

MANAGEMENT TECHNIQUES FOR LABORATORIES AND OTHER SMALL INSTITUTIONAL GENERATORS TO MINIMIZE OFF-SITE DISPOSAL OF LOW- LEVEL RADIOACTIVE WASTE

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Management Techniques for Laboratories and Other Small Institutional Generators to Minimize Off-Site Disposal of Low- Level Radioactive Waste

**Recommendations of the
NATIONAL COUNCIL ON RADIATION
PROTECTION AND MEASUREMENTS**

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Preface

In recognition of the social and economic costs associated with the storage and deposition of radioactive waste, the Scientific Program Area Committee of the National Council on Radiation Protection and Measurements (NCRP) on Radioactive and Mixed Waste recommended that a scientific report be developed with the aim of minimizing the amount of waste generated. As a result, this Report was prepared by NCRP Scientific Committee 87-1 on Waste Avoidance and Volume Reduction. NCRP wishes to thank the U.S. Department of Energy for their financial support, in part, of this Report.

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1. Summary

Public concern and increased cost of the disposal of low-level radioactive waste (LLRW) have led to a need to address the minimization of these wastes particularly as they pertain to research laboratories and other small users of radioactive materials. The information in this Report will prove valuable not only to the generator of this waste but to those organizations responsible for licensing and regulation.

Since risks associated with waste are related to the concentration of the hazardous material, the quantity and form of the waste, and the potential for dispersion in the environment, the generator's first priority should be the partial or total elimination of the source of the waste stream. Furthermore, waste that cannot be eliminated should be recycled in an environmentally safe manner. Next, waste that cannot be eliminated or recycled should, when feasible, be treated to reduce its hazards and to reduce the volume of the wastes. The final step is that of selecting a disposal method consistent with protection of the public health and the environment which is in compliance with federal and state laws and regulations.

An overview of applicable laws and regulations is essential in understanding the needs for a waste minimization program. The production and disposal of radioactive wastes are ultimately guided and controlled by federal laws beginning with the Atomic Energy Act of 1954 (AEA), as amended, and now include the following:

- Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA)
- Hazardous and Solid Waste Amendments Act of 1984 (HSWA)
- Low-Level Radioactive Waste Policy Act of 1980 (LLRWPA)
- Low-Level Radioactive Waste Policy Amendments Act of 1985 (LLRWPA)
- Nuclear Waste Policy Act of 1982 (NWPAA)
- Pollution Prevention Act of 1990 (PPA)
- Resource Conservation and Recovery Act of 1976 (RCRA), as amended
- Toxic Substances Control Act of 1976 (TSCA)

These laws and resulting regulations are discussed in detail in Section 2.

Regulations derived from these laws are usually administered and enforced by the U.S. Environmental Protection Agency (EPA), U.S. Nuclear Regulatory Commission (NRC), U.S. Department of Energy (DOE), U.S. Department of Defense (DOD), U.S. Department of Transportation (DOT), and the Occupational Safety and Health Administration (OSHA). The authority for implementing and enforcing many of EPA regulations is delegated to the states.

The decreasing trend in waste generation by nuclear power utilities has been driven by the increased cost of waste disposal and by increased emphasis on overall plant performance by industry groups such as the Institute for Nuclear Power Operations. For example, it appears that the volume of these wastes has decreased sharply while the total radioactivity has remained nearly constant indicating that, in general, costs of disposal of LLRW are volume based.

This reduction in utility waste is not seen in the small generators of waste, which suggests that waste minimization may be effective in reducing costs for them. Cost reduction for small generators can be a significant saving in overall project budgets. For the small generator, two sources of waste streams deserve particular mention. First, is the waste associated with analytical procedures, which has become a new source of wastes and can be expected to increase substantially with new activities such as decommissioning and environmental restoration. Second, is the large volume of scintillation fluids generated in research, academic and medical facilities. Currently these wastes in part are disposed into sanitary sewers without further regard to the radioactive materials content if they meet the requirements of 10 CFR Part 20.2003 (NRC, 2002a).

An effective waste minimization program is required for each facility generating waste. To be effective, it is essential that the program be supported at all levels of management. A single individual with direct access to senior facility management should have responsibility for organizing, planning and promotion of all waste minimization functions. Waste minimization and management should be an integral part of the project and institutional planning and budgeting process. Effective strategies need the attention of senior management.

Within this program an important element is the establishment of definitive and realistic goals. Employee awareness, incentives and training are essential to ensure that each individual involved in the program is an active participant in minimizing waste.

An important management tool is trend analysis which can assist not only in delineating the progress in meeting goals but the data can focus attention on where additional resources may be needed. Detailed guidance is given in Section 4.

Characterization of the individual sources of waste streams, which is required by regulations, can substantially aid in maximizing volume reduction and waste minimization. This characterization should include the chemical and radiological composition of the waste, information on input material, material usage, the generation process, applicable regulatory standards, minimization methods, and disposal costs.

Information exchange and technology transfer is of great importance in bringing innovative approaches to the waste minimization program. Section 5 contains a compendium of internet and other sources of information exchange.

The selection of waste minimization methods should begin with consideration of source reduction or elimination. This should then be followed by consideration of recycling the waste. The next step is treatment of the waste prior to disposal. Optimization of treatment and disposal should be evaluated from regulatory compliance and cost perspectives.

Although source reduction has been effective in manufacturing and other industrial applications, it is more difficult in the research and educational environment, particularly in medicine, where substitution of materials can be difficult. Section 5 provides general guidance on waste minimization.

Section 6 provides discussion and examples on the importance of attention to equipment, layout and process changes for minimizing waste. For example, introduction of microscale techniques. Examples of good operating practices are also discussed and examples given in this Section. Waste segregation in all its facets is the predominate issue: radioactive/nonradioactive, long/short half-life, radioactive/hazardous, etc.

Detailed discussion and examples for each technique of minimization are presented in Section 7 which deals primarily with biomedical applications of radioactive material. For example, it has been shown that savings obtained through bulk purchases can be lost in disposing of the unused material and short-lived radionuclides can often be substituted for long-lived radionuclides.

The last method discussed in Section 7 is treatment for storage or disposal. In the discussion and in the examples a number of approaches are given. For radioactive waste, the objectives are to reduce the radiotoxicity, the volume, and mobility of the contained

radioactive materials. Further it is important to meet transportation, processor and disposal site requirements for waste that needs to be sent elsewhere for management. For mixed and multihazardous waste, an objective is to eliminate one or more of the hazardous properties to allow disposal as a single waste type. For multihazardous waste it is important to inactivate pathogens and other characteristics of regulated medical wastes.

Section 8 provides specific guidance for the design of facilities with emphasis on the needs of the small user. Institutions handling radioactive material should incorporate pollution prevention and waste minimization considerations during the design of facilities. A primary issue during design is planning for a variety of waste handling areas such as satellite collection and assembly areas, temporary staging areas, central marshaling and processing areas, and treatment, storage and disposal areas. The objectives of good facility design will be met most effectively when the planners evaluate the complex interrelationships among the various processes, from construction to operation, decommissioning and demolition.

There are a number of unresolved issues that adversely impact waste minimization. These are identified in Section 9. Of particular note are regulatory barriers to effective waste minimization. This is exemplified by the inconsistent approach to these issues by various federal and state regulations. For the small user, there is an absence of a well defined and focused infrastructure for waste.

