NEW DIRECTIONS IN LLW DISPOSAL SITE EVALUATION CRITERIA

L. S. Karably and H. S. Arora
Law Engineering Testing Company
Marietta, Georgia

ABSTRACT

The Nuclear Regulatory Commission's (NRC) proposed 10CFR61 reflects the lessons learned over the last 30 years related to siting, operating, and closing low-level radwaste disposal (LLWD) facilities. The six commercial, ten U.S. Department of Energy (DOE), and other smaller LLW disposal facilities provide a substantial base of information upon which to draw historical and technical perspective on the relevant radwaste isolation issues. Operational experience has been gained at LLW disposal sites in a wide variety of geologic and climatic settings. This paper summarizes the new approaches proposed for (1) meeting LLW disposal site performance objectives by optimizing local geologic and hydrologic conditions, (2) selecting waste form treatments which can reduce the leachability of the LLW, and (3) taking measures which can mitigate unfavorable site characteristics. The ultimate aim of these activities is to reduce risk and increase public confidence in the performance of future sites.

Extensive LLWD operational and research experience has been acquired by the site operators, DOE, the National Labs, EPA, and NRC on technologies related to radwaste isolation, transport modeling, remedial measures, monitoring, risk assessments, and numerous other areas of practical concern. In general, these efforts have led the operators and regulators of LLW disposal sites to the following conclusions.

First, judicious site selection can minimize the risk of off-site contamination and thereby enhance the licensing process. Areas with deep water tables, complimentary soil characteristics, and licensable geologic and hydrologic environments can be found in most regions of the country.

Secondly, LLW can be treated prior to burial to minimize leaching and subsequent migration even under adverse environmental circumstances. This preburial waste treatment may take the form of volume reduction, embedding processes, and confining stabilized waste in appropriate containers.

Third, areas which have marginal licensability due to less than optimal geologic or hydrologic characteristics may require "site upgrade treatments" prior to, during, or after the operation of the LLW disposal site.

The combination of the three LLWD site development activities (judicious site selection, preburial waste treatment, site treatment) can be shown to reduce the real and imagined radiation hazard by meeting the performance objectives.

INTRODUCTION

Typical LLW materials are generated by a wide variety of present day societal institutions such as hospitals, research laboratories, nuclear generating stations, and weapons research programs. A continuing increase in the volume of these wastes is expected to be generated[1]. In general, LLW being buried today are in a solid form and consist of items such as irradiated laboratory specimens, surgical gloves, spent resins from ion exchange columns, contaminated equipment, and decommissioned reactor vessels. Land burial of these wastes in shallow trenches has been routinely practiced as an efficient and economic alternative; it is anticipated that this technique will be the primary mode of disposal for the foreseeable future in the United States.

NRC's proposed 10CFR61 reflects the lessons learned over the last 30 years in regard to siting and operating LLW disposal facilities. The six commercial, ten U.S. Department of Energy, and other smaller facilities provide a substantial base of information upon which to draw historical and technical perspectives on relevant radioactive waste isolation issues (Fig. 1). Operational experience to date at a majority of these disposal facilities, especially for those located in the humid east, indicate that these wastes are not completely isolated and are subject to the action of wind, water, and biological activities. Recent studies have raised questions concerning the environmental acceptability of shallow land burial, which has caused concern and public awareness of the waste disposal problem[1,2]. There has been no evidence of injury to the public from the minimal releases that have occurred[3]. Most of the existing disposal sites were primarily selected for convenience during a period when rigorous criteria for siting of these facilities were nonexistent.

Fig. 1. LLW Sites[1].

Extensive research has been conducted by and through the DOE, the national laboratories, EPA, WES and NRC on technologies related to radioactive waste isolation, risk assessment, monitoring and transport issues. This report addresses the three technical cornerstones of a near-surface LLWD facility isolation characteristics. These include (1) site specific conditions, (2) pretreatment of wastes, and (3) site upgrade techniques (Fig. 2). We will look at previous practices and existing LLW disposal operations and how they will be modified by NRC's proposed 10CFR61.

