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SECY-81-267 - 10 CFR PART 60, "DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES IN GEOLOGIC REPOSITORIES: TECHNICAL CRITERIA

ATTACHED IS ENCLOSURE J TO THE SUBJECT PAPER, WHICH EDO INDICATED WOULD BE FORWARDED SEPARATELY.

ATTACHMENT:
AS STATED

THE SECRETARIAT

# RATIONALE FOR PERFORMANCE OBJECTIVES AND REQUIRED CHARACTERISTICS

# OF THE GEOLOGIC SETTING:

# TECHNICAL CRITERIA FOR REGULATING GEOLOGIC DISPOSAL OF

# HIGH-LEVEL RADIOACTIVE WASTE

Division of Waste Management
U.S. NRC

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Enclosure J

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# RATIONALE FOR PERFORMANCE OBJECTIVES AND REQUIRED CHARACTERISTICS OF THE GEOLOGIC SETTING

## I. Introduction.

High-level radioactive waste (HLW) is a byproduct of the irradiation of nuclear fuel in nuclear reactors. In the United States, commercial nuclear reactors are principally light water reactors, whose fuel consists of pellets of $UO_2$. The uranium is a mixture of isotopes that is mostly U-238, but includes about 2 to 3 percent U-235 and trace amounts of other isotopes of uranium. During irradiation, the U-235 fissions and releases energy. During irradiation, some of the U-238 is converted to Pu-239, which, like U-235, can fission and release energy.

After the fuel has been removed from the reactor, the Pu-239 and remaining uranium can be removed (fuel reprocessing) and recycled. This has led to the conceptual development of several fuel cycles. Three fuel cycles have been considered by the Environmental Protection Agency (EPA) (1979a) in developing its high level waste standard and the Department of Energy (DOE) (1979) in its draft Generic Environmental Impact Statement (GEIS) on Commercial Waste Management.

1. The "throwaway" cycle in which low-enriched uranium as $UO_2$ is irradiated in a light water reactor (LWR), with direct disposal of the spent fuel as waste;

2. Uranium-only recycle in which low-enriched $UO_2$ is irradiated in an LWR, the spent fuel is reprocessed, the recovered uranium is recycled, and the plutonium is stored;

3. Mixed-oxide recycle in which mixed $PuO_2$ and low-enriched $UO_2$ is irradiated in an LWR, the spent fuel is reprocessed and the recovered uranium and plutonium are recycled.

In its final GEIS, DOE (1980) deleted the uranium only recycle case because of the low likelihood it would ever be implemented. Storch and Prince (1979) discuss several other potential fuel cycles that are found in the literature, but are not being commercially developed at present.

The different fuel cycles are significant because they result in different waste products. The EPA, to develop its standard, has been considering the throwaway, uranium-only recycle, and mixed-oxide fuel cycles for characterizing radioactive waste. The NRC staff has also used these same cycles, since we consider their wastes have characteristics that will bound those of wastes from any fuel cycle likely to be commercially developed.

The more important nuclides in radioactive waste result either from fission or from neutron capture in actinide isotopes. Both processes occur during irradiation of the fuel in the reactor. When the spent fuel is removed from the reactor, it consists principally of fission products and actinides in addition to some activation products in the fuel assembly structures and fuel cladding (DOE, 1979; ADL, 1979a). Each has certain general characteristics that are described in ADL (1979a, 1979c) and DOE (1979, 1980).

For the most part, the fission products are relatively mobile in the geologic environment, have short half-lives, and high specific activities. In consequence of their high specific activities, the fission products generate heat at a significant rate. In contrast, the actinides tend to be relatively immobile, have long half-lives, and lower specific activities. In addition, they generate heat at a lower rate than the fission products and, like uranium ore, they emit primarily alpha radiation.

In the throwaway cycle, the spent fuel assemblies are the waste. The uranium-only recycle and the mixed-oxide fuel cycle both involve reprocessing of the spent fuel. That operation is generally carried out by the PUREX process, which produces a nitric acid solution containing the fission products and various amounts of actinides as a waste stream. This waste can be solidified before final disposal and is called reprocessed high-level waste.

High level radioactive wastes from these fuel cycle will need to be disposed of in a manner that does not represent a hazard to public health and safety. Three Federal agencies have major roles in the national program for disposal of high-level radioactive wastes. The EPA is responsible for establishing generally applicable environmental standards for protection of the general environment from radioactive material. The standards apply to all uses of radioactive materials, including disposal of high-level wastes. The Department of Energy has the responsibility to develop the technology and to select the sites for safe disposal of high level wastes. The Nuclear Regulatory Commission (NRC) is responsible for developing technical criteria to be used in implementing EPA's standard. The technical criteria that the NRC proposes includes the following performance objectives and required characteristics of the geologic setting:

§60.111 Performance objectives.

(a) Performance of the geologic repository operations area through permanent closure.

(1) Protection against radiation exposures and releases of radiological material. The geologic repository operations area shall be designed so that until permanent closure has been completed, radiation exposures and radiation levels, and releases of radioactive materials to unrestricted areas, will at all times be maintained within the limits specified in Part 20 of this Chapter and any generally applicable environmental standards established by the Environmental Protection Agency.

(2) Retrievability of waste. The geologic repository operations area shall be designed so that the entire inventory of waste could be retrieved on a reasonable schedule, starting at any time up to 50 years after waste emplacement operations are complete. A reasonable schedule for retrieval is one that requires no longer than about the same overall period of time than was devoted to the construction of the geologic repository operations area and the emplacement of wastes.

(b) Performance of the geologic repository after permanent closure.

(1) Overall system performance. The geologic setting shall be selected and the subsurface facility designed so as to assure that releases of radioactive materials from the geologic repository following permanent closure conform to such generally applicable environmental standards as may have been established by the Environmental Protection Agency.

(2) Performance of the engineered system.

(i) Containment of HLW. The engineered system shall be designed so that even if full or partial saturation of the underground facility were to occur, and assuming anticipated processes and events, the waste packages will contain all radionuclides for the first 1,000 years after permanent closure and for as long thereafter as is reasonably achievable.

This requirement does not apply to TRU waste unless TRU waste is emplaced close enough to HLW that the TRU release rate can be significantly affected by the heat generated by the HLW.

(ii) Control of releases.

(A) For HLW, the engineered system shall be designed so that, after the first 1,000 years following permanent closure, the rate of release of radionuclides from the underground facility is as low as is reasonably achievable. As a minimum, the design shall provide that the annual release of any radionuclide does not exceed one part in 100,000 of the maximum amount of that radionuclide calculated to be present in the underground facility (assuming no release from the underground facility) at any time after 1,000 years following permanent closure.

(B) For TRU waste, the engineered system shall be designed so that following permanent closure the rate of release of radionuclides from the underground facility is as low as is reasonably achievable. As a minimum, the design shall provide that the annual release of any radionuclide does not exceed one part in 100,000 of the maximum amount calculated to be present in the underground facility (assuming no release from the underground facility) at the time of permanent closure.

(3) Performance of the geologic setting.

(i) Containment period. During the containment period, the geologic setting shall mitigate the impacts of premature failure of the engineered system. The ability of the geologic setting to isolate wastes during the isolation period, in accordance with paragraph (b)(3)(ii) of this section, shall be deemed to satisfy this requirement.

(ii) Isolation period. Following the containment period, the geologic setting, in conjunction with the engineered system as long as that system is expected to function, and alone thereafter, shall be capable of isolating radioactive waste so that transport of radionuclides to the accessible environment shall be in amounts and concentrations that conform to such generally applicable environmental standards as may have been established by the Environmental Protection Agency and thereby will not result in significant doses to any individual. For the purposes of this paragraph, the evolution of the site shall be based upon the assumption that those processes operating on the site are those which have been operating on it during the Quaternary Period, with perturbations caused by the presence of emplaced radioactive wastes superimposed thereon.

§60.112 Required characteristics of the geologic setting.

(a) The geologic setting shall have exhibited structural and tectonic stability since the start of the Quaternary Period.

(b) The geologic setting shall have exhibited hydrogeologic, geochemical, and geomorphic stability since the start of the Quaternary Period.

(c) The geologic repository shall be located so that pre-waste emplacement groundwater travel times through the far field to the accessible environment are at least 1,000 years.

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The design of a geologic repository for disposal of high level wastes must provide for protection of public health and safety during two periods: (1) during repository operations, when the principal concern involves exposure of operators or releases of radioactive materials to unrestricted areas in liquid or gaseous effluents, and (2) after repository sealing, when the principal concern involves long-term migration through groundwaters to the accessible environment. The performance objectives of 10 CFR 60.111 apply to both of these periods.

(1) Releases during operation

Several operations will be needed prior to disposal of waste in the geologic repository. These operations could include storage of materials, chemical separation, solidification of waste, packaging and emplacement. Each of these operations could result in releases to the operations area or to the general environment.

The EPA is preparing a standard that will limit ambient levels of radioactive materials resulting from operation of a high level waste disposal facility. Part 20 of the Commission's regulations will implement this standard. Part 20 already contains limits for doses to the operating personnel. The performance objective §§60.111(a)(1) requires that the geologic repository operations area be designed to operate within the limits of Part 20. Since the problems likely to be encountered during the operational phase will be similar to those dealt with in similar radioactive materials handling facilities, no special performance objectives in addition to those contained in Part 20 are considered to be necessary.

(2) Releases after decommissioning

The objective of waste disposal is to isolate the waste from the environment for a long period of time. The EPA is preparing a standard that will set limits on ambient levels of radioactivity in the general environment from any disposal system. While the EPA standard has not yet been published in proposed form, we expect that it will require quantities of radioactive materials released to the environment over a long period of time to be limited to very small amounts. The performance objective §§60.111(a)(2) requires that the geologic repository be designed in a way that provides reasonable assurance that ambient levels of radioactive materials will be within limits that EPA may establish.

Disposal of radioactive waste in a manner that will assure safety for many thousands of years represents a unique problem not previously dealt with in other NRC or EPA standards. The NRC staff has considered several performance objectives to address this unusual regulatory problem. The remainder of this chapter provides the technical bases for the performance objectives selected as well as evaluation of alternatives considered for siting and design of the repository to assure effective long-term isolation of the wastes. Section II discusses the alternatives considered in selecting a regulatory approach and the rationale for the approach selected. Section III describes the alternatives considered for the major barriers of the waste isolation system and the rationale for the required barriers. Section IV describes alternatives considered for the specific performance objectives for the major barriers and required characteristics of the geologic setting and provides the basis for the numerical valves that were selected. Section V describes the rationale for requiring the repository to be designed so that the option to retrieve the wastes is preserved and gives the basis for the numerical value selected for the period this option shall be preserved.

## II. Selection of the Regulatory Approach

### A. Need for Numerical Models

While the EPA standard has not been cast in its final form, its implementation will require quantitative predictions of radionuclide releases to the general environment. NAS (1979) notes that this can be done only through the use of numerical modeling of the repository system because of the very long time frame involved. The IRG (1979) also concluded that the degree of long term isolation provided by a repository can only be assessed through analytical modeling.

Predictive modeling of the repository will require that postulated releases be traced from the deeply buried waste through the geologic and hydrologic environment to those parts of the general environment that are accessible by people. Thus, the procedure for repository evaluation will involve the determination of release scenarios, characterization of the geologic and hydrologic environment, and numerical modeling of the many physical and chemical processes involved in the release and transport of radionuclides.

B. Sources of Uncertainty in Numerical Models

Bredehoeft and others (1978), IRG (1979), NAS (1979), Craig (1979), Davis (1980), and many others have each noted uncertainties associated with at least one of the steps of this procedure for repository evaluation. The use of numerical modeling methods introduces errors and uncertainties through the use of approximative techniques, undiscovered logic errors in complex computer codes, and undiscovered errors in algorithms.

Bredehoeft and others, LBL (1979), and Davis discuss a second contribution to overall uncertainty: uncertainties that are attendant to site characterization. Davis points out that uncertainties in the methods used to determine data and uncertainties associated with undetected features will contribute to the overall uncertainty in repository performance.

A third contribution to the overall uncertainty arises from the uncertainties that exist in our understanding of the basic physical processes from which the release scenarios that form the basis for the evaluation of performance are to be constructed (Davis, 1980). In that connection, Bredehoeft and others discuss the complex perturbations on the geologic and hydrologic environment caused by the presence of the waste and the repository. DOE (1979) also discusses the uncertainties associated with waste-rock interactions and notes that it is a major area of concern.

Bredehoeft and others point out an additional area of concern: the potential for unanticipated interactions in complex systems. They observe that unanticipated interactions have occurred in many engineering systems whose components were thought to be well characterized. They also observe that other investigators have argued that because of the complexity of identified and unidentified possible interactions between processes in the earth sciences, long-term prediction is unreliable and impossible to perform with high confidence.

Taken together, the uncertainties in site characterization, in basic physical processes, and in the possible interactions in complex systems, suggest that the evaluation of repository performance will be subject to considerable uncertainty.

