

**U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT**

**NUCLEAR WASTE TECHNICAL REVIEW BOARD
FULL BOARD MEETING**

**SUBJECT: SOURCE TERM FOR THE PNL
TOTAL SYSTEM PERFORMANCE
ASSESSMENT**

PRESENTER: DAVID W. ENGEL

**PRESENTER'S TITLE
AND ORGANIZATION: TASK LEADER
PACIFIC NORTHWEST LABORATORY (PNL)
RICHLAND, WASHINGTON**

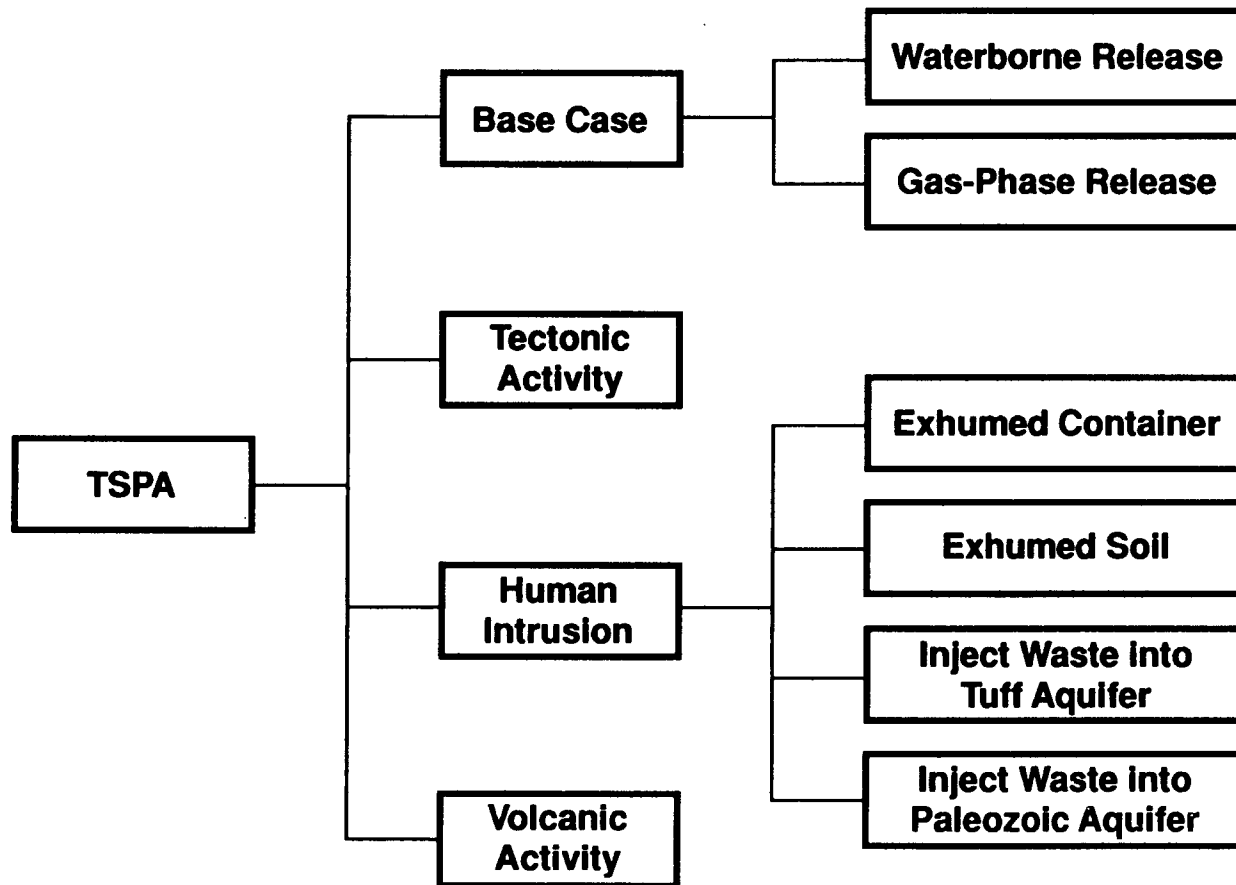
**PRESENTER'S
TELEPHONE NUMBER: (509) 375-2307**

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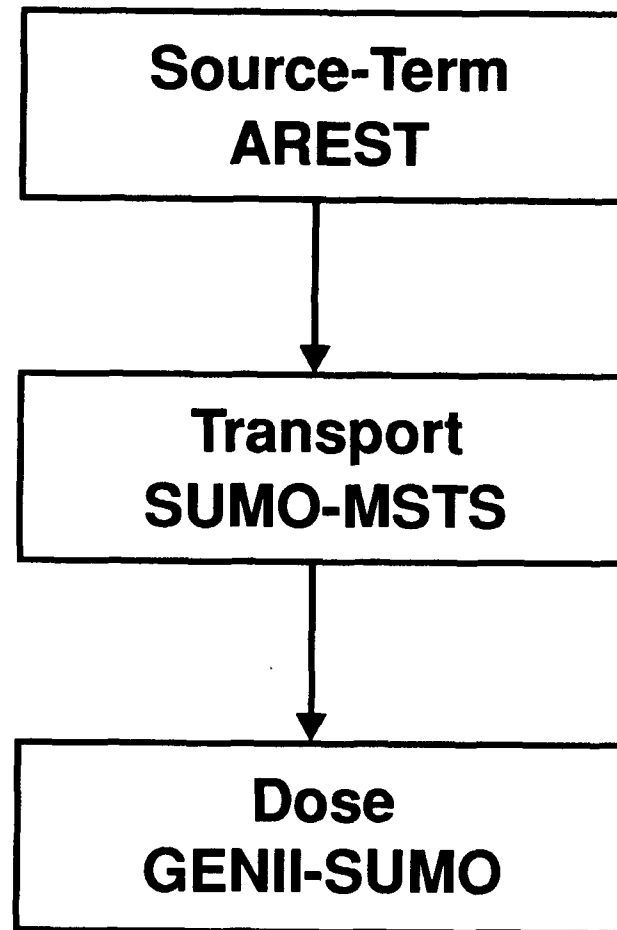
Presentation Topics

- **Description of the Total Systems Performance Assessment (TSPA)**
- **Description of models**
- **EBS results**
- **Thermal effects**
- **Conclusions**

Scenarios Modeled



Total System Performance Assessment Data Flow



Source-Term Specific Cases

Human Intrusion

- Tuff aquifer
- Paleozoic aquifer

Base case

- Spent fuel and glass (SRL-202)
 - 0.01, 0.05, 0.5 mm/yr infiltration rate
 - Diffusion-controlled

Gaseous release

- No infiltration
- 0.01 mm/yr infiltration
 - Early failures ~ U(300, 2000)
 - Late failures ~ U(2000, 5000)

Human Intrusion Analysis

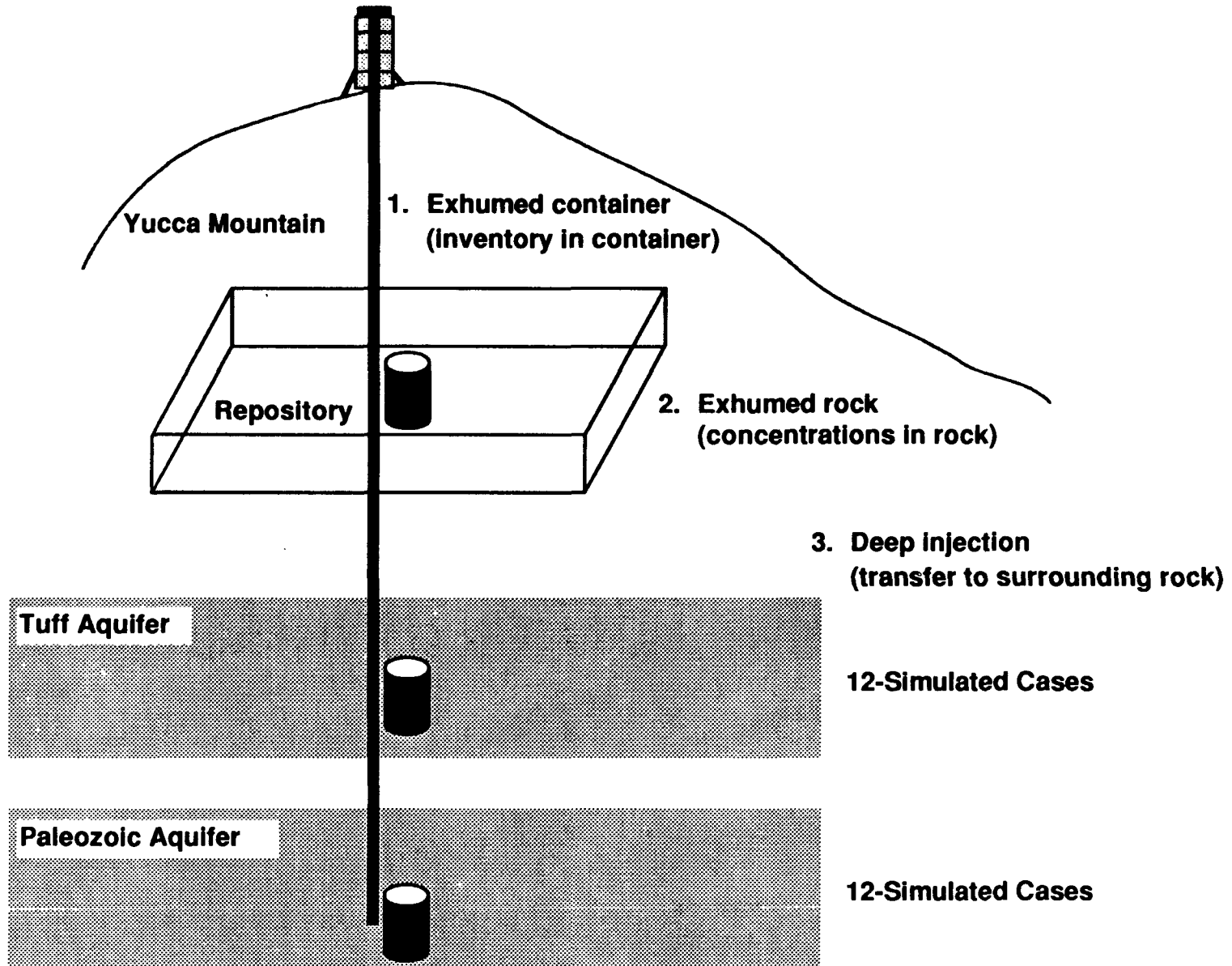
Assumptions

- **Single container displaced to aquifer**
 - Tuff
 - Carbonate (Paleozoic)
- **Wet-drip/Flow-through release model**
- **Wet-continuous release model**

Uncertainties

- **Drilling times ~ log uniform (10^2 , 10^4)**
- **Groundwater velocity**
 - Hydraulic head ~ uniform
 - Conductivity ~ spatial log normal

