nonradioactive disposal options now available for certain ^{3}H- and ^{14}C-containing liquid scintillation wastes, cost savings are possible through segregation of these wastes from LLW. Commercial disposal firms will accept these wastes for incineration, after which the empty drums are returned to the generating sites. Fees are reportedly of the order of \$10/ft^3, which, when compared with LLW disposal costs, is more nearly \$5/ft^3 due to the near doubling of the packaging efficiency when the wastes are considered as non-LLW. One firm which was contacted estimated that they would generate approximately 75 drums (55-gallon or 208-liter each) of these wastes per year if the wastes were disposed of as LLW. If these wastes were disposed of as LLW, the estimated cost to this firm would be about \$10^4/year. However, by electing to use the alternative incineration (non-LLW) option instead, this firm is currently saving approximately three-quarters of this amount (besides the saving of unused space at the LLW burial site). Significant savings are also possible where LLW containing short-lived radioactivity is stored on-site for decay to nonradioactive levels, and where suspect-TRU wastes can be shown to be LLW rather than TRU wastes (disposal costs for LLW are much less than for TRU wastes).

Increased occupational exposures may result from adoption of waste segregation practices. Workers, particularly at the burial sites, could experience a greater exposure to ionizing radiation from the increased handling which might result from burial site segregation requirements [19]. If so, these incremental man-rems should be factored into all calculations of cost vs. benefit for any assumed operational changes.

Benefits accruing from the adoption of waste segregation practices would be enjoyed by all parties of the management system for LLW. These include potential reductions in disposal costs and radiation exposure to personnel (except at the burial sites where there might be increased exposures). As discussed in Section 1.1, the segregation of wastes can lead to more efficient waste processing and indeed is a necessary pretreatment if advanced treatments such as incineration or smelting are to be successfully applied. Waste segregation can also lead to a reduction in waste volumes resulting from improved waste packaging and utilization of space. Improved operations and disposal practices at the burial sites, subsidence control, better containment of radioactivity, and a generally much more streamlined waste management system could all be effected through the more widespread use of waste segregation technology.

Many other countries have nuclear facilities and operations similar to those in the U.S.A., and generally similar waste management practices are employed throughout the world. Taylor and co-workers [57] have discussed segregation practices for plutonium-bearing wastes in Western Europe. Bähr and his co-workers [58] have discussed the segregation of plutonium-bearing wastes at the Karlsruhe Nuclear Research Center. Segregation controls used during decommissioning of a reprocessing plant at Eurochemic were reported on by Broothaerts et al. [59]. LLW segregation and management practices in Czechoslovakia were reported on by Malášek and Tittlová [60]. Details of the experiences at the Bhadha Atomic Research Center in India were discussed by Thomas et al. [61]. LLW segregation practices in Belgium have been reported on by Van de Voorde and co-workers [62]. Johnson [63] has discussed operational techniques to minimize, segregate, and account for alpha-bearing wastes at Windscale in the United Kingdom. Burns and co-workers [64,65] have discussed waste management practices including segregation at the Harwell Atomic Energy Research Establishment in the United Kingdom. The state of technology at these facilities and elsewhere is similar to that of this country, which has been discussed in other sections of this report. An excellent summary of the important considerations relative to the adoption of waste segregation technology is given in the International Atomic Energy Agency (IAEA) Bulletin Number 24 of the Safety Series [66].

5. RECOMMENDATIONS FOR WASTE SEGREGATION TECHNOLOGY DEVELOPMENT AND TRANSFER

Enhanced LLW segregation practices should be established at shallow land burial sites in the future, provided that the accruing benefits are reasonably in line with the incremental operational costs (e.g., if the acceptance of an increased radiation exposure to the site personnel due to increased handling can be justified). Greater use of segregation, coupled with volume reduction technologies for LLW, should be encouraged for economic reasons as well as to conserve waste and trench volumes, and to reduce potential for subsidence or related problems at the burial site. Segregation controls are, of course, essential for the efficient implementation of incineration and other volume reduction technologies.