In view of the above, IRG (1979) recommended that the EPA recognize the large range of inherent uncertainty involved in determining the performance of waste management systems and permit the NRC to account for it in its implementation and licensing process. In principle, uncertainties in the numerical models, uncertainties in characterization of the site and engineered elements, and uncertainties in basic physical processes can be estimated and bounded. Therefore, it might be possible to account for them directly in determining whether the EPA standard will be met. However, a direct accounting of uncertainties has not been done in any modeling to date. The potential for unanticipated interactions and occurrences cannot be bounded even in principle.

Compensation for uncertainty that would otherwise confound adequate demonstration of compliance with the EPA standard is an essential part of the NRC staff's regulatory approach. Since any licensing proceeding will involve the question of adequately demonstrating compliance with an EPA standard, the NRC staff has placed primary emphasis on selecting approaches to facilitate resolution of this issue. Other approaches which might prove useful in the long run, but which are hard to demonstrate compliance has been achieved and could involve years of delay in a licensing proceeding, have been de-emphasized.

C. Alternatives

Three alternative approaches to regulating geologic disposal of HLW were considered in the development of the technical criteria of 10 CFR Part 60. Each was examined in light of its ability to compensate for the major uncertainties in the quantitative prediction of the performance of geologic disposal. The alternatives considered were:

1. Regulation of repository systems by setting a single overall performance standard that must be met by the system. The performance standard in this case would be the EPA standard;

2. Regulation of repository systems by setting minimum performance standards for each of the major system elements as well as requiring the overall system to conform to the EPA standard ; and

3. Regulation of repository systems by setting numerical criteria on critical engineering attributes of the system.

The NRC staff has examined each of these alternatives from the standpoint of its ability to compensate for uncertainty in evaluating compliance with the EPA standard in a licensing proceeding. The NRC staff further examined each alternative with two objectives in mind: (1) providing as much guidance and detail as may be warranted by generic considerations; and (2) avoiding undue constraints upon system design.

The alternative of setting a single system performance standard is often referred to as the "systems approach." It has as its principal advantage the fact that regulation would be through a single figure of merit, overall system performance. This leaves maximum flexibility for the designer to make trade-offs among components of the system. The systems approach can include the concept of multiple barrier design to compensate for uncertainty in overall system performance (see for example DOE, 1979).

Unfortunately, the systems approach as interpreted above is not practical from a regulatory point of view. As noted earlier, a quantitative assessment of the expected performance of a geologic repository is a complex and difficult task. The results of such an assessment contain the uncertainties described above. Compensation for uncertainties can be achieved, however, without imposing ancillary requirements on the systems approach by introducing conservatism. Either the measure of performance can be made more stringent than is truly needed, or the method of evaluation, or both. Unfortunately, estimates containing worst case and bounding assumptions necessarily depart from reality and therefore become less certain than the already uncertain realistic estimate. Further, conservative standards need a reasonably precise realistic measure against which to be conservative. Hence, neither method of introducing conservatism affords a very clear picture of just how much conservatism has been introduced. Hence neither method gives a very clear picture of how much gain in confidence should be realized from that conservatism.

The second alternative establishes major subelements of the repository system, called barriers, and assigns minimum performance objectives to each while maintaining the EPA standard as the measure of overall system performance. This alternative has two advantages over the systems approach. First, if the barriers are chosen judiciously, the uncertainty in the evaluation of repository performance can be reduced by requiring the barriers to perform in ways which reduce their relative contribution to the uncertainty. Second, by judicious choice again, multiple barriers can be prescribed which act independently and thereby enhance confidence that the wastes will be isolated. As is discussed in subsequent sections, the NRC staff has secured these advantages through performance objectives which 1) serve to reduce the effective source term for the repository evaluation, using reasonably verifiable engineering methods thereby reducing calculational uncertainty, and 2) independently provide confidence that the wastes will not reach the environment during the period when they present the greatest hazard.

An additional benefit follows from the establishment of major barriers and their associated performance objectives. Once the barriers and objective are known, that knowledge can be used by the DOE as input to the design of the repository. Design issues related to repository performance can be addressed early on, reducing the potential for major design changes resulting from the licensing process. Yet since only the major subsystems and their performance are specified, design flexibility is retained.

The third alternative, use of numerical criteria for certain engineering attributes of the system (a peak canister wall temperature, for example) has two major advantages. It would provide clear guidance to designers as to exactly what is required for licensing. Secondly, the criteria can be selected to compensate directly for uncertainty by introducing conservation into the acceptable levels for each significant attribute of the system.

The approach also has several disadvantages. Of the three alternatives, it is most restrictive of design flexibility. In fact, it begins to force the regulator into a designer role. In addition, criteria must be set on the basis of existing knowledge to be effective. Therefore, the approach cannot fully accommodate the benefits of future research and development work.

During the development of its regulatory approach, the NRC staff received peer comments from two workshops in addition to the public comments received on the Advance Notice of Proposed Rulemaking published in the Federal Register on May 13, 1980 (46 FR 13971). The workshops were sponsored by the Keystone Center for

Continuing Education (see Craig, 1979) and the University of Arizona (see Davis, 1980).

The participant at both workshops supported the use of minimum performance standards fo barriers. The Keystone group emphasized the importance of multiple barriers to compensate for gaps in understanding of the response of deep geologic formations to the disposal of high-level radioactive waste. The Keystone group further noted that minimum performance objectives can reasonably be placed separately on the major parts of the system. The University of Arizona workshop also supported an approach based on minimum performance objectives. In its report, the workshop stated that the multibarrier concept and common sense approach to the establishment of performance objectives is a practical way to achieve a viable regulation.

Several commenters on the Advance Notice of Proposed Rulemaking pointed to the strength of the systems approach as interpreted in alternative one as providing the designer with flexibility to make trade-offs between system elements, provided that the overall performance standard is met. These commenters argued that a regulatory approach based on minimum performance standards for individual barriers is unnecessarily restrictive.

To the contrary, however, the United States Geological Survey (USGS, 1980) commented as follows:

> "In particular we believe that section 60.111(c), Performance of Required Barriers and Engineered Systems, represents a sound approach to licensing. It is sometimes stated that only the performance of the <u>total</u> waste isolation system is relevant to licensing and performance requirements. But assessing the total system, whether by models or some other approach, is an extremely complex undertaking

> subject to considerable uncertainty as the supplementary information points out. By requiring each major element in the waste isolation system to independently meet certain performance objectives, the proposed rule breaks the problem down into more manageable parts and allows for uncertainties in the performance of some components."

No commenters supported the third alternative, the use of numerical criteria for engineering attributes of the system. The NRC staff considers that alternative two, based on minimum performance standards, achieves the best balance between the need to compensate for uncertainties in demonstrating compliance with the EPA standard in the licensing process and the need to preserve flexibility for the designer.

## III. <u>Selection of the Major Barriers</u>

The staff considered three alternatives for regulation of the system of barriers:

1. Rely entirely on the natural barriers of the site to meet the system performance standard;

2. Rely entirely on engineered barriers to meet the system performance standard; and

3. Rely on a combination of engineered and natural barriers to meet the system performance standard.

In considering the alternatives the staff gave particular emphasis to reducing or limiting uncertainty in assessment of system performance over the long term.

The first alternative, that of total reliance on the site for isolation, has a straightforward rationale: if a geologic formation has been undisturbed for many millions of years, there is reason to believe that it will remain undisturbed into the future even if it is mildly disturbed by placing waste in it. In principle, isolation by the geologic medium can be accomplished by placing the waste at depth in a tectonically, hydrologically and mechanically stable medium that is essentially free of and isolated from mobile groundwater. In addition, the medium would be capable of absorbing radiation and diffusing heat without impairing the integrity of the formation.

Large areas of the North American continent have been tectonically stable for millions of years. Moreover, some of these stable areas contain geologically old rock salt formations that are deep enough and thick enough to be able to host a geologic repository. Because salt is highly soluble in water, the very existence of an old salt formation suggests that it has been isolated from mobile groundwater for a long time. Other rock formations such as shale or granite can have low enough intrinsic permeabilities to be able to host a repository and can also be found in these stable areas.

Certain natural analogues also seem to suggest that geologic formations can be found that can effectively isolate the waste. Most uranium ore deposits in the United States were formed many millions of years ago at sites having peculiar geologic and geochemical conditions. During the time since formation, radionuclides from these deposits have dispersed only very slowly. Although high-level radioactive waste contains many radionuclides that are not found in uranium ore, another natural analogue, at Oklo, in Gabon, West Africa, suggests that such additional radionuclides might be isolated by the geologic medium (Cowan, 1976).

About 1.8 billion years ago, criticality occurred in a uranium ore deposit at Oklo. Fission of U-235 in this natural reactor produced the full spectrum of radionuclides found in high-level radioactive waste. With the exception of some of the fission products, little migration of radionuclides appears to have occurred even though the reaction stopped more than a billion years ago. These are the types of considerations that originally led to consideration of geologic disposal for permanent isolation of high-level wastes.

There are two major uncertainties involved with adopting alternative one for regulation of the system of barriers: (1) construction of the repository and emplacement of the wastes disturbs the natural systems in a number of ways that are difficult to evaluate and that have the potential to compromise the ability of the site to isolate wastes; and (2) our ability to characterize and rigorously predict the performance of the large regional hydrologic and geologic systems depended on for isolation is relatively limited.

Bredehoeft and others (1978) observe that perturbations resulting from the emplacement of waste will affect the host rock and included water for a long time. They identify three distinct types of perturbation: (1) stress and mechanical effects from excavation, (2) chemical effects from changes to the chemical equilibrium by adding the waste, and (3) thermal effects from the decay heat generated by the emplaced waste.

The hydrologic flow at a site can be affected by the following: (1) creation and circulation of convection cells; (2) induced pressure gradients; (3) decreased viscosity; (4) changes in the bulk permeability of the rocks; (5) changes in the rock stress field; and (6) changes to solubility characteristics. Each of these will be affected by the thermal load that will result from waste emplacement (Bredehoeft and others, 1978; DOE, 1979, 1980).

A number of chemical reactions can occur that are significant with respect to repository performance: hydration, dehydration, formation of strong acids, sorption, solution, buffering reactions, reactions that produce gasses, reactions that produce volume changes, and the formation of concentrated brines in salt. Each of these reactions will be affected by the temperature at which it occurs. Heat breaks down hydrated minerals to release water and hot moving fluids may alter existing minerals, causing changes in permeability.

In addition to the uncertainties that arise from perturbations of the site by emplacement of waste, there will also be uncertainties in the characteristics of the site. The characterization of geologic parameters can be a difficult task. Questions arise regarding the transferability of data from one site to another. Considerable difficulty often arises in characterizing and quantifying important geologic conditions or features.

With respect to geomechanical characterization, there are limitations in testing and exploration technology. In characterizing the thermal and mechanical response of the rock mass, the rock's thermomechanical properties, time-dependent properties, the distribution and the influence of fractures, potential for movement of gaseous or liquid inclusions, determination of in situ stress, the validation of laboratory and in situ experiments, and the development of instrumentation for monitoring present particular difficulty (Wawersik, 1978).

In the groundwater system, field techniques for measuring and characterizing important parameters such as hydraulic conductivities in tight rocks, dispersion, and fracture flow are neither well developed nor well understood, IEC (1979), Golder (1977).

Sensitivity analyses done by Heckman and others (1979) show that the geochemical system is a critical site component in isolating waste. However, as discussed by Isherwood (1978), it is the least understood. A wide disparity in our knowledge of the geochemistry of radionuclides exists, EPA ad hoc (1978). There are some 30 to 45 significant radionuclide isotopes in spent fuel or high-level waste, Cloninger (1979), Heckman (1979), ADL (1979c). Of these radionuclides, the major potential contributors to radiological dose (under more favorable conditions) appear to be Tc-99, I-129, C-14, Np-237, and Ra-226, (Hill, 1979; ADL, 1979c). Under less favorable conditions where path length is short, groundwater velocity high, or sorption low, other nuclides such as Sr-90, Sn-126, U-234, Pu-239, Pu-240, Am-243, and Cm-245 have been identified as being potentially significant contributors to dose.

The applicability of data obtained in laboratory experiments over short times and using small sample sizes to geologic situations over long time periods and path lengths of kilometers has not been demonstrated, Serne (1977). Additionally, little work has been done regarding retardation at elevated temperature. Thus, little work is applicable to the disturbed zone of a repository. In the field, the problem is compounded by having to define the behavior of a number of nuclides, each with respect to a number of rocks, each of which must, in turn, be taken in context of different groundwater chemistries. Significant variations in measured sorption in the same rock, but taken from different depths in boreholes, have been reported (Erdal and others, 1978).

Members of the NRC staff visited five national laboratories during June, 1980 (see Robbins and others, 1980). During these visits, the staff investigated experimental work on geochemical retardation and found little progress in reducing uncertainties in this area. While it is likely that geochemical retardation will contribute to waste isolation, the magnitude of its contribution will be difficult to quantify now or in the foreseeable future, based on current DOE programs.

In summary, emplacement of the waste will modify the mechanical, hydrological, and chemical properties of the host rock through a variety of phenomena, some which are as yet not entirely understood, and some which the data do not now exist to adequately describe their effects under expected repository conditions. Also, which methods should be used to obtain the site specific data needed to assess the ability of a site to isolate wastes is still a point of discussion within the scientific community. Thus, the NRC staff has concluded that the undertainties associated with the prediction of site performance are likely to be so great that it would be difficult to conclude a licensing proceeding, and that independent criteria are needed to allow the Commission to find that ther is reasonable assurance that the health and safety of the public are protected.