2. Introduction

2.1 Purpose

The beneficial use of radioactive material and ionizing radiation in education, research, medicine and industry results in the generation of LLRW. This waste requires environmentally safe methods of management and disposal. The cost of disposal has increased dramatically in recent years, and public concern regarding the safety of current and proposed disposal methods has also escalated. It is therefore timely and worthwhile to examine current LLRW generation and management practices to search for ways, both technical and institutional, to address this issue. The most effective way of addressing this waste management issue is to implement effective institutional practices that eliminate or significantly reduce the generation of these wastes. This is the subject of this Report.

This Report identifies waste minimization principles, practices and techniques that generators can adopt and benefit from, and that regulators can use in developing regulations. Because of an identified need (NAS/NRC, 2001), the intended audience for this Report consists primarily of small institutional (biomedical, research and academic) generators and their regulators. It is believed that other larger generators, such as nuclear power utilities and DOE facilities, may also benefit from the general principles and the specific recommendations developed in this Report. An extensive list of references is appended to provide sources of additional information.

2.2 Background

LLRW is defined under various federal laws as radioactive waste that is not high-level radioactive waste, transuranic waste, spent nuclear fuel, or certain byproduct materials defined in Section 11(e)(2) of AEA (1954). NRC is authorized under AEA to regulate all non-DOE byproduct, source, and special nuclear materials, and the waste generated by their use. NRC, in turn, can delegate

the authority to regulate most of this radioactive material and waste to states under the its Agreement State program. The responsibility to regulate non-DOE naturally occurring and accelerator-produced radioactive material (NARM) resides with the states.

For purposes of this Report, waste is considered to be material that has served its useful purpose in its present form, and is intended to be discarded with or without further processing. For radioactive waste, the point at which material becomes waste has not been specifically defined in regulations. For hazardous chemical waste, the conditions under which material becomes a solid/hazardous waste is defined in 40 CFR Part 261 (EPA, 1980a).

This lack of a precise definition of “radioactive waste” has not generally been a problem, since radioactive materials and wastes are regulated similarly under AEA (1954). Generators that are regulated under AEA are required by the regulatory agency, *i.e.*, NRC or Agreement State, to keep exposures from radiation as low as reasonably achievable (ALARA) at all times and to provide for safe disposal of LLRW.

There have been dramatic changes in the management and disposal of LLRW over the past couple of decades for several reasons. One is the rapidly escalating costs for disposal. Another is that public concern about the issue of nuclear waste disposal has grown considerably. And finally, LLRWPA (1980) and the Low-Level Radioactive Waste Policy Amendments Act (LLRWPA, 1986) have given the responsibility of providing commercial LLRW disposal to the states, who are allowed to address this issue individually or by forming a Compact of states, which in turn has created the need for them to implement laws and regulations. Although LLRWPA primarily addresses ultimate disposal of LLRW, some state and Compact laws and regulations more clearly recognize the value of improved waste minimization practices.

The primary goal of any minimization program should be the elimination or reduction to the extent practicable of the hazardous components that are present in the waste. In addition to wastes that contain a low-level radioactive component, the scope of this Report also covers low-level mixed waste (LLMW) that contains hazardous or toxic chemical constituents or biohazardous materials. For purposes of this Report, such wastes are called low-level multihazardous waste (LLMHW). Regulated LLMW is a subset of LLMHW which contains radioactive material as defined by AEA (1954) and hazardous wastes that are regulated under HSWA (1984) of RCRA (1976) as amended and EPA regulations

implementing RCRA. LLMW also includes waste which contains radioactive material defined by AEA and hazardous materials regulated under laws other than RCRA such as TSCA (1976). LLMHWS, on the other hand, can include a full range of other hazardous materials, such as medical wastes that are regulated under state or federal laws and regulations. For these wastes, the requirement for minimizing waste is clearly established. RCRA (1976), for example, includes mandates that require waste minimization.

The U.S. Congress has shown strong intent to address the prevention of pollution regardless of the source. PPA (1990) states “pollution should be prevented at the source; pollution that cannot be prevented should be recycled in an environmentally safe manner, whenever feasible; and finally, disposal or other release into the environment should be employed only as a last resort and should be conducted in an environmentally safe manner.”

There are three major reasons for adopting and implementing waste minimization as part of an overall management program. First, it usually makes disposal inherently safer because of the reduced toxicity and volume of the waste needing disposal. This, in turn, makes such disposal methods more publicly acceptable, particularly when responsible waste management programs designate disposal as the last resort after exhausting all other options that may be cost effective. Second, it reduces the overall cost of waste management and disposal. The savings arise not only from a reduction in the volume and toxicity of the waste, thereby leading to smaller direct costs for waste management and disposal, but also from a decrease in indirect costs, *e.g.*, insurance, long-term liability, and potential for resource recovery. Finally, such a program is responsive to the national policy of pollution prevention expressed in RCRA (1976), PPA (1990), and other federal, state or local laws and regulations.

2.3 Common Terms Used in this Report

Various terms are used in the literature and regulations regarding waste minimization practices and principles. This has resulted in some of the common terms being used differently to describe the various waste minimization activities. The most common waste minimization activities and terms as used in this Report are given below. More detailed definitions and references to regulatory definitions may be found in the Glossary.

- “*Waste avoidance*” is a general term that describes the partial or total avoidance of generating waste at the source. Waste avoidance can be enhanced through process modification, product substitution, improvements in input material purity, imposition of stringent house-keeping and management practices, segregation of waste as it is produced, increases in the efficiency of machinery, and process reuse. These techniques are generally exercised as a first step in a waste management program. When waste generation is totally prevented, it is called “source elimination”; when the volume or hazard exhibited by a waste is decreased, but not eliminated, it is called “source reduction.” As defined above, the terms source reduction or elimination exclude out-of-process recycling, dewatering, compaction, reclamation, and other out-of-process treatments.
- “*Disposal*” means the intentional discharge, deposit, injection or placement of any hazardous waste into or on any land or water so that the waste or any constituent thereof may enter the environment by being emitted into the air or discharged into any waters, including groundwaters. Disposal activities are not generally considered to be waste minimization (EPA, 1986a).
- “*Recycling*” is using, reusing or reclaiming materials/waste, including processes that regenerate a material or recover a usable product. In-process, closed-loop reuse, where the reclaimed material is fed back into the process, is considered here to be “source reduction,” rather than recycling.
- “*Pollution prevention*” is often used synonymously with “waste avoidance.” As commonly used in environmental regulations, “pollution prevention” means “source reduction,” as defined below, and other practices that reduce or eliminate the creation of pollutants through increased efficiency in the use of raw materials, energy, water, or other resources; or protection of natural resources by conservation.
- “*Source reduction*” means any practice that reduces the amount of radioactive material, hazardous substance, pollutant, or contaminant entering any waste stream or otherwise released into the environment (including fugitive emissions) prior to recycling, treatment or disposal; and reduces the hazards to public health and the environment associated with the release of such substances, pollutants or contaminants. The term “source reduction” does not include

any practice which alters the physical, chemical, or biological characteristics; or the volume of a hazardous substance, pollutant or contaminant through a process or activity which itself is not integral to and necessary for the production of a product or the providing of a service. In some classification systems, however, recycling activities are sometimes considered source reduction.

