Lawrence Livermore Laboratory

ABSTRACTS - NRC WASTE MANAGEMENT PROGRAM REPORTS

R. A. Heckman and C. Minichino, Editors

August, 1979

This is an internal report intended primarily for internal or limited external distribution. The opinions and conclusions stated are those of the author and may or may not be those of the laboratory.

This work was supported by the U.S. Nuclear Regulatory Commission under Interagency Agreement DOE 40-550-75 with the U.S. Department of Energy.

ABSTRACT

This document consists of abstracts of all reports published by the NRC Waste Management Program at Lawrence Livermore Laboratory. It will be updated at regular intervals.

Reports are arranged in numerical order, within each category.

For copies of the reports or for information concerning them, contact

DOCUMENT CENTER
NRC Waste Management Program
L - 390
Lawrence Livermore Laboratory
Livermore, California 94550

NOTICE

This report was prepared as a result of work performed for the U.S. Department of Energy by Lawrence Livermore National Laboratory, under contract number W-7400-ENG-48, with the U.S. Department of Energy. The report contains information that is proprietary to the U.S. Department of Energy. It is being made available to the public for informational purposes only. It is not to be used for any other purpose without the express written permission of the U.S. Department of Energy. The information contained herein is not to be distributed outside the U.S. Department of Energy without the express written permission of the U.S. Department of Energy.

Table of Contents

Abstract.	iii
NUREGs.	1
UCRLs -- 50,000 series.	11
UCRLs -- 70,000 and 80,000 series.	29
UCPLs -- 70,000 and 80,000 series "Abstracts Only"*.	43
UCIDs -- 17,000 and 18,000 series.	65
UCRLs -- 13,000 and 15,000 series (Subcontractor Reports).	57

* "Abstracts Only" refers to meeting paper abstracts for which no full report was written.

NUREGs

Title: "DETERMINATION OF PERFORMANCE CRITERIA FOR HIGH-LEVEL SOLIDIFIED NUCLEAR WASTE"

Author: J. J. Cohen, et al (LLL)

Reference: NUREG/CR-0279, July, 1977

Abstract: Present federal regulations require that high-level radioactive waste liquids resulting from the reprocessing of irradiated nuclear reactor fuel be converted to a dry solid with sufficient thermal, radiological, and chemical stability such that the pressure in the canister encapsulating the waste would not exceed the safe operating pressure of the container for a period of at least 90 days following receipt of the waste at a federal repository. Insofar as the mechanical, radiological, and chemical properties of the dry solid waste form chosen could potentially affect the public health and safety during the handling, storage, transportation, and disposal of the wastes, the Nuclear Regulatory Commission (NRC) requested Lawrence Livermore Laboratory to determine what further constraints, if any, should be placed on the properties of high-level solid wastes. It is the purpose of this study to identify and recommend performance orientated criteria and/or standards which, if applied, would reduce the risk to the environment and to the public health and safety due to solid HLW management operations including final disposal. The study will result in a two-part technical report describing the study and results and in an Environmental Impact Statement which will assess the potential impacts of a rule making action to establish performance criteria for solidified high-level waste. This document (Part 1 of the technical report) describes the study approach, the calculational model developed, factors considered in the evaluation, and the preliminary results obtained to date. Part 2, which will contain the technical basis for the criteria recommended, is scheduled for completion in July 1977. A draft Environmental Impact Statement is scheduled for completion in August 1977.

Discussion

The study was conducted using a systems analysis approach which considered the various situations which could lead to potential releases of radioactive materials during the handling, storage, transportation, and disposal of high-level solid wastes (HLSW). A systems analysis approach was chosen to facilitate the identification of potential release points and mechanisms which would be limiting in establishing criteria, i.e., to identify potential points of release in the management cycle most sensitive to the waste form characteristics.

Title: "WASTE MANAGEMENT TECHNICAL SUPPORT PROJECT FY76, END OF YEAR REPORT"

Author: R. A. Heckman, T. R. Donich (LLL)

Reference: NUREG/CR-0538 - OURL 52547, December, 1976

Abstract: This report covers the progress made during 1976 in the various tasks of the Waste Management Technical Support Project which the Lawrence Livermore Laboratory is conducting for the Nuclear Regulatory Commission (NRC). The project's goal is to develop a technical base to be used by the NRC in developing regulations and regulatory guides for the disposal of radioactive waste in deep geologic repositories. The report covers primarily the ongoing work of Task I: Waste Form Performance and Task II: Site Suitability. Results from these and other tasks are summarized and referenced. All analyses and conclusions are preliminary and do not reflect NRC positions.

Title: "RADIOLOGICAL PERFORMANCE OBJECTIVES DERIVED FROM PUBLIC VALUES FOR NUCLEAR WASTE MANAGEMENT"

Author: J. W. Lathrop, S. R. Watson, V. W. Campbell, J. J. Cohen (LLL)

Reference: NUREG/CR-0540 - UCRL 52574 Draft, December 5, 1978

Abstract: This report presents a methodology for devising Radiological Performance Objectives (RPO's) to guide the development of regulations for nuclear waste management. The methodology described here is based on Risk Evaluation Indices, which represent relevant social values assessed from small samples of people. Four such indices are presented, based on actual value assessments of 58 people. Several alternative methods are discussed for deriving an acceptable risk limit on the Risk Evaluation Index. An index and limit together comprise an RPO. An example is adduced that illustrates the use of RPO's in the evaluation of proposed regulations. In addition, this report presents example Regulation Implementation Aids (RIA's), approximations to RPO's that provide more explicit guidance for the drafting of actual regulations.

Title: "PROBABILISTIC SAFETY ANALYSIS FOR SOLIDIFIED HIGH-LEVEL NUCLEAR WASTE MANAGEMENT SYSTEM"

Author: R. A. Heckman, T. Holdsworth (LLL)

Reference: NUREG/CR-0577 - UCRL 52632, August 1977

Abstract: The Lawrence Livermore Laboratory is providing technical support to the Nuclear Regulatory Commission to help develop standards for the management and disposal of nuclear wastes in deep geologic repositories. This report covers work completed during 1977 on those characteristics of solidified high-level waste which influence radiological risk during both the pre-emplacement portion of the waste management system and the repository postcuring period. It is intended as a status report with emphasis on reducing the uncertainties associated with the analyses of the chemical and physical processes involved in the waste management system.

Title: "HIGH-LEVEL WASTE REPOSITORY SITE SUITABILITY STUDY -
STATUS REPORT"

Author: R. A. Heckman, D. F. Towse, D. J. Isherwood, T. F. Harvey
T. Holdsworth (LLI)

Reference: NUREG/CR-0578 - UCRL 52633, February 1979

Abstract: This report covers the progress made during the work period
October, 1976 to January, 1978, by the Waste Management Technical
Support Project of the Lawrence Livermore Laboratory for the
Nuclear Regulatory Commission.

As need for regulations, standards, and models has emerged, LLL
capabilities have provided technical support towards the development
of disposal criteria for radioactive wastes in general. This
report describes progress made in particular on site suitability
criteria for SHLW repositories.

This report describes, in turn, 1) a physical model which
simulates the natural environment of many potential sites,
2) mathematical models for the calculation of the performance
of hypothetical repository sites, 3) a parameter data base
representative of the natural environment, and 4) analyses and
results. The appendices give details of the mathematics and
of the analytic methods employed.

Title: "SUGGESTED NUCLEAR WASTE MANAGEMENT RADIOLOGICAL PERFORMANCE OBJECTIVES"

Author: J. J. Cohen (LLL)

Reference: NUREG/CR-0579 - UCRL 52626, December 1978

Abstract: Development of criteria for the safe disposal of nuclear wastes in geologic media requires the establishment of definitive objectives against which the adequacy of various waste management methods may be judged. This report suggests certain guidelines that might serve as first approximations pending promulgation of official criteria. These include:

- The allowable radiation dose to individuals should be related to the predicted probability of receiving the dose such that as the dose increases, the events leading to that dose should become less probable. A quantitative relationship is developed and discussed.
- Selection of a waste management method should be made in accordance with the principles of ALARA.
- Doses to future generations should be considered to be equally as serious as doses to present populations.
- When the hazard potential of an underground nuclear waste repository becomes less than that of typical hazardous ore formations (i.e., 0.2% uranium ore), further concern is unwarranted.

Title: "GEOSCIENCE PARAMETER DATA BASE HANDBOOK"

Author: D. J. Isherwood (LLL)

Reference: NUREG/CR-0912 - UCRL 52719, July 1, 1979

Abstract: This handbook contains reference information on parameters that should be considered in analyzing or modeling a proposed nuclear waste repository. Only those parameters and values that best represent the natural environment are considered. We avoid rare extremes. Where laboratory and field data are inadequate, we rely on theoretical treatments and informed engineering judgments.

The handbook is divided into seven chapters: 1) Geomechanics of Bedded Salt, 2) Hydrology, 3) Geochemistry, 4) Seismology, 5) Geology of Bedded and Dome Salt, 6) Natural Features, and 7) Man-Made Features. The handbook is primarily directed at bedded salt as the repository medium, but includes data on other rock units associated with the bedded salt environment.

The current edition is a working draft. The next edition will contain additional information on bedded salt and a partial coverage of the alternative media - dome salt, basalt, granite, and shale.

UCRLs
50,000 series

Title: "DEVELOPING CRITERIA FOR THE MANAGEMENT OF NUCLEAR WASTES"

Author: R. A. Heckman (ILL)

Reference: UCRL 52000, Energy & Technology Review, October 1977

Abstract: As highly radioactive wastes continue to accumulate from both commercial and military reactors, the problem of disposal systems and permanent storage sites becomes ever more pressing. We are studying this problem to provide the Nuclear Regulatory Commission with a firm technical basis for its decisions in setting up regulations and guidelines for the management of nuclear wastes and for the licensing of reprocessing and storage facilities.

This study has developed the mathematics for comprehensive and systematic modeling of complete nuclear waste disposal scenarios. For the widely accepted waste disposal scheme of deep burial, our research suggests that transportation to the disposal site is potentially the most hazardous aspect. Our work has also indicated several performance criteria that would greatly decrease the risk.

Title: "SURVEY OF NATURALLY OCCURRING HAZARDOUS MATERIALS IN
DEEP GEOLOGIC FORMATIONS: A PERSPECTIVE ON THE RELATIVE
HAZARD OF DEEP BURIAL OF NUCLEAR WASTES"

Author: E. A. Tonnessen, J. J. Cohen (LLL)

Reference: UCRL 52199, January 14, 1977

Abstract: Hazards associated with deep burial of solidified nuclear waste are considered with reference to toxic elements in naturally occurring ore deposits. This problem is put into perspective by relating the hazard of a radioactive waste repository to that of naturally occurring geologic formations. The basis for comparison derives from a consideration of safe drinking water levels. Calculations for relative toxicity of fast breeder reactor (FBR) waste and light water reactor (LWR) waste in an underground repository are compared with the relative toxicity indices obtained for average concentration ore deposits. Results indicate that, over time, nuclear waste toxicity decreases to levels below those of naturally occurring hazardous materials.

Title: "A REVIEW OF METHODS FOR THE DETECTION AND ANALYSIS OF
TRANSURANIC ISOTOPES IN SOLID WASTE"

Author: W. C. King (LLC)

Reference: UCRL 52200, January 7, 1977

Abstract: A U.S. Atomic Energy Commission has defined transuranic-contaminated waste as material that is contaminated with greater than 10 nCi/g of long-lived and highly toxic radionuclides. In this report we review the analyses and techniques that show potential for detection at this low level. The physics involved with the methods described is relatively straightforward, but difficulties arise in the actual application of the techniques. Therefore, we concentrate our discussion on the application of the analyses, including the necessary calculational considerations and the potential problems that may be encountered.

We conclude that no simple method presently exists for measuring transuranic isotopes in solid waste material at the low level of 10 nCi/g. In the absence of an interfering background ($< 1 \text{ mR/hr}$), gamma-ray spectroscopy is the best method available. Monitoring helium production in sealed waste material shows good potential for detection at the 10-nCi/g level. The only other viable method involves a complex procedure of counting spontaneous-fission neutrons, neutron irradiation, and counting delayed neutrons. However, if the minimum detectable level permitted in waste material were raised to 1 $\mu\text{Ci/g}$, we would be able to use several more measurement methods and detect almost all the transuranic isotopes present in solid waste.

Title: "A BIOETHICAL PERSPECTIVE ON ACCEPTABLE-RISK CRITERIA
FOR NUCLEAR-WASTE MANAGEMENT"

Author: W. M. Maxey (LLL)

Reference: UCRL 52320, July 15, 1977

Abstract: Wisely managing the profound human and environmental risks of nuclear wastes requires complex moral and ethical judgments. Whereas traditional ethics is limited to interpersonal relations, a new system of ethics--bioethics--concerns man's relation with nature.

Environmentalists claim that technology has upset the balance of nature, that nature is sacred and has inviolable rights, and that man must therefore regulate his behavior to conform to earth's limited carrying capacity. They also say that Judeo-Christian monotheism and anthropocentrism have sanctioned the exploitation of nature in the West, whereas Eastern religions teach adaptation to nature.

Evidence suggests, however, that the balance of nature is neither absolute nor precarious, but is continually changing. Moreover, technology has brought more good than harm to man, and man's needs should supersede nature's. Other evidence indicates that the earth's resources may be neither limited nor nearly exhausted. Persuasive arguments also demonstrate that man's relation with nature is not traceable to religious assumptions.

In assessing the risks/benefits of nuclear-waste management, we should avoid risks that jeopardize the rights of future generations without imposing excessive sacrifices on the present generation.

Title: "DETERMINATION OF ACCEPTABLE RISK CRITERIA FOR NUCLEAR
WASTE MANAGEMENT"

Author: J. J. Cohen (LLL)

Reference: UCRL 52404, October 21, 1977

Abstract: The Laboratory and its subcontractors have provided technical support to the U. S. Nuclear Regulatory Commission in its Waste Management Program. Part of this support has been to develop acceptable risk criteria (ARC) for waste management operations. The initial phase of the work performed during FY 1977 consisted of performing a "scoping" study to define issues, determine an optimal methodology for their resolution, and compile a data base for ARC development. The issues, spanning technical, psychological, and ethical dimensions, were categorized in seven major areas: (1) unplanned or accidental events, (2) present vs future risks, (3) institutional controls and retrievability, (4) dose-response mechanism and uncertainty, (5) spatial distribution of exposed populations, (6) different types of nuclear wastes, and (7) public perception. The optimum methodology for developing ARC was determined to be multi-attribute decision analysis encompassing numerous specific techniques for choosing, from among several alternatives, the optimal course of action when the alternatives are constrained to meet specified attributes. The data base developed during the study comprises existing regulations and guidelines, maximum permissible dose, natural geologic hazards, nonradioactive hazardous waste practices, bioethical perspectives, and data from an opinion survey.

Title: "GEOLOGIC FACTORS IN NUCLEAR WASTE DISPOSAL"

Author: D. E. Lowe (EIT)

Reference: OGIPL 52522, July 1976.

Abstract: The study of geosciences and their relation to nuclear waste disposal and management entails analyzing the hydrology, chemistry, and geometry of the nuclear waste migration process. Hydrologic effects are determined by analyzing the porosity and permeability (natural and induced) of rock as well as pressures and gradients, dispersion, and aquifer length of the system. Chemistry parameters include radionuclide retardation factors and waste dissolution rate. Geometric parameters (i.e., parameters with dimension) evaluated include repository layer thickness, fracture zone area, tunnel length, and aquifer length. The above parameters act as natural barriers or controls to nuclear waste migration, and are evaluated in three potential geologic media: salt, shale, and crystalline rock deposits. Parametric values, in addition to other important inputs, are lumped as a hydrology input into a computer simulation program used to model and calculate nuclear waste migration from the repository to the biosphere, and potential individual and population dose and radiation effects. These results are preliminary and show trends only; they do not represent an actual risk analysis.