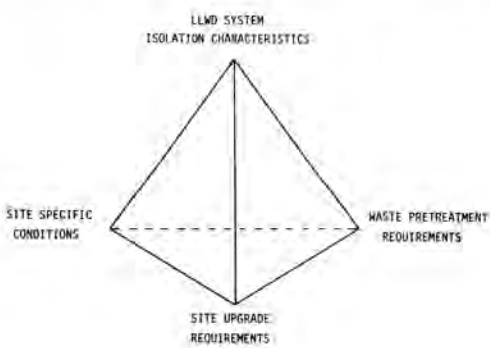

Fig. 2. Isolation Variables of a LLWD Facility.

PERFORMANCE OBJECTIVE TRADEOFFS

Establishing Performance Objectives

Operational experience has been gained in a wide variety of hydrogeologic environments at existing LLWD sites. However, regulatory establishment of clearly defined and measureable performance objectives are a prime necessity for evaluating site suitibility and to arrive at optimum design criteria for a proposed site. Constructive input from the concerned scientific community and active public participation has established these objectives. A lack of performance-based objectives appears to have hampered the critical evaluation of site characteristics during the development of several existing LLWD sites.

Site Suitability

The concept of LLWD site suitability has evolved through the years. The early idealized concepts of near-surface LLWD isolation, which depended solely on the impermeability of the local geology and trench caps, has proven to be ill-conceived. The realization that isolation and containment of radionuclides is a function of the total LLWD system has reoriented the concept of future site suitability.

The ultimate fate of buried radionuclides depends on their interaction with the near-surface geologic host materials and the prevalent hydrologic regimes. Typical mechanisms affecting potential transport of radionuclides consist of a combination of geochemical, physical, and biochemical interactions. Since shallow land burial of LLW in one form or another will probably be necessary for the foreseeable future, a site specific approach to preventive and corrective measures is necessary.

The philosophy today is that the proposed site within the region of interest will be expected to meet certain 10CFR61 site suitability requirements (Table I). The relative suitability of a specific site will establish the baseline for the LLWD site system analysis. If the site proves to have excellent environmental characteristics, then requirements for waste-form pretreatments and site modifications will be minimized. However, if the site is less than optimal, then design alternatives must be selected to upgrade the isolation variables to meet the overall LLWD site performance objectives.

Table I. Site Suitability Requirements.

(1) Site can be characterized, modeled, and analyzed

(2) Avoidance of population growth areas

(3) Avoidance of natural resource areas

(4) Avoidance of flood-prone areas

(5) Minimize upstream drainage areas

(6) Sufficient depth to water table

(7) Proximity of groundwater discharge to site

(8) Avoidance of adverse tectonic processes

(9) Avoidance of adverse geologic processes

(10) Avoidance of unmonitorable areas

Preburial Waste Treatment

Historically, preburial treatment of LLW of any significance was a rare practice prior to the advent of the non-technically motivated shutdown or volume cutbacks at some of the commercial disposal facilities. Regulations lacked specific standards or criteria for the disposal of LLW. Up to 70 percent of LLW has been estimated to be compactable; lack of compaction has perhaps contributed to the use of large acreages of land at existing disposal facilities. The proposed 10CFR61 regulations now consider waste pretreatment as a necessary measure to assure long-term performance objectives at the LLWD sites.

Primary emphasis in determining disposal site suitability in the proposed 10CFR61 regulations is given to isolation of wastes through long-term performance objectives for the site. A comprehensive systems analysis consisting of radionuclide release pathways, systems model, sensitivity and optimization, and dose assessment is performed to predict whether the existing site and waste forms meet the projected performance-based objectives. If not acceptable, a design change in waste form characteristics or site upgrading techniques is necessary (Fig. 3). The LLWD system is reevaluated after the necessary design modifications to determine if it meets the performance objectives required for licensed operations.