- “*Treatment*” is defined as any method, technique or process designed to change the physical, chemical, biological character or composition or renders it in a form that is acceptable for disposal (e.g., storage for decay). Some forms of treatment may be required by regulation for, or as a prerequisite, to disposal. It is noteworthy that some waste streams may actually increase in volume after treatment, although they would be environmentally safer for disposal due to an improved waste form.
- “*Waste management*” used here includes all activities such as handling, treatment and storage applied to control the characteristics and disposition of wastes that have been generated. In broader usage the term may also include source reduction activities.
- “*Waste minimization*” refers to management activities intended to reduce, to the maximum extent feasible, waste that is generated or subsequently treated, stored or disposed. It includes any source reduction or recycling activity undertaken by a generator that results in either (1) the reduction of total volume or quantity of waste or (2) the reduction of toxicity of the waste, or both, so long as such reduction is consistent with the goal of minimizing present and future threats to human health and the environment.

2.4 Hierarchy of Waste Minimization Steps

The risks associated with waste are determined by the concentration of its hazardous constituents, the quantity of waste, the waste form, the potential for dispersion in the environment, and how easily it can be isolated from the biosphere. Hazard reduction is a primary goal of waste minimization. Waste management practices such as treatment may result in a smaller quantity or a better waste form. This suggests that planning for waste minimization should normally consist of the following four levels of activity taken in sequence:

- The generator's main processes or activities are evaluated for possible opportunities for partial or total elimination of waste streams.
- Processes and materials are managed, recycled or reclaimed to reduce the hazard and/or volume of the anticipated disposal of wastes produced during operation.
- The materials and wastes intended for disposal are treated to reduce hazards and/or volume, enhance the long-term stability of the waste form, and comply with the regulations and waste acceptance criteria of disposal facilities.
- A disposal method is selected that is protective of public health and the environment and in accordance with federal and state laws and regulations.

The partial or total elimination of waste streams is the first priority of this hierarchy because it diminishes or eliminates the hazard and, at the same time, reduces the need for further waste management. The second priority achieves similar results, but requires some handling, is generally less efficient, and results in some potential for the generation of pollutants. The third involves further hazard or volume reduction for wastes that must be disposed. Table 2.1 lists the steps of this hierarchical waste minimization scheme, with waste disposal shown as the last step.

In summary, this Report recommends the following philosophy for waste minimization:

- Waste generation should be *avoided* or reduced at the source whenever feasible.
- Waste that cannot be prevented should be *recycled* in an environmentally safe manner, when possible.
- Waste that cannot be prevented or recycled should be *treated* whenever feasible to render it less hazardous to individuals handling the waste or to the environment, and to optimize its volume.
- Land disposal of waste should be employed as a last resort and must be conducted in an environmentally safe and legal manner.

2.5 Scope of this Report

The primary target audience for this Report is small institutional LLRW generators such as biomedical facilities, laboratories,

TABLE 2.1—*Hierarchical waste minimization steps.*

Level 1 Source Reduction	Level 2 Recycling	Level 3 Treatment	Level 4 Disposal
Material substitution	Reclamation reuse	Compaction	Land disposal
Waste reduction		Incineration	in a licensed
Process modification		Chemical treatment	and/or permit-
Management of material going into process		Encapsulation	ted facility or
Segregation		Solidification	release as per-
		Storage for decay	mitted under
			applicable
			regulations

and academic institutions regulated by NRC or Agreement States. Although not specifically targeted, other categories of generators may also find the general recommendations of this Report useful. The recommendations address not only activities during facility operation, but also the entire life cycle of the facility from initial design to final decontamination and decommissioning. This Report is applicable to materials covered by AEA (1954) and to discrete NARM. Because of its unique nature and the different required management techniques, diffused naturally occurring radioactive material (NORM) (generally defined as containing ^{226}Ra concentrations less than 74 Bq g^{-1}) is not covered. This Report also does not include minimization techniques for wastes from remediation of contaminated land. However, this Report considers not only LLRW, but also LLMHW.

2.6 Organization of this Report

This Report is intended to serve both as a general reference and as a handbook on specific methods for minimization of all forms of LLRW. Section 3 provides the regulatory framework for waste minimization activities. Section 4 provides information on waste generation trends to justify the focus of this Report. General guidance for managers of waste minimization programs is presented in Section 5. Section 6 provides guidance on selection of waste minimization techniques, and examples of each waste minimization technique are presented in Section 7. Section 7 is extensively referenced so that readers may find additional information on these techniques. Section 8 provides design considerations for waste minimization facilities that address activities over the entire life

cycle, including decontamination and decommissioning activities. Finally, Section 9 discusses various institutional and regulatory impediments to effective waste minimization practices and makes recommendations for regulatory changes needed to enhance minimization.

This Report concludes with Appendix A that contains examples of effective waste minimization programs that have been implemented by various types of generators, an extensive Glossary, and a compendium of references on radioactive waste minimization, arranged alphabetically by author. Recent advances in pollution prevention and waste minimization technologies have led to a rapidly growing number of publications in this area. Readers are urged to consult electronic bulletin boards or Internet sites operated by government agencies, professional societies, and vendors to obtain the most current information on topics of interest. Some specific suggestions are provided in Section 5.3.

2.7 A Guide for Implementing an Effective Waste Minimization Program

Since the beneficial use of radioactive materials in many circumstances results in the production of LLRW, it is important from a health and safety standpoint to safely and efficiently manage this waste. One of the most effective ways of managing this LLRW is to ensure that it contains insignificant long-lived radionuclides. Waste in a form that requires off-site disposal or storage should be produced only when necessary to achieve a significant benefit.

Because of the escalation in cost of LLRW treatment and disposal and the almost certain higher cost of future disposal, waste avoidance and recycling are often the most cost-effective management practices that can be implemented. In addition, it is widely recognized that effective waste minimization and pollution prevention programs are the foundation of acceptance by the public of the beneficial use of any hazardous materials. It is reasonable to assume that before land disposal of any type of hazardous waste begins to be acceptable to the public, it must be demonstrated that all possible waste minimization and treatment options have been considered. Other benefits from an effective waste minimization program include:

- reducing worker and public exposure
- improving process efficiency

- reducing or eliminating the potential for accidents or release of toxic materials
- reducing compliance and other life-cycle costs
- minimizing the potential for future liabilities
- enhancing the image and credibility of the organization

The following discussion provides a suggested strategy for implementation of the recommended waste minimization program elements and practices that are included in this Report.

2.7.1 *Waste Minimization Planning*

Proper planning is a very important aspect of the implementation of an effective waste minimization program. Ideally, planning for waste minimization should be initiated before new facilities are constructed or new processes that may generate waste are initiated. Some of the principal issues that must be considered in this planning process are discussed in Section 5.2. In the discussion that follows, some of these principles, as well as other necessary elements, are presented in a generally sequential manner. This discussion is directed primarily toward a radiation safety officer at a small, institutional type generator, but much of it can be applied to all types of generators.