Title: "DETERMINATION OF RADIOACTIVE WASTE CLASSIFICATION SYSTEM"

Author: J. L. Cohen, A. G. King (LLI)

Reference: OERI 52535, March 1976

Abstract: Several classification systems for radioactive wastes are reviewed and a system is developed that provides guidance on disposition of the waste. The system has three classes: high-level waste (HLW), which requires complete isolation from the biosphere for extended time periods; low-level waste (LLW), which requires containment for shorter periods; and innocuous waste (essentially nonradioactive), which may be disposed of by conventional means. The LLI/innocuous waste interface was not defined in this study. Reasonably conservative analytical scenarios were used to calculate that HLW/LLW interface level which would ensure compliance with the radiological exposure guidelines of 0.5 rem/y maximum exposure for a few isolated individuals and 0.005 rem/y for large population groups. The recommended HLW/LLW interface level for ^{239}Pu or fixed transuranic waste is 1.0 pci/cm^2 of waste. Levels for other radionuclides are based upon a risk equivalent to this level. A cost-benefit analysis in accordance with as low as reasonably achievable (ALARA) and National Environmental Protection Act (NEPA) guidance indicates that further reduction of this HLW/LLW interface level would entail marginal costs greater than $\$10^6$ per man-rem of dose avoided. The environmental effects considered were limited to those involving human exposure to radioactivity.

Title: "AN APPLICATION OF A METHOD FOR COMPARING ONE-DIMENSIONAL AND TWO-DIMENSIONAL MODELS OF A PUMPED-WELL FLOW SYSTEM"

Author: L. G. Nayak (EIT)

Reference: UOPL 52541, August 21, 1976

Abstract: To evaluate the inability of one-dimensional ground-water model to interact continuously with surrounding hydraulic head gradients, simulations using one-dimensional and two-dimensional ground-water flow models were compared. This approach used two types of models:

- Flow-conserving one-and-two dimensional models.
- One-dimensional and two-dimensional models designed to yield two-dimensional solutions.

The hydraulic conductivities of confining features were varied and model comparison was based on the travel times of marker particles. The solutions within each of the two model types compare reasonably well, but a three-dimensional solution is required to quantify the comparison.

Title: "WASTE MANAGEMENT TECHNICAL SUPPORT PROJECT FY78, END OF YEAR REPORT"

Author: K. A. Heckman, T. R. Donich (LLL)

Reference: UCRL 52547, NUREG/CR-0538, December 1978

Abstract: This report covers the progress made during FY78 in the various tasks of the Waste Management Technical Support Project which the Lawrence Livermore Laboratory is conducting for the Nuclear Regulatory Commission (NRC). The project's goal is to develop a technical base to be used by the NRC in developing regulations and regulatory guides for the disposal of radioactive waste in deep geologic repositories. The report covers primarily the ongoing work of Task I: Waste Form Performance and Task II: Site Suitability. Results from these and other tasks are summarized and referenced. All analyses and conclusions are preliminary and do not reflect NRC positions.

Title: "NUMERICAL SIMULATION OF MATERIAL TRANSPORT IN A REGIONAL GROUND-WATER FLOW SYSTEM"

Author: T. G. Naymik, L. D. Thorson (LLL)

Reference: UCRL 52556, December 31, 1973

Abstract: A numerical model of a regional ground-water flow system (not site specific) was coupled with a material transport model in order to study the influence of porosity and distribution coefficients in bedded media. The effects on model performance were discerned from long-term material transport simulations. Model performance was based on initial breakthrough time, average breakthrough time, and the standard deviation of the breakthrough curve at a discharge surface. Large differences in model performance occurred when the distribution coefficient was changed less than an order of magnitude, while small differences resulted from changing porosity several orders of magnitude.

Title: "GEOSCIENCE PARAMETER DATA BASE HANDBOOK"

Author: D. F. Towse (LLL)

Reference: UCRL 52557 Draft, January 15, 1979

Abstract: This handbook contains representative data useful for assessing radiological risks associated with repositories for high-level, transuranic, and spent fuel wastes. The data will also be useful for deriving generic deep geological modeling parameters and as a standard for weighing other data presented in licensing applications for deep geological waste repositories. More data are now being developed by an LLL subcontractor. Later revisions will contain mechanical and thermal data more relevant to facility design. An earlier broad treatment of this material is now in preparation for publication as a separate document.

This edition of the handbook deals with data for the bedded salt environment. Future editions will contain additional information, on salt and on other media.

Title: "RADIOLOGICAL PERFORMANCE OBJECTIVES DERIVED FROM PUBLIC VALUES FOR NUCLEAR WASTE MANAGEMENT"

Author: J. W. Lathrop, S. P. Watson, W. A. Campbell, G. J. Jonen (LLI)

Reference: UCRL 52574 Draft, UCRL-52574-0040, December 1, 1976

Abstract: This report presents a methodology for deriving Radiological Performance Objectives (RPO's) to guide the development of regulations for nuclear waste management. The methodology described here is based on Risk Evaluation Indices, which represent relevant social values assessed from small samples of people. Four such indices are presented, based on actual value assessments of 50 people. Several alternative methods are discussed for deriving an acceptable risk limit or the Risk Evaluation Index. An index and limit together comprise an RPO. An example is adduced that illustrates the use of RPO's in the evaluation of proposed regulations. In addition, this report presents example Regulation Implementation Aids (RIA's), approximations to RPO's that provide excellent guidance for the drafting of actual regulations.

Title: "SUGGESTED NUCLEAR WASTE MANAGEMENT RADIOLOGICAL PERFORMANCE OBJECTIVES"

Author: J. J. Cohen (LLL)

Reference: UCRL 52626, NUREG/CR-05/9, December 1973

Abstract: Development of criteria for the safe disposal of nuclear wastes in geologic media requires the establishment of definitive objectives against which the adequacy of various waste management methods may be judged. This report suggests certain guidelines that might serve as first approximations pending promulgation of official criteria. These include:

- The allowable radiation dose to individuals should be related to the predicted probability of receiving the dose such that as the dose increases, the events leading to that dose should become less probable. A quantitative relationship is developed and discussed.
- Selection of a waste management method should be made in accordance with the principles of ALARA.
- Doses to future generations should be considered to be equally as serious as doses to present populations.
- When the hazard potential of an underground nuclear waste repository becomes less than that of typical hazardous ore formations (i.e., 0.2% uranium ore), further concern is unwarranted.

The Lawrence Livermore Laboratory is currently conducting support to the nuclear regulatory community to help develop standards for the management and control of nuclear wastes in long geological time scales. The project covers work completed during FY88 on the development of solidified high-level waste management systems and the management system and the regulatory system. It is intended as a study with emphasis on regulatory chemical and physical processes involved in the waste management system.

Abstract:

Reference:

Author:

P. A. Beckman, L. Lawrence Livermore

Title:

"PROBABILISTIC ASSESSMENT OF THE EFFECTS OF NUCLEAR WASTE MANAGEMENT SYSTEMS ON THE ENVIRONMENT"

Title: High-level Waste Site Suitability Tests -
Status Report

Authors: M. J. Reeser, J. E. Lowe, W. D. Luterwald, L. E. Harvey,
L. Holdsworth (LLL)

Reference: ORNL-52833, NUREG-0576, February 1979

Abstract: This report covers the progress made during the work period October, 1976 to January, 1978, by the Waste Management Technical Support Project of the Lawrence Livermore Laboratory for the Nuclear Regulatory Commission.

As need for regulations, standards, and models has emerged, LLL capabilities have provided technical support towards the development of disposal criteria for radioactive wastes in general. This report describes progress made in particular on site suitability criteria for SBLW repositories.

This report describes, in turn, 1) a physical model which simulates the natural environment of many potential sites, 2) mathematical models for the calculation of the performance of hypothetical repository sites, 3) a parameter data base representative of the natural environment, and 4) analyses and results. The appendices give details of the mathematics and of the analytic methods employed.

Title: "GEOSCIENCE PARAMETER DATA BASE HANDBOOK"

Author: D. J. Isherwood (LLL)

Reference: UCRL 52719, NUREG/CR-0912, July 1, 1979

Abstract: This handbook contains reference information on parameters that should be considered in analyzing or modeling a proposed nuclear waste repository. Only those parameters and values that best represent the natural environmental are considered. We avoid rare extremes. Where laboratory and field data are inadequate, we rely on theoretical treatments and informed engineering judgments.

The handbook is divided into seven chapters: 1) Geomechanics of Bedded Salt, 2) Hydrology, 3) Geochemistry, 4) Seismology, 5) Geology of Bedded and Dome Salt, 6) Natural Features, and 7) Man-Made Features. The handbook is primarily directed at bedded salt as the repository medium, but includes data on other rock units associated with the bedded salt environment.

The current edition is a working draft. The next edition will contain additional information on bedded salt and a partial coverage of the alternative media - dome salt, basalt, granite, and shale.

UCRLs

70,000 and 80,000 series

Title: "RISK ASSESSMENT AND RADIOACTIVE WASTE MANAGEMENT"

Author: J. J. Cohen (LLL)

Reference: UCRL 79293, August 16, 1977

Abstract: Problems associated with radioactive waste management, both technological and administrative, have become a serious constraint in the development of nuclear power. An approach toward understanding these problems consists of placing them in a perspective where the risks of radioactive waste management might be evaluated in relation to similar problems facing society so that consistent judgments can be made.

Title: "AN ANALYSIS OF CAPITAL AND OPERATING COSTS ASSOCIATED WITH HIGH-LEVEL WASTE SOLIDIFICATION PROCESSES"

Author: B. G. Kniazewycz (TERA), R. A. Heckman (LLL)

Reference: UCRL 80064, March 1978

Abstract: Performance criteria are being established by the NRC for evaluating the acceptability of the solidified waste forms with regard to the health and safety of the public. The performance criteria will address the maintenance of an acceptable level of protection for both normal and accident conditions. The NRC principle of environmental protection is that the risks from a planned activity should not only be reduced below an acceptable level but should be reduced to levels considered "as low as reasonably achievable." This principle requires that incremental changes in levels of protection be weighted against the incremental cost to achieve further protection.

An analysis has been performed to evaluate the sensitivity of annual operating costs and capital costs of waste solidification processes to various parameters defined by the requirements of a proposed FWK.

The process methods and waste forms examined were:

- Salt Lake
- Spray Calcine
- Fluidized Bed Calcine
- Borosilicate Glass
- Supercalcine Multibarrier

Title: "SOCIAL VALUE CONSIDERATIONS IN NUCLEAR WASTE MANAGEMENT"

Author: J. W. Lathrop (LLL)

Reference: UCRL 20754, 1978

Abstract: The social value problems of nuclear waste management are outlined and analyzed. A decision analytic approach is presented as a methodology for determining bounds on acceptable social risk. Particular problems with this approach are discussed and ideas for solutions presented.

Title: "REVIEW OF ISSUES RELEVANT TO ACCEPTABLE RISK CRITERIA"
FOR NUCLEAR WASTE MANAGEMENT"

Author: J. J. Cohen (LLL)

Reference: UCRL 80793, February 22, 1978

Abstract: A few years ago at the Waste Management 75 Symposium, it was suggested that systems analysis be applied to the problems of Nuclear Waste Management. It was brought out that waste management programs required definitive objectives against which one could adequately judge the acceptability of any operation or methodology. Since that time, several projects have been devoted to achieving this purpose. These have included EPA sponsored workshops on the development of environment protection criteria for radioactive wastes, and an interagency sponsored conference on public policy issues in nuclear waste management.

These meetings were largely designed to receive public input for the determination of criteria for acceptability of nuclear waste management programs. In addition, several studies have been conducted to determine suitable objectives for waste management programs. Among these is a current study conducted at LLL sponsored by the Nuclear Regulatory Commission. The purpose of this paper, is to review and discuss some of the insights from this and other studies.

Title: "GEOCHEMISTRY AND RADIONUCLIDE MIGRATION"

Author: D. J. Isherwood (LLL)

Reference: UCRL 80841, Waste Management '78 Symposium, March 6-8, 1978

Abstract: Effective isolation of nuclear waste in a deep geologic depository can be described in terms of interacting multiple barriers. The simplest to describe is the geometric barrier or physical isolation of the waste as defined by the size of the buffer zone around the repository, the thickness of the rock layers, and the area of the fracture zone around the depository due to construction of the tunnels and shafts.

Of greater complexity is the hydrologic barrier, that is, the group of parameters that determines the waste dilution factor (dispersion) and groundwater flow rates; for example, permeability, heads, gradients, etc. In general, the hydrologic and geometric barriers control waste migration by determining both the resaturation time of the depository after decommissioning and the time it takes for groundwater to flow from the depository to the biosphere.

The least understood is the geochemical barrier, identified as a series of waste/water/rock interactions involving sorption (ion exchange), ion filtration, hydrolysis, precipitation, complexing, and the leach resistance of the waste form. This paper includes a demonstration of how these chemical processes can interact to control waste migration.

Title: "SYSTEMS ANALYSIS STUDY FOR WASTE MANAGEMENT CRITERIA"

Author: R. A. Heckman, W. A. Johnson, T. Holdsworth (LLL)

Reference: UCRL 80850, March 1, 1978

Abstract: The Lawrence Livermore Laboratory is providing technical support to the U. S. Nuclear Regulatory Commission (NRC) in the development of standards for the management and disposal of high-level and transuranic wastes. The problem logically splits into two phases; the pre-emplacment phase of the waste management system, and the repository post-sealing phase. Using a system analysis approach, we have structured our modeling effort in such a way as to produce societal risk evaluations at stated confidence levels so that the NRC can develop regulations for the broadest set of conditions possible.

We are using a multicycle approach in developing the societal risk evaluations. The modeling effort uses a three level concept. At the first level, simple models are developed from first principles of chemistry and physics. These initial models use lumped parameters to provide insight into important processes. The second level modeling effort is designed to provide a flexible, fast running system analysis model. The third level of modeling provides a method for validating the second level models, inputting numerical data, and development of algorithms for use in the second level models.

Title: "DETERMINATION OF PERFORMANCE CRITERIA FOR HIGH-LEVEL
SOLIDIFIED NUCLEAR WASTE FROM THE COMMERCIAL NUCLEAR FUEL
CYCLE: A PROBABILISTIC SAFETY ANALYSIS"

Author: R. A. Heckman (ILL)

Reference: UCRL 80927, Rev. 1, March 30, 1978

Abstract: To minimize the radiological risk from the operation of a
waste management system for the safe disposal of high-level
waste, performance characteristics of the solidified waste form
must be specified. The minimum waste form characteristics that
must be specified are the radionuclide volatilization fraction,
airborne particulate dispersion fraction, and the aqueous
dissolution characteristics. The results indicate that the
pre-emplacment environs are more limiting in establishing the
waste form performance criteria than the post-emplacment
environs. The actual values of expected risk are sensitive to
modeling assumptions and data base uncertainties. The trans-
portation step appears to be the most limiting in determining
the required performance characteristics.

Title: "EVALUATION OF SOCIAL RISK"

Author: J. W. Lathrop (LLL)

Reference: UCRL 81059, April 28, 1978

Abstract: The implementation of nuclear waste management technology raises several issues involving the regulation of social risk. This paper will present a decision analytic approach to resolving some of those issues. Lawrence Livermore Laboratory is developing a technical basis for the regulation of nuclear waste management for the Nuclear Regulatory Commission. As part of that effort, a multi-dimensional measure of social risk is being developed that incorporates value tradeoffs. Considerations in the form and the elicitation of that social risk measure are discussed, and the risk measure itself is presented in its current state of development. Alternative definitions of acceptable levels of risk in terms of this risk measure are discussed, and the definitions identified that are most appropriate for regulating nuclear waste management. On a more general level, the role of decision analysis in the regulatory process is discussed.

Title: "MEASURING SOCIAL RISK AND DETERMINING ITS ACCEPTABILITY"

Author: J. W. Lathrop (LLL)

Reference: UCRL 81060, July 14, 1978

Abstract: The implementation of a nuclear waste management technology raises several issues concerning the regulation of social risk. This paper will present a decision analytic approach to resolving some of those issues. A methodology for developing a radiological risk measure is presented, and several approaches to defining acceptable levels of that risk measure are considered. The methodology presented is oriented toward the development of radiological performance objectives for use as guidance in the drafting of regulations.

