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DEPARTMENT OF ENERGY
LOW-LEVEL WASTE TECHNOLOGY DEVELOPMENT PROGRAM*

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I. INTRODUCTION

Low-level waste (LLW) has been generated from the nuclear weapons materials program beginning in the 1940's. The controlled disposal of LLW resulting from production and R&D activities of the Atomic Energy Commission and its successor agencies, the Energy Research and Development Administration and now the Department of Energy (DOE), has continued to the present. The primary means of disposal of LLW has been the accepted practice of shallow land burial (SLB), i.e., the random dumping or orderly placement of LLW in trenches 5 to 10m deep. On site SLB allows DOE operations to dispose of LLW in a safe and environmentally acceptable manner because of the physical characteristics of the sites and their remoteness from the population while at the same time avoiding the transportation of quantities of waste on public highways and the attendant risk of accidents or exposure to the public. At present, DOE has 13 active and 3 inactive sites to dispose LLW by SLB.

In the late 1970's public concern was raised for the adequacy of the management practices of sites operated by the commercial sector and DOE. Although reviews of each site's disposal practices and performance indicated that there were no releases to the environment that would affect public health and safety, it became clear that (1) several old burial grounds were not performing as designed, (2) long-term maintenance of closed trenches continued to be a costly and time-consuming problem, and (3) more cost-effective technologies can be developed for the treatment, packaging, and disposal of LLW. As a result of these site reviews, DOE developed the LLWMP to increase technology development to improve existing practices, correct deficiencies, and establish closure methods to avoid expensive long-term maintenance and surveillance. These technology development activities support DOE waste management operations by providing a better understanding of the fundamental physical and chemical mechanisms governing LLW treatment and disposal and by developing treatment and disposal processes that assure performance in accordance with site performance objectives. The supported research activities and their attendant documentation are aimed at developing more cost-effective ways to provide the equivalent protection afforded by the performance objectives contained in the final NRC rulemaking 10 CFR 61 on the land disposal of radioactive waste.

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II. APPROACH OF DOE LLW DEVELOPMENT

The objective of the technology development component of the DOE LLWMP is to develop and document the technology to dispose of materials that have been designated as LLW in a manner that will protect the public health and safety in both the short- and long-terms. In order to accomplish this objective, the DOE LLW Technology Development Program was developed with the intent of assuring the adequacy of practices from a safety and quality perspective, developing technologies that are more cost-effective than existing methods, and producing technical results that not only support DOE waste operations but that can be transferred for use to the commercial sector.

The total DOE program includes the development of standards (in the absence of EPA promulgated standards) and implementing procedures as well as technology development. Environmental release criteria establish acceptable limits for the release of materials which provide for the protection of the public and environment. Such standards are incorporated in DOE 5480.1, the DOE implementing procedures, which the LLW program uses in measuring the effectiveness of the health and safety protection programs. This paper focuses on the program's technology development activities which include (1) improved methods for waste treatment, packaging, and handling; (2) improved methods for shallow land burial; (3) methods for correcting inadequate performance at existing sites; and (4) methods for achieving greater confinement disposal. In order to ensure the scientific and technical accuracy of these research efforts, many of these technology tasks are subjected to a peer review by members of the scientific and user community. Following peer review, documentation that is useful to both DOE and commercial operators is emphasized for timely technology transfer.

III. AREAS OF DEVELOPMENT AND EMPHASIS

The technology development program addresses four technical areas: (1) waste treatment, packaging, and handling; (2) improved shallow land burial; (3) corrective measures; and (4) greater confinement disposal. Technology development activities in the areas of shallow land burial practices and waste treatment are aimed principally at managing about 90% of the LLW generated today. Greater confinement disposal relates to the approximately 10% of LLW remaining that has a higher hazard and may require an appropriately higher degree of confinement. Corrective measures are aimed at correcting inadequate performance at closed sites. Of these four technology areas, the major emphasis is placed on developing improved shallow land burial

practices. In addition to protecting the health and safety of the public in the short-term by providing more effective confinement, these improvements would avoid recurring maintenance and provide for the long-term protection of the biosphere. Cost-effectiveness analyses of improved disposal methods will consider savings from minimizing routine maintenance and corrective measures efforts. Waste generation reduction would extend burial ground capacity; while improved waste treatment technologies would generally reduce the volume of waste for disposal and would produce improved waste forms, thereby providing increased structural stability of the disposal system. The remaining area, corrective measures, investigates activities that will remedy problems, such as subsidence, that have required continual routine maintenance. These technology improvements will provide both interim and long-term solutions for both active and inactive sites.