The second alternative, that of relying on engineered barriers alone to meet the overall system performance objectives, has the advantage of being less dependent on site related characteristics, with their associated uncertainties. Under this alternative, the waste disposal system would be designed to incorporate very leach resistant waste forms, high integrity packages capable of containing the wastes for long periods of time, sorptive backfills capable of retarding nuclide migration, and low permeability plugs and seals that prevent intrusion of groundwater and release of radionuclides.

Engineered barriers have the advantage that materials can be selected and barriers can be designed to perform specific functions. Once designed, prototypes can be set up and tested under conditions that provide increased assurance that the design objective will be met. Finally, engineered barriers can be fabricated and emplaced under rigorous standards of quality assurance to increase confidence they will perform as designed. On the other hand, with geologic systems, it is hard to know for sure what the system even is, since much of the information must be obtained indirectly. In addition, it is difficult to characterize the properties of the geologic materials we are dealing with, even when they are accessible for testing. To this is added the difficulty of predicting how natural systems will perform to isolate the waste. Therefore, it is possible in theory to obtain a relatively higher degree of confidence by replacing the isolation capability of the site with reliance on engineered barriers.

It is impossible, however, to make the engineered system entirely independent of the site, since the site provides the environment in which the engineered system is constructed. Further, there are also uncertainties involved with assessing the performance of the engineered barriers under conditions affected by the emplacement of the waste and over the long periods required for isolation of high level wastes.

The third alternative, that of supplementing the isolation capability of the geology with engineered barriers that are designed to contain the waste for a period and then control the rate at which radionuclides are released, has the advantages of both the preceding alternatives. In addition, the use of engineered barriers can provide the means of compensating for the uncertainty in our ability to assess isolation of the wastes by the site.

Others who have considered the problem of geologic disposal have reached similar conclusions. Bredehoeft and others (1978) point out that the waste form, the host rock, and the groundwater flow path provide potential barriers. ADL (1979b) suggests four principal barriers: the waste form, the container in which the waste form is packaged, the geologic environment, and adsorptive phenomena in the geologic environment. Ringwood (1978) describes essentially the same barriers as ADL (1979b), but considers adsorptive phenomena to be a part of what he calls the geologic barrier.

The NRC staff finds that the physical nature of the problem lends itself to classification of the major barriers as the waste package, the underground facility, and the geologic setting. In this scheme the geologic setting is equivalent to Ringwood's geologic barrier and the waste package is equivalent to ADL's waste form and container considered as a system. In identifying the underground facility as a potential major barrier, the NRC staff has recognized the need for careful excavation of the repository to avoid creation of pathways to the biosphere and the potential for placement of additional engineered barriers in the underground excavation before sealing of the repository.

The uncertainties in evaluating the performance of the system caused by emplacement of the waste are to a large degree time dependent. Many of the perturbations that are expected to occur are the result of the increased temperature in the host rock due to radioactive decay heat. Temperatures peak and begin to fall within the first few hundred years after the waste has been emplaced (ADL, 1979b). During the same period total radioactivity of the waste decays by several orders of magnitude (ADL, 1979a). As the temperature decreases, many of the uncertainties in near-field behavior decrease as well. The decrease in total radioactivity represents a decrease in the source term available to be released as well.

Our approach, for this initial period of high temperatures and radionuclide inventory is to contain the wastes within a corrosion resistant package that confines the radionuclides within a physical boundary. Such "waste packages" can be designed to provide assurance of their ability to perform to specifications under anticipated near field conditions. Thus, this alternative provides a reasonably verifiable barrier to compensate for geologic uncertainty during the period when the specific activity of the waste is high and the perturbations of the natural systems are large.

Engineered barriers can also be designed to limit the rate at which radioactive materials are released from the engineered system after the containment period and thereby supplement the geologic system in limiting the rate of release to the environment.

The rate at which radionuclides are released to the site can be limited by using waste forms and overpacks that limit releases from the package to some maximum rate; by emplacing materials (e.g., backfill) around the waste that have chemical properties that retard or inhibit radionuclide transport; or by some combination of the above. Either way, in principle, the source term to the geologic system can be maintained at a low level and can be tested to verify release rates under anticipated conditions.

The NRC staff has considered these three alternative approaches to selecting the major barriers in light of their ability to compensate for uncertainty in assessing system performance without unduly constraining system design.

Alternative three, that of supplementing the isolation capability of the site with engineered barriers, is considered by the NRC staff to be superior in that it allows the flexibility of a combination of independent engineered and natural barriers that compensates for the major sources of uncertainty in the natural system.

This approach has also been adopted by DOE in its program for geologic disposal of high level radioactive wastes (DOE 1980).

In arriving at its conclusion the NRC staff received important guidance from peer reviews by the Keystone Radioactive Waste Discussion Group and a panel of earth scientists convened by the University of Arizona. The sense of both groups was in agreement with a subdivision of the repository system into three major barriers: waste packages, the engineered underground facility, and the geologic environment. The Keystone group suggested that the entire engineered system should be considered the barrier which limits the rate of release of waste. Following their suggestion, the NRC staff decided to set a long-term release rate for the underground facility and waste packages working together as opposed to a release rate for the waste form alone. Both workshops emphasized the importance of a program of testing and verification to evaluate barrier performance.

IV. Major Barrier Performance

The next issue considered by the NRC staff was "What minimum performance criteria should be set for the major natural and engineered barriers in light of the uncertainties in predicting system performance over long periods of time under repository conditions?"

For the purpose of assessing repository performance, the multiple barriers are treated as a series of elements that form the repository system. For a given initial inventory, the overall performance of a geologic repository with respect to releases to the biosphere can be described ~~is determined~~ by three characteristics: (1) the length of time after closure during which radionuclides are contained, (2) the time over which radionuclides are released from the engineered system after containment fails, and (3) the travel time through the geologic setting for radionuclides to reach the biosphere (see Burkholder, 1976; DOE, 1979; Cloninger, 1979). The effects of disruptive events on system performance can be considered in terms of reducing these times.

The performance of the individual barriers can also be specified in terms of these three characteristics. The performance of waste packages or the underground facility is determined by specification of a containment time and a fractional release rate that is equal to the reciprocal of the release time. Site performance is determined by the travel time. Thus, all of the major barrier performance standards can be specified in terms of an appropriately chosen containment time, release rate, and travel time.

In order to evaluate reasonable minimum performance criteria for the individual barriers, we next considered in more detail the properties of the wastes as a function of time and the uncertainties associated with containment and isolation of high level wastes.

As noted earlier, thermal effects of decay heat generated by the waste are one of the principal causes of uncertainty in predicting the performance of the repository system. These have also been assessed in our consideration of performance objectives for the major barriers.

Several investigators have calculated the temperature distribution in space and time that would result from waste emplacement (see for example DOE, 1979; Wang and others, 1979; ADL, 1979b). Figures 1 through 9 have been taken from ADL (1979b) to illustrate the following qualitative characteristics of temperature distributions of a geologic repository for HLW:

1. The magnitude of the maximum temperature at the canister mid-plane and the time at which it is reached depend on the age of the waste before burial (Fig. 5), the planar heat density (Fig. 6), and the fuel cycle (Fig. 8). On the other hand, the magnitude of the maximum temperature and the time at which it occurs are relatively independent of the host rock type (See Fig.4).

2. The maximum temperature of the repository as a whole is reached during the period 100 to 500 years after emplacement and near maximum temperatures persist for a few hundred more years (See Fig. 4). Aged wastes and wastes with a higher concentration of long-lived materials (Mixed oxide and throwaway fuel cycles), reach maximum temperatures at the later times (See Figs. 5 and 8).

3. Maximum temperature gradients in the host rock occur within 100 years for all fuel cycles and host rocks.

4. After 1,000 years, both temperatures and thermal gradients in the repository have peaked and are decreasing for all fuel cycles, and by 10,000 years, temperatures and thermal gradients are near pre-emplacement conditions.

Table 1 is from ADL (1979a) and shows the differences between the general characterist of HLW generated by the each of three fuel cycles. Because of these differences, the time behavior of the waste characteristics also differ from one fuel cycle to another.

ADL (1979a) has characterized the source term as a function of decay time for HLW from each of the three fuel cycles. The results of their calculations are displayed graphically in Figures 10-15. For each fuel cycle, the following data are plotted:

1. Radioactivity versus decay time (Figures 10-12); and

2. Decay heat generation versus decay time (Figures 13-15).

In all cases the fuel was assumed to have been irradiated in a pressurized water reactor (PWR) rather than a boiling water reactor (BWR) because PWR fuel is irradiated to a higher burnup before refueling. Higher burnups yield higher fission product inventories per unit of fuel, and therefore provide an upper bound on the radioactivity and decay heat rates from a light water reactor.

Examination of Figures 10-15 leads to the following observations:

1. In all cycles for the first few hundred years, the fission product activity is the principal contributor to the total radioactivity. Sr-90 and Cs-137 are the principal contributors to the fission product activity.

2. The radioactivity levels, and the decay heat generation are similar for all three fuel cycles during the first few hundred years. This is because fission product activity per unit of energy produced is largely independent of fuel cycle.

3. The actinides become the dominant isotopes after the first few hundred years. Differences in actinide content in the waste from the three fuel cycles then cause significant differences in the properties of the wastes.

4. During the first 1000 years, the radioactivity, and decay heat generation rate of the fission products in the wastes decrease by five to six orders of magnitude and then level off.

5. During the first 1000 years, the radioactivity, and decay heat generation rate of the wastes from the three fuel cycles decrease by three orders of magnitude.

(1) Waste Package Performance

In light of the above information on repository thermal conditions and waste characteristics as a function of time, the staff examined a range of containment times as performance objectives for the design of the waste package. Our objective is to require the waste package to be designed to contain the wastes during the period when the perturbations in the near field due to emplacement of the waste are large and would cause unacceptably large uncertainty in our ability to predict waste isolation performance. Our intent is that during this period the waste would be contained within the waste packages. We examined the following alternatives for the waste package containment time:

(i) 300 years;

(ii) 1,000 years; and

(iii) 10,000 years.

(i) Containment of the wastes for 300 years, as suggested by DOE in its comments on our Advance Notice of Proposed Rulemaking, would prevent releases from occurring until the bulk of the fission products would have disappeared by decay and the heat generation rates will have decreased by about 2 orders of magnitude for wastes from all fuel cycles. Containment for 300 years is within the range that DOE is considering for repositories in bedded salt and appears to be achievable at reasonable cost (Magnani and Braithwaite, 1980).

A minimum containment time of 300 years has the disadvantage, however, that packages fail and releases begin to occur when temperatures in the repository are near their peak and when the thermal gradients that provide the driving force for convective transport are still relatively high. Under these conditions of high temperature and high thermal gradients, hydrothermal reactions of the waste form and mineral phase changes of the backfill materials and near-field host rock will be most severe, and the leaching and transport of radionuclides through the underground facility will be most difficult to evalute. A containment time of 300 years presents considerable uncertainty in the prediction of the releases from the underground facility which constitute the source term for the far field transport models due to the effects of temperature on leach rate, hydrologic flowpaths viscosity, rock permeability and geochemistry.

(ii) Containment for 1,000 years would prevent releases from occurring until the fission products will have essentially disappeared and decay heat generation rates will have decreased by three orders of magnitude. More importantly, containment for 1,000 years has the effect of delaying releases until temperatures in the underground facility are past their peak and are decreasing and until thermal gradients in the underground facility and surrounding rock have decreased substantially from the first few hundred years. Lower temperature and temperature gradients allow release rates and radionuclide migration rates to be predicted with greater confidence under these conditions. Containment for 1,000 years also requires only extrapolation by a small factor beyond what DOE has already been considering for repositories in bedded salt (Magnani and Braithwaite, 1980).

(iii) Containment for 10,000 years would prevent releases from occuring until the bulk of the fission products and some intermediate-lived transuranics (e.g., Am-241, half life 450 yr) would have decayed to negligible levels. Heat generation rates would have decreased by over four orders of magnitude and temperatures and thermal gradients in the repository and host rock would have nearly returned to pre-waste emplacement conditions. Under these conditions, we consider that many of the transport processes can be modeled with some confidence and analoges between the transport of actinides and their daughters and migration from ore bodies are more reasonable. However, design of a package to contain wastes for 10,000 years requires a considerable extrapolation beyond those concepts DOE has considered in the past and for which any test information exists. Costs for such a package are uncertain and may not be justified by the reduction in uncertainty that might be achieved.