One of the most critical elements needed for an effective waste minimization program is top-level management support. The adoption of a waste minimization philosophy should be an integral part of the organization's policy. This implies acceptance of up-front costs as well as all of the other necessary elements of a successful program, such as quality assurance, training, incentives, and the holding of realistic expectations. Ideally, the policy for implementing a waste minimization program should be directed by management. Then the radiation safety officer's role is one of providing assistance in planning and implementation. If, however, management is not providing the impetus for program implementation, then engendering top management support needs to be the first step of the planning process. Probably the best way to achieve full management support is to perform a detailed cost and liability analysis that clearly shows the long-term cost effectiveness of a good waste minimization program.

Management support should include the following specific elements (EPA, 1993):

- Emphasis on the need for continuing evaluation and improvement;

- Encouragement to each individual in the organization to identify opportunities for effective waste minimization at all levels and support functions;
- Incentives and recognition for those employees that develop new ideas and methods and those who do a good job with implementation of the program (recognition and publicizing of successes);
- Explicit (quantitative or qualitative) goals that are achievable within a reasonable time frame;
- Management commitment to implement recommendations from assessments and to consider suggestions; and
- Designation of a waste minimization coordinator or teams from all levels of the organization.

Proper and effective communication up and down the management chain is extremely important for promoting and evaluating a waste minimization program. Promotional messages to the employees need to be simple and clear to be effective. In a large institutional setting, one approach to attracting the individual generator's attention is to allocate waste management costs directly to the user.

A thorough understanding of the applicable regulations and regulatory guidance is critical. This is particularly true for facilities that may generate LLMW. It is incumbent upon the regulators to provide clear, concise waste management guidance when appropriate. Section 3 provides an overview of this issue.

Another critical element is the development of a thorough understanding of the need for proper handling of all radioactive, hazardous, and other toxic materials that are being used or generated by the facility. This includes detailed knowledge of all processes and procedures that use these toxic materials. With this understanding and knowledge in place, one can begin to develop materials flow and balance sheets. These can be used early on to evaluate whether the very simple waste avoidance techniques of materials substitution, better inventory control, or process changes can eliminate or allow recycling of hazardous materials.

If possible, facility design and layout should be evaluated and changes made to minimize the spread of contamination, reduce flow distance of materials, and provide in advance for the facilitation of decontamination and eventual decommissioning. For new facilities, planning for waste minimization should begin during the design phase. The design and layout aspects should be evaluated and incorporated during the conceptual design of a facility. Issues

that should be considered in initial facility design are discussed in Section 8.

2.7.2 *Program Goals and Evaluation*

The setting of program goals is an important responsibility of management. Program goals must be realistic, well defined and articulated, and be capable of being achieved within reasonable time frames. An effective waste minimization program must be flexible enough to be revised if goals are not being met.

Periodic waste minimization evaluations should be performed. These evaluations must be based upon well-defined and understood criteria and procedures. Key parameters need to be identified and trending analysis should be performed. The evaluations should also consider overall program effectiveness and results. Evaluations by independent auditors may be helpful to ensure that new ideas are being considered. Management should commit to the implementation of all reasonable recommendations from this evaluation process.

2.7.3 *Program Implementation*

Section 6 provides a description of an approach that could be used for the implementation of this recommended hierarchical waste minimization strategy. Table 6.1 shows the specific techniques and an outline for the examples that are discussed in Section 7. These sections have extensive references that will provide additional details, if needed.

A waste accounting system should be established that keeps track of all waste generated and of all the hazardous constituents in the waste. This should provide the data necessary to assess progress toward goals and the need for program changes.

In addition, the costs of waste management should be determined. These include direct costs, compliance and regulatory costs, occupational exposure and employee health costs, and savings in future potential liability. Only with this full accounting can the real benefits of waste minimization be known and reported.

2.7.4 *Training*

The availability of an effective training program is essential for a good waste minimization program. The training program must be focused at the user level and should stress practical

applications and procedures. The level of training should be commensurate with the job function and how it influences the generation of waste. Training programs should include: general awareness of the problem and why it is important to the workplace and safety, knowledge of all procedures and proven techniques for waste minimization, and advanced training of higher level employees for improved techniques and for innovative problem solving.

There is also a need for improved technology and the rapid transfer of good practices within the organization and between generators. A clearinghouse for collection and dissemination of this information would facilitate this transfer.

3. Applicable Laws and Regulations

3.1 Introduction

The passage of the Clean Air Act (CAA, 1963) and the Clean Water Act (CWA, 1972) were clear signals of the intention of the U.S. Congress to address the problem of the contamination of the air, water and land with hazardous pollutants. It is now apparent that such efforts must go beyond simply limiting discharges into specific environmental media. The ideal strategy would clearly be to avoid the production of potential pollutants. This involves the decisions of manufacturers and others to redesign products, find substitute materials, modify equipment and processes, and generally improve the management of production, all of which may entail some initial effort. But not only are such tactics environmentally sound, they also frequently prove to be cost-effective over the long term.

The intent of this Section is to provide an overview of the legal and regulatory framework put in place to protect people and the environment from LLRW and LLMW, and an awareness of the aspects of that framework that support the minimization of those wastes. An annotated list of regulations applicable to the management of commercial LLRW has been published (DOE, 1992a) if more detailed information is needed.

3.2 Laws and Regulations

The production, use and disposal of radioactive and other hazardous materials is ultimately guided and controlled by federal laws as discussed in Section 2.2, such as AEA (1954), RCRA (1976), LLRWPA (1980), and LLRWPA (1986). These statutes are general in nature, in that they do not contain specific requirements for implementing the objectives of the statutes (*e.g.*, requirements directed at protection of human health and the environment) but

they authorize federal agencies to develop and enforce specific regulations for their implementation.

NRC, for example, has considerable authority under AEA to write and enforce regulations on the use and handling of radioactive materials, including LLRW. To promulgate or amend a regulation, NRC will publish a Notice of Proposed Rulemaking in the Federal Register, followed by a Notice of Final Rulemaking (including responses to public comments), and then codify the final rule in the Federal Register. Once the regulation is in place, NRC's inspectors have the authority (and responsibility) to visit licensees on a routine basis to ensure that its provisions are being properly adhered to, and to impose sanctions if they are not.

For some activities, no federal agency has been given regulatory authority. Where Congress has been silent, authority to regulate can only be exercised by the states. In addition, Congress has enacted numerous environmental laws since the 1970s under which EPA has issued federal regulations. The authority implementing and enforcing some EPA regulations is delegated to the states.

3.3 Federal Laws and Regulations that Pertain to Low-Level Radioactive Waste

3.3.1 *Atomic Energy Act of 1954 and Related Laws*

The creation, safe management, and proper disposal of various kinds of LLRW are covered by a variety of laws and regulations. The Atomic Energy Act (AEA), first published in 1946 and amended in 1954 (AEA, 1954), was the first nuclear-related legislation enacted by Congress. It vested in the federal government complete control over the use of materials relating to nuclear energy; subsequent legislation allowed participation by private enterprise to encourage technological advances. The paramount objective of this act was to ensure our national defense and security, but it was also intended to direct the development, control, and safe use of atomic energy for peaceful purposes.