Segregation and good housekeeping at the source of LLW production should be utilized to keep the contamination of nonradioactive waste to the lowest practicable level, and to facilitate placing waste into suitable categories for particular burial facilities. Applying these practices will also tend to reduce the volume of solid LLWs that are candidates for shallow land burial.

Segregation considerations should take into account the final LLW package and other features such that an optimal degree of compatibility with burial practice is achieved.

Several types of wastes should receive special treatment to immobilize the radionuclides, to reduce the hazard from chemically toxic materials, and to reduce handling risks in transportation and disposal. All waste processing should occur prior to delivery at the burial site.

At the burial site, some wastes should be identified for special emplacement due to their special characteristics, e.g., special segregation is needed for LLW containing or capable of producing organic chelating agents, and for biological wastes that can undergo bacterial decomposition yielding organic acids, gases, and other undesirable products.

Segregation is also recommended for combustible wastes and for those containing long-lived radionuclides, isotopes of high radiotoxicity, high specific activity, and certain wastes such as unsolidified spent ion exchange resin.

Segregation of LLW is best done at the point of generation, of course. Thus, it is mainly the responsibility of the waste generator to implement those LLW segregation practices leading to an improved disposal of these wastes. It is important that generators of LLW are made aware of the potential benefits of waste segregation through wider dissemination of this information. LLW generators should be encouraged to do a self-evaluation of their own situation and should consider adopting improved LLW management practices wherever it can reasonably be done.

We have concluded that the small waste generators (e.g., institutional LLW generators) have the most to gain by the adoption of segregation practices or by a wider dissemination of information relating to improvements in LLW management. While the total volumes of LLW that each of these generate might be relatively small, the ever increasing disposal costs are becoming a more significant factor in their budgets. The large commercial waste generators (e.g., nuclear power plants) enjoy the benefits of a large staff which can keep pace with regulatory changes and adequately evaluate the economic benefits of alternative procedures. Similarly, at DOE sites, an informed staff and plentiful disposal space are frequently available.

There appears to be a need to assemble and illuminate those regulations which are particularly relevant to the small LLW generators so as to assist them in reducing costs. If feasible, it would be very desirable to prepare a modest sized Manual on Waste Segregation Technologies which would include a discussion of standard and novel procedures, and an illuminated compilation of regulations for LLW. Such a document would be of considerable value to the average radiation safety officer at the smaller facilities.

An appropriate classification system is central to the concept of waste segregation. The development of such a system is currently being sponsored by the NLLWMP. When finalized, this updated classification system should be useful for developing waste segregation strategy in the future. (It should be noted that various classification systems have been proposed in the past [67,68]; the NRC has proposed a classification system [69] as part of the technical criteria for shallow land burial in the draft 10 CFR Part 61, dated May 13, 1981.) Likewise, it is recommended that an alphanumeric code be developed in conjunction with the establishment of a LLW classification system.

Based on a suitable classification system, waste segregation offers the improved ability to keep accurate records of the wastes from generation to final disposal, including explicit information on chemical and radionuclide content, compositions, and solidification agents. In a large LLW generating facility, modern data processing methods could easily be applied to obtain and store the quantities of data that might be required for tracking the various waste streams and the individual waste units. However, there is a need to develop and establish appropriate computer techniques (including the necessary software) for the accurate characterization and tracking of LLWs, particularly as they pass through the various processing and packaging steps, and undergo combination with other waste streams.

Improved procedures for the assay of waste units for radioactive contents are needed. To the greatest extent achievable with safe operations, radioactive wastes should be free of nonradioactive constituents. Certainly, administrative controls could be more universally applied to eliminate the unnecessary materials from radiation zones that otherwise find their way into the radioactive waste streams. In some installations, it would appear that the radiation zones could be redefined such that fewer suspect wastes were generated. Understandably, most workers tend to err on the conservative side in attempting to decide whether a given waste object or assemblage is radioactively contaminated. To assist the LLW generator, many sites have made very effective use of

Health Physics personnel for monitoring the waste streams and screening out nonradioactive constituents.