Human Intrusion Scenarios



Base Case Analysis

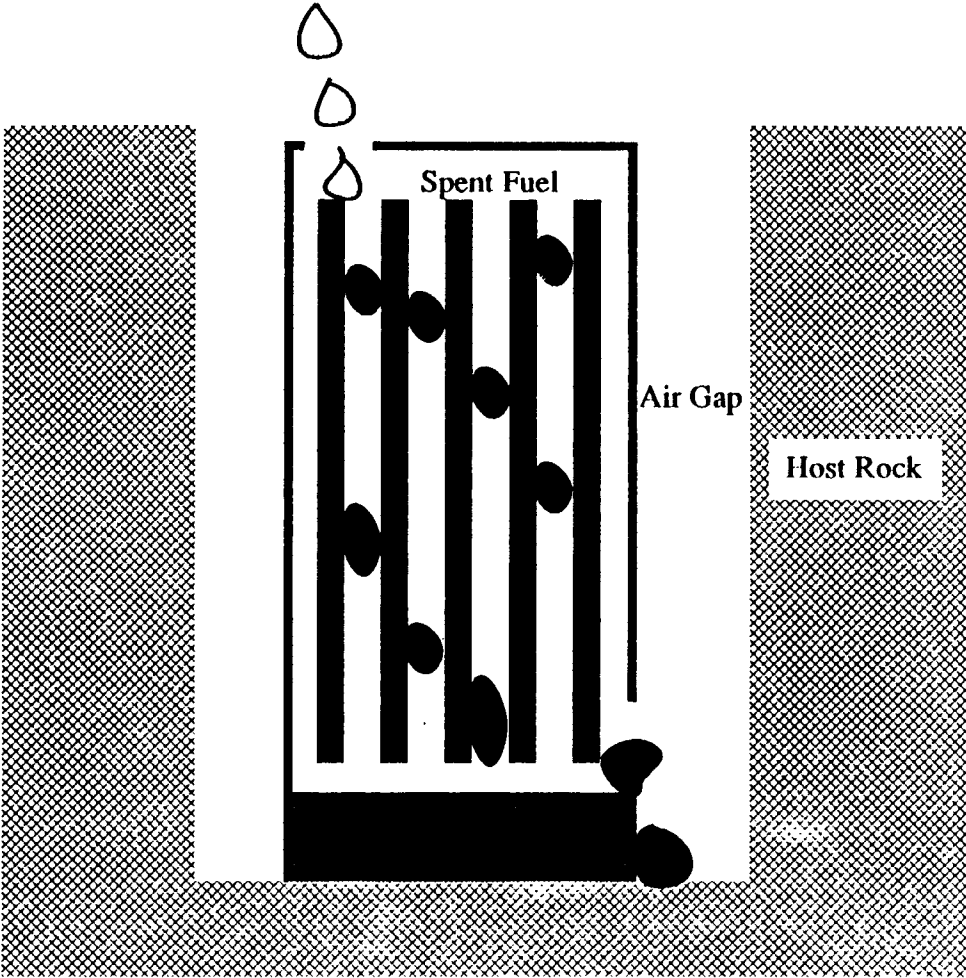
Assumptions

- **Gaseous release (C-14)**
 - **Impulse release of gas at failure**
 - **Slow water-release (flow-through model)**
- **Waterborne release**
 - **Wet-drip/flow-through**
 - **Wet-continuous**
 - **Assumed cladding not a barrier**

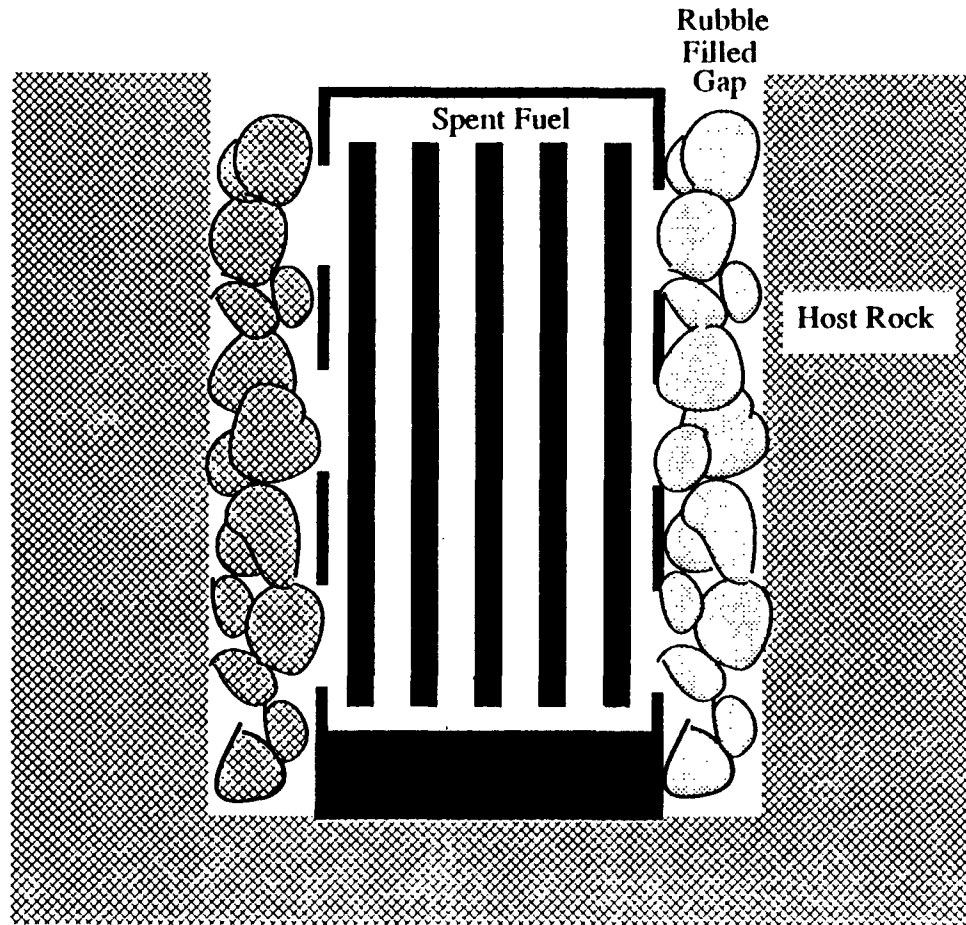
Uncertainties

- **Failure times ~ U(2000, 5000)**
- **Temperature**
- **Boundary conditions**
 - **Surface solubility**
 - **Glass reaction control**