The staff considers that a containment requirement for the waste package of 300 years is insufficient to increase confidence in long-term performance predictions. If packages fail and migration begins after 300 years, in order to evaluate overall performance, it will be necessary to consider transport from the waste packages through the disturbed zone under environmental conditions that will make calculation of the source term for the transport through the geologic setting highly uncertain. On the other hand, containment for 10,000 years would delay the onset of radionuclide migration until temperatures and temperature gradients in the disturbed zone had returned to near pre-emplacement conditions, and the source term for migration could be predicted with much less uncertainty. The staff considers that if containment for 10,000 years could be achieved, it would reduce uncertainty in prediction of long-term performance by reducing the source term available for migration; by better control of the chemical form of the waste when migration begins; and by delaying the start of migration until the perturbations in the geologic environment due to temperature have substantially decreased. At present the amount of the reduction in uncertainty cannot be quantified and the costs to achive containment for 10,000 years are very tenuous. However, the staff considers that DOE should be encouraged to investigate the practicality of a package with a 10,000 year life. Therefore, we have framed our performance objective for the waste package such that DOE is required to design the package to provide reasonable assurance of containment for at least 1,000 years and as long as is reasonably achievable thereafter. We consider that containment for 1,000 years will substantially reduce the hazard associated with a release from the package and will increase our confidence in our ability to evaluate the effectiveness of the disposal system to maintain releases to the environment to within the EPA standard. We further consider that such a requirement is achievable at reasonable cost by a reasonably straightforward extrapolation of current DOE programs. However, we consider containment for periods as long as 10,000 years to be a desirable goal and consider that DOE should continue to develop information on the performance and costs of packages for long-term containment and to include them in the repository system if found to be reasonably achievable. Since specific designs that would result in a favorable licensing decision are not available now or likely to be available in the near future, we do not consider that a detailed balancing of costs and benefits of longer lived packages can reasonably be performed now, but should be considered by DOE in its application.

(2) <u>Long-Term Performance Objective for the Engineered System</u>

In order to evaluate reasonable minimum performance objectives for the engineered system after the initial period of containment, the NRC staff evaluated the following information.

In the Draft Generic Environmental Impact Statement on Management of Commercially Generated Radioactive Waste (GEIS) (DOE, 1979), DOE evaluates the lifetime (50 yr) accumulated total body doses to maximum individuals as a function of time of release and release rate for spent fuel and reprocessed $UO_2$ wastes. The calculations are performed for a repository that has a 100-year water transit time to the environment and employs sorption equilibrium constants (Kds) typical of subsoils at the Hanford site. The calculations show that for approximately the first 1000 years after breach of containment, lifetime doses to the maximum individual are approximately proportional to the release rate (leach rate). For individuals exposed one million years after breach of containment, the release rate showed little effect on lifetime dose because doses were due to daughters of U-238 which had been entirely released during the previous one million year period.

Cloninger (1979) calculated potential dose to individuals who may be exposed to radioactivity released from a repository in salt via a groundwater leach/transport pathway. A sensitivity analysis was performed of the waste form leach rate, the delay prior to groundwater contact with the waste, aquifer flow velocity and flow pathlength. He concluded that even for a site with fairly good hydrologic characteristics, there is benefit in providing a leach resistant waste form or some equivalent engineered system that will limit the rate of release of the nuclides into the flowing groundwater. The results also show that for a well intrusion event, reduced leach rate causes a significant reduction in the lifetime dose commitment to the maximum individual.

The NRC staff has calculated the effect of the annual release rate on the fraction of long-lived nuclides released from a repository system (White, et al., 1979). Limiting the release rate from the engineered system compensates for uncertainty in the prediction of long term performance by reducing the source term that is available for transport through the hydrologic systems. The calculations show that annual release rates in the range of $10^{-5}$ to $10^{-7}$ per year result in a significant reduction in the fraction of several environmentally significant long-lived isotopes that could potentially be released from the repository, which could result in corresponding reductions in population doses.

Based on the above considerations, the NRC staff considered the following alternatives for the criterion for the release rate from the engineered system after the containment period:

(i) a range of $10^{-3}$ to $10^{-4}$/yr, which is typical of leach rates of many borosilicate glasses at low temperature;

(ii) a release rate of $10^{-5}$/yr; and

(iii) a release rate of $10^{-7}$/yr.

(i) Typical leach rates of borosilicate glasses being tested by DOE are in the range of $10^{-5}$ to $10^{-6}$ g/cm²/day (Weed and others, 1980). It is expected that the glasses will crack due to thermal and mechanical stresses during heating and cooling in the repository to fragments on the order of ten centimeters on a side. These parameters result in a range of annual release rates of $10^{-3}$ to $10^{-4}$ of the waste inventory. Dissolution rate of $UO_2$ fuel pellets in simulated repository groundwaters are also in this range. Thus, annual release rates after package failure of $10^{-3}$ to $10^{-4}$ of the waste inventory appear achievable based on current DOE programs, considering the leach rate of the waste form as the only engineered barrier controlling the release rate. However, an annual release rate of $10^{-3}$ to $10^{-4}$ of the waste inventory is insufficient to achieve much reduction in the quantities of long-lived material that would be released, and we would still be in the position of relying almost entirely on the geology and the far field geochemistry to provide isolation for the long-lived radionuclides in the waste.

(ii) Leach rates of high-temperature nepheline syenite glasses are 2 to 3 orders of magnitude lower than borosilicate glass (Walton and Merritt, 1980), as are leach rates of a number of ceramic and composite materials being considered by DOE for high-level waste forms. Some newly developed borosilicate glasses may fall into this range also. In addition, Nowak (1980) has described commonly available clay backfill materials that have the potential to delay breakthrough of Pu and other transuranics for 10,000 to 100,000 years. We consider that, based on technology currently being developed by DOE, annual release rates of $10^{-5}$ of the waste inventory are achievable at reasonable cost using combinations of waste forms and engineered barriers. In addition, a release rate after containment failure of $10^{-5}$ of the waste inventory per year, while not adequate to isolate waste on its own merit, is long enough that significant decay of long lived species takes place before release. This limit will contribute to reducing doses to both populations and the maximum individual, and will substantially reduce our reliance on less certain geochemical retardation to limit releases to the accessible environment.

(iii)An annual release rate of $10^{-7}$ of the waste inventory after containment failure will reduce doses to individuals and releases to very low levels with little or no reliance on geochemical retardation. An engineered system that could meet this criterion would best satisfy our objective of reducing reliance on being able to characterize and model the behavior of the far-field geochemical system and placing reliance on known materials whose properties can be controlled and tested. However, DOE has not yet demonstrated whether such a release rate is achievable and the costs are very uncertain.

The staff considers that an annual release rate after package failure in the range $10^{-3}$ to $10^{-4}$ of the package inventory is insufficient to achieve our objectives, since little reduction is achieved in the quantity of long lived radioactive material that would be released, and the repository system would rely almost entirely on the site to provide long term isolation. The staff considers that if an annual release rate from the engineered system as low as $10^{-7}$ of the package inventory at 1000 years could be achieved, it would compensate for uncertainty in the calculation of the transport of radionuclides through the groundwater pathway by limiting the source term to a relatively low value. Maintaining the release rate at a value this low would result in decay of most radionuclides within the engineered system. At present the amount of the reduction in uncertainty cannot be quantified, and the costs to achieve a release rate this low are very uncertain. However, the staff considers that DOE should be encouraged to investigate the practicality of maintaining release rates at very low levels. Therefore, the staff developed a minimum performance objective of an annual release rate no larger than $10^{-5}$ of the package inventory and as long as is reasonably achievable thereafter. We consider that a release rate of $10^{-5}$ per year is low enough that appreciable benefit will be gained by radioactive decay before release, and is achievable at reasonable cost by methods currently being developed by DOE. However we consider a release rate of as low as $10^{-7}$ per year to be a desirable goal and consider that DOE should continue to develop information on materials and costs to achieve such low release rates and should include them in the repository system if found to be reasonably achievable.

(3) Minimum Performance Objectives and Required Characteristics for the Geologic Setting

Engineered barriers designed to minimum performance standards can provide reasonable assurance that the overall performance objective of the HLW disposal system will be met for an initial period of time. After containment failure, engineered barriers can be designed to limit the rate of release of radioactive materials from the repository.

However, once materials are released from the engineered system, the site must provide whatever additional isolation is needed in order to meet environmental standards. Reliance on the geology to provide one of the major barriers to releases also introduces diversity into the waste disposal system that can compensate, in part, for any unanticipated failures of the engineered system, as well as acting as one of the system barriers. The geologic setting is characterized by a variety of parameters that could themselves be regulated.

Examples of such parameters that could be considered are permeability, interstitial groundwater velocity, and equilibrium sorption coefficients, to name a few. However, all of these parameters combine to determine two characteristics of the geologic setting, assuming radionuclides have escaped the engineered system: (1) the transport time of groundwater from the underground facility to the accessible environment and (2) the transport time of individual radionuclides from the underground facility to the accessible environment. The second characteristic differs from the first in that it takes into account the geochemical characteristic of the medium and accounts for retardation of the nuclides by precipitation and ion exchange.

Based on the above, we considered three alternatives for setting performance objective for the geologic setting:

(i) require the nuclide travel times from the underground facility to the accessible environment under repository conditions to exceed some minimum value;

(ii) require the groundwater travel time for the undisturbed geologic setting to exceed some minimum value; and

(iii) not specify a minimum value but simply require the geologic setting to provide whatever margin is needed to complement the engineered barriers to ensure that the overall performance criterion for the disposal system is met.

(i) In order to implement a requirement of the type that the geologic setting provides a minimum nuclide travel time, it would be required that a model for the hydrogeologic system be developed that could predict the behavior of the flow system and the geochemical system under the thermal field of the repository, and of the far field geochemical system. Such a model would be subject to many of the same types of uncertainties that modeling of the entire disposal system involves. A performance objective of this type would not achieve our regulatory objective of bounding or eliminating uncertainty in the analysis and increasing confidence in the performance of the system.

(ii) A requirement that the undisturbed geologic setting provide a minimum travel time to the accessible environment avoids the need to model the thermal effect or the hydrologic system and the geochemical impacts of nuclide transport. It requires only the measurement of parameters and modeling of aquifer flow that is commonly done in water resource analyses. Computer codes for these types of analyses are commonly used by the USGS and in the oil industry. Some uncertainty will result because the number of boreholes for measuring permeabilities and hydraulic heads will be limited because of the desire to preserve the integrity of the site, but the uncertainty will be less when compared to measuring geochemical parameters and modeling nuclide transport. The objective of this requirement is that for the long term when the site plays a major role in isolation, the perturbations due to emplacement of the waste will have died down, and the site can be relied on with greater confidence to provide isolation. In order for this to be a useful approach for regulating repository performance, the geologic setting must be stable to provide confidence that waste will continue to be isolated. Also a complementary requirement is needed on the engineered system. This requirement is that the underground facility not provide a preferential pathway that bypasses or short circuits the hydrologic flow system, providing a direct pathway to the accessible environment.

(iii) A requirement that the geologic setting provide whatever margin is needed to ensure that the overall system performance criterion is met is an implicit performance requirement, since this would always be required. It is subject to the same uncertainties as alternative (i), since it would require an assessment of overall system performance. Also, this alternative does not in any way bound or reduce uncertainty in predicting the performance of the system and does not increase confidence that the overall performance objectives will be met.

Based on the above reasoning, we have selected alternative (ii) as the framework for establishing performance objective for the geologic setting. We next considered what the minimum travel time should be.

Travel times of a hundred years or less would require considerable reliance on the geochemical system to ensure that the overall performance objective for the system is met. While geochemical retardation is expected to be a strong factor in providing waste isolation, there will be considerable uncertainty in the magnitude of its contribution. This uncertainty results from the fact that it is very difficult to know how much geochemical retardation will occur. There is currently no agreement among the scientific community on how such an evaluation can be made. A rigorous, agreed on correlation between laboratory data and real site performance doesn't yet exist. This would likely be a major source of contention in a licensing proceeding. A travel time of only one hundred years does not provide any margin to compensate for uncertainties. Also, from groundwater dating studies, travel times well in excess of 100 years are known to be achievable in a variety of hydrogeologic environments and we would not consider a travel time for an unperturbed site as low as 100 years to be suitable for a repository. We, therefore, considered longer times, viz 1,000 and 10,000 years.

A travel time for groundwater from the repository to the accessible environment of 10,000 years would be sufficient for many shorter-lived nuclides to meet the system's overall performance objectives with no reliance on site geochemistry. For several long-lived nuclides, e.g., Pu-239, Tc-99, some reliance on geochemical retardation would be required, but considerable margin would exist between equilibrium distribution coefficients (Kds) measured in the laboratory and actual site geochemistry performance required to meet the release limits of the EPA standard. We are uncertain, however, to what extent such a groundwater travel time is achievable. We do not want to rule out otherwise good repository sites by unnecessarily restrictive requirements. However, this could be used as a goal.

Groundwater travel times from repository depths to the accessible environment of 1,000 years are achievable in many hydrologic systems. For a groundwater travel time of 1,000 years, sorption equilibrium coefficients of 100 ml/g or less are sufficient to prevent most of the principal contributors to dose from reaching the accessible environment. Sorption equilibrium coefficients measured in the laboratory for the actinides and other nuclides that are principal contributors to dose are in the range of $10^2$-$10^4$ ml/g, so that some margin is provided to compensate for the uncertainty in actual values of Kd under repository conditions. Because of the greater confidence in our ability to measure hydraulic rather than geochemical parameters, and the conservatism that is introduced, it seems prudent to select the water travel time rather than Kd to meet the overall performance standard. Therefore, we have framed our site performance objective so that the travel time from the repository to the accessible environment be at least 1,000 years and we intend that DOE consider during site screening that sites with longer water travel time are preferred.