It is widely felt that there should be defined "de minimus" levels of radioactivity for solids below which the wastes would no longer be considered LLW. In the latest draft 10 CFR Part 61, this need has been acknowledged. NRC's position is that such exemptions should be determined on a specific waste basis (such as was recently done with liquid scintillation and biological wastes containing ^{3}H or ^{14}C), and the NRC has announced its intention to provide such exemptions where needed over the next two years or so. The granting of certain exemptions would be highly desirable, for example, for institutional wastes, many of which might then be diverted from the burial site disposal route. However, it would also appear that blanket acceptable release level ("de minimus") definitions could be developed and that such information could be more easily communicated to and acted upon by the respective users.

In some facilities, it appears that there could be a more effective segregation of non-TRU from TRU wastes than presently is the case. Many non-TRU wastes become classified as TRU simply because they are "suspect" and a direct determination of their transuranic contamination is exceedingly difficult if at all feasible. Again, administrative controls might be usefully applied reducing overall waste volumes. Likewise, technology is available to interrogate waste packages and to segregate non-TRU from TRU wastes under many different conditions [70-72], and this could be applied for a net benefit. Also in this connection, the commonly accepted definition of TRU wastes (a specified alpha contamination in excess of 10 microcuries/kilogram) perhaps should be reexamined, both in terms of its practicability and the actual hazards relative to those of other toxic materials.

Alternate disposal options should be made available for some of the LLWs that are currently disposed of at shallow land burial sites. For example, many of the institutional LLWs pose relatively little radiological hazard (in some cases, the chemical toxicity is much greater than the radiotoxicity). Except for ^{3}H and ^{14}C, the institutional or non-fuel cycle wastes mostly contain relatively short-lived radioisotopes (usually the half-lives are less than one year). In many instances, these wastes could be segregated and stored on site for radioactive decay to acceptable release levels, after which they could be disposed of as ordinary waste. Similarly, a reexamination of restrictions relating to incineration is needed since this option could be made more readily available to institutional generators of LLW.

Centralized LLW treatment facilities could be established by waste brokers or other parties servicing multiple small users of radioisotopes. Collectively, institutional waste such as produced by universities, research centers, hospitals and medical institutions represents an important category of LLW requiring disposal (it represents approximately one-fourth of the commercial LLW volume but contains less than 1% of the radioactivity). The individual generators, ranging from very small to moderate-sized, can hardly be expected to use advanced treatment or volume reduction techniques. However, incentives could be developed for the small users to adopt waste segregation policies that might greatly facilitate subsequent treatment.

D&D activities are underway at many sites, and can be expected to contribute significant volumes of LLW in the future. It is expected that many diverse waste forms will result from these activities. Additional study is needed of D&D and other advanced treatment technologies so that rational use may be made of segregation technology, and developmental needs can be recognized and planned for.

A suggested checklist for establishing a waste segregation program at a LLW generating facility is shown in Figure 5.1. This checklist summarizes a successful approach used by some facilities in implementing waste segregation (and other treatment technologies) for LLW. The list is not intended to be all-inclusive, but merely to highlight those efforts that do appear to be generally applicable when they are properly coordinated.