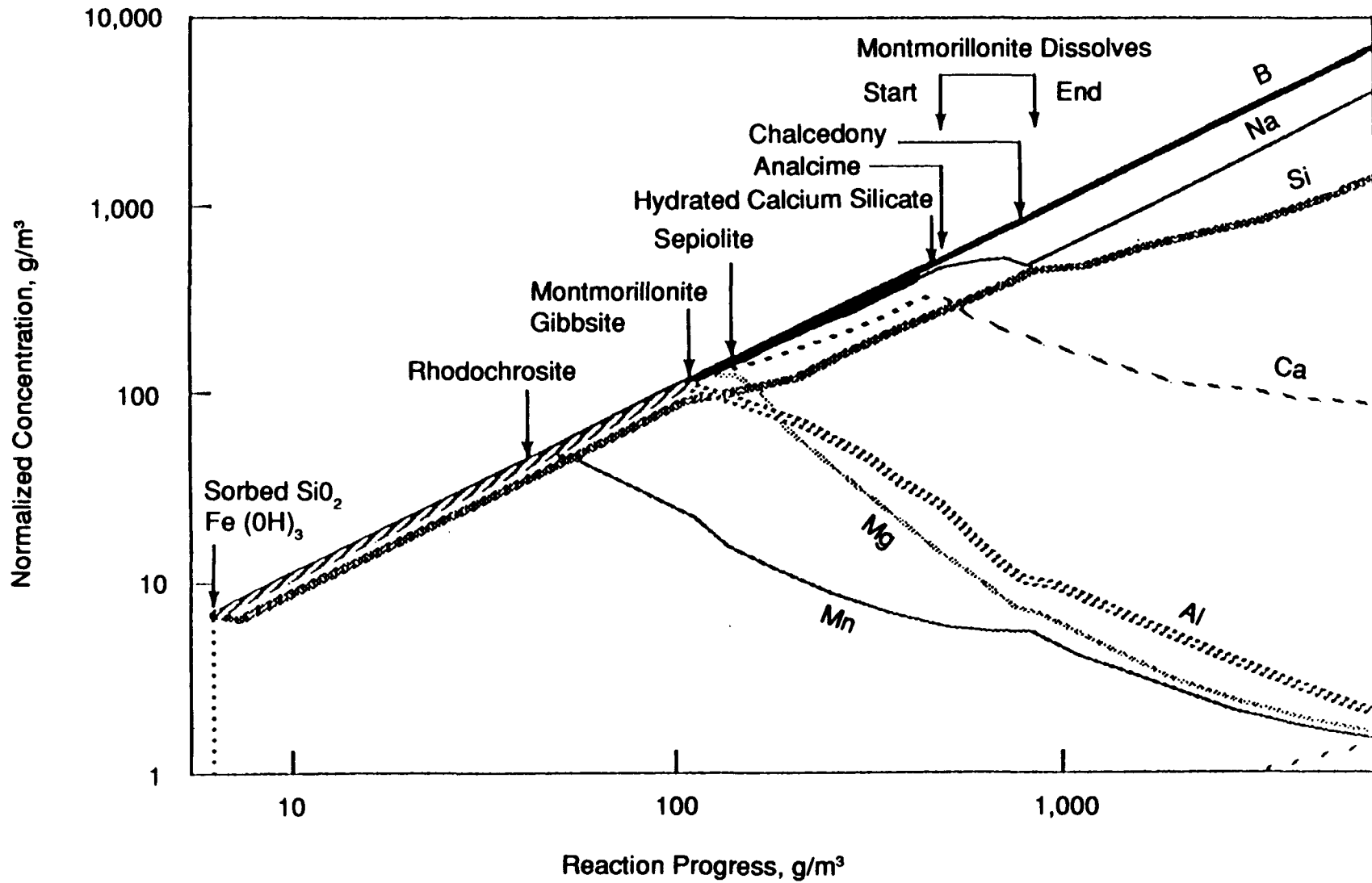
Flow-Through Mode



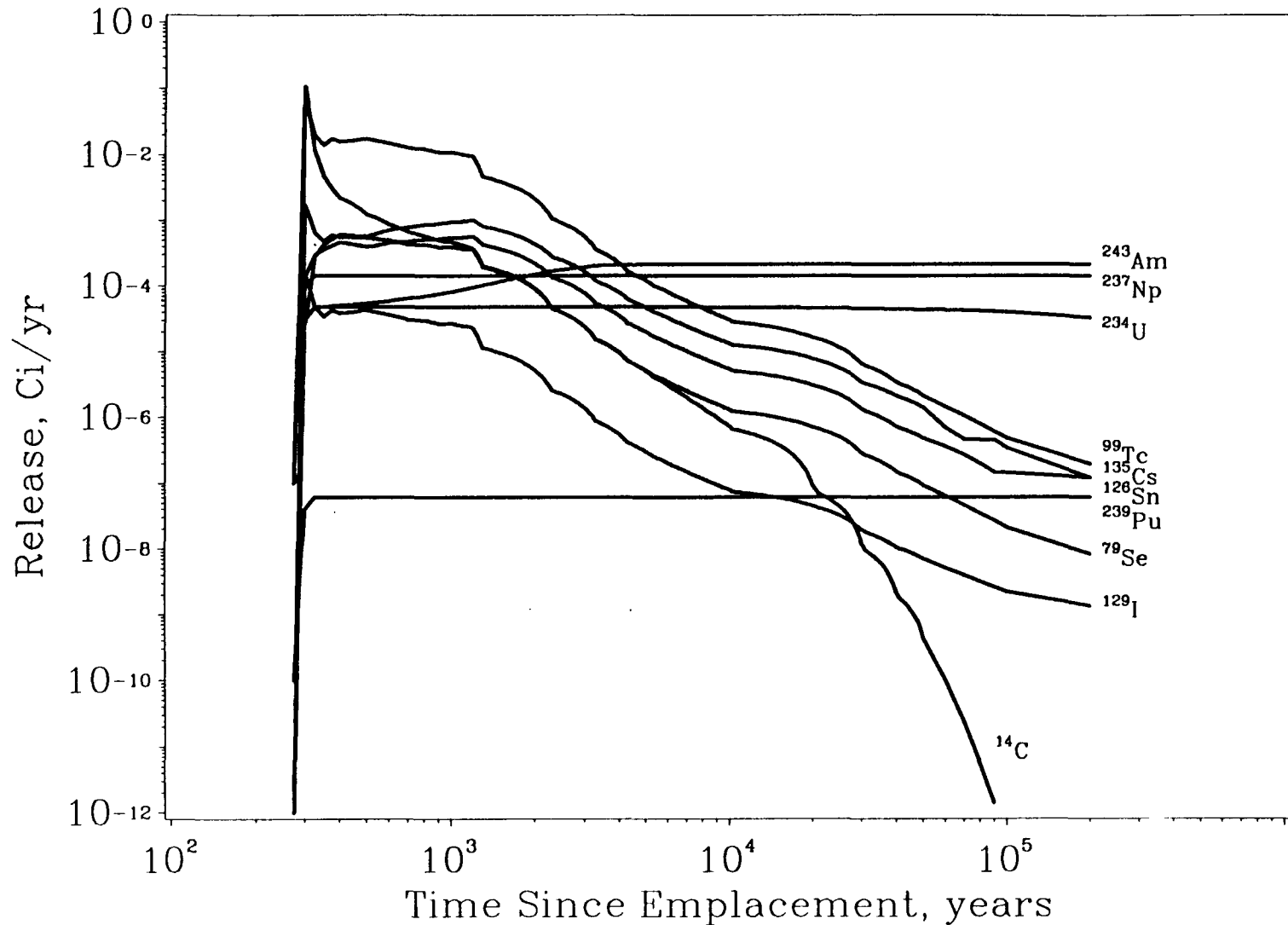
Wet-Continuous Mode



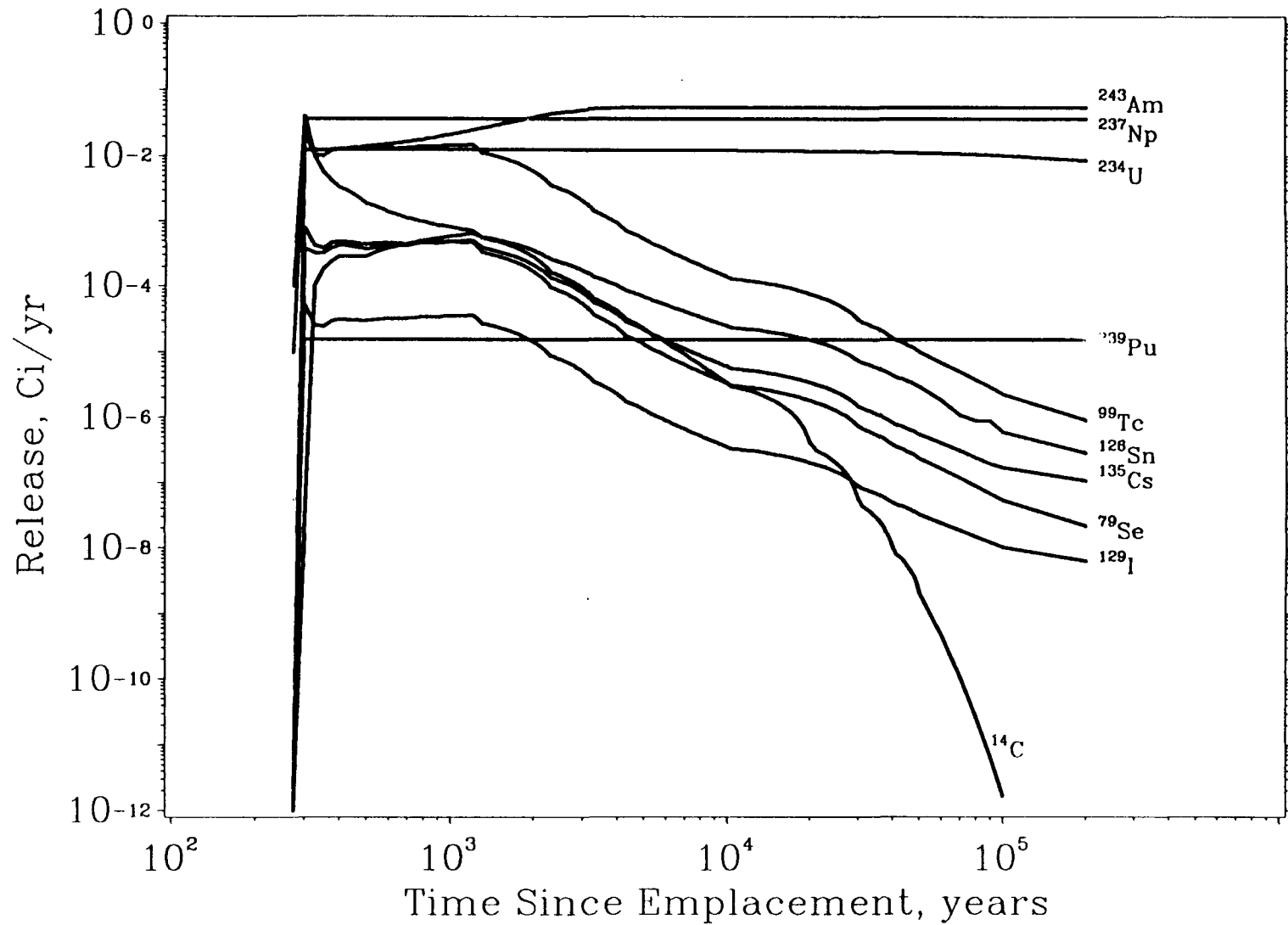
Glass Dissolution Model



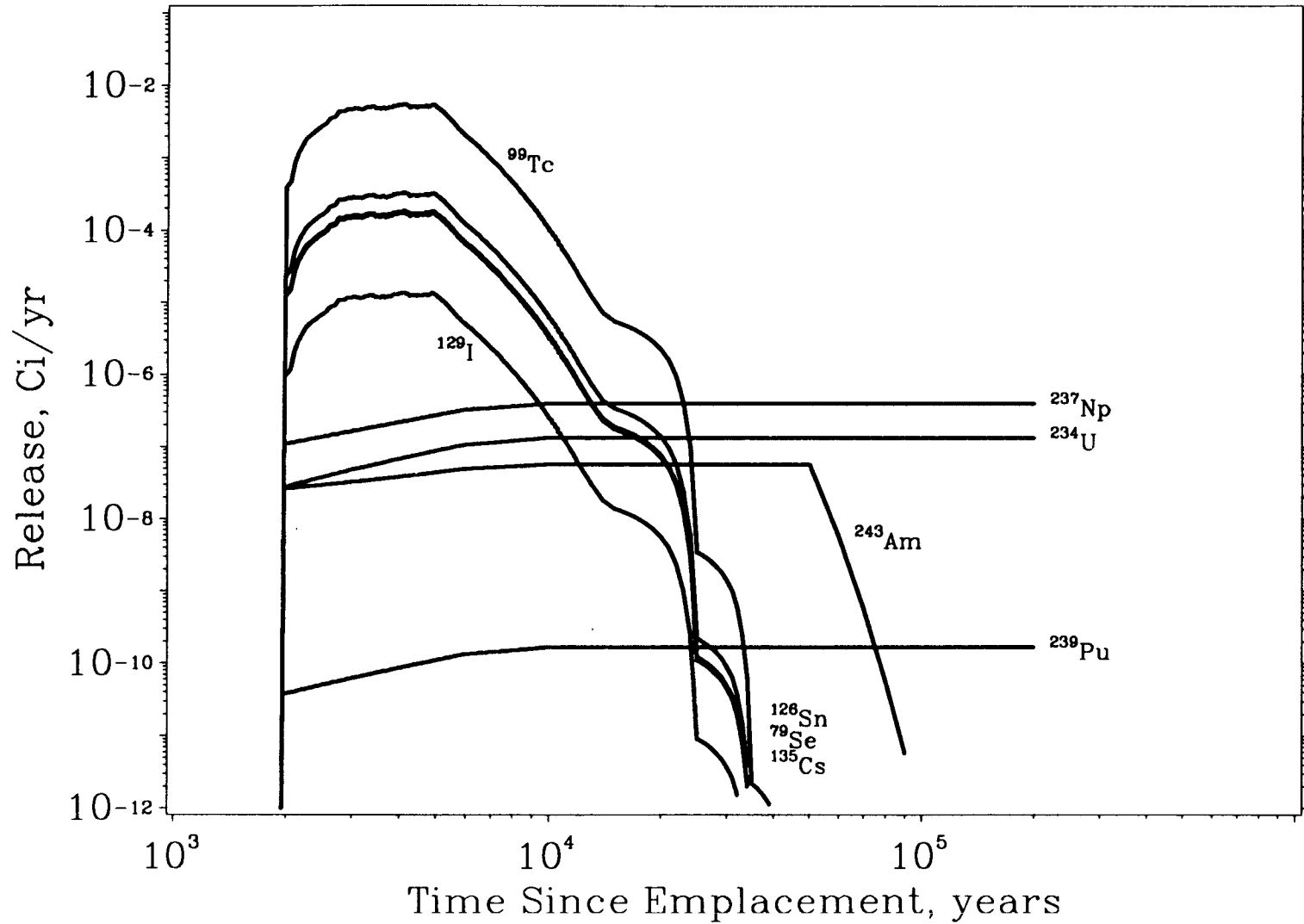
Human Intrusion Analysis, Spent Fuel, Tuff Aquifer (Case 12)



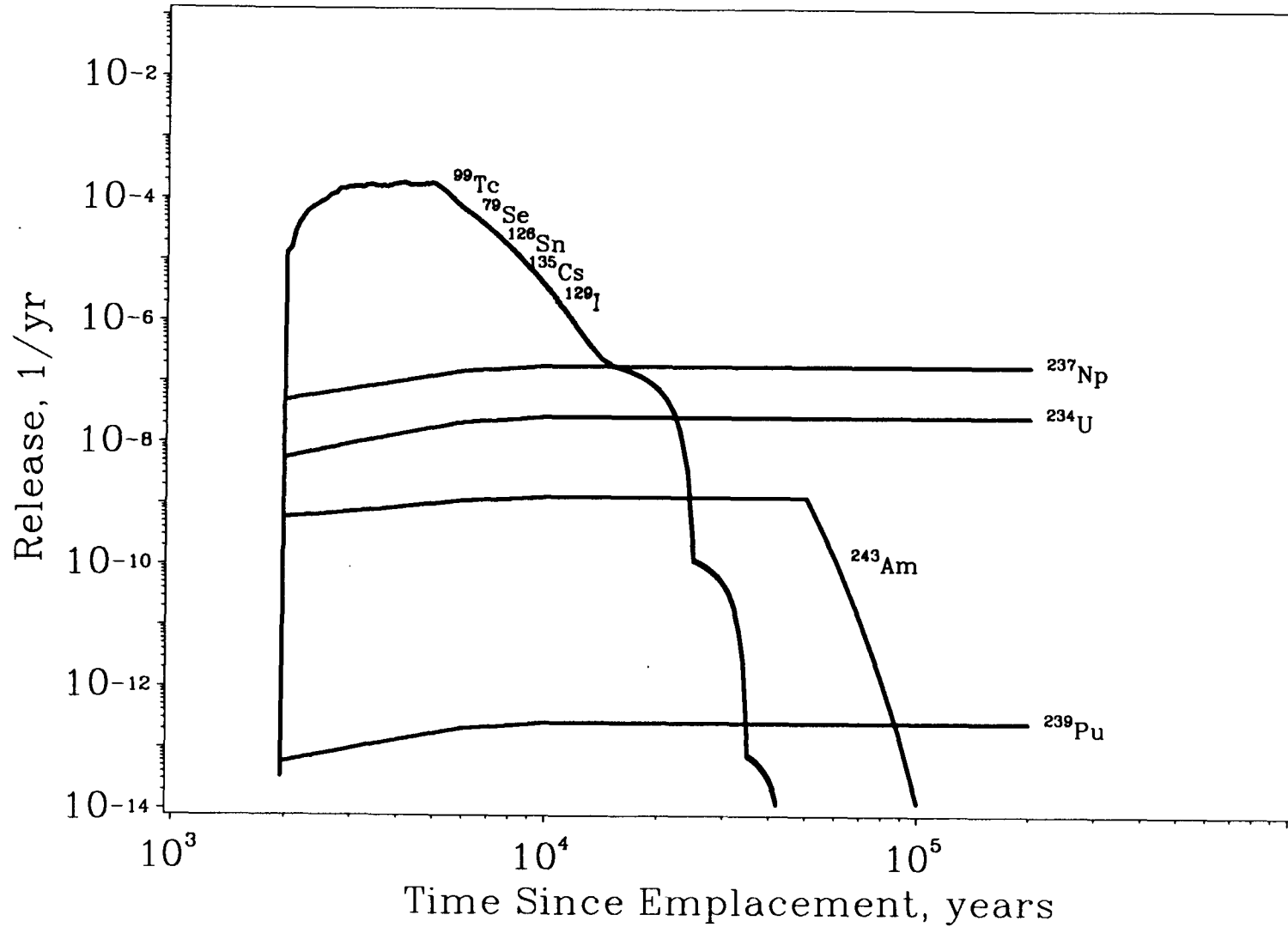
Human Intrusion Analysis, Spent Fuel, Paleozoic Aquifer (Case 12)