Title: "CALCULATED RADIATION DOSE FROM A 100,000 GALLON LOW-LEVEL WASTE REPOSITORY"

Author: A. W. Kaufman, U. S. Environmental Agency, U. S. Environmental Agency

Reference: OGP 61148, May 10, 1971

Abstract: Transport by groundwater is the most likely means of release for radioactive waste contained in a geologic repository. The rock formations through which the ground water flows are characterized by inhomogeneities on all distance scales. Large scale inhomogeneities cause plumes of dissolved pollutants to spread both in the direction of flow and transverse to it. This phenomena is known as macroscopic dispersion. Similarly inhomogeneities in the chemical properties of the rock will cause this spreading to be longer for species whose movement through the rock is retarded by waste-rock chemical interactions.

Previous risk analyses of nuclear waste disposal which have ignored macroscopic dispersion found that predicted radiation doses to individuals are very sensitive to the waste dissolution time. When macroscopic dispersion is incorporated into the analysis, however, the sensitivity of risk to dissolution time is greatly reduced.

Title: THE RISK OF THE ESTIMATION OF LIMITED AND ACTIVE RELEASES
IN NUCLEAR WASTE MANAGEMENT

Author: M. T. VEIG (USA)

Reference: IAEA, 1981, Revision 1, January, 1981

Abstract: The estimation of the risk attendant to accidental radioactive releases is a necessary step in the assessment of the safety of any nuclear waste management system or subsystem. The amount of a radioactive nuclide and the manner in which it is released under a given set of conditions serve as part of the input data to the subsequent transport, decay, and dosage models. The result of these model calculations gives a measure of the consequence of the release. This measure may be some dosage rate, or the number of expected fatalities, or some other measurable impact on the biosphere. In this context risk is often defined as the expectation value of the consequence.

UCRLs
70,000 and 80,000 series
Abstracts Only*

* "Abstracts Only" refers to meeting paper abstracts for which no full report was written.

Title: "THE RELATIVE HAZARD OF NUCLEAR WASTES AND NATURALLY OCCURRING TOXIC MINERALS"

Author: K. A. Tonnessen, J. J. Cohen (LLL)

Reference: UCRL 79096 Summary, Spring Meeting of the American Chemical Society, Honolulu, Hawaii, 1979

Abstract: A useful insight into the problem of high level radioactive waste management may be gained by assessing the hazard to man of an underground waste repository relative to that of certain naturally occurring geologic formations. Relative hazard indices were formulated for such a comparison. Certain toxic heavy metal elements (for which EPA drinking water standards are available), as well as certain of the naturally occurring radioactive ores, are considered in this analysis.

To evaluate the hazardous nature of these elements, two approaches were used:

1. Determination of the crustal abundance of the mineral in the lithosphere and then calculation of the amount of water needed to dissolve the inventory down to drinking water standards, as promulgated by the Environmental Protection Agency (EPA) and the National Council on Radiation Protection (NCRP). Using ^{235}U as the modulus item, a toxicity index was arrived at for each of the naturally occurring elements.
2. Based on the average concentration of a toxic element in its constituent ore, the amount of water needed to dilute one cubic meter of ore to safe drinking water standards (DWC) was calculated as the toxicity index for each of the cited elements. Using low grade uranium ore (0.2%) as the modulus item, "toxicity indices" were calculated and graphically presented in comparison with the relative toxicity indices devised by Haug for light water reactor wastes and fast breeder reactor wastes as stored in a typically proposed underground repository.

Assuming comparable solubility of solidified nuclear wastes in repositories and natural ore formations, this graphic treatment indicates that deposits of some industrially important minerals may be more hazardous to human health than the proposed "deposits" of buried nuclear waste as time progresses. It may be concluded that after approximately 1000 years of decay, actinides in the waste will have a radiotoxicity equal to that of low-grade uranium ore and a toxicity considerably less than many of the naturally occurring heavy metals.

This analysis does not represent an attempt to demonstrate the validity or acceptability of any type of waste disposal. Rather, it puts into a rational perspective the hazards to which man may be exposed daily from natural geologic sources.

Title: "A COMPUTER SIMULATION MODEL OF A NUCLEAR WASTE FACILITY"

Author: D. F. Towse (111)

Reference: UCRL 79579 Abstract

Abstract: A model of the geology, radiochemistry, food chain, and future geologic events at a nuclear waste facility incorporates data on site geometry, lithology, hydrology, and geochemistry in order to study the phenomena of waste transport and to develop technical criteria for waste disposal. Input can simulate any type of nuclear or non-nuclear waste, and quantitative results are stated as concentrations, or radiation dose vs. time.

Analyses of parameter sensitivity evaluate the waste dispersion processes and the relative importance of factors in the geologic environment. These have shown the importance of hydrologic factors and the need for study of the geochemistry of the radionuclides, their solubility and complexes, and absorption in the natural environment. The effects of future geologic events are calculated either deterministically, or probabilistically, using a markov chain to determine future states of the geologic system.

This waste management model differs from others in that: (1) many geologic environments can be simulated; (2) any type of nuclear or non-nuclear waste can be modeled; (3) the effects of a number of future geologic events can be analyzed. Novel features include a simple one-dimensional hydrology approximation calibrated against more sophisticated calculations. Estimates of future geologic events are a unique application of predictive geology.

Title: "THE GEOCHEMICAL BARRIER TO RADIONUCLIDE MIGRATION FROM A NUCLEAR WASTE REPOSITORY"

Author: D. J. Isherwood (LLL)

Reference: UCRL 80018 Abstract, 1977

Abstract: Effective isolation of nuclear waste in a deep geologic repository can be described in terms of interacting multiple barriers. The simplest to define is the geometric barrier; i.e., the physical isolation of the waste at some depth within the rock unit. Of greater complexity is the hydrologic barrier; i.e., parameters which determine the waste dilution factors and groundwater flow rates. The least understood is the geochemical barrier, identified as a series of waste/water/rock interactions involving sorption (ion exchange), membrane filtration, hydrolysis, precipitation and complexing. Of these, sorption is the primary geochemical control.

A mass transport hydrologic model tested the relative importance of the various parameters. Sorption was quantitatively expressed in the model as the retardation factor; that is, the relative velocity of the groundwater to the radionuclides. (Retardation factors can be estimated from the ion exchange distribution coefficients for individual radionuclides.) A parameter sensitivity analysis showed the model to be most sensitive to the chemistry. Changes in the retardation factors produced dramatic changes in the radionuclide concentrations. This was particularly true for the long-lived nuclides. Those with short half-lives were effectively isolated by the combined efforts of the geometric and hydrologic barriers.

The importance of low solubilities in limiting radionuclide concentrations in groundwater was also evaluated. Solubilities based on thermodynamic calculations show a number of the radionuclides have equilibrium concentrations within those limits now considered acceptable by the Federal Government. However, the theoretical solubilities of In and Sn are below concentrations actually found in natural waters. This is no doubt due to the formation of unidentified soluble complexes.

Title: "DEVELOPMENT OF HIGH-LEVEL WASTE MANAGEMENT AND STANDARDS - THE LLL TECHNICAL SUPPORT PROGRAM"

Author: R. A. Heckman (LLL)

Reference: UCRL 80319 Abstract

Abstract: The Nuclear Regulatory Commission (NRC) has recognized the need to develop procedures for safely managing and disposing of all types of nuclear waste. In addition, the NRC is aware that the safe management of nuclear waste is one of the pivotal issues affecting the future role of nuclear power. In mid-1975 the Nuclear Regulatory Commission (NRC) established a separate waste management unit to coordinate all NRC waste management activities.

The NRC waste management program (WMP) efforts are directed toward (1) establishing objective performance goals (technical, social, economic, and environmental) for management of nuclear wastes; (2) developing a regulatory framework (regulations, standards, and guides) which reflects these goals; and (3) preparing licensing procedures (and assessment methodologies) needed to evaluate proposed waste management programs and strategies against these regulations.

The Lawrence Livermore Laboratory (LLL) is under contract to the NRC to provide technical support in these areas: (1) performance criteria for solidified high-level waste; (2) high-level waste repository site suitability criteria; (3) high-level waste repository design/performance criteria; (4) waste form criteria for transuranic contaminated wastes; (5) nuclear waste classification criteria; (6) acceptable risk criteria; and (7) other related tasks.

LLL's approach to the problem is the development of a probabilistic consequences analysis model. With this model we have studied the radiological risks associated with a high-level nuclear waste management system over a full spectrum of operations and times. We have developed some new tools to study the post-encapsulation history of a deep geologic waste repository. Specific examples of risk estimations will be discussed.

Title: "ANALYSIS OF THE GEOLOGIC FACTORS IN NUCLEAR WASTE DISPOSAL"

Author: D. F. Towse (LLL)

Reference: UCRL 80906 Abstract

Abstract: The deep geologic option for nuclear waste disposal requires the selection, construction, operation, and decommissioning of underground disposal sites for wastes from the manufacture and use of nuclear fuels.

The many real and imagined factors in an apparently very complex system can be analyzed by an integrated systems approach utilizing the geological sciences and related geotechnical and engineering disciplines.

By simulating the waste migration system and calculating radiologic consequences and risks, we can identify and quantify the critical parameters. These critical parameters could form the basis for analysis and for control of waste disposal from site selection to final decommissioning.

The public health and safety could be served by ensuring that the waste products are removed from the biosphere until radioactive decay operates so that releases are low enough to meet health standards. The geometric, hydrologic, and chemical geologic factors form "barriers" that singly or in combination control waste migration and release.

Geometric factors include the dimensions that determine the length of the release path. Long paths help increase confinement time.

The most likely waste release is, probably via flowing water. Rock characteristics and pressure distribution determine the direction, velocity, and amount of water flow. These can be calculated from measured parameter values.

The very important geochemical factors include absorption, solution, precipitation, and many other poorly understood processes and substitutions.

Nuclear waste disposal concerns require assessment of stability over periods in the future that are uniquely long compared to most engineering predictions. A concept for those estimates is based on documented rates of past geologic processes.

Considerations of stability together with the other geologic factors provides a method to evaluate technical criteria for nuclear waste disposal.

Title: "THE HAZARD OF BURIED NUCLEAR WASTE RELATED TO NATURALLY OCCURRING TOXIC MINERALS"

Author: J. J. Cohen, R. A. Tonnesen, H. A. Lewis (LLL)

Reference: UCRL #1647 Abstract

Abstract: Acceptability of any system for geologic disposal of radioactive waste is dependent upon the resulting hazard potential. A useful perspective on the nature of this hazard can be attained by comparing the characteristics of the waste repository with those of naturally occurring toxic mineral formations. Relevant properties affecting the hazard include not only the toxicity of the materials, but also their leachability, and potential for movement into the biosphere. This study compares these properties for proposed high-level waste (HLW) repositories and various mineral deposits. The method used for evaluation of relative toxicity involves determination of the quantity of water required to dilute a given volume of the waste repository or ore deposit to accepted drinking water standards assuming total solubility. Based upon this analysis it appears that the relative toxicity of the waste repository becomes less than that of typical Cinnabar (HgS) deposits in a few hundred years and less than that of typical Uranium Ore (U₂S₃) in about 1000 years. Comparisons are also made with deposits of Cr, Se, Pb, Cd, Ag, Ba, and As. Based upon the crustal abundance of toxic minerals the incremental increase in overall crustal toxicity assuming various scenarios for nuclear power development is also evaluated. A comparison of the relative leachability and mobility of various solidified HLW forms in various emplacement media reveal these properties to be similar to those of toxic minerals. Data on these relative properties are shown and discussed.

Title: "DEVELOPMENT OF RADIOLOGICAL CRITERIA FOR WASTE MANAGEMENT"

Author: J. J. Cohen, R. A. Tewer (eds)

Reference: OCKL 416/1 Summary

Abstract: Nuclear waste containing highly radioactive materials characterized by long half-lives requires safe handling and effective isolation from the biosphere. Many of the currently proposed methods for the management of this waste call for its disposal in geologic media. Determination of criteria for the safe disposal of nuclear waste in geologic media requires the establishment of definitive objectives against which the adequacy of alternative waste management methods may be judged.

Development of these objectives has been the goal of several past and ongoing efforts consisting primarily of review and assessment of the issues involved and development of a methodology for establishing criteria. However, definitive criteria have not as yet been set. Current programs are designed to determine performance criteria for various waste management programs such as waste solidification and repository site suitability. The effectiveness of these programs depends upon the establishment of definitive overall criteria which reflect the design goals and objectives for nuclear waste management (NWM).

It is generally accepted that the overriding objective of acceptable Waste Management programs is to protect present and future generations from the adverse effects of exposure to ionizing radiation. To judge the effectiveness of any Waste Management method or operation it is therefore necessary to develop objectives for limiting the exposure of the public to radiation, or Radiological Performance Objectives (RPO). The purpose of this study has been to determine and suggest a set of unambiguous, quantitative RPO for exposure resulting from Waste Management operations.

To accomplish this goal, a study was conducted at the Lawrence Livermore Laboratory (LLL) to assess the issues and develop a consensus on quantitative criteria. The assessment was based on existing standards, rules, regulations, criteria, accepted methods for good practice, and current recommendations in the literature. Where no precedent existed, best professional judgment was used. A summary of the study conclusions follows:

- Waste management methods and operations should be designed such that the predicted radiological exposure to both "maximum" and "average" individuals is below suitable limits.
- The limits set for potential consequences should scale according to the probability of any event or combination of events which could lead to those consequences, (i.e., as predicted consequences should be core less probable).

- Suggested numerical limits for "maximum" individuals are:
for annual dose limit (D) in rem.

$$D = 0.5p^{-0.33}$$

for lifetime dose (50 yr. dose) in rem

$$D = 25p^{-0.2}$$

- where p is the probability for the occurrence of the event(s) resulting in the predicted dose.
- The limiting dose to average individuals should be $\approx 1/100$ of that for maximum individuals.
- Where more than one alternative Waste Management method meets the limiting criteria for individual dose, the collective dose should be predicted and an alternative selected on the basis of "as low as reasonably achievable" (ALARA) principles.
- Doses to future generations should not be discounted (i.e., predicted doses delivered at any time in the future are considered to be equally serious as doses currently being delivered.
- Predicted organ doses should be considered on the basis of equivalent whole body doses as per ICRP #26.
- Risk from exposure to radiation should be spatially allocated such that the total collective risk is no greater than twice that which would apply locally or to that population receiving the benefit.
- When the hazard potential of the waste repository becomes less than that of a 0.2% uranium-ore deposit, continued concern is not warranted.

The data and rationale behind these conclusions are presented and discussed.

Title: "GEOCHEMICAL ASPECTS OF ISOLATION"

Author: D. J. Isnerwood (LLL)

Reference: UCRL 8167 Abstract, Int. Contractors' Conference, Coalfont, W. Virginia, September 18-20, 1973

Abstract: The geochemical barriers to radionuclide migration are important to waste isolation. The first geochemical barrier is the solubility of the waste form. If groundwater eventually reaches the waste, dissolution will begin. To study the rate of dissolution, the radionuclide species likely to be present in the groundwater and the various controlling chemical and physical processes, we are developing a waste dissolution model. This model will combine a chemical equilibrium code which predicts the chemical behavior of the waste in a wide variety of environments with a hydrology model simulating groundwater movement around a canister.

The second geochemical barrier is the sorption of radionuclide species by the repository rock. This waste-rock interaction is represented in the mass transport model as a retardation factor -- the relative velocity of the groundwater to that of the radionuclide species. An extensive literature search provided data for estimating retardation factors for three groups of radionuclides: fission products with no sorption, fission products with sorption and sorbed actinides. The importance of retardation in controlling radionuclide migration is easily demonstrated with the mass transport model. Varying the retardation factor resulted in dramatic changes in radionuclide concentrations calculated above the repository.