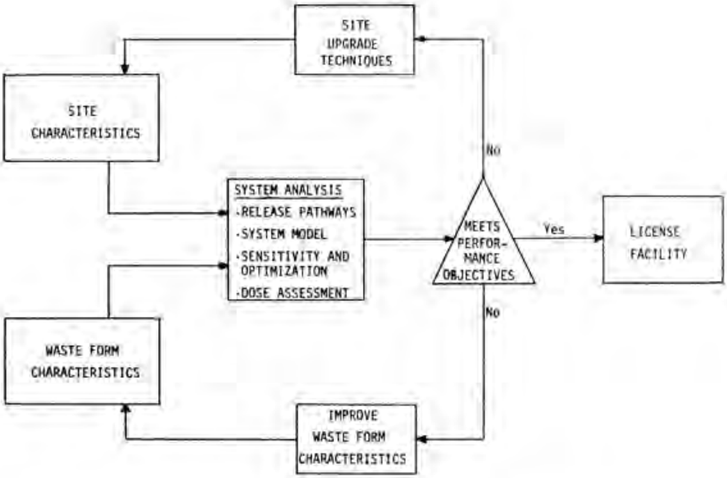

Fig. 3. Alternative Means for Meeting LLWD Site Performance Objectives.

Improved Waste Form Characteristics

Minimal waste treatment in the form of encapsulation/fixation has been accomplished to date at existing LLWD sites. The proposed 10CFR61 regulations, in part, require that the waste must maintain its physical dimensions within 5 percent and its form.

The LLW can be treated prior to burial for minimizing leaching and ultimately migration even under adverse geohydrologic circumstances. Preburial waste treatment technologies can be generally accomplished by two kinds of treatments (Fig. 4). Firstly, it may take the form of volume-reduction measures such as improved segregation of suspected waste, compaction, incineration, acid digestion, pyrolysis, and decontamination of machinery.

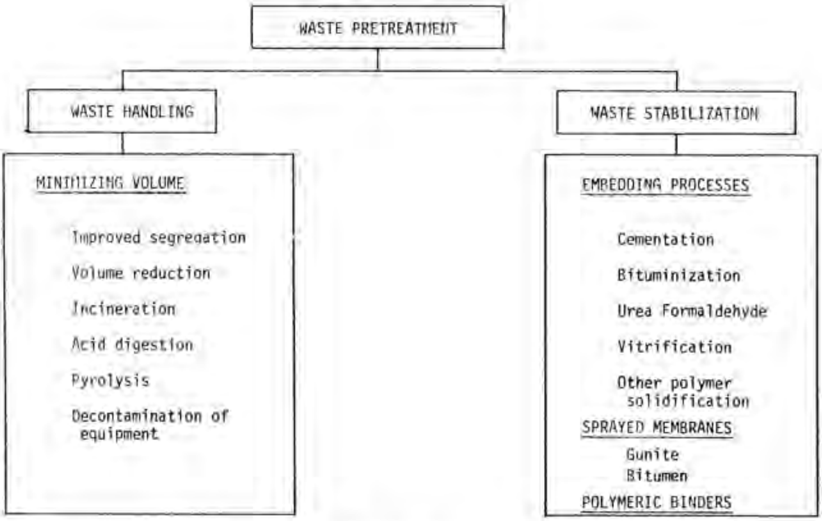

Fig. 4. Waste Pretreatment Technologies.

Secondly, the waste stabilization measures may incorporate encapsulation/fixation technologies which are primarily accomplished to solidify fluid or semi-fluid waste forms or to minimize radionuclide leaching. These measures include a variety of embedding processes such as: cementation, bituminization, urea formaldehyde encapsulation, organic polymer solidification, and vitrification. Sprayed membranes such as gunite, bitumen, and polymeric binders may also be employed to reduce radionuclide leaching from buried wastes. These encapsulation/fixagion processes may be applicable to previously compacted or noncompacted waste forms. Technical criteria for non-radioactive waste applications of most of these encapsulation/fixation processes are readily available from commercial vendors and may be readily adopted for use with solid LLW. Research and development activities on most of these technologies for radioactive waste applications are under evaluation.