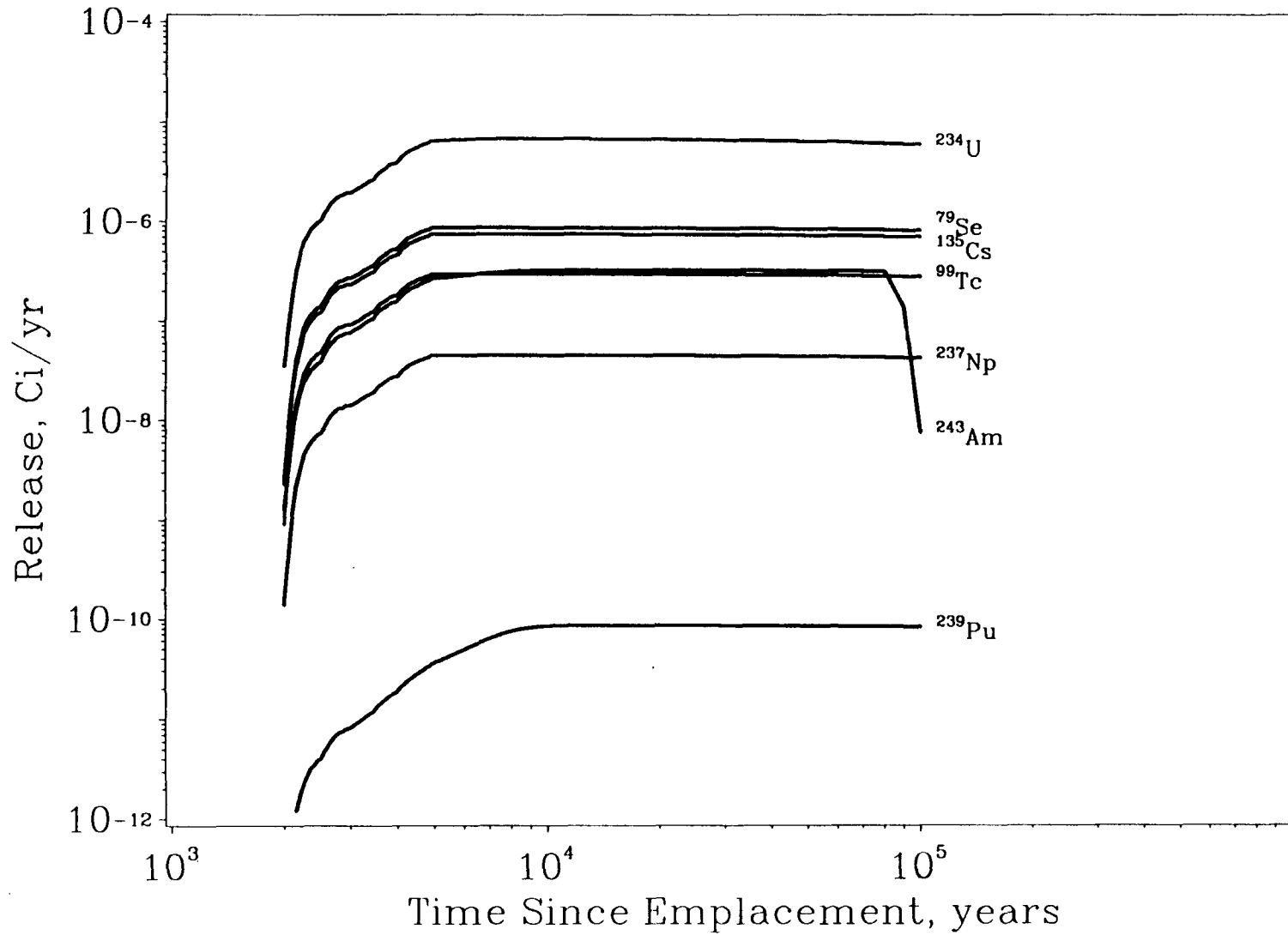
Base Case, Spent Fuel, 0.5 mm/yr.



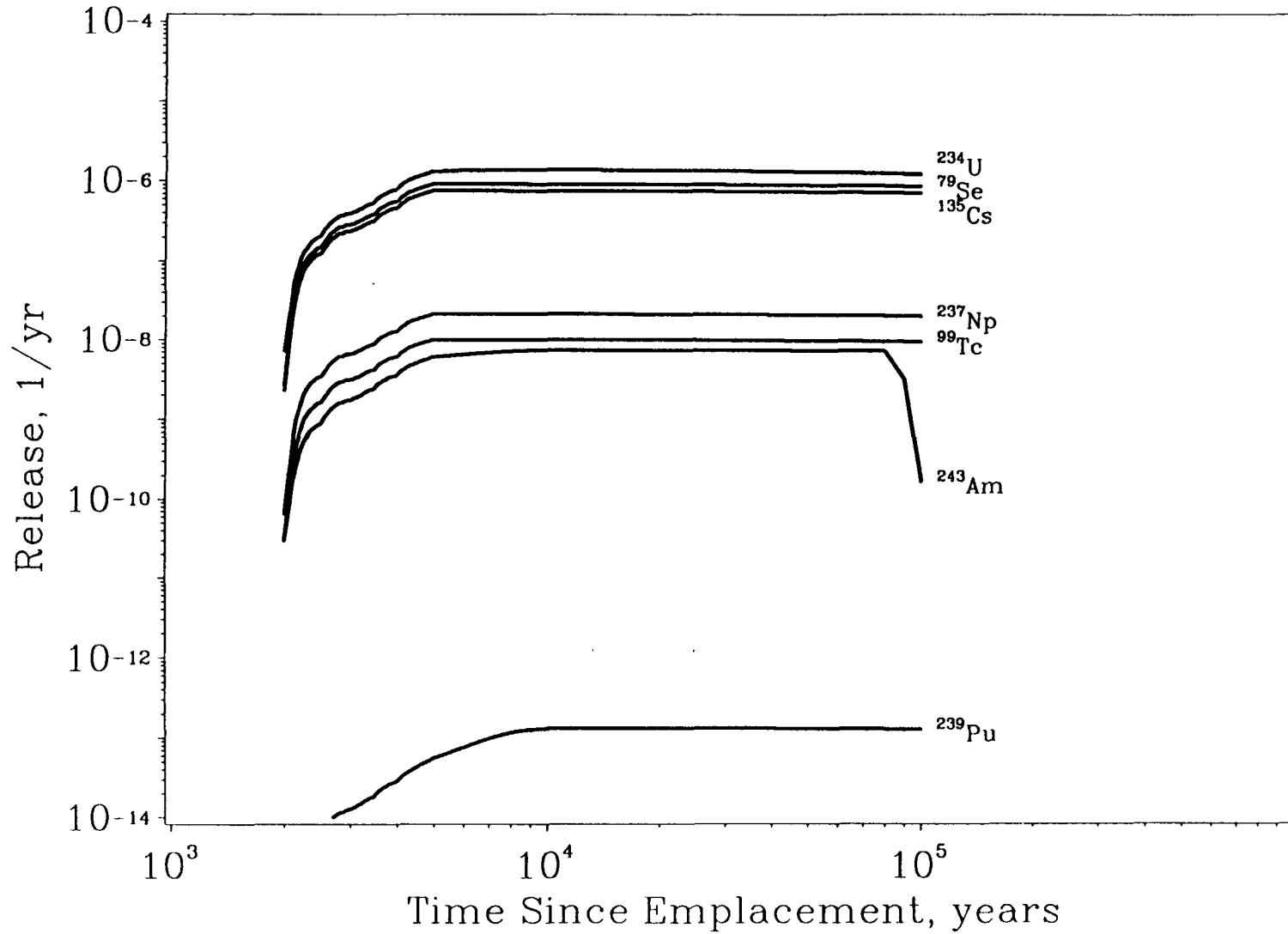
Base Case, Spent Fuel, 0.5 mm/yr.



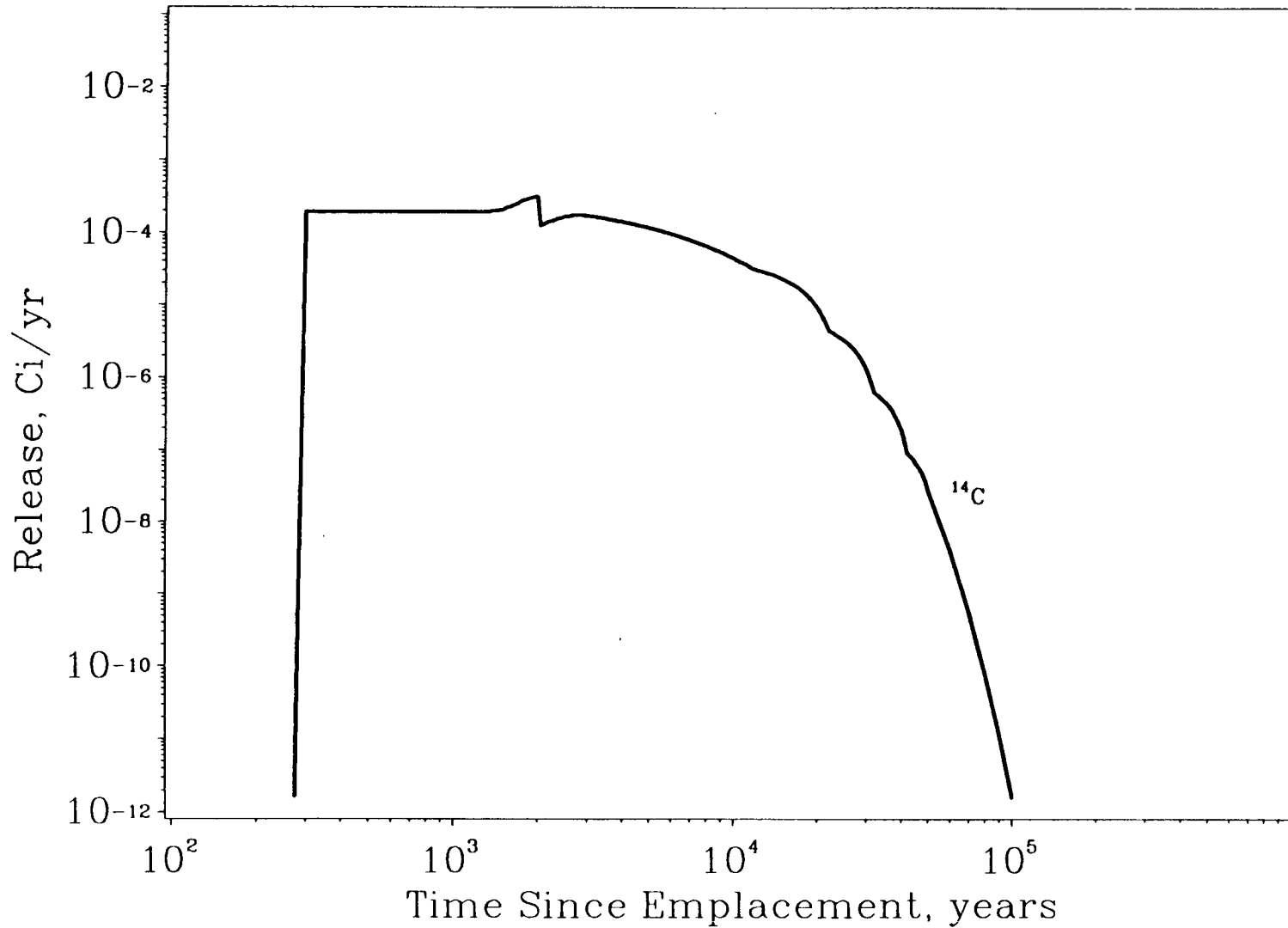
Base Case, Glass, 0.5 mm/yr.