One primary objective of this study is reducing uncertainties in our estimates of dose and concentration. The source of uncertainties that can be attributed to geochemistry includes the reliability of the available data, our lack of knowledge on how physical and chemical processes affect retardation, and, even more importantly, how well our laboratory measurements represent in situ values.

Title: "PACKAGE FAILURE CALCULATIONS FOR LLL"

Author: R. L. Nickell (Pacifica Technology)

Reference: UCRL 81675 Abstract, NRC Contractors' Conference, Coalfont, W. Virginia, September 18-20, 1978

Abstract: Three tasks related to the development of a reference design for retrievable storage canister for radioactive waste are discussed. The three tasks consist of the development of the reference itself, the definition of the failure modes most appropriate for structural integrity evaluations for the reference canister, and the identification of a possible risk methodology for establishing the probability of failure.

The reference design is a sealed storage canister concept based upon the waste isolation pilot plant (WIPP) design, with slight modifications of the end closures, in order to accommodate an alternative lifting yoke arrangement for the top head and a revised bottom head design that provides for enhanced impact energy absorption. A secondary welded closure is provided for both the top and bottom heads, but a full overpack is not included in the preliminary reference design.

A total of six failure modes - loss of function, ductile rupture, brittle fracture, buckling, fatigue, and corrosion - are identified, with four of these selected to be most relevant for waste canister design. Failure scenarios are then constructed for each of the relevant failure modes. Finally, a risk methodology based upon the distribution of demand (stress, strain, etc.), and capacity (failure stress, failure strain, etc.), with respect to each failure mode is suggested.

Title: "GEOLOGIC ASPECTS OF ISOLATION"

Author: T. L. Steinborn, D. L. Iowse (LLL)

Reference: UCRL 61676 Abstract, NRC Contractors' Conference, Coalfont, W. Virginia, September 16-20, 1975.

Abstract: The deep geologic option for nuclear waste disposal requires the selection, construction, operation, and decommissioning of underground disposal sites for wastes from the manufacture and use of nuclear fuels. The many real and imagined factors in an apparently very complex system can be analyzed by an integrated systems approach utilizing the geological sciences and related geotechnical and engineering disciplines. By simulating waste migration and calculating radiologic consequences and risks, we can identify the critical parameters. These critical parameters could form the basis for control of waste disposal from site selection to final decommissioning.

The public health and safety could be served by ensuring that the waste products are removed from the biosphere until radioactive decay operates so that releases are low enough to meet health standards. The geometric, hydrologic, geochemical, and geologic factors form "barriers" that singly and in combination control waste migration and release. Key time factors include the dimensions that determine the length of the release path. Long paths help increase confinement time. The most likely waste release is probably via flowing water. Rock characteristics and pressure distributions determine the direction, velocity, and amount of water flow. These can be calculated from measured parameter values. The important geochemical factors include absorption, solution, precipitation, and other poorly understood processes.

Nuclear waste disposal requires a prior assessment of stability over periods in the future that are uniquely long compared to most engineering problems. These estimates are based on documented rates of past geologic processes. Consideration of stability together with the other geologic factors provides a method to evaluate technical criteria for nuclear waste disposal.

Title: "THE TECHNIQUE OF RISK"

Author: E. A. Donich, III,

Reference: ORNL 61677 Abstract, NRC Contractors' Conference, Coalfield, W. Virginia, September 18-20, 1978

Abstract: The High-Level Nuclear Waste Management program for NRC is the regulation of the site selection, building, and operation of a deep geological repository for the disposal of high-level waste (e.g., currently spent fuel) and transurans from high-level wastes. Preliminary studies have been completed to aid in analyzing the risk during pre-emplacment and post-emplacment periods. The pre-emplacment risk models include the transportation, storage, and handling of several forms of high-level waste.

The post-emplacment problem is factored by NRC into several areas of interest, namely: waste form performance, site suitability, repository design performance, radiological performance objectives, and geoscience data base. Current efforts have been directed towards bedded salt and shale, but other media such as dome salt, basalt, and crystalline rock are being investigated.

Title: "WASIL: WASTE SITE IDENTIFICATION"

Author: A. M. Eastman, et al.

Reference: J. E. 10-18 Abstract, Environmental Conference, Fairfax, VA, Virginia, September 1-5, 1977

Abstract: The assessment of a site potential for a nuclear waste repository will depend on the identification of certain qualitative and quantitative criteria which will affect the site performance of the site and repository. A classification of waste, bedded salt and shale has been the method of evaluation for this purpose. Other media and criteria must be considered but not yet worked on.

Modeling has been the primary concern to which the identification process has been directed. A program called WASIL was developed by EPA and DOE for the purpose of calculating long-term risk and assessing the sensitivity of risk to various model parameters. The well recognized fact that transport by groundwater of waste loaded storage containers is the principal pathway to the biosphere. In excess dose, the WASIL program currently uses the uniform leach system as a model for water use.

Principal results of the study to be used: nuclide retardation contributes most to the uncertainty in the dose, doses from wells sited after declassification near the repository may exceed normal background levels, and mine side openings even through backfilled may represent important pathways from the repository.

Title: "WASTE FORM PERFORMANCE/3-D THERMAL CALCULATIONS"

Author: H. Cheung (LLL)

Reference: UCRL 81679 Abstract, NPC Contractors' Conference, Coalfont, W. Virginia, September 18-20, 1976

Abstract: The waste form performance work at LLL has dealt with three types of wastes: solid high-level waste (SHLW), spent fuel (SF), and transuranic (TRU) waste (non high-level). The performance characteristics with respect to risk to man for the following SHLW: calcine, fluidized bed calcine, borosilicate glass, and supercalcine multibarrier have been evaluated. Risks in terms of whole body dose were analyzed for these waste forms undergoing various SHLW waste management operations: handling, storage, transportation, disposal.

In spent fuel disposal with the option for retrieval, studies are underway to investigate, thermal, radiological, chemical, and physical interactions between the emplaced package and the depository. Specific areas of investigation are: thermal and thermal stress analysis, corrosion, brine migration and dissolution.

The TRU waste studies include considerations of all of the aspect of spent fuel management and, in addition, source and inventory; a functional definition; and effects of emplacing both TRU and SF in the same repository.

The TRUMP finite difference heat transfer code is being used to analyze a 3-D model of the repository. The model uses a unit cell consisting of one spent fuel canister buried in salt beneath a ventilated room in the repository. The primary purpose of the analysis is to evaluate the near-field thermal environment. The model was developed to provide accurate temperatures in the region within a few feet from the canister. The results of this analysis will be used for other studies of the repository environment, such as thermal stress analysis, canister corrosion, radionuclide dissolution, and brine migration.

Thus far, a preliminary analysis is complete. A more detailed thermal analysis and parametric study is in progress.

Title: "LLL MANAGERIAL OVERVIEW"

Author: R. A. Beckman (LLL)

Reference: OURL 81600 Abstract, Int. Contractors' Conference, Coalfont, W. Virginia, September 16-18, 1978

Abstract: Recognizing that the Federal high-level waste Management responsibility is shared between DOE, EPA, and EPA, we have developed a unique approach to the waste management program. One may relate the overall waste management system problem to the individual program elements or tasks through a hierarchical approach. We must use mathematical models to calculate radiological risks to the public and the environment. We build (and couple) macroscopic computer simulation models, with which we can conduct sensitivity/uncertainty analysis. These sensitivity and uncertainty analysis provide a framework for evaluation of the societal impact of these risks. Identification of the critical parameters provides a regulatory information base as well as a conceptual regulatory framework. Thus, the application of uncertainty analysis in a hierarchical system model provides an objective management framework for focusing technical effort only on those questions that have a significant impact on the regulator's confidence level.

Title: "METHODOLOGY FOR ESTIMATING ACCIDENTAL RADIOACTIVE RELEASES
IN NUCLEAR WASTE MANAGEMENT"

Author: H. B. Levy (LLL)

Reference: UCRL 81681 Abstract, NRC Contractors' Conference, Coalfont,
W. Virginia, September 18-20, 1978

Abstract: In the assessment of the radiological risks associated with a nuclear waste management system it is necessary to estimate possible accidental radioactive releases so that the consequences of such releases may be evaluated. There are three mechanisms by which radionuclides may be released to the biosphere -- air dispersion of fine particles; volatilization; and leaching. One must estimate how much of each significant radionuclide is released by each mechanism.

An accidental release of radioactivity generally involves a breach of one or more protective barriers. The probabilities of breaching protective barriers and what fractions of which radionuclides are released depend on the type of accident occurring and the severity of the accident conditions. The methodology of using these probabilities and fractional releases to derive a set of radioactive release functions for a nuclear waste management system will be discussed in this paper.

Title: "TECHNICAL SUPPORT CALCULATIONS FOR LL"
Author: B. Ross (TASC)
Reference: UCRL 81662 Abstract, Nat. Contractors' Conference, Coalfont,
W. Virginia, September 18-20, 1978
Abstract: TASC has been conducting computations and modeling for the
analysis of nuclear waste management issues under subcontract
to Lawrence Livermore Laboratory. Both pre-emplacment
accidents and the long-term hazards from geologic disposal
have been studied.

The pre-emplacment risk model, PREDOSE, calculates expected
values of population dose from all pre-emplacment accidents
for a variety of waste forms. The model for analyzing post-
emplacment releases (POSTRAH) is composed of the ORIGEN code
developed at ORNL and models for nuclide transport in groundwater
(WASTE) and for biosphere transport and doses to man (BIODOSE).
POSTRAH can be used to calculate doses from migration of radio-
nuclides to surface waters or from withdrawal of contaminated
groundwater through wells. The model incorporates a novel
statistical method for analyzing random future events.

Repositories located in bedded salt, shale, and basalt have
been analyzed with this model. Extensive sensitivity studies
have been conducted for both the bedded salt and shale cases.
In addition, a method has been developed of analyzing uncer-
tainties in the results due to uncertainties in values of input
parameters.

Title: "THE EFFECT OF RETARDATION FACTORS ON RADIOACTIVE RELEASE"

Author: M. S. Giuffre, E. Pore (ORNL)

Reference: OORL 6168 Abstract, NEA Contractors' Conference, Coalport, W. Virginia, September 16-20, 1978

Abstract: Burkholder and Glotinger have shown that the predicted maximum discharge rates to the biosphere for certain nuclides contained in deeply buried radioactive waste may increase above the corresponding values for surface storage. This phenomenon is called the reconcentration effect. The effect is due to the difference in sorption retardation factors for members of a nuclide decay chain. It is very large in the case of a parent-daughter decay pair for which the daughter has a much smaller half-life and retardation factor than its parent.

The discharge rates of daughter nuclides can be calculated explicitly using formulas derived by Burkholder et al. However, these formulas are quite complex, would become extremely cumbersome if used for numerical calculations in situations more complicated than those studied thus far, and often obscure the physical significance of the effect. It is therefore useful to be able to calculate daughter discharge rates from the discharge rates of their parents by applying a simple correction factor. This paper presents such a correction factor.

Title: "A CRITICAL REVIEW OF RETARDATION FACTORS USED TO PREDICT RADIONUCLIDE MIGRATION"

Author: D. G. Isherwood (LLL)

Reference: OURL 41716 Abstract

Abstract: Sorption (ion exchange) is considered the primary geochemical control on radionuclide migration from a nuclear waste repository. In computer models used to simulate radionuclide migration, sorption is represented by the retardation factor; that is, the velocity of the groundwater relative to that of the radionuclide. Retardation factors can be calculated from ion exchange distribution coefficients (K_d) provided we assume equilibrium conditions, rock homogeneity, and interstitial groundwater flow rather than fracture flow. Unfortunately, these conditions are often absent in nature, and there is little assurance that the K_d measured in the laboratory represents the in situ sorption properties of the rock. A literature survey shows most K_d measurements are done in an oxidizing environment using simple solutions. This is in sharp contrast to deep groundwaters which are thought to be reducing and contain numerous complexing agents. Since retardation factors take into account only ion exchange, other factors which effect retardation such as polymerization, precipitation, irreversible reactions and kinetic barriers are ignored. As a first step to understanding the complexities of retardation, a chemical equilibrium code was used to test the relative importance of oxidation potential, acidity, and groundwater composition on the formation of stable aqueous species. The results from this initial study suggest that species likely to be present in groundwater are quite different from those used in K_d experiments and that retardation factors currently in use to predict radionuclide migration must be viewed with caution.

Title: "MIGRATION OF FLUID INCLUSIONS IN SALT ADJACENT TO A RADIOACTIVE WASTE CANISTER"

Author: L. S. Gaffney (Pacific Technology), H. Cheung (LLL)

Reference: UCRL 61976 Abstract, Symposium on Salinity Problems in Groundwater, AGU Fall Annual Meeting, December 4, 1976

Abstract: Inclusions on bittern brine are common in bedded salt deposits; at the site of the WIPP they account for about 0.5 percent water by weight (about 1 percent brine by volume). These inclusions will migrate under the influence of temperature and pressure gradients. For inclusions larger than 1 mm and temperatures above 100°C the governing equation for migration velocity (v) is

$$v = - \frac{D C_h}{\rho} \left[\left(\frac{\partial \ln C_h}{\partial \phi} + \psi \right) \frac{d\phi}{dx} \right]$$

where D = diffusion coefficient; C_h = concentration of host in solution; ρ = density of host mineral; ϕ = temperature (T) or pressure (P); ψ = Soret coefficient if $\phi = T$ or $\psi = V_s/RT$ with V_s being the partial molar volume of host and R being the gas constant if $\phi = P$; and x = distance along ϕ gradient. Smaller inclusions will move slower. Applying this relation to the situation of Project Salt Vault an accumulated brine volume of 13 to 26 liters per canister is calculated. This is 2 to 3 times the amount of steam condensate reported for that test. However, when allowance is made for vapor pressure effects in the brine, the two values are quite consistent. Extrapolation to a 10 year retrieval period in WIPP would indicate 15 to 40 liters of brine accumulation.

UCIDs

17,000 and 18,000 series

Title: "INTERIM REPORT TO THE NUCLEAR REGULATORY COMMISSION
ON RADIOACTIVE WASTE CLASSIFICATION"

Author: W. C. King, J. J. Cohen (LLL)

Reference: UCID 17497, April 18, 1977

Abstract: The Lawrence Livermore Laboratory assisted the Nuclear Regulatory Commission in the development of a radioactive waste classification system that will satisfy technical, environmental, and societal concerns.

This is an interim report to the NRC on work accomplished to date. It describes a proposed waste-classification system that is based on the final disposition of waste material. The system consists of three classes of radioactive waste. The classification of any radioactive waste will depend primarily on its hazard potential. Other characteristics such as longevity (half-life) will be considered also.

The levels of hazard that differentiate the three classes of radioactive waste will be determined by ongoing work. This report describes other work to be completed before a suitable radioactive waste-classification system is established.

Title: "PRELIMINARY REPORT ON RETARDATION FACTORS AND RADIONUCLIDE MIGRATION"

Author: D. J. Isherwood (LLL)

Reference: UCID 17551, August 5, 1977

Abstract: The available data and distribution coefficients for the biologically important radionuclides present in high level-waste were used to estimate retardation factors (R_f) for a mass transport hydrologic model. The radionuclides were divided into 3 groups: fission products with no sorption ($R_f = 1$), fission products with sorption ($R_f = 10^2$), and the actinides and their daughter products ($R_f = 10^4$). Minimum and maximum values were assigned the latter two groups. Uncertainties as a function of time were estimated at $\pm$ an order of magnitude.

Title: "SITE SUITABILITY CRITERIA FOR SOLIDIFIED HIGH LEVEL WASTE REPOSITORIES"

Author: R. A. Heckman, T. Holdsworth, D. I. Towse (LLL)

Reference: UCID 17830, March 7, 1979

Abstract: In discharging its responsibilities, the Nuclear Regulatory Commission (NRC) is developing a framework of regulations, criteria, and standards. Lawrence Livermore Laboratory (LLL) provides broad technical support to the NRC for developing this regulatory framework, part of which involves site suitability criteria for solidified high-level wastes (SHLW).