If sites with long enough water transport times are selected as potential repository sites, some of the major uncertainty in site evaluation can be resolved. Licensing issues will then mainly be restricted to ensuring that the proposed repository does not disrupt the hydrologic flow pathways such that shorter travel times to the environment are created, and the adequacy of engineered barriers dealing with disruptive events and natural processes that could result in shorter flow pathways.

V. Retrievability

In its licensing procedures for disposal of high-level radioactive waste in geologic repositories, the NRC has adopted a step-by-step approach that consists of four stages:

(1) Site characterization, during which detailed studies of alternative candidate sites are conducted prior to selection of one of the sites for development as a repository.

(2) Construction authorization, during which NRC reviews a license application prior to construction that contains a detailed design and analysis of the performance of the repository based on the site specific information obtained during site characterization.

(3) License application, when an application for a license to receive waste at the facility is reviewed again prior to operation. At this time, the repository design and performance assessment are updated in light of new information obtained about the site during construction of the repository.

(4) Decommissioning, or permanent closure, at which time an application to terminate operations and seal the repository is submitted. The application will again contain updated analyses of the performance of the repository in light of: (1) information obtained about the site during the operation of the repository; and (2) data collected about the performance of the engineered system to verify that performance is within design limits.

This step-by-step approach and continuing re-evaluation is consistent with earlier recommendations of NAS (1979) and IRG (1979).

NAS (1979) has recommended that repository development "... be a continuing process that includes evaluations of site suitability and satisfactory repository performance before construction, reevaluations during construction and prior to emplacement of wastes, and a final assessment before emplaced wastes are committed to disposal. Corrective actions, including removal of emplaced wastes and site abandonment, should be available options until final qualification and closure of the repository."

At the decommissioning stage, the Commission will determine whether the DOE's comprehensive program of testing, monitoring, and verification indicate that the repository will work as planned. Unless the repository is designed to preserve the option to retrieve the waste starting at any time prior to permanent closure, an action reserved to the Commission could be foreclosed, and an unsafe condition could be transmitted to future generations.

A number of the public comments on the draft criteria published with the NRC's May 13, 1980 Advance Notice of Proposed Rulemaking addressed the issue of retrievability. Several commenters suggested that retrievability be maintained for a period of time after waste emplacement sufficient to conduct a monitoring program of repository behavior. Most of those commenters suggested a period of 10 to 15 years to be satisfactory for this purpose. One commenter (AIF) suggested that retrievability be required only during the emplacement period and until all or a part of the waste disposal facility is defined as a permanent repository. Several commenters interpreted the draft criteria to preclude backfilling of the mined areas until decommissioning.

Along with the commenters, the NRC staff considers that the option to retrieve the wastes must be preserved long enough to complete a program of monitoring and verification of repository performance. The design must also ensure that the option is preserved long enough to permit a decision to decommission the repository or take corrective actions based on the evaluation of the results of the verification program, including the time required to retrieve all or part of the wastes, if shown to be necessary by the results of the monitoring program. Since some of the assumptions and issues that will need to be verified and resolved by the monitoring program may not be identified until the underground facility is excavated, it is not possible to specify,prior to construction the content of the verification program or how long it will take. We expect the verification program to evolve throughout the operating lifetime of the repository.

On the other hand, important design decisions will need to be made prior to submitting an application. Some of these design decisions will affect the length of time available to take corrective action or conduct retrieval, if found to be necessary. For example, the thermal loading of the waste in the emplacement areas will affect the temperature of the host rock and the stability of the underground structure. The items will have a large effect on the ability to retrieve the wastes, since the structure could become too unstable or the rocks too hot to safely recover the wastes. Therefore we concluded that a retrievability period must be chosen early in the design process to permit the design to go forward.

The staff considered how long might be required to carry out a monitoring and verification program that would provide the information to support a decision to decommission the repository or to decide that some corrective action need be taken. One of the key parameters that needs to be monitored is temperature. Temperature is an important variable affecting package corrosion rates, fluid flow rates, geochemical reaction rates, stress in the rock mass and brine migration rates in salt. For conceptual repository designs being considered by DOE in slat, granite, shale and basalt, maximum rock temperatures in the underground facility occur at approximately 35 years after emplacement for reprocessed wastes and at 75 years after emplacement for disposal of spent fuel. By 100 years after emplacement, near-field rock temperatures have started to slowly decrease for both waste types in all four media.

Also, estimates of repository resaturation times for granite, basalt and shale range from a few years to the order of 100 years (EPA 1980D). Finally, experimentally determined (Roedder and Belkin, 1980) and calculated (Cheung 1980) brine migration rates indicate that measurable quantities of brine would accumulate in emplacement holes in a salt repository in a few decades. Thus, within a period of about 50 years after termination of waste emplacement, it is possible to obtain field measurements of the geochemical, hydrologic and geochemical environment in the underground facility under what will likely be the most severe repository conditions that will affect the waste packages and engineered barriers.

A monitoring period of only 10 to 15 years after emplacement, as suggested by some of the commenters, may not be sufficient to provide the information needed to make a decision to decommission. The design must also allow for the time required to thoroughly investigate problems that may be identified during the monitoring program, to evaluate the results of the program, and to take corrective actions, including retrieval of part or all of the waste, if found necessary. The design of the facility must provide access for the time necessary to carry out these operations or else the ability to conduct these activities may be precluded. Therefore, we have required that the repository be designed so that the waste could be retrieved on a reasonable schedule starting at any time up to 50 years after waste emplacement is complete. We consider a resonable schedule is one where the waste could be retrieved in the same overall time that the repository was constructed and wastes were emplaced. We do not intend to preclude a decision to decommission the repository before 50 years has elapsed, if sufficient data are available to support an earlier decision, and if the people charged with the decision to seal the repository are satisfied. However, we do not want the underground facility design to be such that retrieval would be so expensive or difficult or entail such high occupational exposures that the option is foreclosed and needed corrective actions cannot be taken.

Two commenters (AIChE, DOE) incorrectly inferred that the requirement to design the repository to preserve the option to retrieve the wastes would pass an expense and a responsibility on to future generations that should be borne by the present generation. These commenters have misinterpreted our requirement. We only require that the design of the repository preserve the option to retrieve the wastes for future decision-makers. The persons in charge at the time emplacement is complete will have the opportunity to decide whether to decommission and seal up the repository or to continue to monitor its performance. We only require that the design be such that they have this option. We consider that if NRC's regulations do not require that the option be preserved, there is a potential to pass on to future generations an unsafe repository for which corrective actions could be taken only at enormous costs both in dollars and in occupational radiation exposures that far outweigh the costs to design the repository to preserve the option to retrieve the wastes. Maintaining the option to retrieve the wastes does not entail keeping the mined areas open, although DOE may choose to do so in some geologic media. A design in which the emplacement rooms were backfilled and sealed, but corridors and shafts were kept open and surface handling facilities were maintained could be acceptable, provided that the rooms could be remined and the wastes removed, if necessary. Remining of the backfill should not be precluded because of high temperatures or because it was needed for structural stability. Trade-offs between keeping rooms open and ventilated, backfilling, and areal heat densities are design options that DOE must consider in meeting this requirement. The proposed rule does not require that retrieval be the reverse of emplacement. We can foresee no situation where protection of the public health and safety would require the waste to be removed very rapidly.

Rather, we envision that as the results of years of data collection and analysis, a decision is made that the site or design is not adequate to isolate the wastes for the long term, and corrective actions would be required. These operations could be performed over a period of years or decades without an imminent health and safety hazard. Therefore, the proposed rule requires that if a decision to retrieve is made, the design should be such that the inventory of wastes could be removed in about the same number of years in which it was emplaced. We intend for DOE to have considerable flexibility in the design of the repository in meeting these requirements.

A repository designed to permit retrieval of the waste has advantages in addition to the limiting case of preserving a Commission option to order abandonment of the site at as late a stage as decommissioning. From the time waste emplacement starts until decommissioning any of a variety of eventualities may require corrective action. Examples might include repair or replacement of cannisters that prove to have manufacturing defects, changes to more effective backfill, or perhaps installation of additional barriers in the tunnels. Design of the repository for retrievability of the waste assures that it will remain practical to take corrective actions should they become necessary.

Table 1 (From ADL, 1979)

HIGH-LEVEL WASTE CHARACTERIZATION

| Case | Fission Product Characterization | Actinide Characterization | Comments |
|---|---|---|---|
| (1) Throwaway Cycle | All fission products and daughters | All actinides and daughters | 1. Potentially most radiotoxic high-level waste per unit fuel weight of any LWR $DO_2$ or mixed oxide cases. (1-3)<br>2. Decay heat rate per unit fuel weight highest of any of the LWR $UO_2$ or mixed oxide cases (1-3 |
| (2) Uranium Only Recycle | All fission products and daughters<br>Less<br>Some percentage of<br>1. Gaseous Elements (Xe, Kr)<br>2. Volatile Elements (I, Br)<br>3. Tritium | All actinides and daughters Less bulk of U recycled. Pu separated and stored for future use (may be stored contaminated with fission products), or may be made part high-level wastes. | Least raiotoxic and least heat-producing waste of cases (1-3). |
| (3) Mixed-Oxide Recycle | Same as (2) | Same as (2), except bulk of Pu as well as U is recycled. | 1. Waste produced from reprocessed $UO_2$ assemblies different (and less radiotoxic at longer cooling times) than that producec from reprocessed mixed-oxide assemblies.<br>2. Potential radio-toxicity at longer cooling times fron equilibrium mixed-oxide cycle waste per unit fuel weiç approaches that of case 1. |

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Enclosure J

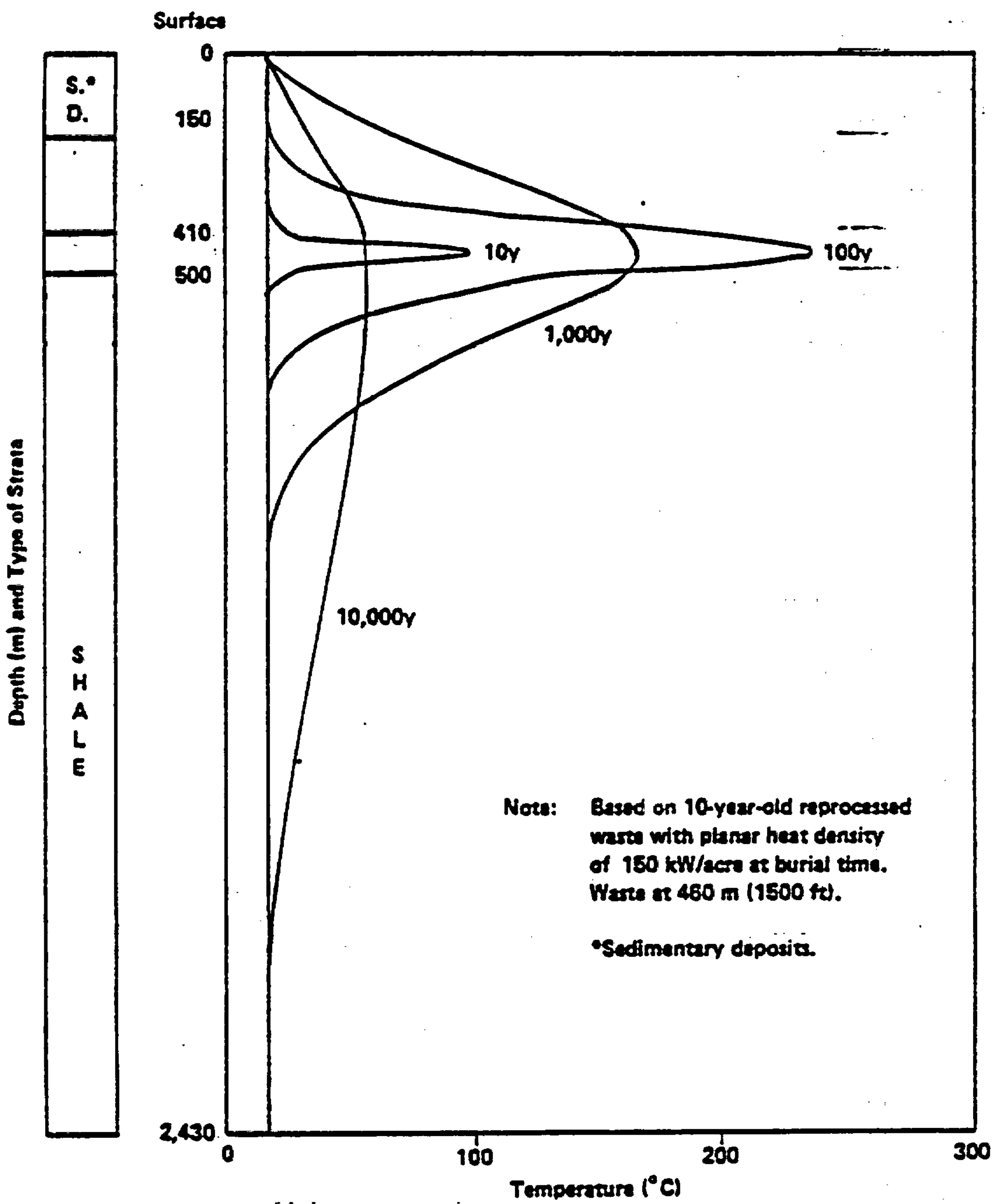



Figure 1 VERTICAL TEMPERATURE DISTRIBUTION IN TYPICAL BEDDED SALT FORMATION (ref. 2).