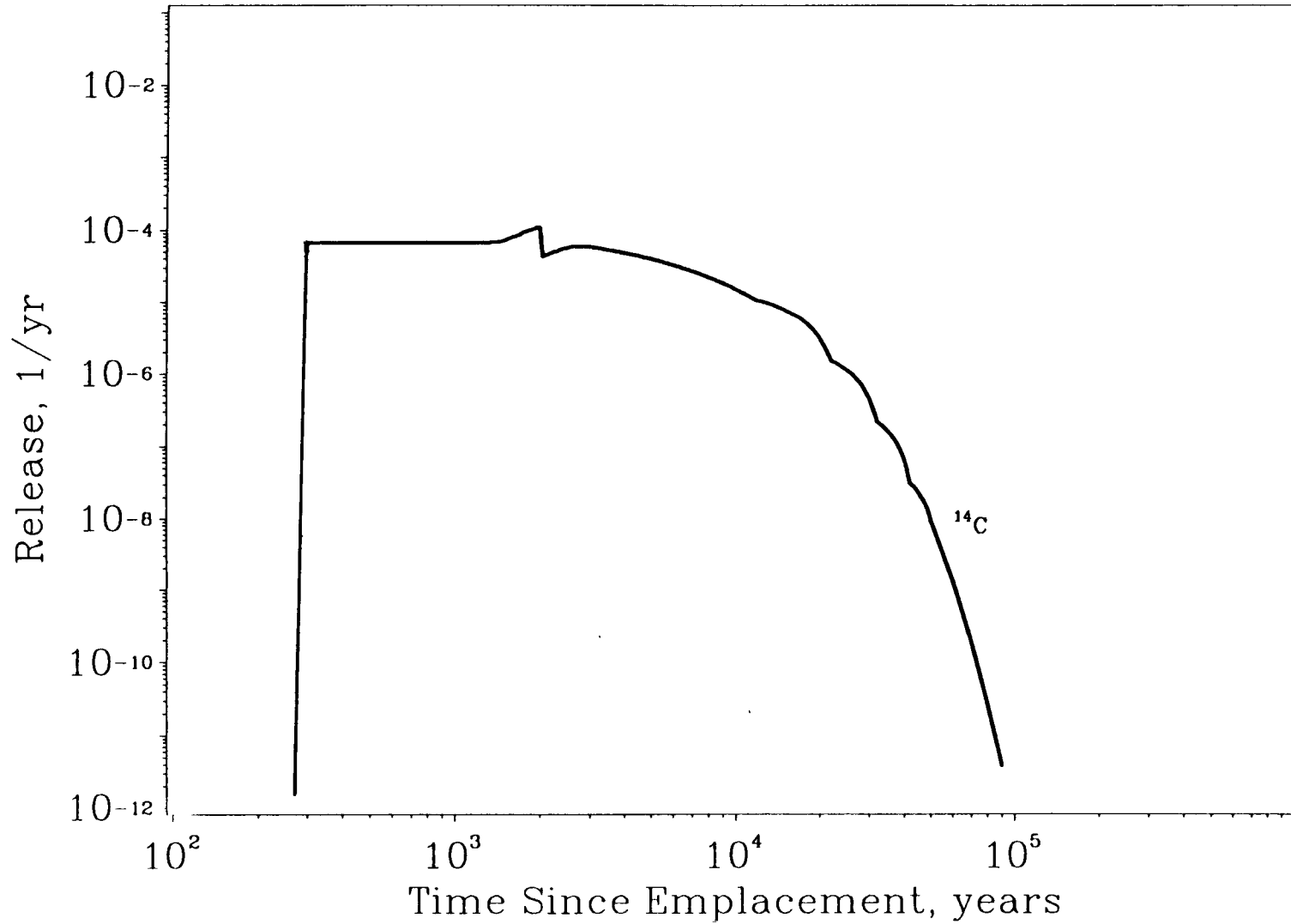
Base Case, Glass, 0.5 mm/yr.



Base Case, Spent Fuel, 0.05 mm/yr.



Base Case, Spent Fuel, 0.05 mm/yr.



Thermal Effects

Objective

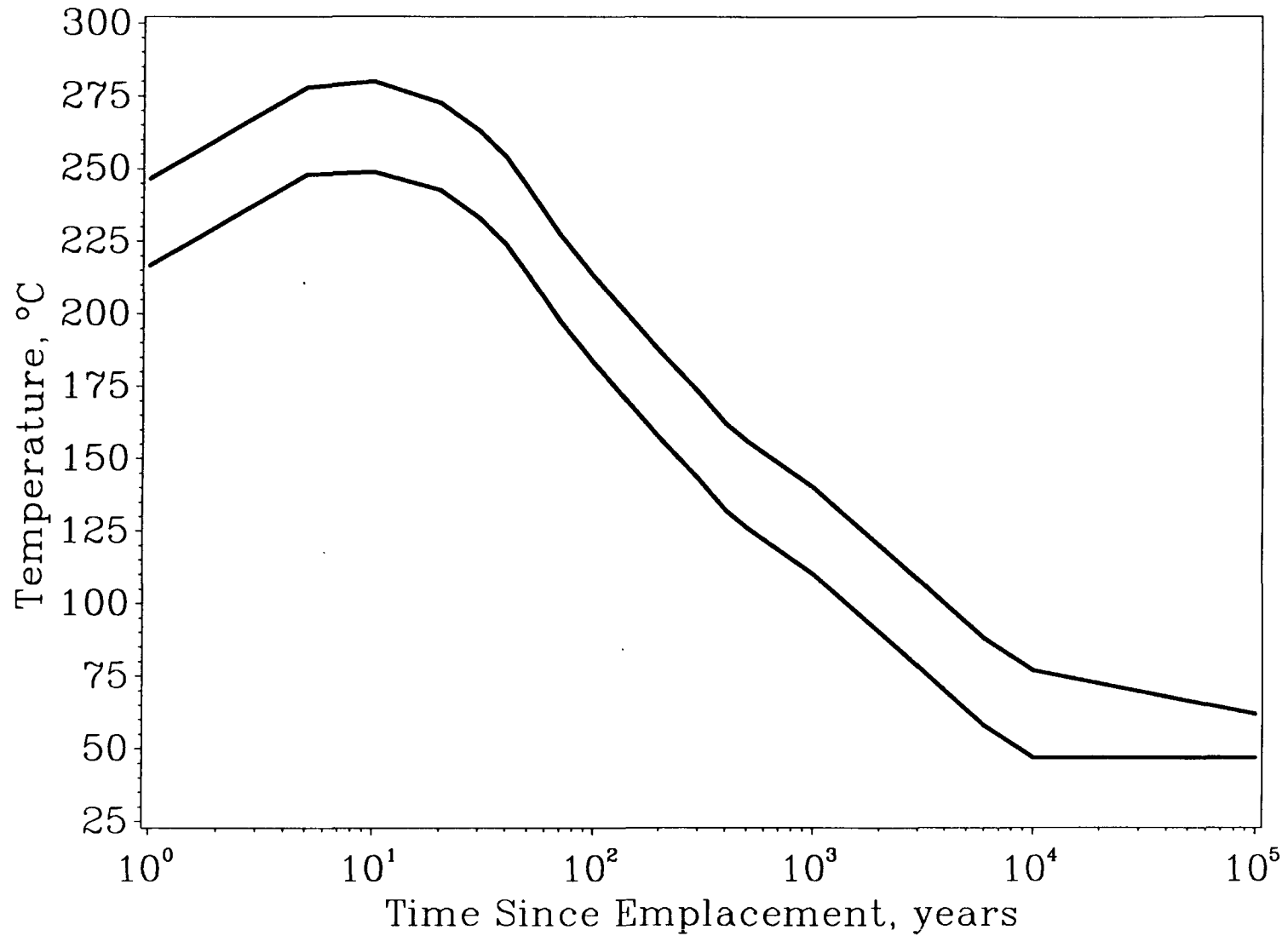
- **Evaluate effects of higher thermal loading on radionuclide release**
- **Resaturation time**
- **Temperature-dependent solubility**
- **Glass dissolution**

Thermal Effects

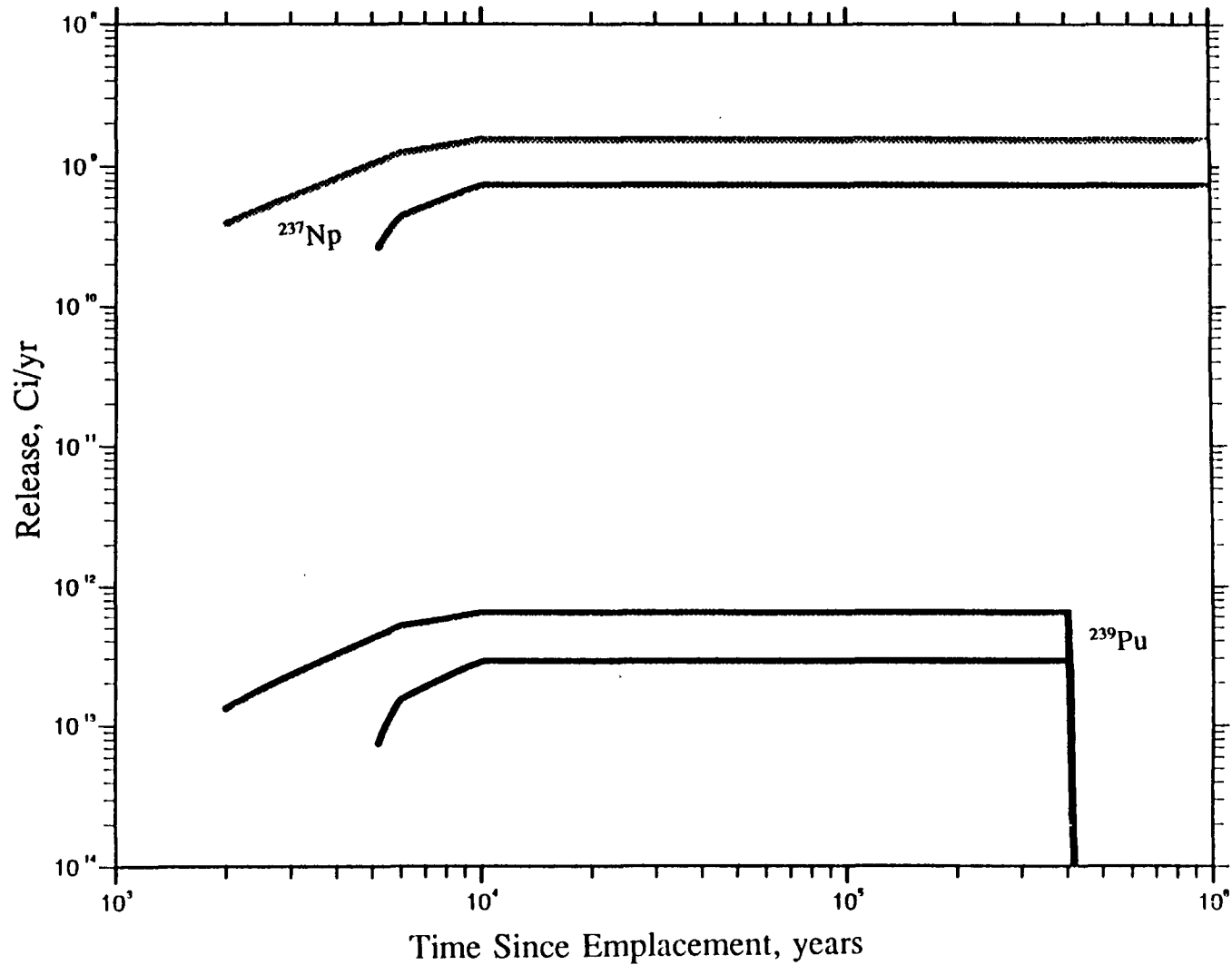
Cases studied

- **Increased temperature**
- **Spent fuel**
 - **Solubility-limited**
 - **Alteration-rate limited**
- **Glass-groundwater coupled reaction**
 - **Fission products**
 - **Actinides**