- ACCUMULATE A DATA BASE BY THOROUGHLY STUDYING THE GENERATION OF LLW AT THE FACILITY
- DISCUSS LLW MANAGEMENT NEEDS WITH ALL INTERESTED PARTIES AT THE FACILITY; ESTABLISH GOALS FOR WASTE SEGREGATION
- INVEST IN NEEDED FACILITIES AND EQUIPMENT; ESTABLISH PROCEDURES; PROVIDE TRAINING
- PROVIDE ORGANIZATIONAL SUPPORT FOR WASTE SEGREGATION; DENOTE RESPONSIBILITIES
- CULTIVATE AN AWARENESS OF THE LLW DISPOSAL PROBLEM AMONG THE PERSONNEL; COMMUNICATE ANY PROGRESS BEING MADE
- DEVELOP INCENTIVES FOR CONFORMING WITH ESTABLISHED PROCEDURES (E.G., ECONOMIC)
- ESTABLISH CONTROLS TO ASSURE CONFORMANCE WITH ESTABLISHED PROCEDURES; PROVIDE THE APPROPRIATE FEEDBACK

FIGURE 5.1. Suggested Checklist for Establishing a Waste Segregation Program at a LLW Generating Facility

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ATTACHMENT B

Congressional Record

United States of America

PROCEEDINGS AND DEBATES OF THE 96th CONGRESS, SECOND SESSION

Vol. 126 WASHINGTON, SATURDAY, DECEMBER 13, 1980 *No. 177*

Senate

(Legislative day of Thursday, November 20, 1980)

SHORT TITLE

SECTION 1. This Act may be cited as the "Low-Level Radioactive Waste Policy Act".

DEFINITIONS

SEC. 2. As used in this Act—

(1) The term "disposal" means the long-term isolation of low-level radioactive waste pursuant to requirements established by the Nuclear Regulatory Commission under applicable law.

(2) The term "low-level radioactive waste" means radioactive waste not classified as high-level radioactive waste, transuranic waste, spent nuclear fuel, or byproduct material as defined in section 11 e. (2) of the Atomic Energy Act of 1954.

(3) The term "State" means any State of the United States, the District of Columbia, and, subject to the provisions of Public Law 96-205, the Commonwealth of Puerto Rico, the Virgin Islands, Guam, the Northern Mariana Islands, the Trust Territory of the Pacific Islands, and any other territory or possession of the United States.

(4) For purposes of this Act the term "atomic energy defense activities of the Secretary" includes those activities and facilities of the Department of Energy carrying out the function of (i) Naval reactors development and propulsion, (ii) weapons activities, verification and control technology, (iii) defense materials production, (iv) inertial confinement fusion, (v) defense waste management and (vi) defense nuclear materials, (vii) defense security and safeguards, (all as included in the Department of Energy appropriations account in any fiscal year for atomic energy defense activities).

GENERAL PROVISIONS

SEC. 3(a). Compacts established under this Act or actions taken under such compacts shall not be applicable to the transportation, management, or disposal of low-level radioactive waste from atomic energy defense activities of the Secretary or Federal research and development activities.

(b) Any facility established or operated exclusively for the disposal of low-level radioactive waste produced by atomic energy defense activities of the Secretary or Federal research and development activities shall not be subject to compacts established under this Act or actions taken under such compacts.

LOW-LEVEL RADIOACTIVE WASTE DISPOSAL

SEC. 4. (a)(1) It is the policy of the Federal Government that—

(A) each State is responsible for providing for the availability of capacity either within or outside the State for the disposal of low-level radioactive waste generated within its borders except for waste generated as a result of defense activities of the Secretary or Federal research and development activities; and

(B) low-level radioactive waste can be most safely and efficiently managed on a regional basis.

(2)(A) To carry out the policy set forth in paragraph (1), the States may enter into such compacts as may be necessary to provide for the establishment and operation of regional disposal facilities for low-level radioactive waste.

(B) A compact entered into under subparagraph (A) shall not take effect until the Congress has by law consented to the compact. Each such compact shall provide that every 5 years after the compact has taken effect the Congress may by law withdraw its consent. After January 1, 1986, any such compact may restrict the use of the regional disposal facilities under the compact to the disposal of low-level radioactive waste generated within the region.