Both the regulatory framework and the technical base on which it rests have evolved in time. This document is the initial report of the technical support project. It was issued as a draft working paper for a programmatic review held at LLL on March 22 and 23, 1977. It was printed and distributed solely as a briefing document on preliminary technology and initial findings for the purpose of critical review by those in attendance.

This briefing document is being reprinted now in its original format as a UCID-series report for the sake of the historical record.

For current (1979) information, the reader is referred to the most recent publications of the LLL technical support project, in particular, "High-Level Waste Repository Site Suitability" (UCRL 52633, NRCRG/CR 0576), which has its genesis in the two 1977 briefing documents.

Title: "SITE SUITABILITY CRITERIA FOR SELECTING HIGH-LEVEL WASTE REPOSITORIES"

Author: R. A. Beckman, L. Holdsworth, D. W. Liverwood, W. E. Foster, and, Nadia L. Layan. (NRC)

Reference: UCRL 17631, April 3, 1979

Abstract: In discharging its responsibilities, the Nuclear Regulatory Commission (NRC) is developing a framework of regulations, criteria, and standards. Lawrence Livermore Laboratory (LL) provides broad technical support to the NRC for developing this regulatory framework, part of which involves site suitability criteria for solidified high-level wastes (HLW).

Both the regulatory framework and the technical base on which it rests have evolved in time. This document is the initial report of the technical support project. It was issued as a *draft working paper for a programmatic review held at LL from August 16 to 18, 1977*. It was printed and distributed solely as a *briefing document on preliminary methodology and initial findings for the purpose of critical review by those in attendance*.

This briefing document is being reprinted now in its original format as a UCRL-series report for the sake of the historical record.

For current (1979) information, the reader is referred to the most recent publications of the LL technical support project, in particular, "High-Level Waste Repository Site Suitability" (UCRL 52633, NRCREG/OR 057-1), which has its genesis in the two 1977 briefing documents.

title: "A Unified Approach to the Management of Data at LSS-1"

Author: L. Harvey (ed.)

reference: LSS-175, July 1977

abstract: A management/planning model employed as a control tool for planning and guiding the development of a nuclear waste repository data base is described. It incorporates the technical assessment goals and objectives of the U.S. Nuclear Regulatory Commission, and it provides a strategy for reaching them. The model strategy includes provisions for the breadth, timeliness, and defensibility of its predictions. Consideration is given to observational data, its structure, and future refinements. The structure of the data is consistent with the needs of a systems model whose structure is designed to resolve questions about repository safety.

Uncertainties are categorized as critical in defining and resolving technical issues. The model provides a framework for ultimately exposing all the sensitive and controversial factors. Some quantitative aspects of data acquisition are presented.

Title: "INTERIM REPORT ON 'GEOLAP' ANALYSIS OF THE 'GEOLAP' ANALYSIS"

Author: I. J. Altenbach (ILL)

Reference: UCID 17665, September 1976

Abstract: A thermal analysis of a deep geologic repository for spent nuclear fuel is being conducted at ILL as part of the NRC Nuclear Waste Management Program. The TPUMP finite difference heat transfer code is used to analyze a 3-dimensional model of the repository. The model uses a unit cell consisting of one spent fuel canister buried in salt beneath a ventilated room in the repository. A base case was studied along with several parametric variations. It is concluded that this method is appropriate for analyzing the thermal response of the system, and that the most important parameter in determining the maximum temperatures is the canister heat generation rate. The effects of room ventilation and different repository media are secondary. Future work will extend this analysis and improve upon some of the simplifications used.

Title: "SUGGESTED NUCLEAR WASTE MANAGEMENT EARLY EVALUATION PERFORMANCE OBJECTIVES"

Author: J. J. Cohen (LLI)

Reference: SCIS 17660, August 1977

Abstract: Development of criteria for the safe disposal of nuclear wastes in geologic media requires the establishment of definitive objectives against which the adequacy of various waste management methods may be judged. This report suggests certain guidelines that might serve as first approximations pending promulgation of official criteria. These include:

- The allowable radiation dose to individuals should be related to the predicted probability of receiving the dose such that as the dose increases, the events leading to that dose should become less probable. A quantitative relationship is developed and discussed.
- Selection of a waste management method should be made in accordance with the principles of ANAPO.
- Doses to future generations should be considered to be equally as serious as doses to present populations.
- When the hazard potential of an underground nuclear waste repository becomes less than that of typical hazardous ore formations (i.e., 0.2% uranium ore), further concern is unwarranted.

Title: "ADDITIONAL MEDIA STUDIES FOR SITE SUITABILITY CRITERIA"

Author: T. K. Donich, A. K. Kaufman, G. B. Seaton, L. L. Sternborn,
D. F. Towse (LLL)

Reference: UCID 17867, August 11, 1976

Abstract: Site suitability studies at LLL to date have considered repositories in bedded salt and shale. The models have been varied to include a number of dimensions, parameter values, histories, and potential failure modes. These model studies have enabled us to provide preliminary site suitability criteria based on parameter sensitivity calculations and to begin uncertainty analyses.

Inasmuch as in situ tests are either underway or planned for the near future in other geologic environments in the United States, and since these environments may be recommended as waste repositories, work should begin immediately to produce results for these environments that are similar to those we have for the bedded media. Once the necessary data are available and the models developed, advanced analyses can be conducted in parallel with those on shale and bedded salt.

In this report we consider domed salt, basalt, and crystalline rock, comparing these three media with each other and with bedded salt and shale.

Title: "SUMMARY OF CLIMATE DATA FOR WASTE MANAGEMENT SITE SUSTAINABILITY CRITERIA AND STATE OF PROGRAM"

Author: G. L. Potter (et al.)

Reference: WTR-17904, May 1994

Abstract: Because groundwater movement can have important effects on buried nuclear wastes, hydrologists need to know if future climatic changes will influence the accuracy of groundwater flow calculations. Groundwater recharge (and therefore groundwater flows) depends on surface water balance. (Surface water balance equals precipitation less losses to evaporation, runoff, and storage.)

The developing data for understanding climatic effects, we have made the following sustainability assumptions:

- Climate (and therefore water balance) will behave in the future very much as it has in the past.
- Groundwater recharge responds linearly to precipitation.
- Future long-term climatic changes can be classified into groups or regions that are similar to those of the past.

Our current research is aimed at providing input data to the Waste Management Program's site sustainability task.

Title: "USER'S MANUAL FOR A 2-D, GROUNDWATER FLOW CODE ON THE OCTOPUS COMPUTER MODEL"

Author: T. G. Taylor (LLI)

Reference: UCID 17908, August 1977.

Abstract: *A groundwater hydrology computer code, programmed by R. L. Taylor (in Proc. American Society of Civil Engineers, Journal of Hydraulics Division, 95(3/2), pp. 25-33, 1967), has been adapted to the Octopus computer system at Lawrence Livermore Laboratory. Using an example problem, this manual details the input, output, and execution options of the code.*

Title: "CORROSION STUDIES OF RETRIEVABLE SPENT FUEL CONTAINERS: A PRELIMINARY REPORT"

Author: W. Eversmann, L. Abrego, R. W. Mounight (ILL)

Reference: UCRL 17917, December 1977.

Abstract: Spent fuel canisters stored in halite (salt) deposits (salt beds) are subject to a severely corrosive environment when the hot brine inclusions, rich in calcium and magnesium chlorides, migrate to the canister. Since no data base exists on corrosion in halite brines, a survey was made of the corrosion resistance of potential canister materials in other concentrated brine environments. Corrosion-resistant metals include Ti, Ti Code 12, Ti-6 Alloy, Inconel 625, Hastelloy C-276, and Fe-base 22-4 Alloy. Although carbon steels have cost and availability advantages, they suffer from excessive corrosion rates in brines. Corrosion-resistant nonmetals include carbon, Teflon-type fluorocarbons, epoxide coatings, and polymer cements. While these materials are not suitable for constructing the canister, they could be used as a protective coating on a carbon steel canister. On the basis of this survey, we recommend a coated carbon steel canister, used with cathodic protection. It is important to start a test program to gather a data base on the corrosion of materials in halite brines and to verify the suitability of canister materials.

Title: "DEVELOPMENT OF RADIOLOGICAL PERFORMANCE OBJECTIVES, INTERIM RESULTS: TRADE-OFFS IN ATTITUDES TOWARD RADIOACTIVE WASTE"

Author: J. W. Lathrop (LLL)

Reference: LLL-17926, July 1976

Abstract: Lawrence Livermore Laboratory is developing a methodology for the generation of radiological performance objectives for the regulation of radioactive waste. Interim reports describing this work have been produced, and a final report will become available by November, 1976. To measure the risk associated with radioactive waste, it is necessary to ascertain public opinion concerning the relative significance of the different possible health effects of radiation, and public attitudes towards uncertainty.

Lawrence Livermore Laboratory has directed Decisions and Designs, Incorporated (DDI), to elicit such views from various members of the public. The purpose of this note is to give a brief account of some of the views so far obtained, provide some interpretation of these results, and briefly demonstrate how these results can be used to guide the drafting of regulations.

Title: "WASTE PIPE CALCULUS"

Author: A. M. Laufman (LLL)

Reference: UCID 17953, October 13, 1976

Abstract: We present a rapid method of calculating transport in a network of one dimensional flow paths or "pipes." The method defines a Green's function for each flow path and prescribes a method of combining these Green's functions to produce an overall Green's function for the flow path network. A unique feature of the method is the use of the Laplace transform of these Green's functions to carry out most of the calculations.

Title: "THREE DIMENSIONAL THERMAL ANALYSIS OF HIGH-LEVEL WASTE REPOSITORY"

Author: L. Allenbach (LLL)

Reference: UCID 17964, April 1979

Abstract: This report documents the three-dimensional thermal analysis of a high-level waste repository. The analysis used the TRUMP computer code to evaluate the thermal fields for six repository scenarios that studied the effects of room ventilation, room backfill, and repository thermal diffusivity. The results for selected nodes are presented as plots showing the effect of temperature as a function of time.

Title: "USER'S MANUAL FOR A MATERIAL TRANSPORT CODE ON THE OCTOPUS
COMPUTER NETWORK"

Author: T. Naymik, G. Mendez (LLL)

Reference: UCID 17966, September 1974

Abstract: A code to simulate material transport through porous media
was developed at Oak Ridge National Laboratory. This code has
been modified and adapted for use at Lawrence Livermore Laboratory.
This manual, in conjunction with report ORNL-4928, explains the
input, output, and execution of the code on the Octopus Computer
Network.

Title: "EVALUATION OF THE ADINA-3D Thermal Stress Analysis Code for a NPP Waste Repository"

Author: B. Davis (11)

Reference: BDB 1461, January 1992

Abstract: Thermal modeling of a nuclear waste repository is basic to most waste management predictive models. It is important that the modeling techniques accurately determine the time-dependent temperature distribution of the waste emplacement media. Recent modeling studies show that the time-dependent temperature distribution can be accurately modeled in the far-field using a 2-dimensional (2-D) plane numerical model, however, the near-field cannot be modeled accurately enough by either 2-D axisymmetric or 2-D plane numerical models for repository analysis. The accuracy limits of 2-D modeling were defined by comparing results from 3-dimensional (3-D) finite element models with results from both 2-D axisymmetric and 2-D plane models. Both ABAQUS and ADINA were employed as modeling tools. Two-dimensional results from the finite element code, ABAQUS, were compared with 2-D results from the finite difference code, ADINA. They showed almost perfect correspondence in the far-field. This result adds substantially to confidence in future use of ADINA and its companion stress code ABUS for thermal stress analysis. ADINA was found to be somewhat sensitive to time step and mesh aspect ratio.

Title: "FLUID INCLUSIONS IN SALT - An annotated bibliography"

Author: D. Isherwood (LLL)

Reference: OCLD 16102, January 1973

Abstract: This annotated bibliography was compiled while searching the literature for information on fluid inclusions in salt for the Nuclear Regulatory Commission's study on the deep-geologic disposal of nuclear waste. The migration of fluid inclusions in a thermal gradient is a potential hazard to the safe disposal of nuclear waste in a salt repository. At the present time, we cannot predict whether this hazard precludes the use of salt for waste disposal. Limited data from the "Salt-Vault" in situ heater experiments in the early 1960's (Bradshaw and McCain, 1971) give little doubt that fluid inclusions can migrate towards a heat source. In addition to the bibliography, there is a brief summary of the physical and chemical characteristics that together with the temperature of the waste will determine the chemical composition of the brine in contact with the waste canister, the rate of fluid migration, and the brine-canister-waste interactions.

Title: *NUCLEAR and Thermal Analysis of a Nuclear Waste Repository*

Author: *G. Davis, et al.*

Reference: *NUH 16193, January 1987*

Abstract: *Time-dependent, two-dimensional finite element analyses of a nuclear waste repository have been performed to determine the physical integrity of the proposed container and its thermal, geomechanical, and irreversibility options. The repository analyses include the effects of dynamic properties and physical parameters on three categories: regimes--forced, natural, and mixed; (2) determine the effects of correlations applicable to calculating heat flow in a repository (forced-air) and in a unventilated nuclear waste repository room; and (3) delineated a computer code that (a) calculates and compares the floor-to-ceiling heat flow by convection and radiation, and (b) determines the nonlinear equivalent conductivity needed for a repository room. The tables use the output of the called code to model surface-to-surface radiation and the logic is set to employ two different emissivity properties when modeling radiation exchange between the surface at two different elevations. The analysis shows that thermal radiation dominates heat flow modes in a nuclear waste repository room.*

Title: "PERFORMANCE CRITERIA FOR HIGH-LEVEL SOLIDIFIED NUCLEAR WASTE"

Author: R. A. Beckman, L. Holdsworth (LLL)

Reference: OJLB 1411, May 1979

Abstract: In discharging its responsibilities, the Nuclear Regulatory Commission (NRC) is developing a framework of regulations, criteria, and standards. Lawrence Livermore Laboratory (LLL) provides broad technical support to the NRC for developing this regulatory framework, part of which involves the determination of performance criteria for high-level solidified nuclear waste.

Both the regulatory framework and the technical base on which it rests, have evolved in time. This document is the briefing document on performance criteria, as required by the 1977 Statement of Work between LLL and the NRC. It is being reprinted now in its original format as a OJLB-series report for the sake of the historical record.

For current (1979) information, the reader is referred to the most recent publications of the LLL technical support project, in particular, "A Probabilistic Safety Analysis for Solidified High-Level Nuclear Waste Management Systems: A Status Report" (UCRL 52532, NUREG/CN-0577).

64615
13,900 and 15,000 series
(Subcontractor Reports)

Title: *High-Level Waste Site Suitability Criteria for High-Level Waste Repository*

Author: *TRCA Corporation*

Reference: *TRCA 127/89, 127/89-1*

Abstract: *The particular subject of the high-level waste repository waste management regulation addressed in this report is the program to develop site suitability criteria for high-level waste site repository. The first phase of this program defined the earth sciences parameters which will be considered in evaluating potential sites for high-level waste repositories. The second phase effort will be directed toward developing acceptable earth sciences criteria for use in determining site suitability, and developing other acceptance criteria including geology, geophysics, and hydrology factors. Preliminary TRCA staff estimates indicate that publication of the proposed site suitability criteria, along with a supporting environmental impact statement (EIS), will occur in mid-1990.*

This report describes the approach, methodology, which has been developed for the preparation of the EIS. A suggested outline is presented for the high-level waste repository site Suitability Criteria EIS together with a detailed description of the approach to be used in preparing the EIS. In addition, a methodology is presented by which the necessary cost/benefit, risk comparisons of alternative sets of site suitability criteria can be made.

1. *Title* *Facility for the production of a new type of*
 metallic material.