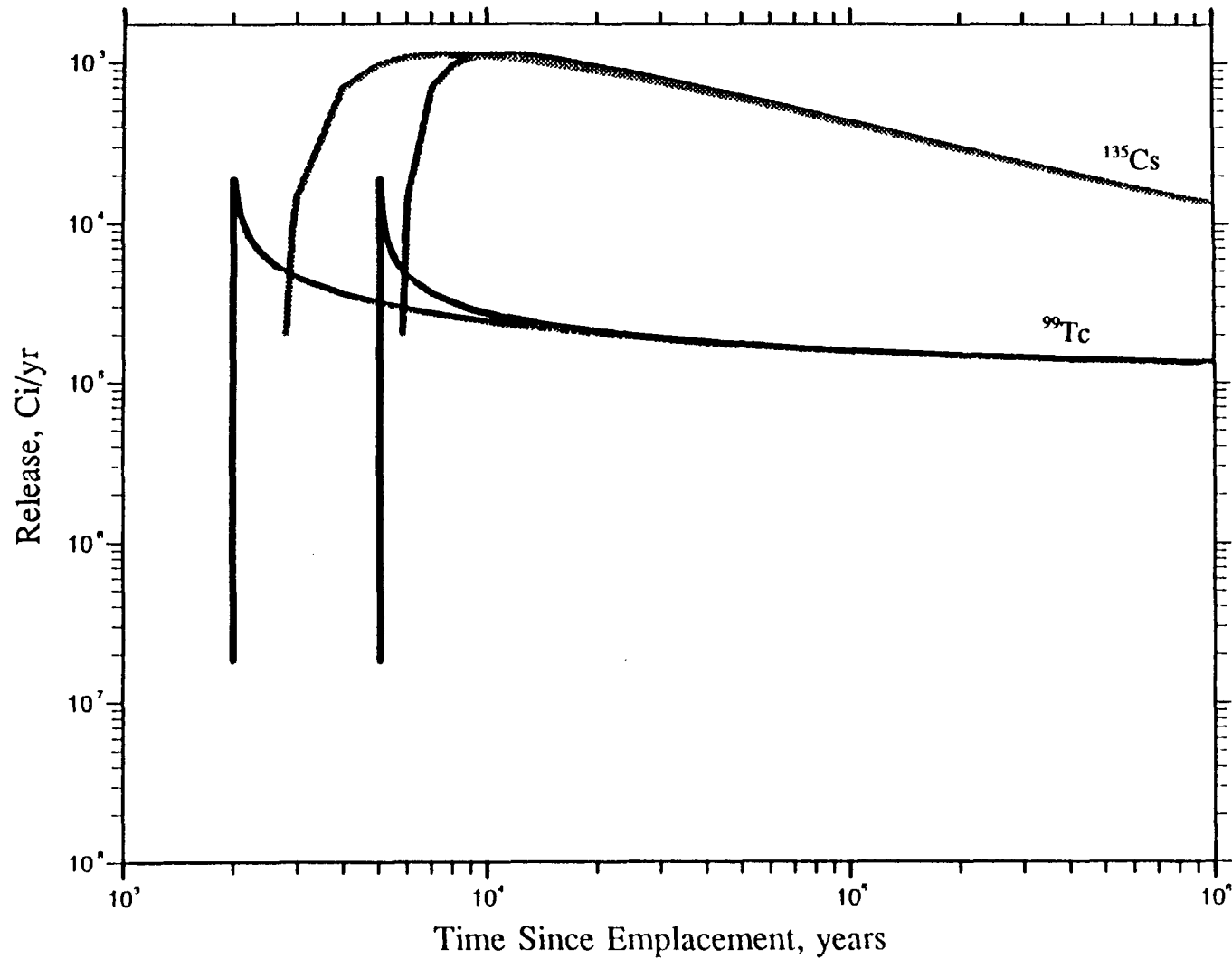
Thermal Profiles Increased Temperature



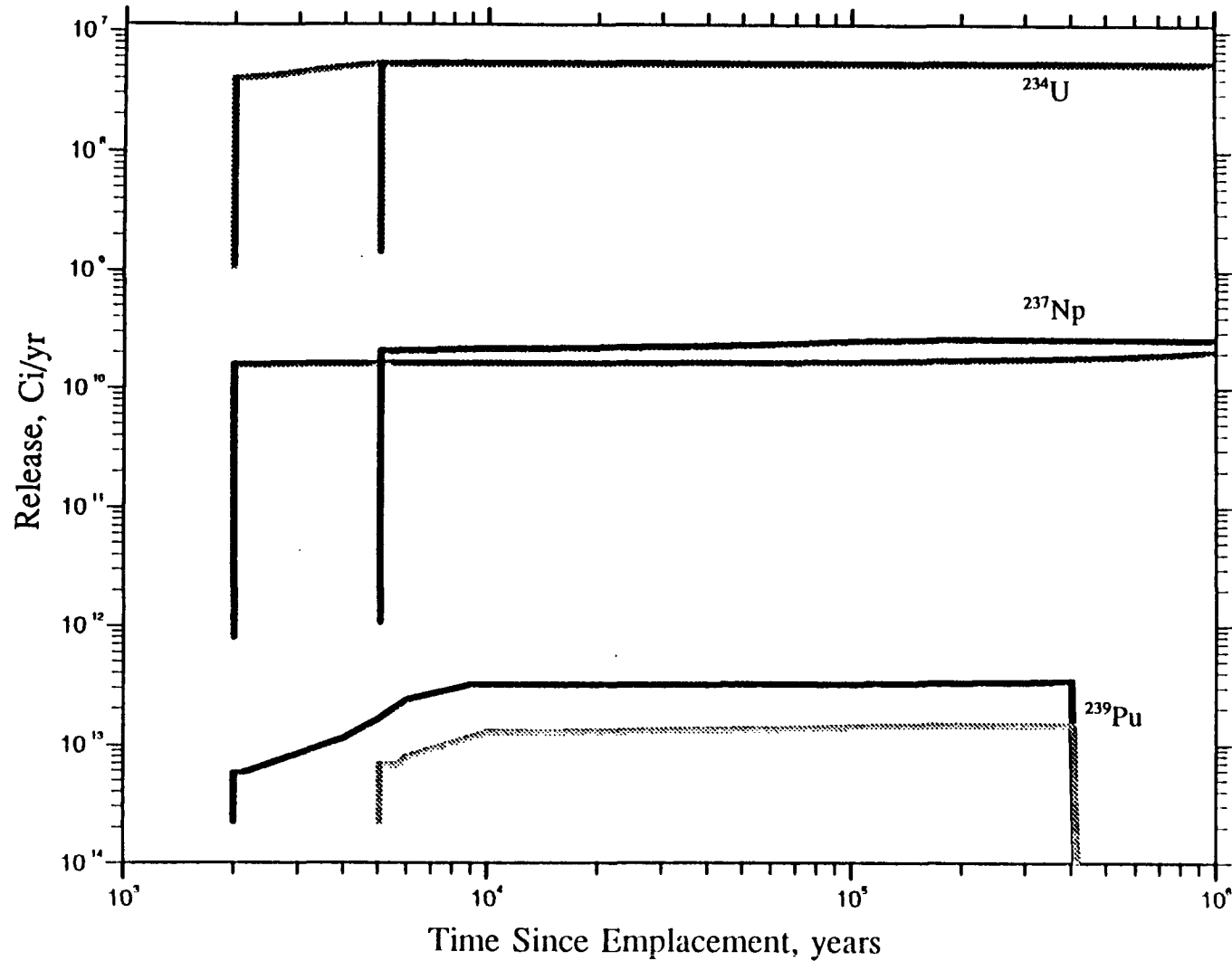
Thermal Effects, Spent Fuel, Solubility-Limited Nuclides



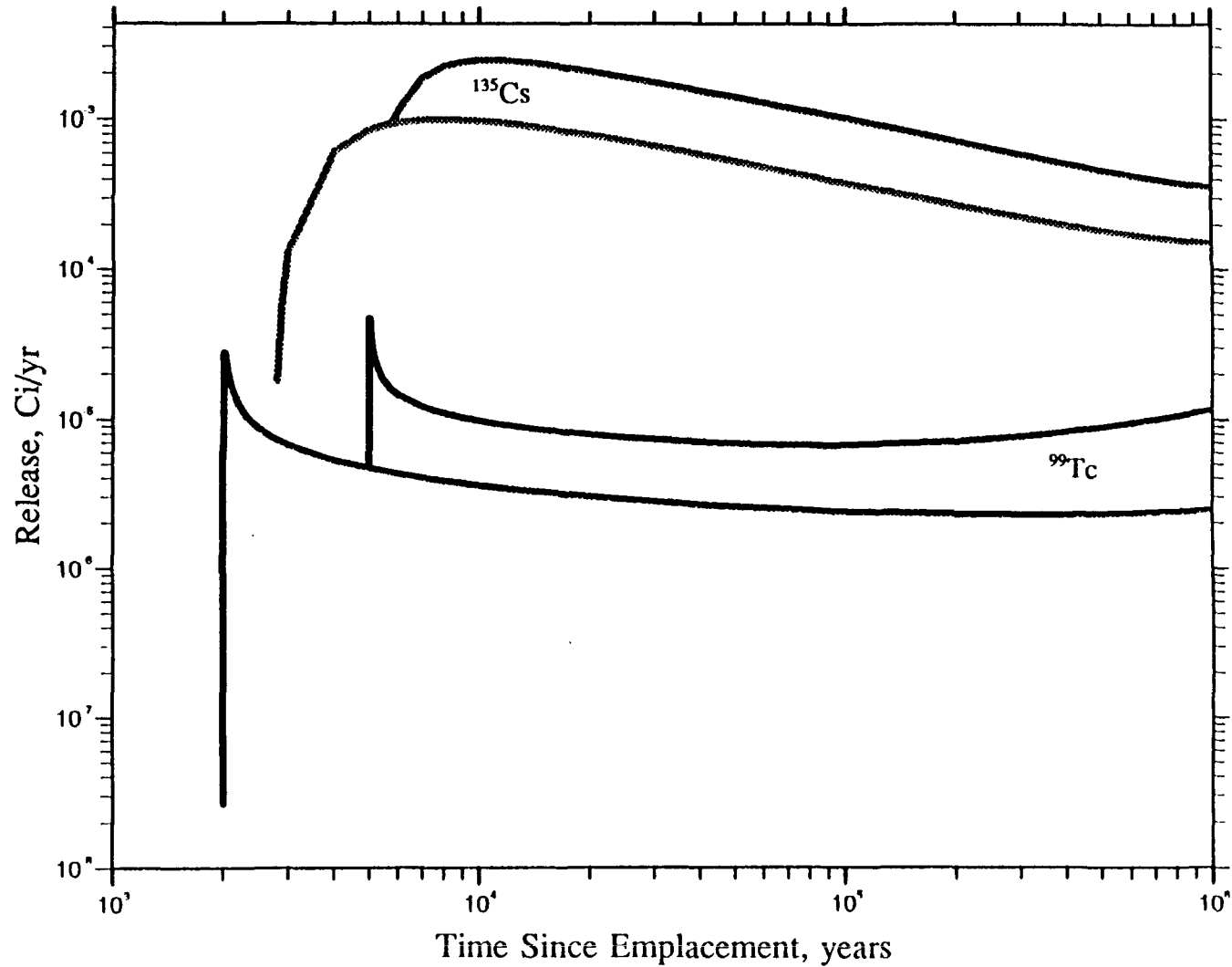
Thermal Effects, Spent Fuel, Alteration-Rate Limited Nuclides