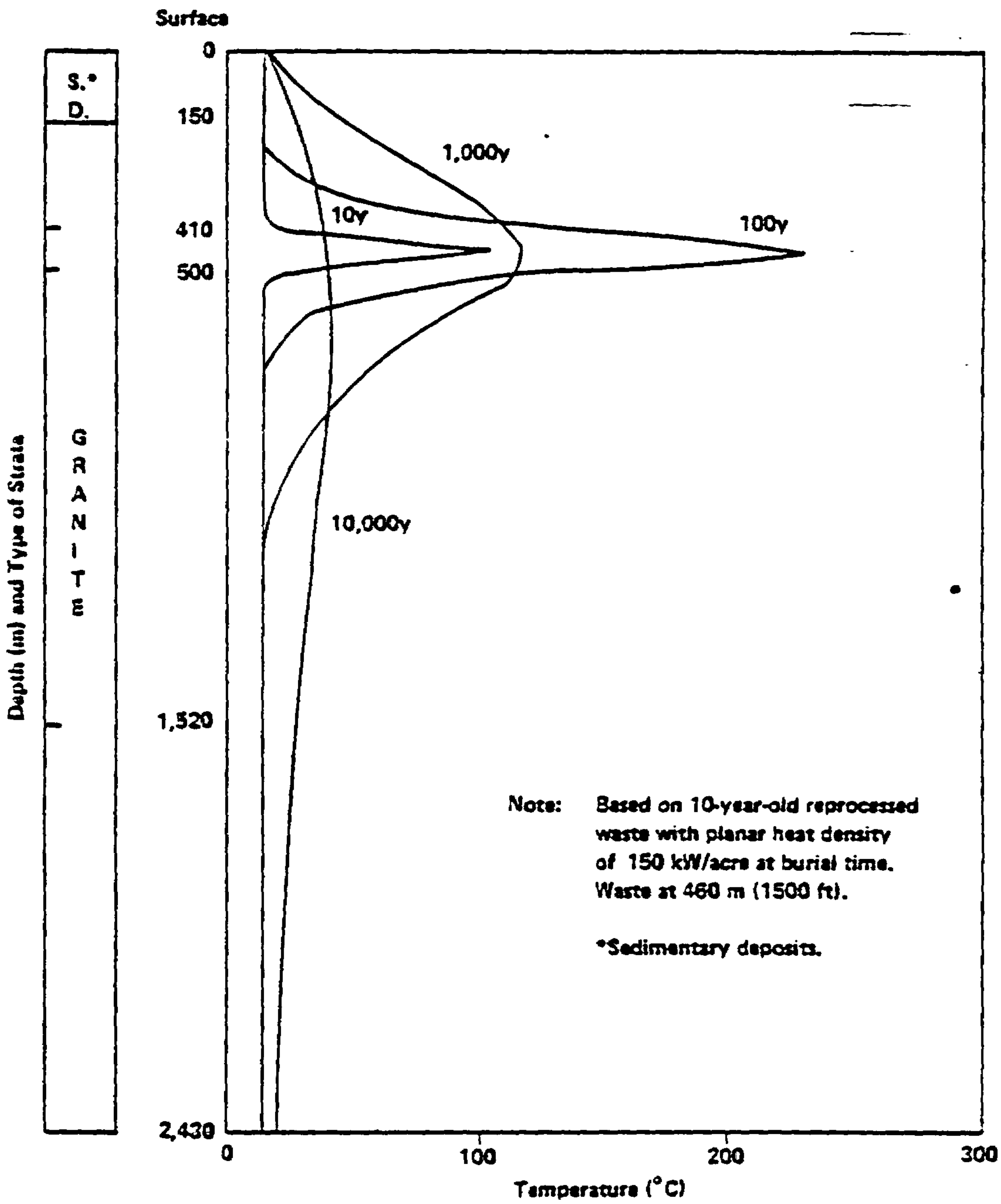



Figure 2 VERTICAL TEMPERATURE DISTRIBUTION IN TYPICAL GRANITE FORMATION (150 kW/ACRE) (ref. 2).

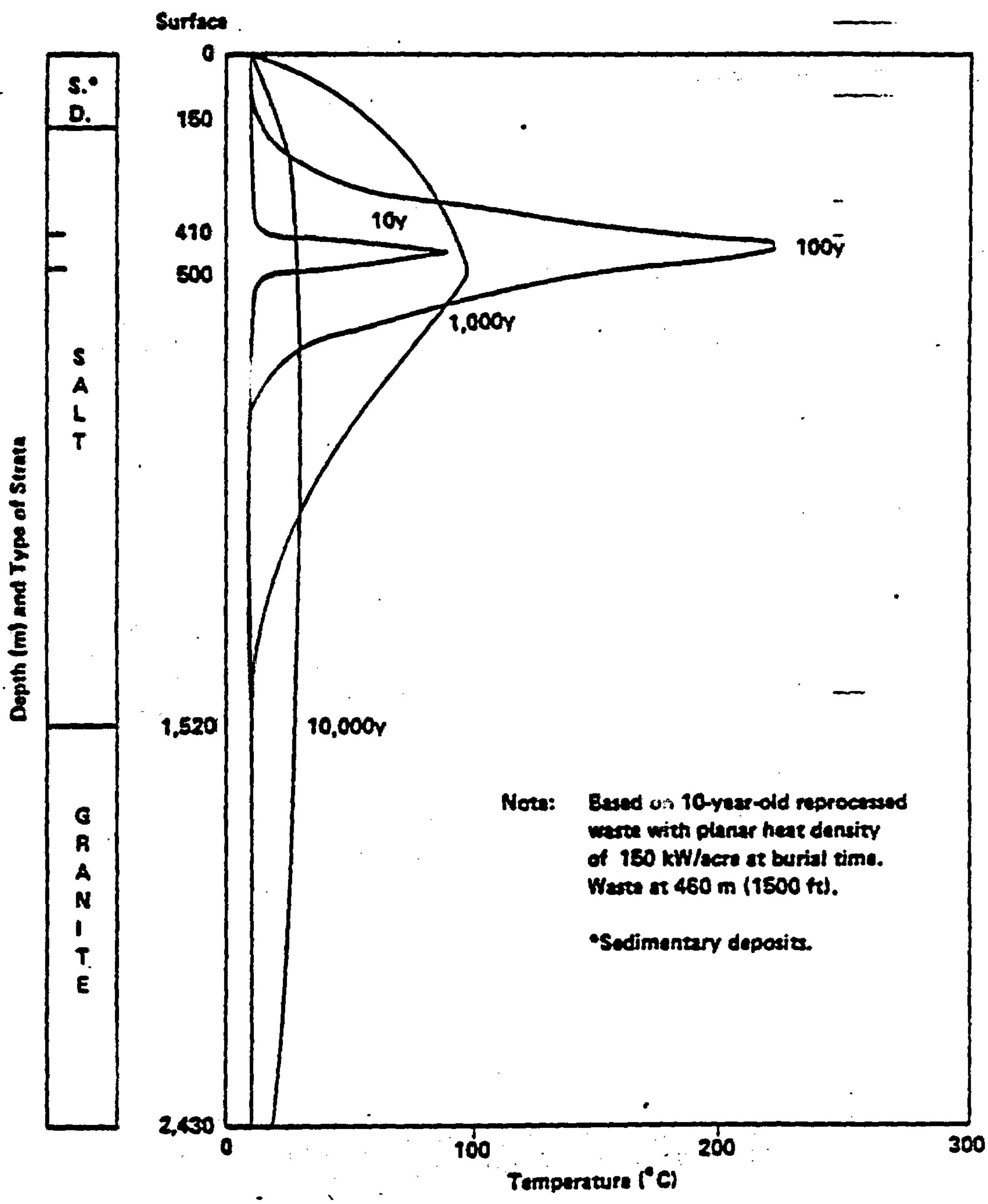



Figure 3 VERTICAL TEMPERATURE DISTRIBUTION IN TYPICAL SALT DOME (ref. 2).

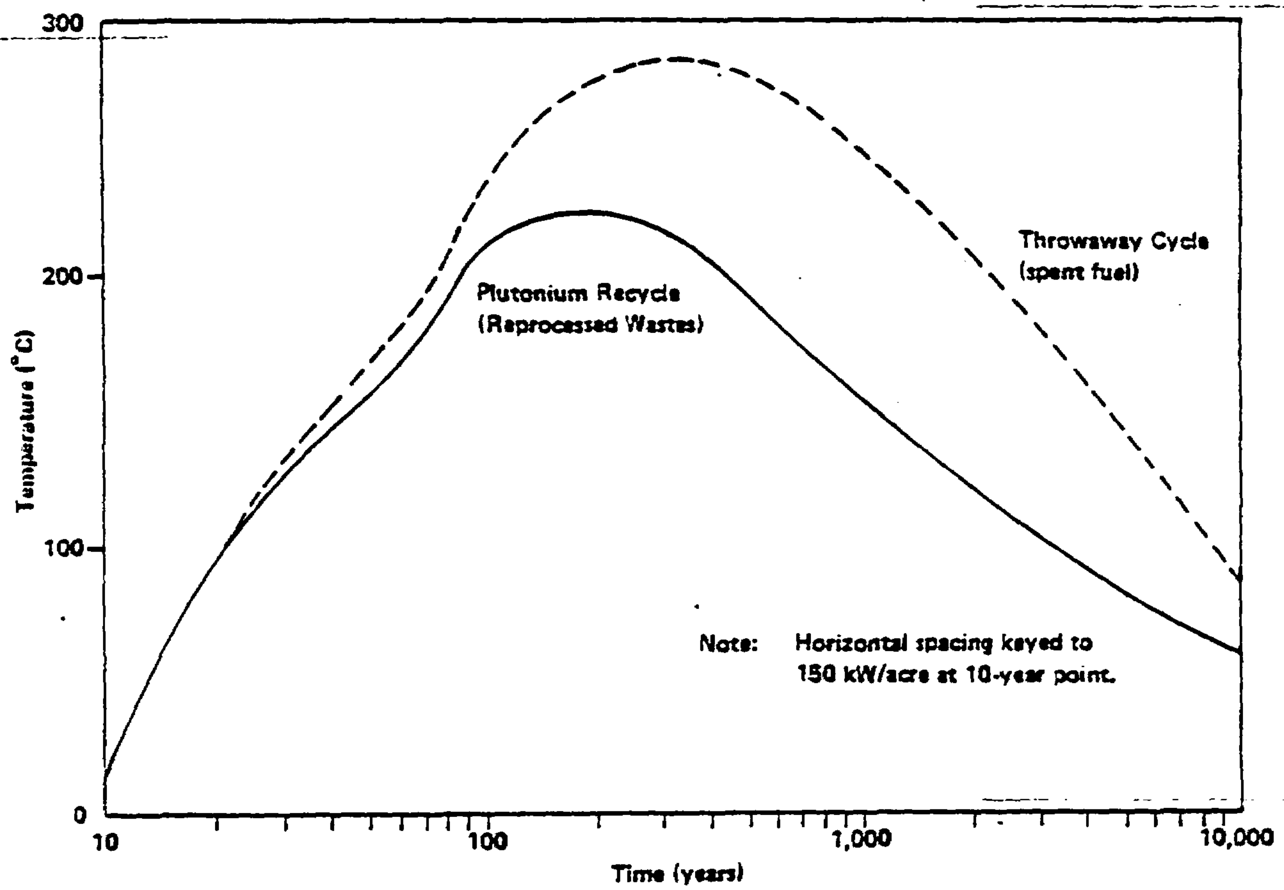



Figure 8 MAXIMUM REPOSITORY TEMPERATURE VS. TIME FOR 10-YEAR-OLD WASTE IN BEDDED SALT FORMATION (ref. 2).