2. *Author* *Engineering Institute.*

3. *Reference* *Engineering Institute.*

4. *Abstract* *The article contains a description of the method for the production of a new type of metallic material, which is characterized by a high degree of resistance to corrosion and a high degree of strength. The method involves the use of a special alloy and a special process of production. The article also contains a description of the method of testing the material and the results of the tests. The article is written in Russian and is intended for the use of engineers and scientists in the field of metallurgy.*

5. *Summary* *The article describes the method for the production of a new type of metallic material, which is characterized by a high degree of resistance to corrosion and a high degree of strength. The method involves the use of a special alloy and a special process of production. The article also contains a description of the method of testing the material and the results of the tests. The article is written in Russian and is intended for the use of engineers and scientists in the field of metallurgy.*

It is not clear whether the above results are due to the fact that the

1. *Chrysomelidae* (100%)

Abstract.—The purpose of this study was to determine the effects of the following factors on the growth of the rainbow trout, *Oncorhynchus mykiss* (Walbaum), in relation to the water temperature and the water oxygen concentration: (1) the water temperature, (2) the water oxygen concentration, (3) the water temperature and the water oxygen concentration, (4) the water temperature and the water oxygen concentration and the water pH, and (5) the water temperature and the water oxygen concentration and the water pH and the water hardness. The results of the study showed that the water temperature and the water oxygen concentration were the most important factors affecting the growth of the rainbow trout. The water pH and the water hardness were not significant factors affecting the growth of the rainbow trout. The water temperature and the water oxygen concentration were the most important factors affecting the growth of the rainbow trout. The water pH and the water hardness were not significant factors affecting the growth of the rainbow trout.

Howard et al., 2001). In addition, the authors found that the samples of two sexes for both populations were not significantly different in the number of eggs per female, and that the proportion of mated females was not different between the two populations. In addition, the authors found that the proportion of mated females was not different between the two populations. In addition, the authors found that the proportion of mated females was not different between the two populations.

This report consists of a survey of the existing literature on vegetation conducted by a student of the Department of Botany, followed by basic data and detailed studies of some of the vegetation types that were studied.

The first of these is the fact that the
 second of these is the fact that the
 third of these is the fact that the
 fourth of these is the fact that the
 fifth of these is the fact that the
 sixth of these is the fact that the
 seventh of these is the fact that the
 eighth of these is the fact that the
 ninth of these is the fact that the
 tenth of these is the fact that the
 eleventh of these is the fact that the
 twelfth of these is the fact that the
 thirteenth of these is the fact that the
 fourteenth of these is the fact that the
 fifteenth of these is the fact that the
 sixteenth of these is the fact that the
 seventeenth of these is the fact that the
 eighteenth of these is the fact that the
 nineteenth of these is the fact that the
 twentieth of these is the fact that the
 twenty-first of these is the fact that the
 twenty-second of these is the fact that the
 twenty-third of these is the fact that the
 twenty-fourth of these is the fact that the
 twenty-fifth of these is the fact that the
 twenty-sixth of these is the fact that the
 twenty-seventh of these is the fact that the
 twenty-eighth of these is the fact that the
 twenty-ninth of these is the fact that the
 thirtieth of these is the fact that the
 thirty-first of these is the fact that the
 thirty-second of these is the fact that the
 thirty-third of these is the fact that the
 thirty-fourth of these is the fact that the
 thirty-fifth of these is the fact that the
 thirty-sixth of these is the fact that the
 thirty-seventh of these is the fact that the
 thirty-eighth of these is the fact that the
 thirty-ninth of these is the fact that the
 fortieth of these is the fact that the
 forty-first of these is the fact that the
 forty-second of these is the fact that the
 forty-third of these is the fact that the
 forty-fourth of these is the fact that the
 forty-fifth of these is the fact that the
 forty-sixth of these is the fact that the
 forty-seventh of these is the fact that the
 forty-eighth of these is the fact that the
 forty-ninth of these is the fact that the
 fiftieth of these is the fact that the
 fifty-first of these is the fact that the
 fifty-second of these is the fact that the
 fifty-third of these is the fact that the
 fifty-fourth of these is the fact that the
 fifty-fifth of these is the fact that the
 fifty-sixth of these is the fact that the
 fifty-seventh of these is the fact that the
 fifty-eighth of these is the fact that the
 fifty-ninth of these is the fact that the
 sixtieth of these is the fact that the
 sixty-first of these is the fact that the
 sixty-second of these is the fact that the
 sixty-third of these is the fact that the
 sixty-fourth of these is the fact that the
 sixty-fifth of these is the fact that the
 sixty-sixth of these is the fact that the
 sixty-seventh of these is the fact that the
 sixty-eighth of these is the fact that the
 sixty-ninth of these is the fact that the
 seventieth of these is the fact that the
 seventy-first of these is the fact that the
 seventy-second of these is the fact that the
 seventy-third of these is the fact that the
 seventy-fourth of these is the fact that the
 seventy-fifth of these is the fact that the
 seventy-sixth of these is the fact that the
 seventy-seventh of these is the fact that the
 seventy-eighth of these is the fact that the
 seventy-ninth of these is the fact that the
 eightieth of these is the fact that the
 eighty-first of these is the fact that the
 eighty-second of these is the fact that the
 eighty-third of these is the fact that the
 eighty-fourth of these is the fact that the
 eighty-fifth of these is the fact that the
 eighty-sixth of these is the fact that the
 eighty-seventh of these is the fact that the
 eighty-eighth of these is the fact that the
 eighty-ninth of these is the fact that the
 ninetieth of these is the fact that the
 ninety-first of these is the fact that the
 ninety-second of these is the fact that the
 ninety-third of these is the fact that the
 ninety-fourth of these is the fact that the
 ninety-fifth of these is the fact that the
 ninety-sixth of these is the fact that the
 ninety-seventh of these is the fact that the
 ninety-eighth of these is the fact that the
 ninety-ninth of these is the fact that the
 hundredth of these is the fact that the

Title: "Methods and Procedures for Identifying and Evaluating Alternative Approaches"

Author: Systems Institute, Inc.

Reference: NRC-1280, 12/10/78

Abstract: This report is developed by the contractor in response to the need of the NRC for the development of alternative risk reduction strategies and methods for the reduction of nuclear waste. The study was funded by the NRC and herein contained the following items:

1. Review existing risk reduction methods and identify for future development alternative methods and strategies.
2. Identify factors which govern the development of the development of risk reduction for nuclear waste management activities.
3. List and define alternative approaches which can be used in risk development for nuclear waste.
4. Assemble a multidisciplinary task force to review the alternative approaches, and provide additional to the set of issues of importance for the development for during the development of the.
5. Utilizing the results of the development, perform a comprehensive review of the pros and cons of each approach.

Title: Review of the Environmental Impacts of Solidified High-Level Radioactive Waste

Author: James R. Smith

Reference: EIS-1134, September 1977

Abstract: This draft environmental impact statement was developed to support the regulation for performance criteria for solidified high-level radioactive waste (HLW).

For the purpose of this study, the high-level waste management system has been defined as the processing of the solidified waste from through the interim storage operation, the transportation of the waste to the federal waste repository site, the handling of the repository, and, finally, the future history after sealing of the repository. In addition, the waste-only recycle fuel cycle is considered. Other alternatives including plutonium and uranium recycle will be investigated in later studies.