AEA gave the U.S. Atomic Energy Commission and its regulatory successor, NRC, broad discretion with respect to developing standards for use and possession of the materials governed by the Act. (The authority of DOE to regulate its own facilities also derives from AEA.) It grants NRC authority to establish standards "as the Commission may deem necessary or desirable to...protect health or

to minimize danger to life or property.” NRC is responsible, in particular, for establishing regulations for the safe management of special nuclear material, source material, and byproduct material, and for licensing the use of these materials. NRC is authorized to delegate some of this responsibility to the states. By 1999, 31 states have entered into agreements with NRC that enable these “Agreement States” to license and control many activities, within their boundaries, that involve the use of these materials. Some radioactive materials, such as commercially produced NARM, are not regulated under any federal statute. Thus, these materials are currently regulated only by the states.

Reorganization Plan No. 3 of 1970 (EPA, 1970) transferred to the Administrator of EPA the authority of the Federal Radiation Council to provide guidance to the President “...with respect to radiation matters, directly or indirectly affecting health...” This includes radiation from NARM. The Plan transferred to EPA the U.S. Atomic Energy Commission’s authority under AEA (1954) to establish protection standards for radioactivity in the environment that apply to radioactive materials regulated under AEA. (NRC is generally responsible for implementing environmental standards established by EPA under this authority.) Thus, EPA can develop protection standards to govern environmental releases accompanying the management and disposal of LLRW, in particular, and to provide environmental protection from other materials and processes that give rise to environmental radiation. NRC has issued regulations that govern disposal and release of LLRW into the environment. This exemplifies the potential awkwardness of different federal agencies (EPA and NRC) exercising authorities in the same area. In such situations, the added burdens of dual standards or regulations often are eliminated when EPA acknowledges that NRC licensing requirements provide a level of protection equivalent to EPA standards and licensees are no longer required to report to EPA.

Other statutes that relate, directly or indirectly, to the minimization of radioactive waste, include:

- RCRA (1976)
- HSWA (1984)
- TSCA (1976)
- LLRWPA (1980) which was replaced in 1985 by LLRWPA (1986)
- CERCLA (1980) as amended in 1986 by the Superfund Amendments and Reauthorization Act

- NWPA (1983)
- PPA (1990)
- a variety of waste management laws of the individual states

Regulations derived from these laws are administered and enforced by EPA, NRC, DOE, DOD, DOT, OSHA, and other federal and state agencies. In nearly all situations, it is obvious which agency has authority and responsibility for writing and enforcing the applicable regulations for a law. Gaps and overlaps in the legal/regulatory framework do exist, however, and must be resolved through administrative arrangements or in the courts.

3.3.2 *Radioactive Materials*

The legal and regulatory aspects of managing LLRW are complicated by the manner in which radionuclides, in general, have been categorized by applicable statutes. That is, the distinctions that have been created by law do not necessarily correspond to physical configurations of the waste, or environmental and safety considerations. The term “radioactive material” is defined, somewhat arbitrarily, in DOT regulations at 49 CFR Part 173.403 (DOT, 2001) as “...any material having a specific activity greater than 0.002 microcuries per gram.” Aside from that, it would appear that the term is not explicitly defined by AEA (1954), LLRWPA (1980), NWPA (1983), or CFR. Section 11 of AEA and 10 CFR Part 20.1003 (NRC, 2002a) only refer to source, special nuclear, and byproduct material. As a result, “radioactive material” has assumed somewhat different meanings, depending upon the context.

In effect, most radioactive materials are encompassed in the definition of AEA materials except for NARM. (The naturally occurring decay progeny of uranium and thorium are not considered “byproduct” materials, except in uranium and thorium mill tailings, which are known as “11(e)2 wastes,” after the section of AEA where they are defined.) Thus most kinds of non-DOE NARM wastes (of which NORM wastes form a subcategory) are not covered by AEA or by the regulations of NRC. The same materials are, however, subject to state laws and regulations.

3.3.3 *Low-Level Radioactive Waste*

This Report addresses waste minimization issues as they pertain to LLRW and LLMW and discrete (*i.e.*, small, localized quantities of) NORM.

The current statutory definitions of LLRW are contained in NWPA (1983), as amended, and LLRWPA (1986). In NWPA, LLRW is defined as radioactive waste that:

- Clause (A) is not high-level waste, spent nuclear fuel, transuranic waste, or byproduct material as defined in Section 11(e)(2) of the Atomic Energy Act; and
- Clause (B) the NRC, consistent with existing law, classifies as low-level radioactive waste.

LLRWPA contains a similar definition, except transuranic waste is not excluded in Clause (A). The two definitions apply only to waste containing radioactive materials that are regulated under AEA (1954). The difference in the two statutory definitions in Clause (A) has little practical significance because the definition in LLRWPA applies only to waste regulated by NRC or an Agreement State (*i.e.*, it does not apply to DOE waste), there is little non-DOE transuranic waste requiring disposal at the present time, and current NRC regulations in 10 CFR Part 61 (NRC, 2001) require disposal of any such non-DOE waste in a geologic repository unless disposal elsewhere is approved by NRC on a case-by-case basis. NRC has not acted to implement the definition in Clause (B). Thus, LLRW currently is defined only by an exclusion as in Clause (A).

The current definitions of high-level waste and spent fuel, as contained in NWPA, and the current definition of transuranic waste, as contained in the Waste Isolation Pilot Plant Land Withdrawal Act (WIPPLWA, 1992), are given in the Glossary. The byproduct material defined in Section 11(e)(2) of AEA essentially is uranium or thorium mill tailings. Note that since NARM is generally not AEA material, by the above definition, it cannot be considered a form of LLRW. Because minimizing this waste is important, the present Report will consider LLRW in its broader meaning, so as to incorporate NARM wastes. The current legal definition of transuranic waste is found in WIPPLWA.

In 1983, NRC provided classifications for LLRW, based on radionuclide concentration and half-life [10 CFR Part 61.55 (NRC, 2001)]. These waste classes, A, B, C, and greater-than-Class-C, set upper limits on the concentrations of certain radionuclides, and thereby determine the waste acceptability for certain disposal methods. NRC regulations also allow licensees to dispose of limited amounts and concentrations of certain types of LLRW through release in gaseous and liquid effluents (10 CFR Part 20.1302),

through incineration (10 CFR Part 20.2004) and into sanitary sewers (10 CFR Part 20.2003) (NRC, 2002a).

LLRWPA (1980) required NRC to “...establish standards and procedures...to exempt specific radioactive waste streams from regulation by the [NRC] due to the presence of radionuclides in such waste streams in sufficiently low concentrations or quantities as to be below regulatory concern.” NRC defined a level of radionuclide content in waste material that would be below regulatory concern (*i.e.*, that would be sufficiently nonhazardous as to not warrant licensing or other NRC regulation) in a policy statement published in the Federal Register at 55 FR 27522 (NRC, 1990). This met with considerable public opposition, and the policy statement was withdrawn 3 y later [58 FR 50635 (NRC, 1993)] as a result of Congressional direction, which was undoubtedly stimulated to some degree by public opposition.

3.4 Federal Laws and Regulations that Pertain to Hazardous, Mixed, and Multiple Hazard Waste

3.4.1 *Hazardous Waste*

The Resource Conservation and Recovery Act (RCRA, 1976), an amendment to the Solid Waste Disposal Act (SWDA, 1965), was enacted in 1976. In 1989, RCRA was amended by HSWA (1984). These amendments expanded the scope of RCRA and increased the level of detail in many of its provisions. RCRA-based regulations can be found in 40 CFR Parts 260 through 280 (EPA, 1986a; 2001a). EPA and/or authorized states have the authority and responsibility for their implementation.