Thermal Effects, Glass Dissolution Model, Solubility-Limited Nuclides



Thermal Effects, Glass Dissolution Model, Alteration-Rate Limited Nuclides



Conclusions

- **Some cases exceeded NRC (10 CFR 60) release criteria**
- **Need for more detailed modeling**
 - **Coupled-reactive transport model**
- **Higher thermal loading**
 - **Delays transport time for ALL cases**
 - **Lowers release rates for some cases (Solubility-limited model)**
 - **No change in release rates for some cases (Alteration-limited model)**
 - **Higher release rates for some cases (Glass dissolution model)**

RALSTON W. BARNARD

EDUCATION: B.A. Math-Physics, Whitman College
Ph.D. Nuclear Physics, University of Colorado

EXPERIENCE:

18 YEARS WITH SANDIA NATIONAL LABORATORIES Senior member of the Technical Staff. More than three years working on the Yucca Mountain Project doing performance assessment analyses. Led the PACE-90 and TSPA 1991 efforts. Prior work at Sandia on safeguards, nuclear weapons components, and innovative ways to explore for uranium. Received a patent for the analysis method used for the Prompt Fission Neutron uranium-assay technique.

6 YEARS WITH BELL TELEPHONE LABORATORIES Member of the Technical Staff. Worked on materials-science projects, including energy-dispersive X-ray analysis, diffusion barriers, and design of telephone transmission media. Received two patents for inventions related to diffusion barriers.

PUBLICATIONS: Numerous documents published at Bell Labs and Sandia Labs. Several publications in scientific journals and conference proceedings.

ROBERT E. EINZIGER

EDUCATION: BS Physics, Georgia Tech
MS Solid State Physics, RPI
PhD Solid State Physics, RPI
Ceramic Engineering Graduate Courses at Rutgers

EXPERIENCE:

THREE YEARS AT PACIFIC NORTHWEST LABORATORY. Manager of the Materials and Chemical Systems Performance Section. Responsible for technical quality of research in areas of (1) tritium target performance, (2) glass and grout hazardous and nuclear waste form composition and performance, (3) fracture and mechanical properties of metals in adverse atmospheres, (4) chemical separation processes for production of medical radioisotopes and separation of nuclear waste, and (5) spent fuel performance and characterization. Responsible for staff of about 70 persons. Project leader on studies of (1) spent fuel oxidations and (2) hydride behavior in spent fuel cladding. Member of the Technical Advisory Group and task forces on the Transportation Source Term for Sandia National Laboratory.

8 YEARS AT WESTINGHOUSE HANFORD COMPANY. Managed Waste Barriers Engineering Group. Conducted experimental studies on bench and in hot cells on (1) spent fuel oxidation and (2) expected behavior of spent fuel and cladding in repositories and dry storage. Served on advisory groups, committees, or as consultant for EPRI, DOE, ONWI, NRC, and others.

6 YEARS AT ARGONNE NATIONAL LABORATORY. Responsible for EBR-II metallic driver fuel qualification. Studied irradiation performance of fuel, cladding and fuel interaction. Developed technique to analytically analyze fuel element ovality. Measured diffusion in refractory metals. Developed techniques in optical pyrometry.

PUBLICATIONS: Approximately 35 publications in scientific journals.

WILLIAM L. BOURCIER

EDUCATION: BS Geology, Oregon State University
PhD Geochemistry and Mineralogy, Pennsylvania State University

EXPERIENCE:

FIVE YEARS AT LAWRENCE LIVERMORE NATIONAL LABORATORY, as a geochemist in the Earth Sciences Department. Research interests include aqueous geochemistry, hydrothermal ore deposits, and computer modeling of water-rock interactions.

TWO YEARS AT THE NASA JOHNSON SPACE CENTER as a National Research Council Research Associate.

PUBLICATIONS: About a dozen publications in scientific journals.

RAY B. STOUT

EDUCATION: BS Mechanical Engineering, Ohio State University
MS Mechanical Engineering, Ohio State University
PhD Engineering Mechanics, Illinois Institute of Technology
MBA Business Administration, University of Pittsburgh

EXPERIENCE:

ELEVEN YEARS WITH LAWRENCE LIVERMORE NATIONAL LABORATORY. Current position is Technical Area Leader for Waste Form Characterization in the LLNL-YMP Nuclear Waste Program. Responsible for waste form experiments and model development to characterize cladding degradation, spent fuel oxidation and dissolution, glass (DHLW) alteration and dissolution, and thermochemical data base activities. Previous work consisted of model development and computer programming to describe material deformation and thermodynamic responses due to dense sets of dislocations, microcracks, and cracks. Also, developed models of shock response for granular materials.

10 YEARS WITH WESTINGHOUSE ELECTRIC COMPANY. Member of the Fuel Element Material Development group at Bettis Atomic Power Laboratory. Position was Fellow Engineer with responsibilities for modeling and analyses of heat transfer, mass transport, stress response, irradiated material response, and failure of UO₂ fuel and cladding for reactor design.

PUBLICATIONS: About 49 publications and reports.

MICHAEL L. WILSON

EDUCATION: B.S. Mathematics and Physics, University of New Mexico
Ph.D. Physics, University of California, Berkeley

EXPERIENCE:

3 YEARS WITH SANDIA NATIONAL LABORATORIES Currently Senior Member of Technical Staff, working on total-system performance assessment for the Yucca Mountain Site Characterization Project. The work has involved modeling of releases of radionuclides from waste packages, modeling of ground-water flow and transport of the radionuclides in unsaturated and saturated rock, modeling of gas flow and transport of gaseous radionuclides, and development of methods for Monte Carlo simulation of the Yucca Mountain systems.

4 YEARS WITH SPECTRA RESEARCH INSTITUTE Worked under contract to Sandia Labs on total-system performance assessment for the Yucca Mountain Site Characterization Project, primarily on development of the TOSPAC ground-water flow and transport computer program.

2 YEARS OF NASA Postdoctoral position, working on basic research in Cosmology; in particular, on the theory of galaxy formation and its relation to the anisotropy of the cosmic microwave background radiation.

6 YEARS AT UCB As a graduate student, teaching assistant for the Physics Department and research assistant for the Astronomy Department. Theoretical work on galaxy formation and the cosmic microwave background radiation.

PUBLICATIONS: Nineteen publications in scientific journals, technical reports, and conference proceedings and abstracts.

Steven A. Steward

EDUCATION: B.S. Chemistry, Indiana University
Ph.D. Solid State Chemistry, Arizona State University
Fulbright-Hayes Graduate Fellowship in Germany

EXPERIENCE:

18 YEARS WITH LLNL, Principal Investigator and Task Leader with Yucca Mountain Project at Livermore for the last two years. Principal Investigator with the Materials Research Group in the X-Ray Laser Program for the prior six years. The first ten years at LLNL were spent successively as Principal Investigator, Group Leader and Deputy Section Leader for Tritium Technology.

PUBLICATIONS: Over 40 publications in scientific journals, and as book chapters, formal reports and abstracts for scientific meetings.

WALTER J. GRAY

EDUCATION

B.S.	Chemistry, Oregon State University	1961
M.S.	Inorganic Chemistry, Oregon State University	1963
Ph.D.	Physical Chemistry, Iowa State University	1968

EXPERIENCE - 25 YEARS WITH BATTELLE/PNL

Radiation damage studies in graphite (1968-1972). Dr. Gray directed a number of in-reactor irradiation experiments wherein irradiation-induced dimensional changes and irradiation creep were the prime areas of investigation. Post irradiation annealing experiments and measurement of changes in thermal and electrical conductivities and in thermal expansion were used to study mechanisms of irradiation damage in graphite.

Graphite studies pertinent to use in fusion reactors (1973-1980). These studies involved the evaluation of graphite performance in the expected environment in fusion reactors (high energy neutron radiation, high temperatures, high vacuum, etc.). Measurements were made of the damage function for graphite at neutron energies up to 15 MeV. Graphite cloths and fibers were irradiation tested, and vacuum degassing studies were conducted.

Radioactive waste disposal programs (1975 to date). Work on these programs has included:

- The measurement of high-temperature vaporization of glasses and other potential waste forms.
- The measurement of graphite oxidation rates in liquid water and determination of water permeability of various graphites.
- Measurement of the leaching of carbon-14 and chlorine-36 from irradiated nuclear graphite.
- Investigation of the effects of fission product transmutations on the properties of potential waste forms.
- Study of alpha- and gamma-radiolysis effects on salt brine solutions and other groundwaters found near potential high-level waste repositories.
- Dissolution studies on spent reactor fuel as part of the effort to model the potential for interaction between groundwater and spent fuel in a geologic repository.
- Characterization of solid and liquid wastes currently stored in underground tanks at the Hanford Nuclear Reservation.

PUBLICATIONS: About 60 publications in scientific journals, symposia proceedings, and government reports.

RICHARD A. VAN KONYNENBURG

EDUCATION: BS Engineering, University of California - Davis
MS Engineering-Applied Science, University of California - Davis
Ph.D. Engineering - Applied Science, University of
California - Davis

EXPERIENCE:

19 YEARS WITH LAWRENCE LIVERMORE NATIONAL LABORATORY, as an Engineer performing research and development in nuclear waste management, materials for nuclear fusion reactors, neutron activation analysis for hydrogeochemical exploration, and neutron and gamma ray dosimetry. Participated in an NRC-sponsored risk analysis project to determine criteria for solidified nuclear waste, the Climax spent fuel test, and the SYNROC-D project to develop a ceramic waste form for defense waste. Areas of specialization are radiation effects and radiation chemistry. For the Yucca Mountain Project, have focused primarily on radiation chemistry effects on the waste package environment and on corrosion of waste package materials, carbon-14 release, and microbiological influenced corrosion.

1 YEAR WITH UNIVERSITY OF CALIFORNIA - DAVIS (part-time) as a lecturer teaching a graduate course in theory and applications of solid state physics.

2 YEARS WITH THE U.S. ARMY as an officer in the Corps of Engineers supervising research and development in detection of land mines using neutron, x-ray, and gamma ray techniques. Conducted joint Army-Navy tests of boat-mounted munitions detection third-harmonic radar in Vietnam.

PUBLICATIONS: About 60 publications in scientific journals, conference proceedings, and Lawrence Livermore National Laboratory reports.

CONSULTING: Gave lectures on neutron physics, neutron dosimetry, and radiation effects on reactor pressure vessel steels for the International Atomic Energy Agency and for the Argentine Atomic Energy Commission. Consulted for Battelle Columbus and for Imatron Corp. on U.S. Army-sponsored research and development of radiation techniques for mine detection.