1. *Introduction*

2. *Methodology*

3. *Results*

4. *Discussion*

5. *Conclusion*

6. *References*

7. *Appendix*

8. *Index*

9. *Table of Contents*

10. *Summary*

11. *Abstract*

12. *Keywords*

13. *Subject Headings*

14. *Notes*

15. *Footnotes*

16. *Endnotes*

17. *References*

18. *Appendix*

19. *Index*

20. *Table of Contents*

21. *Summary*

22. *Abstract*

23. *Keywords*

24. *Subject Headings*

25. *Notes*

26. *Footnotes*

27. *Endnotes*

28. *References*

29. *Appendix*

30. *Index*

31. *Table of Contents*

32. *Summary*

33. *Abstract*

34. *Keywords*

35. *Subject Headings*

36. *Notes*

37. *Footnotes*

38. *Endnotes*

39. *References*

40. *Appendix*

41. *Index*

42. *Table of Contents*

43. *Summary*

44. *Abstract*

45. *Keywords*

46. *Subject Headings*

47. *Notes*

48. *Footnotes*

49. *Endnotes*

50. *References*

51. *Appendix*

52. *Index*

53. *Table of Contents*

54. *Summary*

55. *Abstract*

56. *Keywords*

57. *Subject Headings*

58. *Notes*

59. *Footnotes*

60. *Endnotes*

61. *References*

62. *Appendix*

63. *Index*

64. *Table of Contents*

65. *Summary*

66. *Abstract*

67. *Keywords*

68. *Subject Headings*

69. *Notes*

70. *Footnotes*

71. *Endnotes*

72. *References*

73. *Appendix*

74. *Index*

75. *Table of Contents*

76. *Summary*

77. *Abstract*

78. *Keywords*

79. *Subject Headings*

80. *Notes*

81. *Footnotes*

82. *Endnotes*

83. *References*

84. *Appendix*

85. *Index*

86. *Table of Contents*

87. *Summary*

88. *Abstract*

89. *Keywords*

90. *Subject Headings*

91. *Notes*

92. *Footnotes*

93. *Endnotes*

94. *References*

95. *Appendix*

96. *Index*

97. *Table of Contents*

98. *Summary*

99. *Abstract*

100. *Keywords*

101. *Subject Headings*

102. *Notes*

103. *Footnotes*

104. *Endnotes*

105. *References*

106. *Appendix*

107. *Index*

108. *Table of Contents*

109. *Summary*

110. *Abstract*

111. *Keywords*

112. *Subject Headings*

113. *Notes*

114. *Footnotes*

115. *Endnotes*

116. *References*

117. *Appendix*

118. *Index*

119. *Table of Contents*

120. *Summary*

121. *Abstract*

122. *Keywords*

123. *Subject Headings*

124. *Notes*

125. *Footnotes*

126. *Endnotes*

127. *References*

128. *Appendix*

129. *Index*

130. *Table of Contents*

131. *Summary*

132. *Abstract*

133. *Keywords*

134. *Subject Headings*

135. *Notes*

136. *Footnotes*

137. *Endnotes*

138. *References*

139. *Appendix*

140. *Index*

141. *Table of Contents*

142. *Summary*

143. *Abstract*

144. *Keywords*

145. *Subject Headings*

146. *Notes*

147. *Footnotes*

148. *Endnotes*

149. *References*

150. *Appendix*

151. *Index*

152. *Table of Contents*

153. *Summary*

154. *Abstract*

155. *Keywords*

156. *Subject Headings*

157. *Notes*

158. *Footnotes*

159. *Endnotes*

160. *References*

161. *Appendix*

162. *Index*

163. *Table of Contents*

164. *Summary*

165. *Abstract*

166. *Keywords*

167. *Subject Headings*

168. *Notes*

169. *Footnotes*

170. *Endnotes*

171. *References*

172. *Appendix*

173. *Index*

174. *Table of Contents*

175. *Summary*

176. *Abstract*

177. *Keywords*

178. *Subject Headings*

179. *Notes*

180. *Footnotes*

181. *Endnotes*

182. *References*

183. *Appendix*

184. *Index*

185. *Table of Contents*

186. *Summary*

187. *Abstract*

188. *Keywords*

189. *Subject Headings*

190. *Notes*

191. *Footnotes*

192. *Endnotes*

193. *References*

194. *Appendix*

195. *Index*

196. *Table of Contents*

197. *Summary*

198. *Abstract*

199. *Keywords*

200. *Subject Headings*

201. *Notes*

202. *Footnotes*

203. *Endnotes*

204. *References*

205. *Appendix*

206. *Index*

207. *Table of Contents*

208. *Summary*

209. *Abstract*

210. *Keywords*

211. *Subject Headings*

212. *Notes*

213. *Footnotes*

214. *Endnotes*

215. *References*

216. *Appendix*

217. *Index*

218. *Table of Contents*

219. *Summary*

220. *Abstract*

221. *Keywords*

222. *Subject Headings*

223. *Notes*

224. *Footnotes*

225. *Endnotes*

226. *References*

227. *Appendix*

228. *Index*

229. *Table of Contents*

230. *Summary*

231. *Abstract*

232. *Keywords*

233. *Subject Headings*

234. *Notes*

235. *Footnotes*

236. *Endnotes*

237. *References*

238. *Appendix*

239. *Index*

240. *Table of Contents*

241. *Summary*

242. *Abstract*

243. *Keywords*

244. *Subject Headings*

245. *Notes*

246. *Footnotes*

247. *Endnotes*

248. *References*

249. *Appendix*

250. *Index*

251. *Table of Contents*

252. *Summary*

253. *Abstract*

254. *Keywords*

255. *Subject Headings*

256. *Notes*

257. *Footnotes*

258. *Endnotes*

259. *References*

260. *Appendix*

261. *Index*

262. *Table of Contents*

263. *Summary*

264. *Abstract*

265. *Keywords*

266. *Subject Headings*

267. *Notes*

268. *Footnotes*

269. *Endnotes*

270. *References*

271. *Appendix*

272. *Index*

273. *Table of Contents*

274. *Summary*

275. *Abstract*

276. *Keywords*

277. *Subject Headings*

278. *Notes*

279. *Footnotes*

280. *Endnotes*

281. *References*

282. *Appendix*

283. *Index*

284. *Table of Contents*

285. *Summary*

286. *Abstract*

287. *Keywords*

288. *Subject Headings*

289. *Notes*

290. *Footnotes*

291. *Endnotes*

292. *References*

293. *Appendix*

294. *Index*

295. *Table of Contents*

296. *Summary*

297. *Abstract*

298. *Keywords*

299. *Subject Headings*

300. *Notes*

301. *Footnotes*

302. *Endnotes*

303. *References*

304. *Appendix*

305. *Index*

306. *Table of Contents*

307. *Summary*

308. *Abstract*

309. *Keywords*

310. *Subject Headings*

311. *Notes*

312. *Footnotes*

313. *Endnotes*

314. *References*

315. *Appendix*

316. *Index*

317. *Table of Contents*

318. *Summary*

319. *Abstract*

320. *Keywords*

321. *Subject Headings*

322. *Notes*

323. *Footnotes*

324. *Endnotes*

325. *References*

326. *Appendix*

327. *Index*

328. *Table of Contents*

329. *Summary*

330. *Abstract*

331. *Keywords*

332. *Subject Headings*

333. *Notes*

334. *Footnotes*

335. *Endnotes*

336. *References*

337. *Appendix*

338. *Index*

339. *Table of Contents*

340. *Summary*

341. *Abstract*

342. *Keywords*

343. *Subject Headings*

344. *Notes*

345. *Footnotes*

346. *Endnotes*

347. *References*

348. *Appendix*

349. *Index*

350. *Table of Contents*

351. *Summary*

352. *Abstract*

353. *Keywords*

354. *Subject Headings*

355. *Notes*

356. *Footnotes*

357. *Endnotes*

358. *References*

359. *Appendix*

360. *Index*

361. *Table of Contents*

362. *Summary*

363. *Abstract*

364. *Keywords*

365. *Subject Headings*

366. *Notes*

367. *Footnotes*

368. *Endnotes*

369. *References*

370. *Appendix*

371. *Index*

372. *Table of Contents*

373. *Summary*

374. *Abstract*

375. *Keywords*

376. *Subject Headings*

377. *Notes*

378. *Footnotes*

379. *Endnotes*

380. *References*

381. *Appendix*

382. *Index*

383. *Table of Contents*

384. *Summary*

385. *Abstract*

386. *Keywords*

387. *Subject Headings*

388. *Notes*

389. *Footnotes*

390. *Endnotes*

391. *References*

392. *Appendix*

393. *Index*

394. *Table of Contents*

395. *Summary*

396. *Abstract*

397. *Keywords*

398. *Subject Headings*

399. *Notes*

400. *Footnotes*

401. *Endnotes*

402. *References*

403. *Appendix*

404. *Index*

405. *Table of Contents*

406. *Summary*

407. *Abstract*

408. *Keywords*

409. *Subject Headings*

410. *Notes*

411. *Footnotes*

412. *Endnotes*

413. *References*

414. *Appendix*

415. *Index*

416. *Table of Contents*

417. *Summary*

418. *Abstract*

419. *Keywords*

420. *Subject Headings*

421. *Notes*

422. *Footnotes*

423. *Endnotes*

424. *References*

425. *Appendix*

426. *Index*

427. *Table of Contents*

428. *Summary*

429. *Abstract*

430. *Keywords*

431. *Subject Headings*

432. *Notes*

433. *Footnotes*

434. *Endnotes*

435. *References*

436. *Appendix*

437. *Index*

438. *Table of Contents*

439. *Summary*

440. *Abstract*

441. *Keywords*

442. *Subject Headings*

443. *Notes*

444. *Footnotes*

445. *Endnotes*

446. *References*

447. *Appendix*

448. *Index*

449. *Table of Contents*

450. *Summary*

451. *Abstract*

452. *Keywords*

453. *Subject Headings*

454. *Notes*

455. *Footnotes*

456. *Endnotes*

457. *References*

458. *Appendix*

459. *Index*

460. *Table of Contents*

461. *Summary*

462. *Abstract*

463. *Keywords*

464. *Subject Headings*

465. *Notes*

466. *Footnotes*

467. *Endnotes*

468. *References*

469. *Appendix*

470. *Index*

471. *Table of Contents*

472. *Summary*

473. *Abstract*

474. *Keywords*

475. *Subject Headings*

476. *Notes*

477. *Footnotes*

478. *Endnotes*

479. *References*

480. *Appendix*

481. *Index*

482. *Table of Contents*

483. *Summary*

484. *Abstract*

485. *Keywords*

486. *Subject Headings*

487. *Notes*

488. *Footnotes*

489. *Endnotes*

490. *References*

491. *Appendix*

492. *Index*

493. *Table of Contents*

494. *Summary*

495. *Abstract*

496. *Keywords*

497. *Subject Headings*

498. *Notes*

499. *Footnotes*

500. *Endnotes*

501. *References*

502. *Appendix*

503. *Index*

504. *Table of Contents*

505. *Summary*

506. *Abstract*

507. *Keywords*

508. *Subject Headings*

509. *Notes*

510. *Footnotes*

511. *Endnotes*

512. *References*

513. *Appendix*

514. *Index*

515. *Table of Contents*

516. *Summary*

517. *Abstract*

518. *Keywords*

519. *Subject Headings*

520. *Notes*

521. *Footnotes*

522. *Endnotes*

523. *References*

524. *Appendix*

525. *Index*

526. *Table of Contents*

527. *Summary*

528. *Abstract*

529. *Keywords*

530. *Subject Headings*

531. *Notes*

532. *Footnotes*

533. *Endnotes*

534. *References*

535. *Appendix*

536. *Index*

537. *Table of Contents*

538. *Summary*

539. *Abstract*

540. *Keywords*

541. *Subject Headings*

542. *Notes*

543. *Footnotes*

544. *Endnotes*

545. *References*

546. *Appendix*

547. *Index*

548. *Table of Contents*

549. *Summary*

550. *Abstract*

551. *Keywords*

552. *Subject Headings*

553. *Notes*

554. *Footnotes*

555. *Endnotes*

556. *References*

557. *Appendix*

558. *Index*

559. *Table of Contents*

560. *Summary*

561. *Abstract*

562. *Keywords*

563. *Subject Headings*

564. *Notes*

565. *Footnotes*

566. *Endnotes*

567. *References*

568. *Appendix*

569. *Index*

570. *Table of Contents*

571. *Summary*

572. *Abstract*

573. *Keywords*

574. *Subject Headings*

575. *Notes*

576. *Footnotes*

577. *Endnotes*

578. *References*

579. *Appendix*

580. *Index*

581. *Table of Contents*

582. *Summary*

583. *Abstract*

584. *Keywords*

585. *Subject Headings*

586. *Notes*

587. *Footnotes*

588. *Endnotes*

589. *References*

590. *Appendix*

591. *Index*

592. *Table of Contents*

593. *Summary*

594. *Abstract*

595. *Keywords*

596. *Subject Headings*

597. *Notes*

598. *Footnotes*

599. *Endnotes*

600. *References*

601. *Appendix*

602. *Index*

603. *Table of Contents*

604. *Summary*

605. *Abstract*

606. *Keywords*

607. *Subject Headings*

608. *Notes*

609. *Footnotes*

610. *Endnotes*

611. *References*

612. *Appendix*

613. *Index*

614. *Table of Contents*

615. *Summary*

616. *Abstract*

617. *Keywords*

618. *Subject Headings*

619. *Notes*

620. *Footnotes*

621. *Endnotes*

622. *References*

623. *Appendix*

624. *Index*

625. *Table of Contents*

626. *Summary*

627. *Abstract*

628. *Keywords*

629. *Subject Headings*

630. *Notes*

631. *Footnotes*

632. *Endnotes*

633. *References*

634. *Appendix*

635. *Index*

636. *Table of Contents*

637. *Summary*

638. *Abstract*

639. *Keywords*

640. *Subject Headings*

641. *Notes*

642. *Footnotes*

643. *Endnotes*

644. *References*

645. *Appendix*

646. *Index*

647. *Table of Contents*

648. *Summary*

649. *Abstract*

650. *Keywords*

651. *Subject Headings*

652. *Notes*

653. *Footnotes*

654. *Endnotes*

655. *References*

656. *Appendix*

657. *Index*

658. *Table of Contents*

659. *Summary*

660. *Abstract*

661. *Keywords*

662. *Subject Headings*

663. *Notes*

664. *Footnotes*

665. *Endnotes*

666. *References*

667. *Appendix*

668. *Index*

669. *Table of Contents*

670. *Summary*

671. *Abstract*

672. *Keywords*

673. *Subject Headings*

674. *Notes*

675. *Footnotes*

676. *Endnotes*

677. *References*

678. *Appendix*

679. *Index*

680. *Table of Contents*

681. *Summary*

682. *Abstract*

683. *Keywords*

684. *Subject Headings*

685. *Notes*

686. *Footnotes*

687. *Endnotes*

688. *References*

689. *Appendix*

690. *Index*

691. *Table of Contents*

692. *Summary*

693. *Abstract*

694. *Keywords*

695. *Subject Headings*

696. *Notes*

697. *Footnotes*

698. *Endnotes*

699. *References*

700. *Appendix*

701. *Index*

702. *Table of Contents*

703. *Summary*

704. *Abstract*

705. *Keywords*

706. *Subject Headings*

707. *Notes*

708. *Footnotes*

709. *Endnotes*

710. *References*

711. *Appendix*

712. *Index*

713. *Table of Contents*

714. *Summary*

715. *Abstract*

716. *Keywords*

717. *Subject Headings*

718. *Notes*

719. *Footnotes*

720. *Endnotes*

721. *References*

722. *Appendix*

723. *Index*

724. *Table of Contents*

725. *Summary*

726. *Abstract*

727. *Keywords*

728. *Subject Headings*

729. *Notes*

730. *Footnotes*

731. *Endnotes*

732. *References*

733. *Appendix*

734. *Index*

735. *Table of Contents*

736. *Summary*

737. *Abstract*

738. *Keywords*

739. *Subject Headings*

740. *Notes*

741. *Footnotes*

742. *Endnotes*

743. *References*

744. *Appendix*

745. *Index*

746. *Table of Contents*

747. *Summary*

748. *Abstract*

749. *Keywords*

750.

Title: **Classification of Solid Wastes for Land Disposal**
1970

Author: **John W. Sweeney, Jr., Ph.D.**

Reference: **See Summary, Section 1.1**

Abstract: This report presents the results of a study conducted by the Waste Management Institute, Inc., to develop a waste classification system for developing the methodology for identifying the interfaces of a constructive waste classification system.

The results of the study are presented in this report in sequential fashion. Chapter 1, of 11 illustrations (only format in this format), the contents of each page are presented first in large bold type. More detailed information is then given in a summary paragraph in regular type. Technical details pertinent to the above type are provided in the small type text. On the page facing the text a table or figure illustrates the topic of each section. Additional detailed information is provided in a series of appendices.

This format is useful for those with limited time. Those wanting a general overview can read the large bold type and illustrations to obtain a general idea of the contents of the document. Those with more time can additionally read the medium type summaries. People desiring more details then read the textual material in regular type.

An earlier version of this report was reviewed by a Technical Advisory Panel at a meeting in Las Vegas on July 19 and 20, 1977. Names of participants are given in Appendix I. Comments and suggestions received on the working draft have been incorporated where appropriate into this draft of the report.

Title: SECOND REPORT "DEVELOPMENT OF SITE SUITABILITY CRITERIA FOR THE HIGH-LEVEL WASTE REPOSITORY FOR LAWRENCE LIVERMORE LABORATORY"

Author: Golden Associates, Inc.

Reference: UCRL 13793, November 1977

Abstract: This report presents the results of our mining and geotechnical studies provided to the University in support of the development of site suitability criteria. This work was performed in accordance with our anticipated proposal to Lawrence Livermore Laboratories (LLL) dated May 1977 and authorized by the University Purchase Order #468102. The primary purpose of our work was to expand those areas of analysis described in our first report (Golden Associates, Inc. 1977a) and to include an analysis of those characteristics that are common to both site suitability and site performance criteria. This information is to be integrated into the Site Suitability Repository Model developed by The Analytic Sciences Corporation (TASC) of Reading, Massachusetts. This model is described in detail in various TASC reports (TASC, 1977a, 1977b) and will not be described in this report.

The work presented in this report supplements and expands the work presented in our initial report entitled "Development of Site Suitability Criteria for the High Level Waste Repository for Lawrence Livermore Laboratories" submitted in June 1977 (GAI, 1977a). This current report should be reviewed in conjunction with that June report.

Title: "HIGH-LEVEL WASTE REPOSITORY SITE SUITABILITY CRITERIA -
DRAFT ENVIRONMENTAL IMPACT STATEMENT"

Author: TERA Corporation

Reference: USRL 13604, January 1976

Abstract: Pursuant to the National Environmental Policy Act of 1969 (NEPA), Environmental Impact Statements (EIS) are being prepared by the Nuclear Regulatory Commission (NRC) in connection with the issuance of prospective rulemaking activities. The statements will contain a detailed evaluation of the environmental impacts associated with the rulemaking and a discussion of alternative actions as well as overall assessment of the costs and benefits of the licensing action.

Title: "AN ESTIMATION OF THE STATISTICAL DISTRIBUTION OF FAULTING IN SELECTED AREAS AND THE DESIGN OF AN EXPLORATION MODEL TO DETECT THOSE FAULTS"

Author: San Jose State University

Reference: UCRL 13815, November 1977

Abstract: Selected sites in the United States have been analyzed geo-mathematically as a part of the technical support program to develop site suitability criteria for High Level Nuclear Waste (HLW) repositories. Using published geological maps and other information, statistical evaluations of the fault patterns and other significant geological features have been completed for 16 selected localities. The observed frequency patterns were compared to theoretical patterns in order to obtain a predictive model for faults at each location. In general, the patterns approximate an exponential distribution function with the exception of Edinburgh, Scotland--the control area. The fault pattern of rocks at Edinburgh closely approximate a negative binominal frequency distribution. The range of fault occurrences encountered during the investigation varied from a low of 15 to a high of 10 faults per square mile.

Title: "A NEW NUMERICAL METHOD FOR SOLVING THE SOLUTE TRANSPORT EQUATION"

Author: TASC (B. I. Ross, C. M. Koplik)

Reference: UCKL 13842-1

Abstract: The solute transport equation can be solved numerically by approximating the water flow field by a network of stream tubes and using a Green's function solution within each stream tube. Compared to previous methods, this approach permits greater computational efficiency and easier representation of small discontinuities, and the results are easier to interpret physically. The method has been used to study hypothetical sites for disposal of high-level radioactive waste.

Title: "A STATISTICAL APPROACH TO MODELING TRANSPORT OF
POLLUTANTS I. GROUNDWATER"

Author: TASC (B. I. Ross, C. M. Koplik, B. S. Crawford)

Reference: UCRL 13843-1

Abstract: The transport of pollutants in the subsurface can be affected by random geologic events. Prediction of such transport therefore requires solution of a partial differential equation whose coefficients are random processes. A method of finding the expected (mean) values of solutions of such equations is derived. This method is used to assess the impact of fault movement and formation of breccia pipes on risk from radioactive waste disposal. Preliminary results indicate that these events, considered probabilistically, do not make a large contribution to risk.

Title: "DECOMMISSIONING HIGH-LEVEL WASTE SURFACE FACILITIES"

Author: Engineering Analysis & Tests Co. (R. Perez, M. Deutsch,
S. Horwitz)

Reference: UCKL 13844, April 1976

Abstract: The protective storage, entombment and dismantlement options of decommissioning a High-Level Waste Surface Facility (HLWSF) was investigated. A reference conceptual design for the facility was developed based on the designs of similar facilities. State-of-the-art decommissioning technologies were identified. Program plans and cost estimates for decommissioning the reference conceptual designs were developed. Good engineering design concepts were on the basis of this work identified.

Title: THIRD REPORT "DEVELOPMENT OF SITE SUITABILITY AND DESIGN PERFORMANCE DATA BASE FOR A HIGH LEVEL NUCLEAR WASTE REPOSITORY FOR LAWRENCE LIVERMORE LABORATORY"

Author: Golder Associates, Inc.

Reference: UCRL 13256, May 1976

Abstract: This report presents the results of our mining and geotechnical studies provided to the Lawrence Livermore Laboratory (LLL) as support for the development of a technical data base suitable for the generation of a regulatory framework governing high level nuclear waste disposal. The work was performed in accordance with our unsolicited proposal to LLL dated November 9, 1977 and authorized by University Purchase Order 9157703. The primary purpose of our effort was twofold: expand appropriate areas of site suitability described in our previous reports (GAI 1977a, 1977b), and review a conceptual design in bedded salt. The work presented in this report supplements and expands the work presented in our previous reports (GAI 1977a, GAI 1977b). This current report should be reviewed in conjunction with those reports.

Title: "AN INDEX OF HAZARD FOR RADIOACTIVE WASTE"

Author: Decision and Designs, Inc.

Reference: UCRL 13868-1, June 1976

Abstract: This is an interim report of a study to establish a risk measure for radioactive waste repositories and to generate radiological performance objectives. The problem of regulating radioactive waste repositories is reviewed, and the difficulties associated with this activity are discussed. Risk-benefit analysis as a tool for regulation has been suggested, and its contribution is assessed. Decision analysis as a development of risk-benefit analysis is suggested as an alternative approach, in particular, employing the concept of expected utility.

A utility function which describes the possible consequences of a radioactive waste repository is discussed in some detail, paying particular attention to the public concerns which must be addressable through such a function and how it is recommended to capture them. A specific utility function is developed, and its elicitation from a particular subject is described.

The representation of public values in a decision-analytic approach presents some problems and these are fully discussed; recommendations are made as to appropriate methods to carry this out. The vexed question of determining an acceptable safety limit is studied and recommendations are made concerning the most suitable way to determine "how safe is safe enough." Finally a brief discussion is given of how these concepts may be employed to generate radiological performance objectives.

Title: FINAL REPORT ON "UNCERTAINTIES IN THE DETECTION, MEASUREMENT,
AND ANALYSIS OF SELECTED FEATURES PERTINENT TO DEEP GEOLOGIC
REPOSITORIES"

Author: Geotechnical Engineers, Inc.

Reference: UCRL 13912, July 10, 1974

Abstract: Uncertainties with regard to many facets of repository site characterization have not yet been quantified. This report summarizes the state of knowledge of uncertainties in the measurement of porosity, hydraulic conductivity, and hydraulic gradient; uncertainties associated with various geophysical field techniques; and uncertainties associated with the effects of exploration and exploitation activities in bedded salt basins. The potential for seepage through a depository in bedded salt or shale is reviewed and, based upon the available data, generic values for the hydraulic conductivity and porosity of bedded salt and shale are proposed.