IV. WASTE TREATMENT TECHNOLOGY

Waste treatment technology tasks are designed to resolve issues related to the handling of special wastes by developing treatment processes and improved waste forms. Waste treatment technology activities performed by DOE contractors include waste generation reduction; waste treatment, packaging, and handling; and waste form testing.

Activities in the area of waste generation reduction are limited to documentation of procedures or practices that reduce the volume of LLW produced and thereby may result in significant savings by avoiding costs related to waste handling, transportation, and disposal. Waste processing tasks include the development and documentation of a range of technologies such as physical and chemical volume reduction, ion exchange, ultrafiltration, and chemical conversion, as well as the preparation of a handbook documenting the current state-of-the-art in LLW treatment. Improved solidification techniques include testing guidelines, waste form characterization, standardized test methods, and related quality assurance.

V. IMPROVED SHALLOW LAND BURIAL TECHNOLOGY

Specific tasks for improving shallow land burial practices are designed to resolve issues related to water management, radionuclide migration, monitoring, modeling or performance prediction, and operational implementation. Several contractors are involved in

technology development activities with humid site work being conducted at Oak Ridge National Laboratory and Savannah River Laboratory. Arid site activities are being conducted at Los Alamos National Laboratory and Pacific Northwest Laboratory.

Water management tasks investigate the control of ground and surface water infiltration into buried waste and water erosion control evaluates the effects of these controls on the overall disposal system. Radionuclide migration tasks investigate groundwater transport mechanisms, factoring in chemical and physical effects on the behavior of specific radionuclides. Performance monitoring tasks include development of performance standards, development of monitoring technologies and methodologies, and development of conceptual designs for monitoring systems. Modeling or predictive capability tasks provide for improved input information and verify and validate comprehensive site performance models that depict all significant pathways of radionuclide transport. Operational implementation tasks include review of waste inventory records, waste characterization, and other facility operations' practices.

VI. CORRECTIVE MEASURES TASKS

Tasks in the corrective measures area are designed to correct inadequate site performance which has required significant maintenance to prevent the release of radionuclides from the site. Contractor research activities include efforts to prevent water infiltration, subsidence, erosion, and biological intrusion.

Water infiltration may be prevented by using various trench cap designs, passive subsurface drainage systems, and/or trench treatments. Subsidence is caused by the settling and compaction of backfilled material, the filling of void spaces between waste packages, and the physical and chemical breakdown and decomposition of the package and waste. Tasks are aimed at understanding the fundamental mechanisms and rates of occurrence of subsidence, understanding the effects of subsidence on the disposal system, and developing and documenting methods to avoid subsidence by using improved waste forms, engineered barriers, or trench treatments to increase the structural stability of the disposal system. Control of erosion by wind and water are applicable to both operating and closed trenches. Biological intrusion may be prevented by developing barriers to prevent plant roots and animals from reaching the waste and subsequently transporting the radionuclides from the disposal site. Program efforts are focused on the development of physical biointrusion barriers.

VII. GREATER CONFINEMENT TASKS

Tasks in the greater confinement disposal area are aimed at resolving the need and options for greater confinement disposal. Activities include the analysis and evaluation of LLW requiring greater confinement disposal, identification of options for greater confinement disposal, and development of a proof-of-concept facility to demonstrate and document a specific technology (i.e., the large diameter borehole concept).

VIII. CONCLUSION

The Low-Level Waste Technology Development Program is currently investigating all areas of a LLW disposal management. Documentation of technical results is done initially through publication of proceedings of meetings, conferences, and symposia. Comprehensive documentation will be available as part of the technical documentation of the specific tasks and ultimately with the issuance of draft and final handbooks for each of the technology areas. Although the technology development activities directly support DOE waste operations, it is expected that the resulting information will address the needs of the commercial sector as well.