DAVID STAHL

EDUCATION: BS, Chemical Engineering, cum laude, City College of New York
MS, Metallurgical Engineering, Ohio State University
MBA, University of Chicago
PhD, Metallurgy and Materials Science, New York Polytechnic

EXPERIENCE:

1 YEAR BABCOCK & WILCOX FUEL COMPANY: Responsible for waste-package performance analysis, including the interfacing of the effort with the materials and design efforts within the waste-package development activities, the performance assessment activities of the waste management system.

4 YEARS, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION: Supported materials programs to the DOE's Yucca Mountain Site Characterization Project, involving technical monitoring, review, and direction of the waste-package activities underway at LLNL.

6 YEARS, BATTELLE COLUMBUS DIVISION: Program Manager in the Manufacturing and Advanced Materials Department, managed the multi-million dollar NRC Waste Package Program, which involved long-term performance of materials for nuclear waste packaging. Managed programs for dry storage of nuclear fuels, fuel rod consolidation, and mechanical testing of reactor surveillance capsules and reactor pressure vessel tubes.

9 YEARS, ARGONNE NATIONAL LABORATORY: As a Project Leader, developed and managed the DOE program on low-enrichment fuels for research and test reactors, including the development and use of materials for coal conversion equipment, MHD generators, high-performance batteries, and fast-breeder and light-water reactors. Previous positions included Group Leader, Ceramics Group; Coordinator of Fast Reactor Safety Programs; Coordinator of MSD Coal Programs; Metallurgist in the Irradiation Performance Group; and Chairman of the Reactor Safety Review Committee.

7 YEARS, UNITED NUCLEAR CORPORATION: Section Head in the Materials Group of the R&D Division engaged in nuclear fuels and materials development activities. Responsible for all irradiations experiments on the carbide fuel development program.

3 YEARS, BATTELLE MEMORIAL INSTITUTE: Principal Metallurgist in the Engineering Mechanics Group of the Physics Department, involved in materials evaluations in nuclear systems. Responsible for the design, construction, and operation of irradiation experiments.

PUBLICATIONS:

Over 50 technical reports and six journal articles. He has made technical presentations in the U.S. and Europe.

DIANE J. HARRISON

EDUCATION: AS, Pre-Mathematics, West Virginia Northern Community College,
Weirton, WV
BS, Chemical Engineering, West Virginia Institute of Technology,
Montgomery, WV
Graduate Certificate in Project Management, West Coast University,
Los Angeles, CA

EXPERIENCE:

4 YEARS, U.S. DEPARTMENT OF ENERGY: Currently Chief, Field Engineering Branch, responsible for planning, managing, coordinating, and integrating the development of the repository and waste package major technology projects associated with the development of a Mined Geologic Disposal System (MGDS) for the Yucca Mountain Project (YMP). This includes the management and development of project technical baseline documents dealing with systems requirements and description; interacting with DOE/Headquarters and the NRC on siting, design, and construction of the components and the facility; and directing contractors and other YMP participants. Conducts YMP waste package, repository, and engineered barrier design activities through a subordinate staff. Reviews work for validity of technical adequacy, management direction, completeness of preparation, and adequacy of resulting impact on the performance of the waste package or the repository. Directs a task force comprised of staff from the Management and Operating (M&O) contractor, and Lawrence Livermore, Sandia, and Los Alamos national laboratories that is evaluating the importance of the duration of heater tests and the impact of these tests on the cost, schedule, and licensability of the MGDS.

Previously, as Materials Engineer and WBS Element Manager, was responsible for managing the waste package activities associated with the development of a mined geologic disposal system for the disposal of high level waste and spent nuclear fuel. This included oversight of the M&O and LLNL and their subcontractors who are doing waste-form, container-materials, and near-field environment testing and waste-container design. Member of the Technical Review Group reviewing the documentation generated by the waste producers (West Valley Demonstration Project and the Defense Waste Processing Facility, Savannah River Plant) that documents compilation of results from waste-form testing and analysis.

7 YEARS, ROCKWELL INTERNATIONAL, ROCKETDYNE: As a Nuclear Operations Engineer, responsibilities included managing and processing the radioactive, hazardous, and mixed waste generated at the Rockwell International Hot Laboratory.

4 YEARS, WEIRTON STEEL CORPORATION: Performed field inspections of waste treatment facilities, and stack and water effluent sampling. Also, performed wet, instrumental, and metallurgical analyses of raw materials and finished products.

JOHN K. BATES

EDUCATION: BA, Chemistry, Earlham College, Richmond, IN
MS, Chemistry, University of Michigan, Ann Arbor
PhD, Physical Chemistry, University of Michigan, Ann Arbor

EXPERIENCE:

17 YEARS AT ARGONNE NATIONAL LABORATORY (ANL): Currently, Section Head of the Nuclear Waste Programs Section with ANL, providing integration of radioactive waste disposal programs in the high-level, mixed, and low-level waste areas. Technical activities include glass and spent-fuel reaction, development of methods to study actinide-bearing colloids in solution, development of analytical electron microscopy to study reacted glasses and the distribution of actinides in soil samples, remediation studies of soils at Fernald, OH, and providing input and review of the Compendium of glass characteristics.

Previously at ANL, Group Leader in the High-Level Waste Group providing technical oversight of programs in support of high-level waste disposal at the Yucca Mountain and Basalt Waste Isolation Project sites.

As Staff Scientist at ANL, developed neutron activation analysis and scanned electron microscopy to study the reaction of nuclear waste glass and liquid water and water vapor.

As an Assistant Scientist at ANL, studied the distribution of actinide elements between immiscible molten salt and molten metal mixtures.

PUBLICATIONS:

Over 50 publications related to the performance of glass. Over 10 publications related to spectroscopy and fuel processing.

WILLIAM J. O'CONNELL

EDUCATION: BS, University of Notre Dame
Fulbright Fellowship, Bonn University, Bonn, Germany
MS, Physics, Stanford University
PhD, Nuclear Physics, Stanford University

EXPERIENCE:

14 YEARS WITH LAWRENCE LIVERMORE NATIONAL LABORATORY (LLNL),
Systems Research Group. Currently Project Leader for a Nuclear Waste Transportation Project, performing a risk assessment of transportation of spent fuel for DOE OCRWM Transportation Division. This involves a synthesis of transportation, nuclear, and mechanical engineering and probabilistic risk analysis. Also, Task Leader for Waste Package Performance Assessment for the LLNL-YMP, involving synthesis of engineering and earth sciences information. Previously, performed probabilistic analyses for earthquake safety of nuclear power plants (NPPs) and for reactor seismic trip. Conducted on-site reviews of NPP control-room human-factors upgrade projects and software reliability reviews for NPP safety parameter display systems.

5 YEARS WITH IMPELL INC.: Computer code maintenance manager for piping stress analysis codes used in nuclear power plant design. Conducted piping, structural, and rare event safety analyses for nuclear power plants.

1 YEAR WITH LLNL: Conducted research in nuclear structure using accelerators and gamma ray detectors.

3 YEARS WITH MUNICH UNIVERSITY: Developed and installed gamma ray detector equipment. Performed research in the low-energy range of elementary particle physics using pions and gamma rays, as a visiting researcher at the European Center for Nuclear Research (CERN), Geneva, Switzerland.

PUBLICATIONS:

Numerous publications in conference proceedings, LLNL reports, and journals; chapter lead author for American Society of Civil Engineers (ASCE) Manual of Engineering Practice No. 58, "Structural Analysis and Design of Nuclear Plant Facilities," 1980.

DAVID W. ENGEL

EDUCATION: BS, Mathematics, Central Washington University
MS, Mathematics, University of Washington

EXPERIENCE:

Task Leader at Battelle, Pacific Northwest Laboratory (PNL), responsible for the development, modification, and analysis of the AREST code. The AREST code was developed by the Performance Assessment Scientific Support (PASS) program. The purpose of the code is to provide a tool for making preliminary, quantitative performance assessments of the engineered-barrier and near-field systems of a geologic repository for high-level radioactive waste.

PUBLICATIONS:

Over 20 publications in scientific journals, conference proceedings, and PNL reports.

CYNTHIA E. A. PALMER

EDUCATION: BS, Chemistry, Worcester Polytechnic Institute
PhD, Inorganic Chemistry, Purdue University

EXPERIENCE:

6 YEARS WITH LAWRENCE LIVERMORE NATIONAL LABORATORY (LLNL): As a chemist in the Nuclear Chemistry Division, responsibilities include Core Sampling Project Leader; Detector Custodian; and Radiochemical Diagnostics Chemist. Also, Task Leader for the Yucca Mountain Project--Thermodynamic Data Determination/Evaluations Task; Nevada Environmental Applied Research Project; Hydrology and Radionuclide Migration Project. Responsibilities also include that of Acting Facility Manager and NCD Affirmative Action/Equal Employment Opportunity Coordinator.

PUBLICATIONS:

Over 40 publications in scientific journals, technical and scientific reports, and presentations and conference proceedings.

THOMAS J. WOLERY

EDUCATION: BS, Geochemistry, Bowling Green State University
MS, Geology, Bowling Green State University
PhD, Geological Sciences, Northwestern University

EXPERIENCE:

14 YEARS, LAWRENCE LIVERMORE NATIONAL LABORATORY: As a Geochemist with the Earth Sciences Department, provides technical leadership in geochemical modeling. Modifies and extends the capabilities of the EQ3/6 software package for geochemical modeling, primarily for the Yucca Mountain Project and the Waste Isolation Pilot Plant. Conducts studies of the basic science underlying geochemical modeling.

For the Nuclear Waste Management Group, provided technical direction of geochemical modeling for nuclear waste isolation projects (mostly for the NNWSI, ONWI, and SRPO, with lesser involvement with BWIP and WIPP projects), including continuing development of the EQ3/6 code package. Worked to extend the understanding of basic processes and phenomena upon which geochemical modeling is founded (e.g., mineral dissolution/growth kinetics, activity coefficients in brine solutions). Provided scientific leadership, coordinated, and directed the activities of a growing group of geochemists and computer scientists. Interacted with other parts of the LLNL Nuclear Waste Management Program and with sponsoring agencies.

As a Geochemistry Group Leader, projects included OBES sponsored "Chemistry of aqueous systems," the LLNL NRC Technical Assistance Program, and various ERDA- or DOE-sponsored high level nuclear waste disposal programs (WISAP, WRIT, SYNROC).

PUBLICATIONS:

About 50 publications in scientific journals, conference proceedings, abstracts, LLNL reports and papers.

RICHARD W. SPENGLER

EDUCATION: BA Geology, Humboldt State College

EXPERIENCE: 14 YEARS WITH USGS
4 YEARS WITH GEOTECHNICAL FIRMS

1981-Present: Principal Investigator of Site Geologic Studies, Yucca Mountain Project, responsible for the integration, design, and direction of geologic and geophysical studies for the development of a geologic model of the Yucca Mountain site area.

1978-1981: Project Chief, Tuff Exploration Project, responsible for coordination and direction of subsurface data-gathering activities at Yucca Mountain.

1977-1978: Project Chief, granitic rock studies, Nevada, synthesis and evaluation of geologic data on granitic rock masses within Nevada as potential sites for nuclear waste storage.

1975-1977: Geologist, geologic mapping of 7 1/2-minute quadrangles, Kentucky; subsurface investigations to evaluate potash resources of WIPP, Carlsbad, New Mexico.

1971-1975: Geologist, Fenix & Scisson, Inc. and Nevada Testing Laboratories, Inc., subsurface and geotechnical evaluations.

PUBLICATIONS: About 30 publications in scientific journals, USGS reports, and abstracts, more than 20 of which address aspects of the stratigraphic and structural framework of Yucca Mountain.