Title: "ANALYSIS OF SOME NUCLEAR WASTE MANAGEMENT OPTIONS"
(2 volumes)

Author: TASC (L. E. Berman, D. A. Ensminger, M. S. Giuffre,
C. M. Koplik, S. G. Oston, G. D. Pollak, E. I. Ross)

Reference: UCRL 13917, October 1978

Abstract: This report describes risk analyses performed on that portion of a nuclear fuel cycle which begins following solidification of high-level waste. Risks associated with handling, interim storage and transportation of the waste are assessed, as well as the long term implications of disposal in deep mined cavities. The risk is expressed in terms of expected dose to the general population and peak dose to individuals in the population. Volume I describes the analyses and discusses the results. Volume II consists of appendices which provide technical details of the work performed.

Title: "COMMENT ON 'EXPERIMENTAL STUDY OF THE EFFECTS OF STRESS ON SOLUTION RATE' By E. S. Sprunt and A. Nur"

Author: Pacifica Technology (L. S. Gaffney)

Reference: UCRL 13927

Abstract: Sprunt and Nur (1977) have presented experimental evidence that circular holes in plates of novaculite, Lureka quartzite, Oak Hall limestone, Colomitic limestone, Solenhofen limestone and halite, when loaded perpendicular to the axis of the hole in the presence of a solution, are modified to (approximate) ellipses elongated perpendicular to the load axis. They discuss the possible origin of such a shape and conclude that the shape can be attributed to neither diffusion nor angular dependence of the chemical potential. However, if their expression for the change in chemical potential upon loading (equation (3), Sprunt and Nur, 1977) is modified slightly the change in chemical potential is found to be approximately proportional to the first power of the imposed stress rather than the second power. It can be shown that their data is consistent with a constant solution rate at any given θ which is proportional to the change in this modified chemical potential caused by the imposed load,

$$q(\theta, \sigma) = r(L - \mu')$$

Title: "INVENTORY AND SOURCES OF TRANSURANIC SOLID WASTE"

Author: TERA Corporation (B. G. Knaizewycz)

Reference: UCRL 13934, August 1978

Abstract: The purpose of the report is to support the development of standards and criteria which will specifically address the problem of TRU contaminated waste -- generated by Department of Energy (DOE) nuclear programs and commercial application of nuclear technology.

Section 2.0 of this report presents an overview and introduction to the generation, sources and past practices dealing with TRU contaminated waste. In Section 3.0, the DOE facilities are discussed and supported in more detail in Appendices B through E. Section 4.0 and Appendix F address commercial disposal sites, while Section 5.0 addresses the commercial nuclear industry. The waste inventory is presented in Section 6.0, and waste projections are discussed in Section 7.0. Section 8.0 presents an extensive list of references and related bibliography.

Title: "SCOPING STUDY OF SALT DOME, BASIN, AND CRYSTALLINE
ROCKS AS RELATED TO LONG-TERM RISK MODELING FOR THE
GEOLOGIC DISPOSAL OF NUCLEAR WASTE"

Author: Golder Associates, Inc.

Reference: UOGL 13945, November 1977.

Abstract: The purpose of this study is to provide a preliminary geotechnical
data base sufficient to initiate the development of Long-Term
Risk Models (LTRM), for salt domes, basins, and crystalline rocks,
and identify technical issues requiring additional investigation.

The report is organized to provide general brief comments on
each rock type in the text while presenting the detailed data
base information in the appendices. The data base includes both
general and site specific geologic and hydrologic information.

Title: "NOTES ON THE LLEWELLYN WASTE DISPOSAL STUDY"

Author: Kaplan & Associates

Reference: OJPL 13900-1, March 1979

Abstract: The purpose of these notes is to suggest some language, ideas, and points of view which may be useful in focusing discourse and work on the LLEW waste disposal study.

Title: "NOTES ON THE USE OF AN ALGORITHM FOR THE ANALYSIS OF
ARITHMETIC RELATIONS IN THE CASE OF A FINITE SET OF
DISPOSAL OF NUCLEAR WASTE"

Author: Kaplan & Associates

Reference: DOE-13988-2, May 1978

Abstract: Our previous note on the use of an algorithm for the
analysis of nuclear waste disposal systems. The purpose of
the present note is to describe briefly the content of that
formalism, namely the probabilistic calculation necessary
for its implementation. We shall also note the underlying
philosophy and the computational tools used in these calculations.

Title: "PRELIMINARY STUDY OF RADIOACTIVE WASTE DISPOSAL IN THE
VADOSE ZONE."

Author: Senteschik Engineers, Inc.

Reference: Oct 1992, January 1993

Abstract: To investigate the characteristics of the vadose zone with
respect to radioactive waste disposal, the mechanics of
unsaturated flow in arid regions and the geohydrology of
four areas with a deep water table were studied.

The studies indicated that (1) arid sites with a water table
deeper than 200 ft can be found in at least three distinct
geologic settings in the western United States, (2) the physics
of unsaturated flow in soils and rock with interstitial porosity
at low water contents, particularly under thermal gradients, is
not yet completely understood, and (3) under certain conditions
unsaturated flow can be so slow that analytic modeling of an
unflawed repository is unnecessary to prove effective containment.

Title: "NOTES ON THE NEXT GENERATION MACROMODEL, A UNIFIED COMPUTATIONS SYSTEM FOR PREDICTING POST SEALING WASTE DEPOSITORY PERFORMANCE"

Author: S. Kaplan (KAI), A. M. Kaufman, J. W. Lathrop (LLL)

Reference: UCRL 13997, August 1978

Abstract: At the current time, development and improvement activities are underway on computer software and on several analytical ideas related to the calculation of the risk from waste migration after sealing of a depository. These ideas and software modules may be viewed as components of a total system model for such risk calculations. This total model has been dubbed "The Macromodel" and is so referred to among project personnel. The set of component improvements now underway can be viewed thus as a round of improvements to, or as a new generation of the macromodel that now exists and has been used up till this time.

The purpose of the present notes is to pull together these software and analytical ideas into an overall portrayal or blueprint of the new macromodel that is evolving. The purpose of the blueprint is to clarify the relationship of the components and the interfaces required, to facilitate the alignment of all parties concerned and to allow a definitive specification of the work remaining to be done.

Title: "NOTES FOR A WORKSHOP ON RISK ANALYSIS AND DECISION UNDER UNCERTAINTY"

Author: Kaplan & Associates

Reference: UCRL 15007, April 1979

Abstract: The purpose of this workshop is to clear away the confusion and controversy surrounding the use of probabilistic, and especially Bayesian, methods and to replace these with a soundly based understanding of the extreme beauty, simplicity, and power of these methods so that at the end of the course the participant will have the ability and the confidence to use these methods and ways of thinking to produce clarity, communication, and consensus in the decision situations of his daily life.

Since most of the controversy results, historically, from nonuniformity and imprecision in the use of the language of the subject it is part of our purpose that the participants reach an agreed upon body of concepts and definitions which can become a standard framework at the Laboratory, and ultimately among its contractors and clients, for dealing with and communicating about problems involving uncertainty and risks.

Title: "DOCUMENTATION INFORMATION FOR PEER GROUP REVIEW REPORT, SITE SUITABILITY CRITERIA STUDY"

Author: Golder Associates, Inc.

Reference: UCRL 15011, October 1977

Abstract: This report presents documentation of the geotechnical input data provided by Golder Associates, Inc. (GAI) for the Cycle II repository model analysis. The input data was developed during the period from January to May 1977 and presented to LLNL in a letter dated May 31, 1977. Information relating to the proposed uncertainty analysis and several appropriate comments pertinent to the overall site suitability study are also included.

It is important to understand the precision of the information provided and the general operation of the site suitability study program. The purpose of our work was to provide the best available current information for use in the initial Site Suitability models. These models required definition of preferred values and probable ranges of all parameters relevant to the model. Where data was not available or poorly understood, we were requested to make our best engineering estimate. In general, the probable ranges of most parameters are reasonably well known. Where engineering estimates had to be made, they are noted. As the project develops, factors identified as being significant may require further research, analytical study and/or specific modeling. In fact, many of the input data to the Cycle II model are currently being re-evaluated and may be revised in subsequent cycles.

Title: "PRELIMINARY ASSESSMENT OF THE THERMAL EFFECTS OF AN ANNULAR AIR SPACE SURROUNDING AN EMPLACED NUCLEAR WASTE CANISTER"

Author: Southwest Engineering Enterprises (B. W. Davis)

Reference: UCRL 15014, October 1978

Abstract: Modeling results have previously shown that the presence of a large air space (e.g., a repository room) within a nuclear waste repository is expected to cause a waste canister's temperature to remain cooler than it would otherwise be. Results presented herein show that an annular air space surrounding the waste canisters can have similar cooling effects under certain prescribable conditions; for a 16' x 1' diameter canister containing 650 PWK rods which initially generate a total of 4.61 kw, analysis will show that annular air spaces greater than 11" will permit the canister surface to attain peak temperatures lower than that which would result from a zero-gap/perfect thermal contact. It was determined that the peak radial temperature gradient in the salt varies in proportion to the inverse of the drill hole radius. Thermal radiation is shown to be the dominant mode of heat transfer across an annular air space during the first two years after emplacement. Finally, a methodology is presented which will allow investigators to easily model radiation and convection heat transfer through air spaces by treating the space as a conduction element that possesses non-linear temperature dependent conductivity.

Title: "PI/PD April 1968, Vol. 1, No. 1, 1968"

Author: Pacific Technology, Inc., Report

Reference: BCP-1541, August 1968

Abstract: Three tasks related to the reference design of structural storage canisters for radioactive waste have been completed. The three tasks consist of the reference design study, the definition of failure modes and appropriate failure stress and integrity determination for the reference canister, and the development of a more efficient design for structural integrity of the canister. The reference design is a welded storage canister concept based upon the waste isolation pilot plant (WIPP) design, with slight modifications. The modifications consist of an alternate loading case requirement for the top head and a revised bottom head design for distribution of impact energy. Welded cladding provides the seal at each end. Overpacking is considered as a possibility, but is not included in the preliminary reference design. The four failure modes that are deemed the most appropriate for the design of the reference canister are: (1) a loss of functional capability; (2) ductile rupture of the canister; (3) buckling of the structural members; and (4) stress corrosion cracking. Failure scenarios are provided for each of the relevant failure modes. In addition, a risk methodology based upon the distribution of demand and the distribution of capacity for the structural members, with respect to each failure mode, is outlined.

Title: "ANALOGS OF THE KIRCHHOFF HYDRAULIC MODEL"

Author: New Millennium Associates

Reference: OERI 15022, November 1976

Abstract: The equations governing the flow of incompressible fluids and those governing the flow of electrical currents are virtually identical; all that is required to transform one set of equations into the other is to replace one set of variables by the other according to a simple one-to-one correspondence. It is this similarity that we propose to exploit in the following work.

Title: "RETRIEVAL SYSTEM FOR EMPLACED SPENT UNREPROCESSED FUEL
(SURF) IN SALT BED DEPOSITORY
BASELINE CONCEPT CRITERIA SPECIFICATIONS AND MECHANICAL
FAILURE PROBABILITIES"

Author: ILCO (L. Hudson, J. McCleery)

Reference: UCRL 15025, May 1979

Abstract: Describes entire retrieval scenario of degraded SURF
canisters from subterranean depository to surface and
presents criteria specifications on each piece of retrieval
equipment.

Title: "REPFLU MODEL EVALUATION, PHYSICAL AND NUMERICAL CONSISTENCY"

Author: New Millennium Associates

Reference: UCRL 15027, November 1978

Abstract: This report contains a description of some suggested changes and an evaluation of the REPFLU computer code, which models groundwater flow and nuclear-waste migration in and about a nuclear-waste repository. The discussion contained in the main body of the report is supplemented by a flow chart, presented in the Appendix, of this report.

The suggested changes are of four kinds: (1) Technical changes to make the code compatible with a wider variety of digital computer systems, (2) Changes to fill gaps in the computer code, due to missing proprietary subroutines, (3) Changes to (a) correct programming errors, (b) correct logical flaws, and (c) remove unnecessary complexity, and (4) Changes in the computer code logical structure to make REPFLU a more viable model from the physical point of view.

The evaluation of the REPFLU model is carried out largely in the main body of the report; however the last section (Section 4) of the report contains a brief evaluation summary.

Title: "RECHARGE AND REPRESSURIZATION IN THE REPFL0 MODEL"

Author: New Millennium Associates

Reference: UCRL 15028, January 1979

Abstract: The question we address in this short report is how recharge and repressurization can be taken into account in the REPFL0 code. We do not attempt a definitive discussion of the problem. Rather, our first goal is to determine whether any treatment of these effects is required, and if so, to provide a crude model that requires no major restructuring of the code.

Title: "FINITE MEDIUM GREEN'S FUNCTION SOLUTIONS TO NUCLIDE
TRANSPORT IN POROUS MEDIA"

Author: TASC

Reference: JGRL 15040, April 1979

Abstract: Current analytical techniques for predicting the transport of nuclides in porous materials center on the Green's function approach -- i.e., determining the response characteristics of a geologic pathway to an impulse function input. To date, the analyses all have set the boundary conditions needed to solve the 1-D transport equation, although such pathways were infinite in length. The purpose of this work is to critically examine the effect that this infinite pathway assumption has on Green's function models of nuclide transport in porous media. The work described herein has directly attacked the more difficult problem of obtaining suitable Green's functions for finite pathways whose dimensions, in fact, may not be much greater than the diffusion length.

Two different finite media Green's functions describing the nuclide mass flux have been determined, depending on whether the pathway is terminated by a high or a low flow resistance at the outlet end. The former has been used to determine the nuclide mass flux for a pathway of finite length, and the latter has been used to determine the nuclide mass flux for a pathway of infinite length. The results of these calculations are presented in the form of plots of nuclide mass flux versus time, and the effect of the boundary conditions on the results is discussed.

Title: "SUPPLEMENTARY ANALYSIS OF NUCLEAR WASTE MANAGEMENT OPTIONS"

Author: TASC

Reference: UCKL 15048, June 15, 1979

Abstract: This report describes studies pertaining to long-term risks from the disposal of high-level nuclear waste in deep mined cavities. The results presented supplement previously reported work. Previously studied scenarios are examined in greater depth, and the analysis is extended to deal with alternative fuel cycles.

Title: "MONITORING INSTRUMENTATION SPENT FUEL MANAGEMENT PROGRAM"

Author: Engineering Analysis and Test Company, Inc.

Reference: UCRL 15060, January 1979

Abstract: Preliminary monitoring system methodologies are identified as an input to the risk assessment of spent fuel management. Conceptual approaches to instrumentation for surveillance of canister position and orientation, vault deformation, spent fuel dissolution, temperature, and health physics conditions are presented. In future studies, the resolution, reliability, and uncertainty associated with these monitoring system methodologies will be evaluated.

Title: "RECHARGE AND REPRESSURIZATION OF A BEDDED SALT DEPOSITORY"

Author: TASC

Reference: UCRL 15070, July 1979

Abstract: Estimates for the rate of migration of nuclear wastes from a depository are predicted on the specification of a key initialization time. This marks the point at which the depository first becomes recharged and repressurized by groundwater subsequent to sealing of the facility. Errors in estimating the recharge-repressurization time (RRT) affect the waste migration predictions not only as a simple bias, but more importantly because the isotopic composition of the waste changes significantly during the early phases of containment. A "worst case" (minimum time) estimate of the depository recharge-repressurization period was made by Golder Associates. The purpose of the study reported herein has been to review the adequacy of the referenced study with regard to RRT. The present study has been restricted to consideration of a bedded salt depository with specific concern for possible thermal effects. The effort has consisted of a brief literature and data review. Its scope permitted neither modeling studies nor numerical verification of the results. The conclusions have therefore been non-rigorously developed, but represent rather the professional judgments of this author. They are, thus, intended purely as guidance for the development of more comprehensive modeling efforts.