Subtitle C of RCRA (1976) created a comprehensive federal program for the systematic, “cradle-to-grave” control of hazardous waste, covering the generation, transportation, treatment, storage and disposal of such wastes, and focusing on active and future facilities [as opposed to CERCLA (1980), which primarily addresses abandoned contaminated sites, including inactive or closed hazardous or radioactive waste disposal sites that were not properly permitted under current environmental laws]. Under Subtitle C, anyone generating more than threshold quantities of hazardous waste is required to notify EPA of the fact. Hazardous waste generators and transporters must employ management practices and procedures that comply with regulations established by EPA

and DOT, including those designed to ensure the effective operation of the manifest system that is used to track wastes from their point of generation, along their transportation routes, to the place of final treatment, storage or disposal. Owners and operators of a treatment, storage or disposal (TSD) facility must be in possession of a RCRA permit to actively manage RCRA hazardous wastes, and are thus subject to far more exacting and complex requirements than are those entities that only generate or transport hazardous wastes.

The definition of “solid waste,” of which hazardous waste comprises a subcategory, covers “...sludge..., and other discarded material, including solid, liquid, semisolid, or contained gaseous material...” 40 CFR Part 261 (EPA, 1980a) defines a solid waste as “hazardous” if it exhibits characteristics of ignitability, corrosivity, reactivity or toxicity, or if it appears on a list of certain waste types, discarded commercial chemical products, or certain nonspecific sources. In a notable exclusion, byproduct, source and special nuclear material are specifically excepted from the definition of solid waste and hazardous waste under 40 CFR Part 261.4(a)(4) (EPA, 1980a). While NORM are not explicitly excluded from coverage, EPA’s Office of Solid Waste has not defined radioactivity as a characteristic of hazard under RCRA, and has not addressed NORM wastes through RCRA (1976).

RCRA acknowledges the desire of most states to regulate their own hazardous wastes, and the federal government has even provided financial incentives for states to do so. EPA has authorized most states, Washington, DC, and the territory of Guam to implement the “base” RCRA hazardous waste program, which corresponds to the federal program prior to the enactment of HSWA in 1984. Individual states can receive approval from EPA to implement the more than 140 RCRA (1976) regulations that have been issued since then, if they incorporate the corresponding provisions into their state regulations. In general, once a state has received base-program authorization, it is generally required, by 40 CFR Part 271.21(e) (EPA, 2002), to adopt changes that are less stringent than the federal regulations. A few states are somewhat behind in this process, in particular with regard to the regulation of LLMW.

3.4.2 *Low-Level Mixed Waste*

In 1986, EPA noted that there existed confusion as to whether radioactive LLMW was covered by both AEA (1954) and RCRA (1976) or, since RCRA excluded AEA materials, by AEA alone:

While source, special nuclear, and by-product material are clearly exempt from RCRA, the extent of the statute's applicability to wastes containing both hazardous waste and source, special nuclear, or by-product material has been less evident... Given the lack of clarity on this issue, EPA did not previously require, as a condition of State authorization, that the State have regulatory authority over the hazardous components of radioactive mixed wastes... [51 FR 24504 (EPA, 1986b)].

The confusion was dispelled, and a change in policy announced, as this Federal Register notice continued:

Today, we are hereby publishing notice that...radioactive mixed wastes are to be part of authorized State programs.

The situation was further clarified by the Federal Facilities Compliance Act (FFCA, 1992). Part of the this Act amends Section 1004 of RCRA (1976) by adding:

The term "LLMW" means waste that contains both hazardous waste and source, special nuclear, or by-product material subject to the Atomic Energy Act of 1954.

(Note here, too, that a mixture of RCRA hazardous waste and NARM would not formally be considered LLMW.)

The hazardous waste component of LLMW is now clearly subject to EPA's RCRA regulations at 40 CFR Part 261 *et seq.* (EPA, 1980a), while the radioactive component is generally regulated by NRC or DOE. Any approach to the management of LLMW must address both RCRA and NRC and DOE handling and disposal requirements, if the waste cannot be physically separated into its two components.

A state can assume responsibility for regulating the hazardous component of LLMW if it is a RCRA base-program authorized state and, in addition, has obtained additional authorization from EPA to regulate LLMW.

3.4.3 *Medical and Biological Waste*

As with LLMW, the handling and disposal of radioactively contaminated medical or biological wastes is governed not only by regulations that cover the radioactive material component, but also by others that deal with the medical/biologic or hazardous component.

The management of medical/biological wastes in general (whether or not they are radioactively contaminated) has been addressed in a variety of ways. In 1989, largely as a rapid response to the concern of the public and news media about empty syringes and drug vials washing up on beaches, the Medical Waste Tracking Act (MWTa, 1988) was passed as an amendment to RCRA (1976), becoming Subtitle J. It defined seven classes of medical wastes to be regulated:

- cultures and stocks of infectious materials
- human pathological waste
- human blood and blood products
- used sharps (*i.e.*, syringes, glass vials, knife blades, and other items capable of cutting tissue, which should be deposited in “sharps” containers)
- contaminated animal wastes
- biological wastes from people and animals isolated because of infection with highly communicable diseases
- unused sharps

MWTa initially applied only to 10 covered states, and expired 2 y after it was passed, but regulations promulgated under this Act remain in 40 CFR Part 259 (EPA, 1989). Perhaps the greatest continuing significance of MWTa is that a number of states have adopted similar rules, requiring careful tracking and management of the regulated materials.

Other federal regulatory agencies have promulgated regulations on medical/biohazardous wastes. OSHA regulations in 29 CFR Part 1910.1030 (OSHA, 2001) are designed to protect employees against occupational exposure to diseases borne by blood or other body fluids. DOT's rules, published in the Federal Register in 1991 [56 FR 66124 (DOT, 1991)], require that packages containing regulated medical waste be properly identified and be capable of withstanding impacts and hostile environmental conditions. Similar regulations have been prepared by the U.S. Postal Service. In addition, several nonregulatory agencies, health care facility accreditation organizations, and other professional groups have developed pertinent guidelines.

3.5 Federal Laws and Regulations that Deal with the Minimization of Radioactive, Hazardous, Mixed, and Multiple Hazard Waste

3.5.1 *Minimization of Low-Level Radioactive Waste*

The federal government has long been aware of the value of efforts to minimize LLRW. Indeed, NRC published a policy statement in 1981 that called on all generators of LLRW to reduce the volume of waste for disposal, and to establish programs that incorporated good volume reduction practices. Still, the issue of the minimization of LLRW has not been addressed in detail in the relevant federal acts or regulations.