Site Upgrading Measures

Aqueous transport is potentially the most basic mechanism for radionuclide mobility from buried wastes. Complete hydrologic isolation of wastes is highly unlikely especially in a humid environment. A number of site upgrading measures can be adopted to improve the sites capacity to retard the potential movement of radionuclides (Fig. 5).

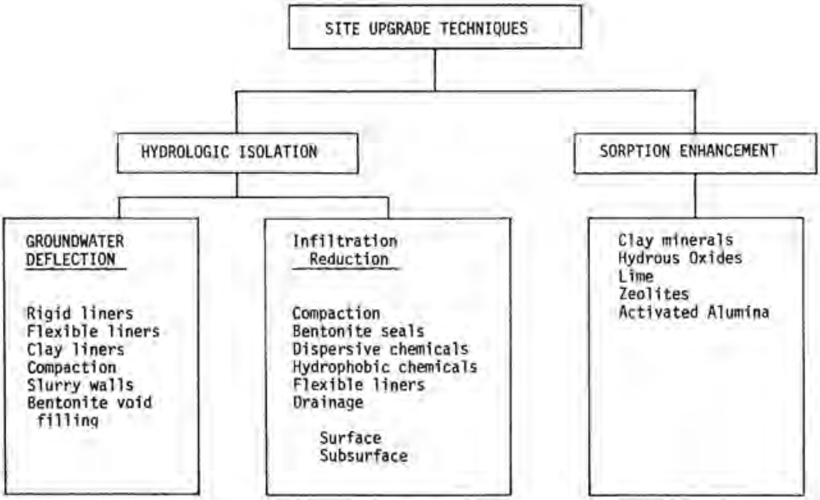

Fig. 5. Potential Site Upgrade Techniques.

The ability of the site soil to retard the movement of radionuclides is dependent upon its physical, chemical, and biological characteristics. Use of clay minerals and other sorbents as inexpensive precipitating and adsorbing agents for radionuclides appears promising for supplementing the natural retardation capacity of soils. Illite and K-hydrobiotite exhibit a high affinity for trace levels of radiocesium[4]. Zeolite minerals, clinoptilolite[5] and mordenite[6], have also been reported to show high selectivity for cesium. Raising the soil pH with lime and other alkaline materials is also expected to enhance the ability of the natural soil to retain certain radionuclides. Filling of voids with low permeability materials such as bentonite would also mitigate the movement of groundwater off site.

LLWD Facility Isolation Trade-Offs

In the final analysis, some balance must be struck between site suitability, and upgrades of the waste form or site (Fig. 6). The systems analysis will probably determine whether the site will require upgrading of the waste form or site. The decision between upgrading the waste form or site will probably be made by the applicant following a cost-benefit analysis. It is conceivable that the cost of upgrading the site or waste form could outweigh the cost of characterizing an alternative candidate site.

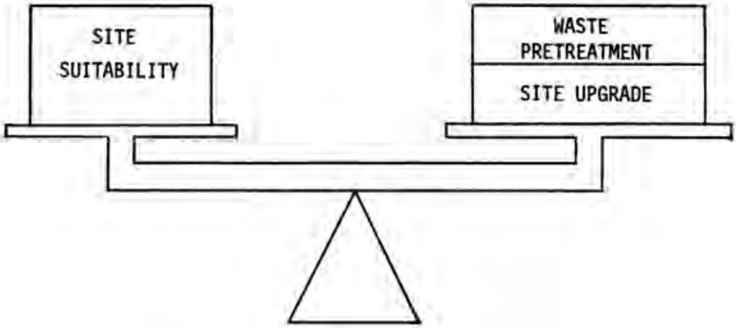

Fig. 6. LLW Facility Isolation Trade-Offs.

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