(b)(1) In order to assist the States in carrying out the policy set forth in subsection (a)(1); the Secretary shall prepare and submit to Congress and to each of the States within 120 days after the date of the enactment of this Act a report which—

(A) defines the disposal capacity needed for present and future low-level radioactive waste on a regional basis;

(B) defines the status of all commercial low-level radioactive waste disposal sites and includes an evaluation of the license status of each such site, the state of operation of each site, including operating history, an analysis of the adequacy of disposal technology employed at each site to contain low-level radioactive wastes for their hazardous lifetimes, and such recommendations as the Secretary considers appropriate to assure protection of the public health and safety from wastes transported to such sites;

(C) evaluates the transportation requirements on a regional basis and in comparison with performance of present transportation practices for the shipment of low-level radioactive wastes, including an inventory of types and quantities of low-level wastes, and evaluation of shipment requirements for each type of waste and an evaluation of the ability of generators, shippers, and carriers to meet such requirements; and

(D) evaluates the capability of the low-level radioactive waste disposal facilities owned and operated by the Department of Energy to provide interim storage for commercially generated low-level waste and estimates the costs associated with such interim storage.

(2) In carrying out this subsection, the Secretary shall consult with the Governors of the States, the Nuclear Regulatory Commission, the Environmental Protection Agency, the United States Geological Survey, and the Secretary of Transportation, and such other agencies and departments as he finds appropriate.

ATTACHMENT A

National Conference of State Legislatures

Office of State Federal Relations

444 North Capitol Street, N.W.
2nd Floor
Washington, D.C. 20001
202/624-5400

President
Richard S. Hodes
Speaker Pro Tempore, Florida House of Representatives

Executive Director
Earl S. Mackey

APPENDIX A

POLICY ADOPTED BY DECEMBER SFA

LOW-LEVEL RADIOACTIVE WASTE MANAGEMENT

COMMITTEE: NATURAL RESOURCES AND ENVIRONMENT IN COOPERATION WITH THE ENERGY COMMITTEE

The disposal and transportation of low-level radioactive wastes is an issue of major and increasing concern because of the increasing quantity of such wastes in relation to the available disposal sites and because of such wastes. For the purposes of advising the federal government of nuclear waste management, President Carter established a State Planning Council on Radioactive Waste Management that includes state governors and legislators among its membership.

NCSL believes that the management of low-level radioactive wastes is an activity that can best be exercised within the general responsibility of states to protect the health and welfare of their citizens.

Therefore, NCSL declares its belief that primary responsibility for the management of low-level radioactive wastes rests with the states. Further, NCSL believes that the federal government should recognize and support through appropriate technical and financial assistance the primary role of the states in managing these wastes.

Therefore, NCSL urges states (in cooperation with tribal governments) to take action quickly to manage low-level radioactive wastes in an effective and safe manner either individually or jointly through interstate compacts and agreements. Conferences convened by legislators for the purpose of pursuing a regionalized approach for the management of low-level wastes should whenever possible be held in cooperation with state executives and local officials and appropriate regional organizations. NCSL should provide staffing and technical assistance.

Furthermore, NCSL urges the federal government and Congress to work cooperatively with states to:

1) Pursue a national education program on low-level waste management.

2) Assure that the State Planning Council will continue and will include state legislators and governors. It should be the responsibility of this Council to recommend methods by which the federal government can assist states in their current efforts to manage low-level radioactive waste and by which the federal government may upon request by a state assume the long term extended care of low-level sites upon closure.

3) Include in the Nuclear Regulatory Commission's licensing provisions for adequate performance bonding for site operators/owners. This will assure that the host state would be free from liability in the event of a premature site closure and an inadequate extended care and maintenance fund.

4) Create a special discretionary fund which would provide benefits to host states and communities. This fund should also provide assistance to regions for costs associated with interstate compact development and with technical assistance and site characterizations.

5) Allow states the continuing option of either assuming responsibility for extended care and maintenance of a closed disposal site within their borders or returning this responsibility to the federal government.

6) Expeditiously move to provide a definition and classification of low-level radioactive waste.