As noted above, however, regulations based upon AEA (1954) are suggestive of ways to reduce the volumes and radioactive material content of wastes that must be sent to a licensed radioactive waste disposal facility. 10 CFR Part 20 (NRC, 2002a) describes amounts and physical forms of radioactive materials that can be discharged into the sewage system or released into the air or water. Likewise, scintillation fluids and animal carcasses containing less than a specified amount of tritium or ^{14}C can be disposed of without regard to the fact that they are radioactive. 10 CFR Part 20.2005 and 10 CFR Part 61.56(a)(8) (NRC, 1981; 2001) include minimum disposal site acceptance requirements which state that LLRW must be treated to the maximum extent practicable to reduce the potential hazards from waste containing hazardous, biological, pathogenic, or infectious materials. And, of course, for radionuclides with relatively short physical half-lives, LLRW reduction through storage for decay are accepted by regulatory agencies, as in 10 CFR Part 35.92 (NRC, 2002b).

LLRWPA (1980) contains references to minimization aspects of waste management. Section 102(6)(i) states that any LLRW delivered under emergency conditions for access from one Compact/state to another is required to be reduced in volume to the greatest extent practicable. Also, in Section 102(7), the Secretary of DOE is instructed to provide continuing technical assistance to the Compacts/states for volume reduction and management techniques to reduce LLRW generation. This assistance has been provided by the National Low-Level Waste Management Program.

Although alluded to in several places such as these, it would appear that the minimization of commercial LLRW is not, at present, a high priority item on any federal regulatory agenda. This may be because generators have been effective in minimizing

or reducing their volume of LLRW due to increasing disposal costs; *i.e.*, there is no need for an aggressive regulatory program or federal action. The minimization of hazardous chemical waste, on the other hand, has received considerable attention.

3.5.2 *Minimization of Hazardous Waste*

HSWA (1984) established a national policy for minimizing the generation of hazardous wastes. Section 1003(b) states:

The Congress hereby declares it to be a national policy of the United States that wherever feasible, the generation of hazardous waste is to be reduced or eliminated as expeditiously as possible. Waste that is nevertheless generated should be treated, stored, or disposed of so as to minimize present and future threat to human health and the environment.

Section 3002(b) of RCRA (1976), moreover, provides direction on how waste minimization is to be implemented. It requires certification by a generator that:

(1) the generator of the hazardous waste has a program in place to reduce the volume or quantity and toxicity of such waste to the degree determined by the generator to be economically practicable; and (2) that the proposed method of treatment, storage, or disposal is that practicable method currently available to the generator which minimizes the present and future threat to human health and the environment.

In addition, generators and TSD facilities are required to report biennially on their waste minimization efforts, and on the results of those efforts [40 CFR Part 262.41(a)(6) and (7), (h), and (i)]. This is all described in EPA (2001b). The guidance also states:

EPA is committed to a national policy for hazardous waste management that places the highest priority on waste minimization...EPA believes waste minimization programs should incorporate, in a way that meets individual organizational needs, the following basic elements common to most good waste minimization programs: (1) top management support; (2) characterization of waste generation and waste management costs; (3) periodic waste minimization assessments; (4) appropriate

cost allocation; (5) encouragement of technology transfer, and (6) program implementation and evaluation.

In support of this commitment, Executive Order 12856 (58 FR 41981)¹ requires each federal agency to develop (among other things) written pollution prevention strategies that incorporate the national priority on pollution prevention into its facility management and acquisition procedures.

Along with these broad federal mandates, EPA has proposed a Hazardous Waste Identification Rule for process waste. This regulation would establish a constituent-specific, risk-based “floor” or threshold concentration for solid wastes that are designated as hazardous because they are RCRA-listed, or have been mixed with, derived from, or contain listed hazardous wastes (EPA, 1995a). Under this proposal, low-risk listed hazardous wastes that meet the “exit levels” would no longer be subject to RCRA’s hazardous waste management system as listed wastes. It is expected that this more logical approach, if adopted rule, will encourage pollution prevention and waste minimization.

AEA materials (*i.e.*, source, special and byproduct) are specifically excluded from the definitions of solid waste and hazardous waste under RCRA, and from the definition of a toxic substance under TSCA (1976). Thus, RCRA can serve as an example, since it does provide legal requirements for LLMW minimization programs, but it only applies to the hazardous component of LLMW. RCRA waste minimization programs and procedures can be readily adopted voluntarily for application to LLRW.

3.5.3 *Minimization of Mixed and Multiple Hazard Waste*

Non-DOE LLMW comes under the simultaneous jurisdiction of AEA (1954), LLRWPA (1986), and RCRA (1976) Subtitle C. RCRA requires that the generators have a waste minimization plan and implement it. RCRA also mandates that before hazardous wastes are disposed of in the ground, they must be treated to reduce their toxicity [Land Disposal Restrictions (LDR)]. As noted above, a state with proper authorization from EPA can administer its own LLMW program in lieu of EPA’s. Since such states must have regulations

¹Executive Order 12856 of August 3, 1993 (58 FR 41981) “Federal compliance with right-to-know laws and pollution prevention requirements.”

at least as stringent as RCRA requirements, in theory, they all should include provisions for minimization of LLMW and for LDR.

One situation commonly encountered with LLMW is that while a standard method of minimizing LLRW is storage for decay, RCRA (1976) may impose limitations on the duration of time over which the hazardous component (hence also the radioactive part) may be stored. To assist LLMW generators around this dilemma, EPA and NRC have jointly published guidance on the storage of LLMW (NRC, 1995). The guidance points out areas of flexibility within EPA and NRC regulations that relate to the storage of LLMW, and generally takes the position that decay-in-storage may be considered a "...necessary and useful part of the best demonstrated available technology treatment process." As such, "...the limited periods of approved decay-in-storage of LLMW do not violate the RCRA Section 3004(j) storage prohibition," which otherwise disallows indefinite storage of hazardous waste in lieu of performing the required best demonstrated available technology treatment analysis.

Multiple hazard waste is subject to the same waste minimization incentives as any other LLRW. It is covered by RCRA (1976), but not as a Subtitle C waste, so none of the hazardous waste minimization requirements apply at present.

3.5.4 *The Pollution Prevention Act of 1990*

The only federal statute that directly addresses the issue of waste minimization in general is PPA (1990). This Act was introduced as part of the 1990 Budget Reconciliation bill, and faced little opposition since it was regarded as an "innocuous requirement of data collection and exchange, requiring industry to do some additional bookkeeping, but imposing no obligations on anyone to change modes of production or modes of pollution control."²

PPA (1990) states that it is the policy of the United States that:

...pollution should be prevented or reduced at the source whenever feasible; pollution that cannot be prevented should be recycled in an environmentally safe manner, whenever feasible; pollution that cannot be prevented or recycled should be treated in an environmentally safe manner, whenever feasible; and disposal or other release

²Congressional Record, S.17S23 to S.17S2S (daily edition October 27, 1990).

into the environment should be employed only as a last resort and should be conducted in an environmentally safe manner.

This is also consistent with the waste management hierarchy included in RCRA (1976).

PPA and energy conservation programs are considered by many to make good sense, in general, and to be socially beneficial, but it is not immediately obvious how to make it work in practice. Still, PPA does direct the Administrator of EPA to develop and implement a strategy to promote source reduction. To this end, the Administrator is required to, among other things:

- establish standard methods of measuring source reduction
- ensure that EPA considers the effects of its own regulations and other programs on source reduction
- facilitate the adoption of source reduction techniques by businesses
- recommend to Congress what should be done to eliminate barriers to source reduction
- identify opportunities to use federal procurement to encourage source reduction
- establish an Office of Pollution Prevention within EPA to carry out the purposes of PPA (1990)

It has not been demonstrated how much real impact these requirements will have on the operations of facilities that make use of radioactive materials.