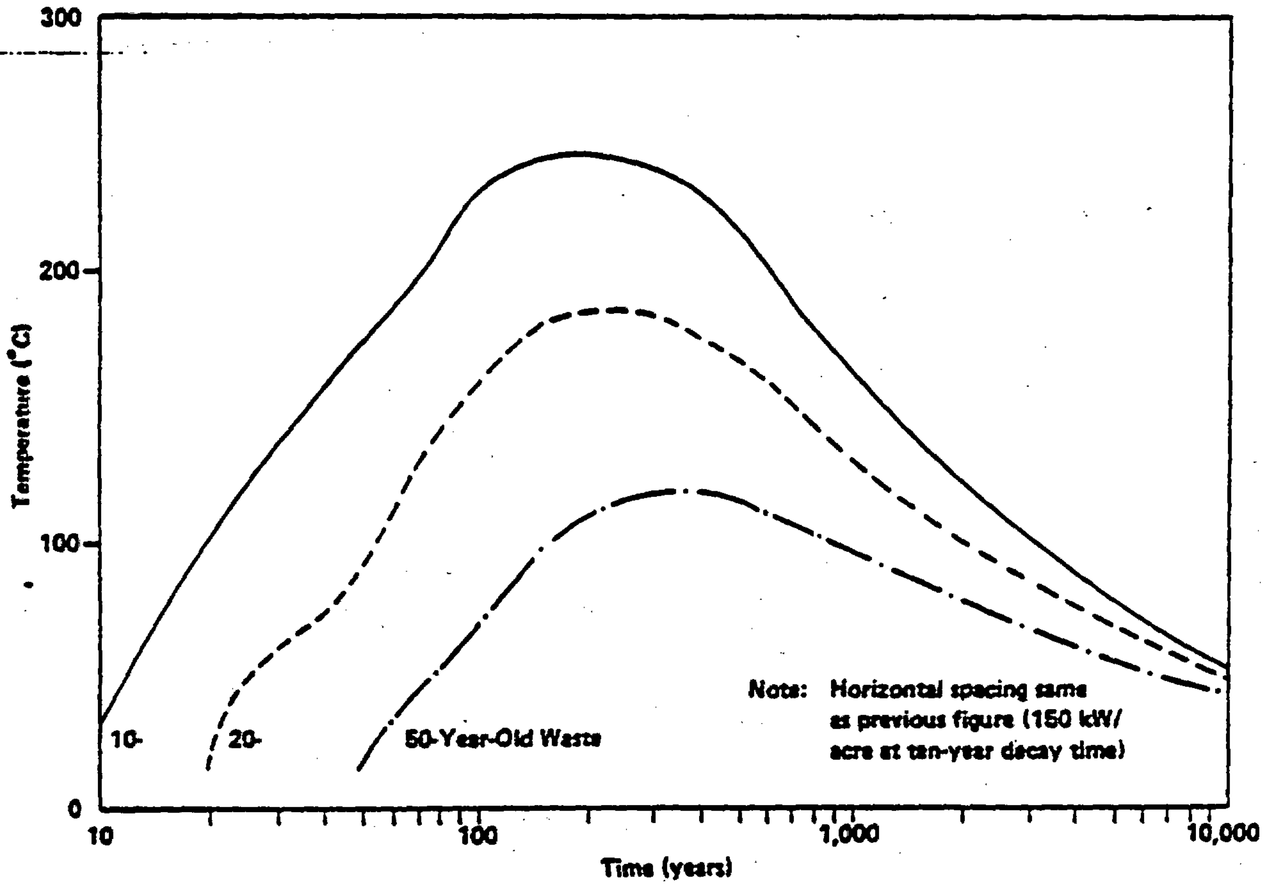



Figure 5 MAXIMUM REPOSITORY TEMPERATURE VS. TIME FOR 10, 20-, AND 50-YEAR-OLD WASTE IN BEDDED SALT (ref. 2).

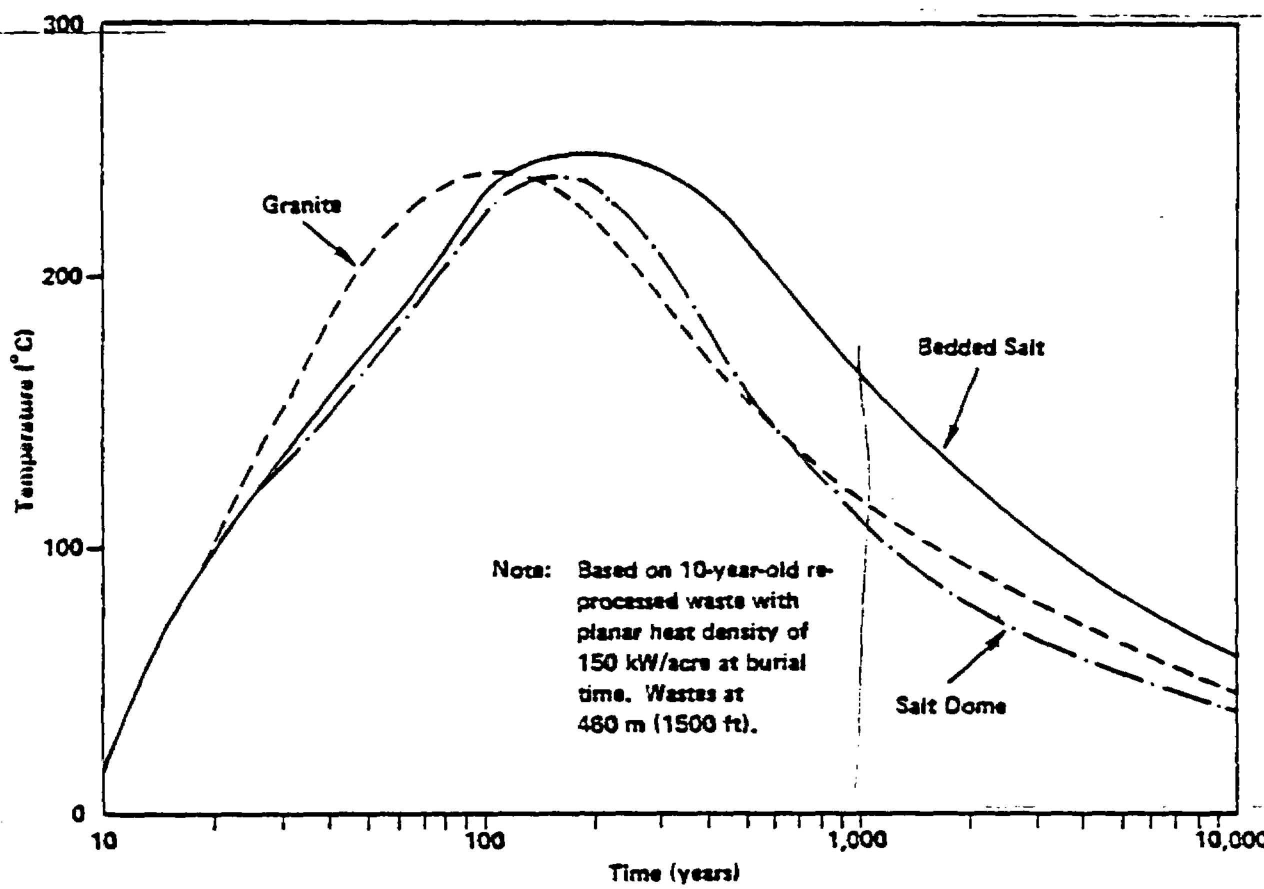



Figure 4 MAXIMUM REPOSITORY TEMPERATURE VS. TIME IN THREE GEOLOGIC FORMATIONS (REPROCESSED WASTE) (ref. 2).

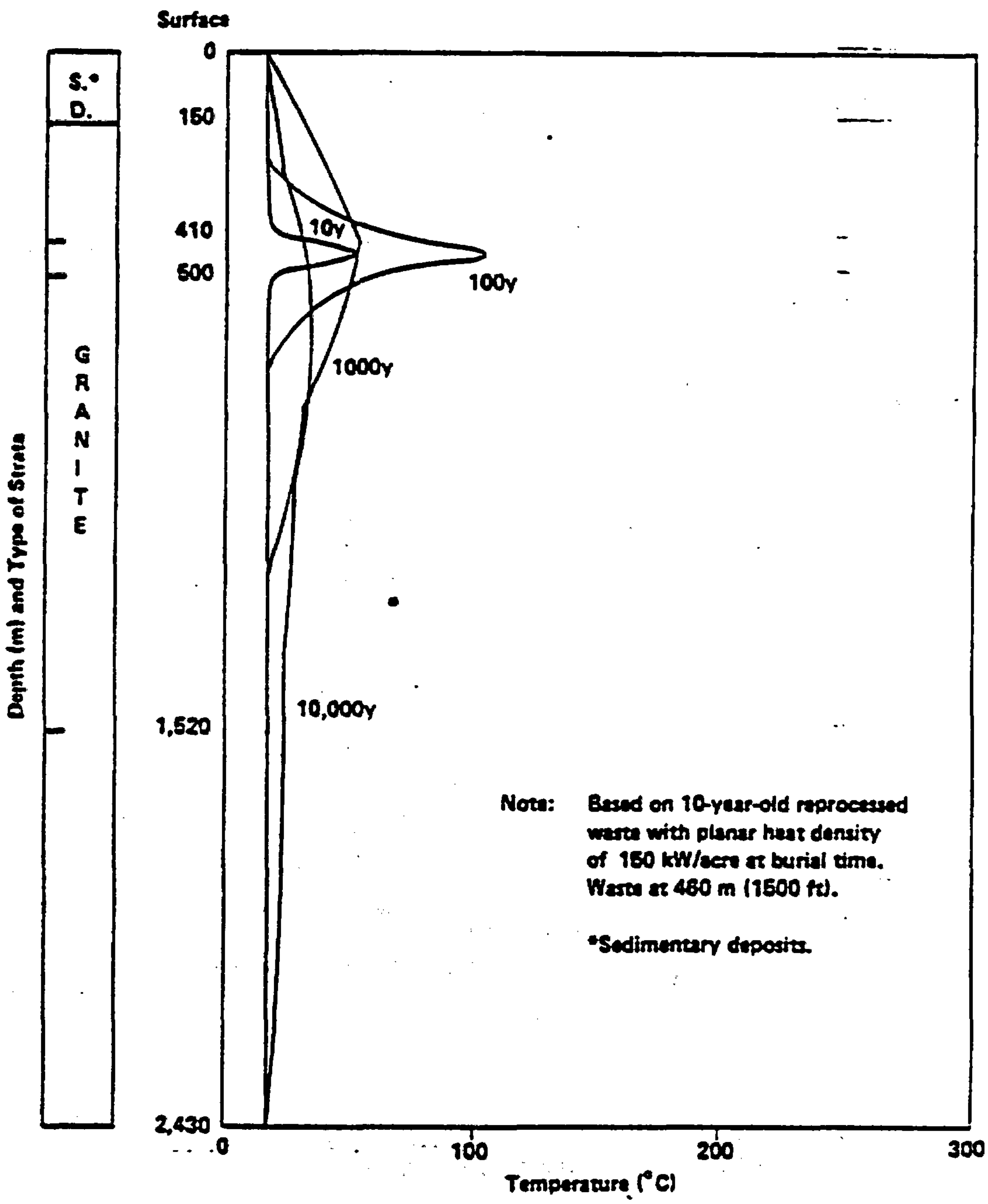



Figure 7 VERTICAL TEMPERATURE DISTRIBUTION IN TYPICAL GRANITE FORMATION (60 kW/ACRE) (ref. 2).

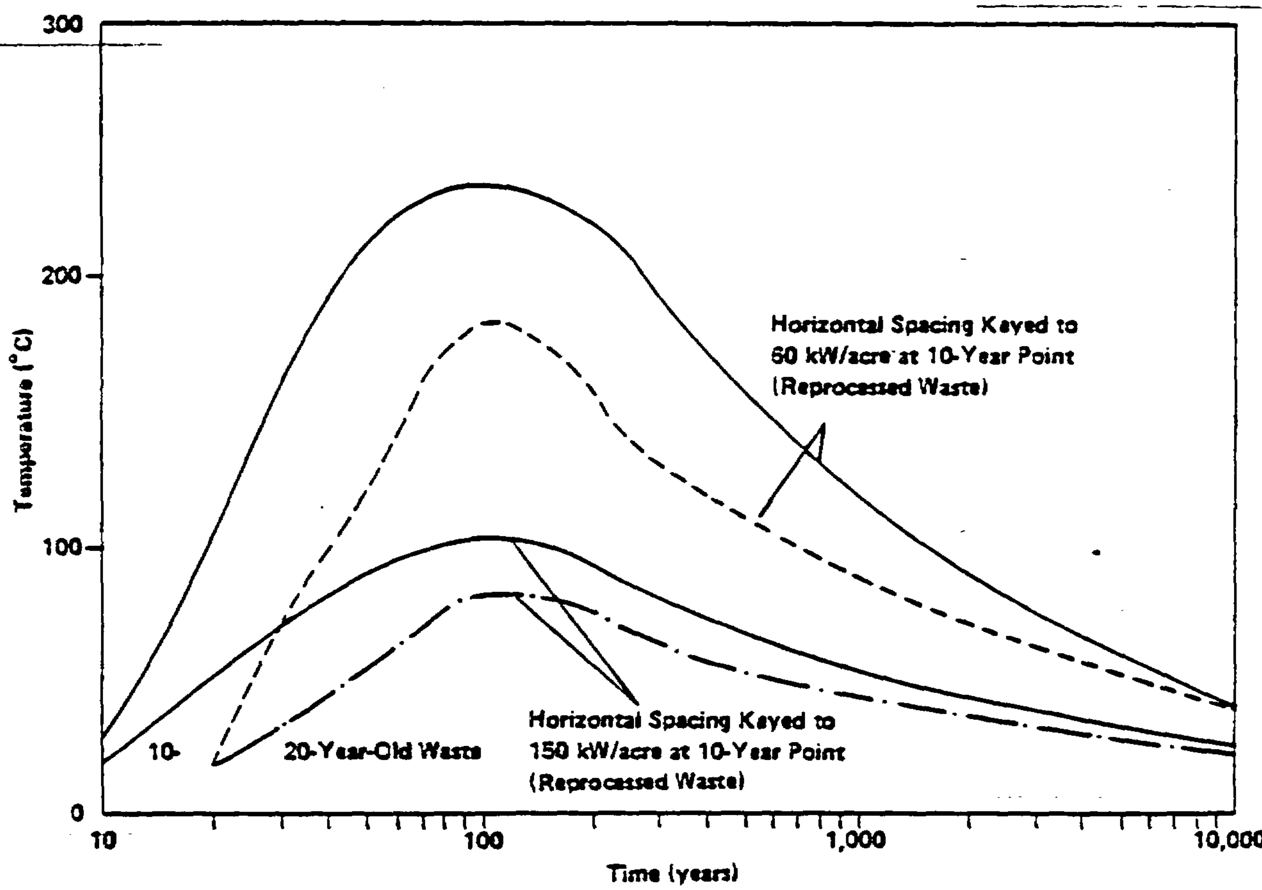



Figure 6 MAXIMUM REPOSITORY TEMPERATURE VS. TIME FOR 10- AND 20-YEAR-OLD WASTE IN GRANITE (ref. 2).