“Source reduction” is defined by PPA (1990) to mean any practice which either reduces the amount of any hazardous substance, pollutant or contaminant entering any waste stream or otherwise released into the environment (including fugitive emissions) prior to recycling, treatment or disposal; or reduces the hazards to public health and the environment associated with the release of such substances, pollutants or contaminants. The term includes equipment or technology modifications, process or procedure modifications, reformulation or redesign of products, substitution of raw materials, and improvements in housekeeping, maintenance, training or inventory control.

Not included within “source reduction,” as defined in PPA (1990), is any practice which alters the physical, chemical or biological characteristics or the volume of a hazardous substance, pollutant or contaminant through a process or activity which itself is not

integral to and necessary for the production of a product or the providing of a service, *e.g.*, simple incineration. A premium is thus placed on ordinary improvements in housekeeping and maintenance. While it is not one of the more action-forcing environmental statutes, PPA does provide the basis for promulgating source reduction standards and goals.

3.6 State Laws and Regulations that Deal with the Minimization of Low-Level Radioactive Waste and Low-Level Mixed Waste

In some states, LLRW and LLMW disposal laws and regulations have already incorporated waste minimization as an explicit condition for waste disposal. There are several obvious reasons for this additional requirement. Less waste volume and toxicity assures safer disposal. Also, the requirement for waste minimization may encourage public acceptance of land disposal by supporting the view that only the components of the waste that cannot be eliminated will need land disposal.

Some states have been designated as host states to develop, construct and operate a LLRW disposal facility for their respective Compacts. As part of this process, they are, under agreement with NRC, developing their own legislation and regulations for management of the facilities, including waste minimization activities. For example, Pennsylvania's Low-Level Radioactive Waste Disposal Act (PALLRWDA, 1988) requires the Pennsylvania Department of Environmental Protection to implement policies, including fee schedules and other incentives, that encourage reduction in the volumes and toxicity of LLRW produced within the Compact region. The Act also requires the development of regulations for the permitting of generators, brokers and carriers for access to the regional disposal facility, and requires that each generator have a plan for reduction of toxicity and volume of LLRW, with stated reduction goals. The laws of a number of other states require similar actions.

Thus it would appear that some state regulatory programs have been more active than their federal counterparts in addressing waste management and minimization issues. It is to be anticipated that this general movement on the part of states toward LLRW and LLMW minimization regulatory activity will continue.

It is clearly advantageous for managers of LLRW and LLMW to establish and maintain close and harmonious working relationships with the state officials who have authority over radioactive

and other waste management activities. This helps ensure that the managers are kept abreast of all relevant and applicable (and possibly changing) regulations; and that when questions of interpretation do arise, they are resolved promptly and fairly.

4. Low-Level Radioactive and Mixed Waste Generation Trends

4.1 Introduction

Over the past couple of decades, commercial LLRW disposal costs have sharply increased due to the increasing surcharges as well as increasing operating costs at disposal sites. Because most fee systems at LLRW disposal sites have been volume based, the volume of LLRW has decreased dramatically. A cursory examination of LLRW disposal trends, prior to 1993 suggest that the volume decrease is due to a concentrated effort to improve LLRW management by the nation's larger generators, where the economical benefit is magnified and substantial, while the smaller generators have been slower to improve management practices.

4.2 Low-Level Radioactive Waste Generation Trends

There is a total of more than 21,000 NRC and Agreement State licenses currently active (NRC, 1994a). The distribution of these licenses by generator category is shown in Figure 4.1. Medical, industrial research and development, and academic generators comprise about 45 percent of all NRC and Agreement State licenses. Utility licenses are not shown (about 100 power reactors nationwide) and some government generators may be included in the medical category. The category labeled "Other" includes mostly source material, special nuclear material, and general or exempt distribution licensees.

Using data collected by the DOE National LLRW Program (Fuchs, 1997), the volume of commercial LLRW disposed by the major categories of generators over the period 1985 to 1996 is compared in Figure 4.2. The activity in the commercial LLRW disposed over the same period is shown in Figure 4.3. The utility category includes only commercial nuclear power reactors. The academic

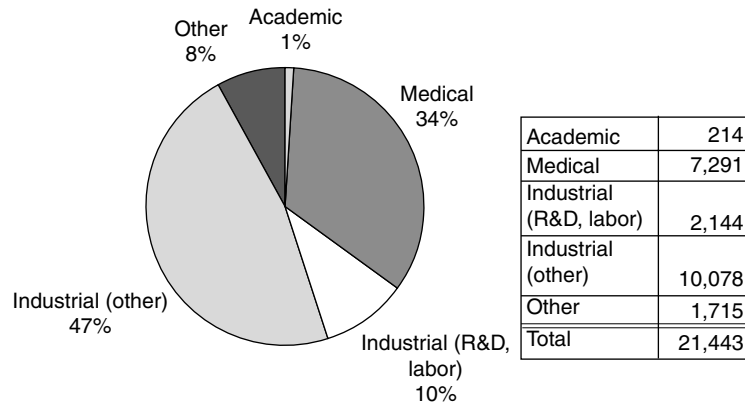


Fig. 4.1. Breakdown of NRC and Agreement State licensees by generator category (NRC, 1994a).

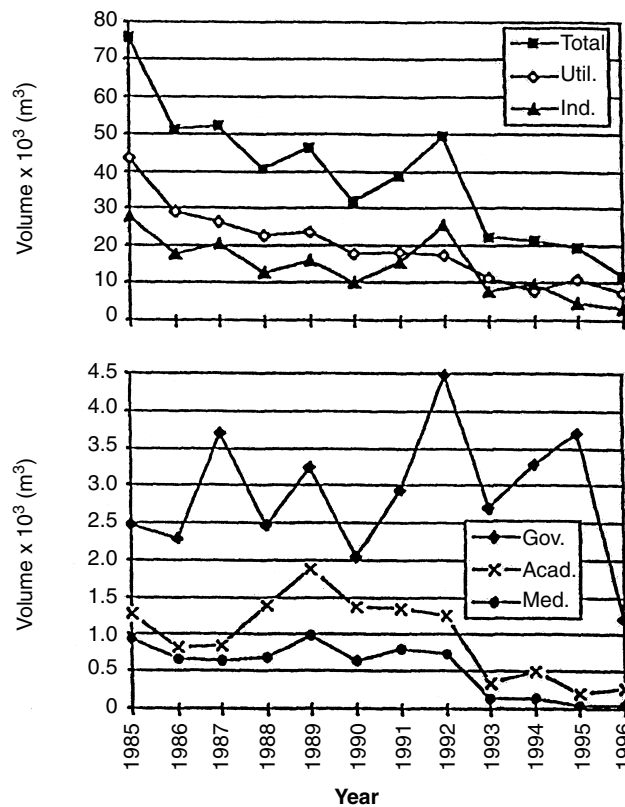


Fig. 4.2. Volumes of various categories of commercially-generated LLRW disposed over the period 1985 to 1996 at commercial LLRW disposal sites (Fuchs, 1997).