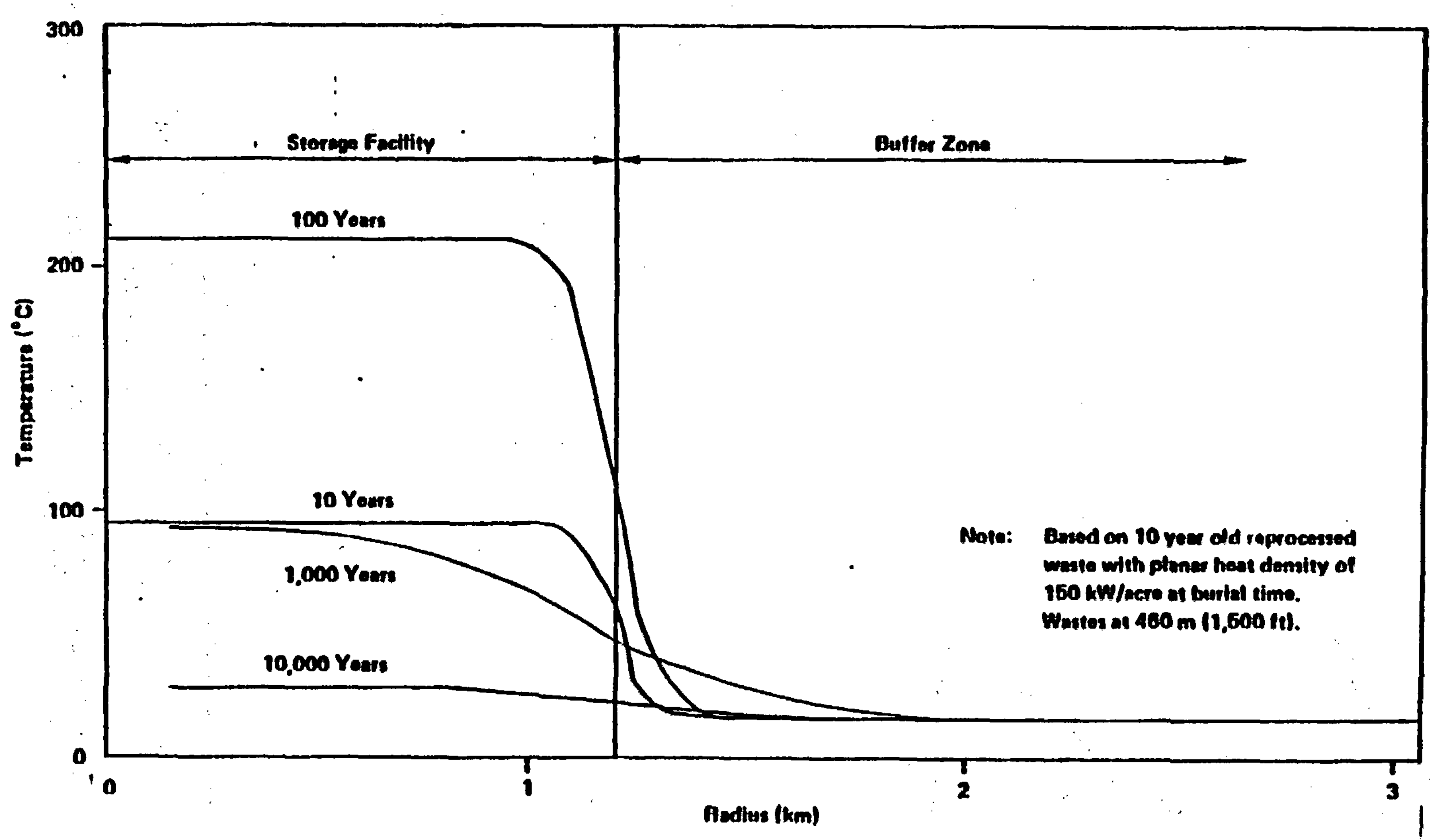



Figure 9. TEMPERATURE RISE VS. RADIUS AT CANISTER MID-PLANE (Z = 0) FOR A 1100-ACRE STORAGE FACILITY IN A SALT DOME (RESULT OF 2-D ANALYSIS) (ref. 2).

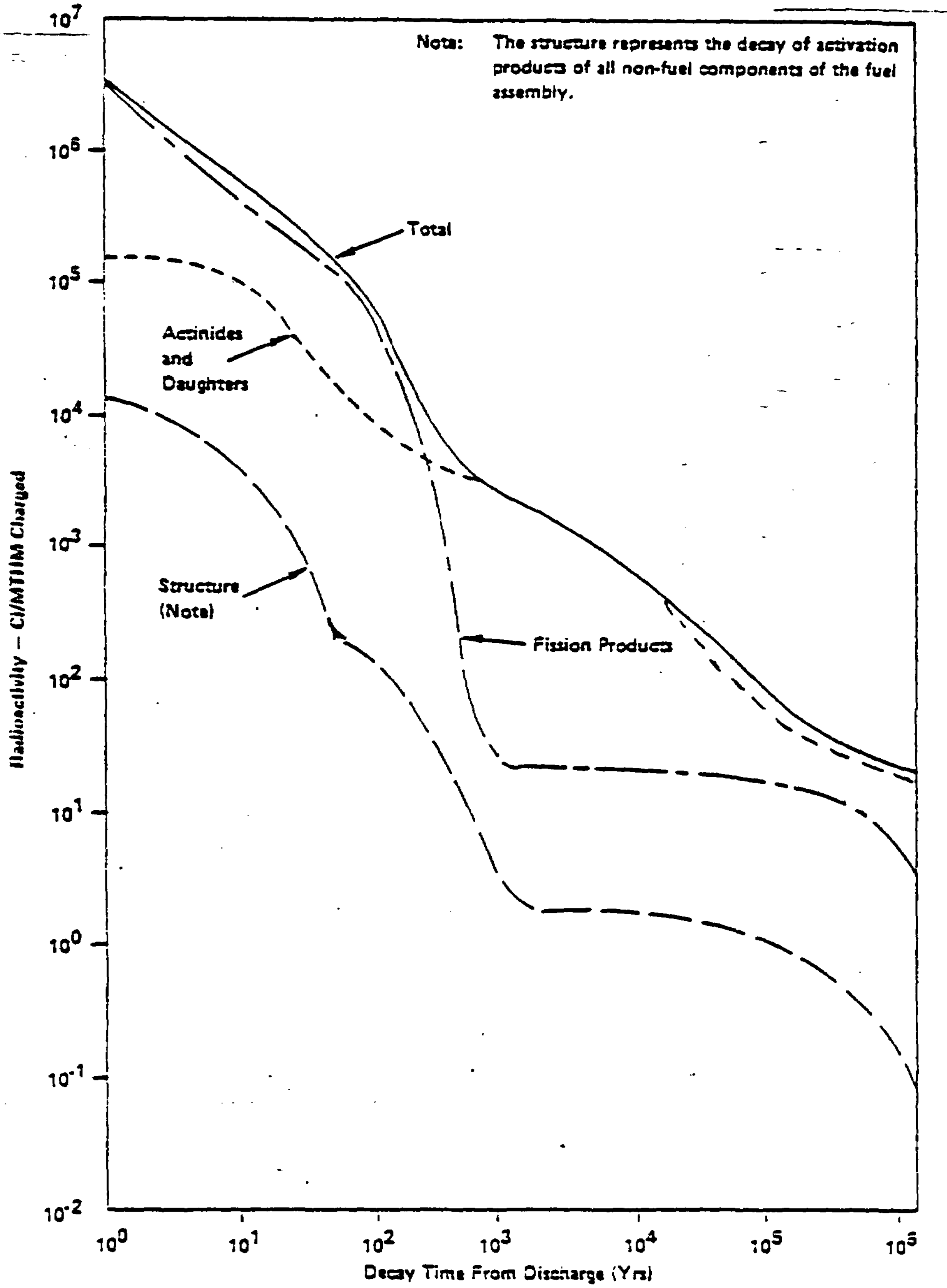



FIGURE 10 - Radioactivity as a Function of Decay Time for High-Level Waste from PWR Throwaway Cycle (ref. 1).

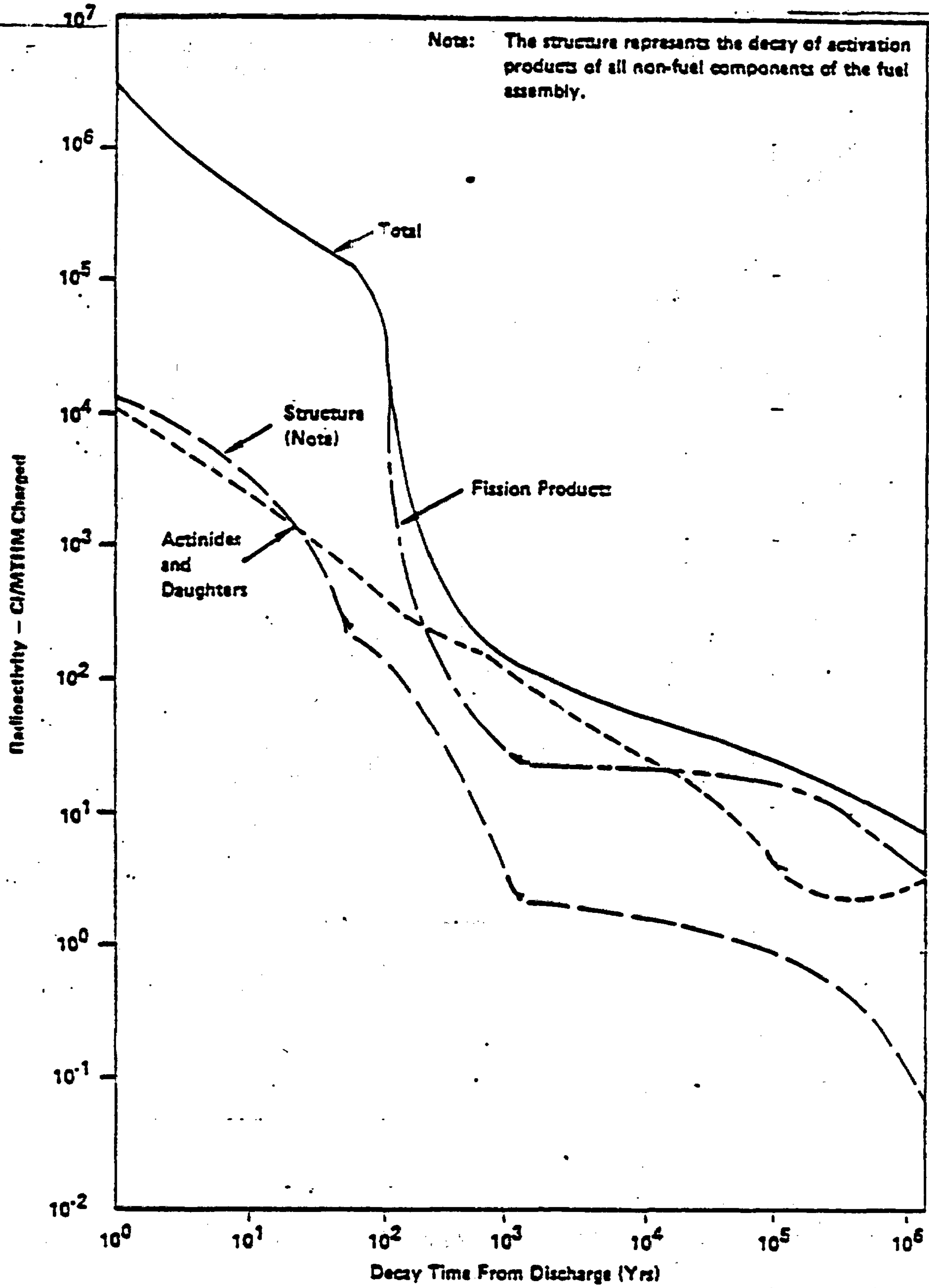



FIGURE 11 - Radioactivity as a Function of Decay Time for Reprocessed High-Level Waste from PWR Uranium Recycle (ref. 1).

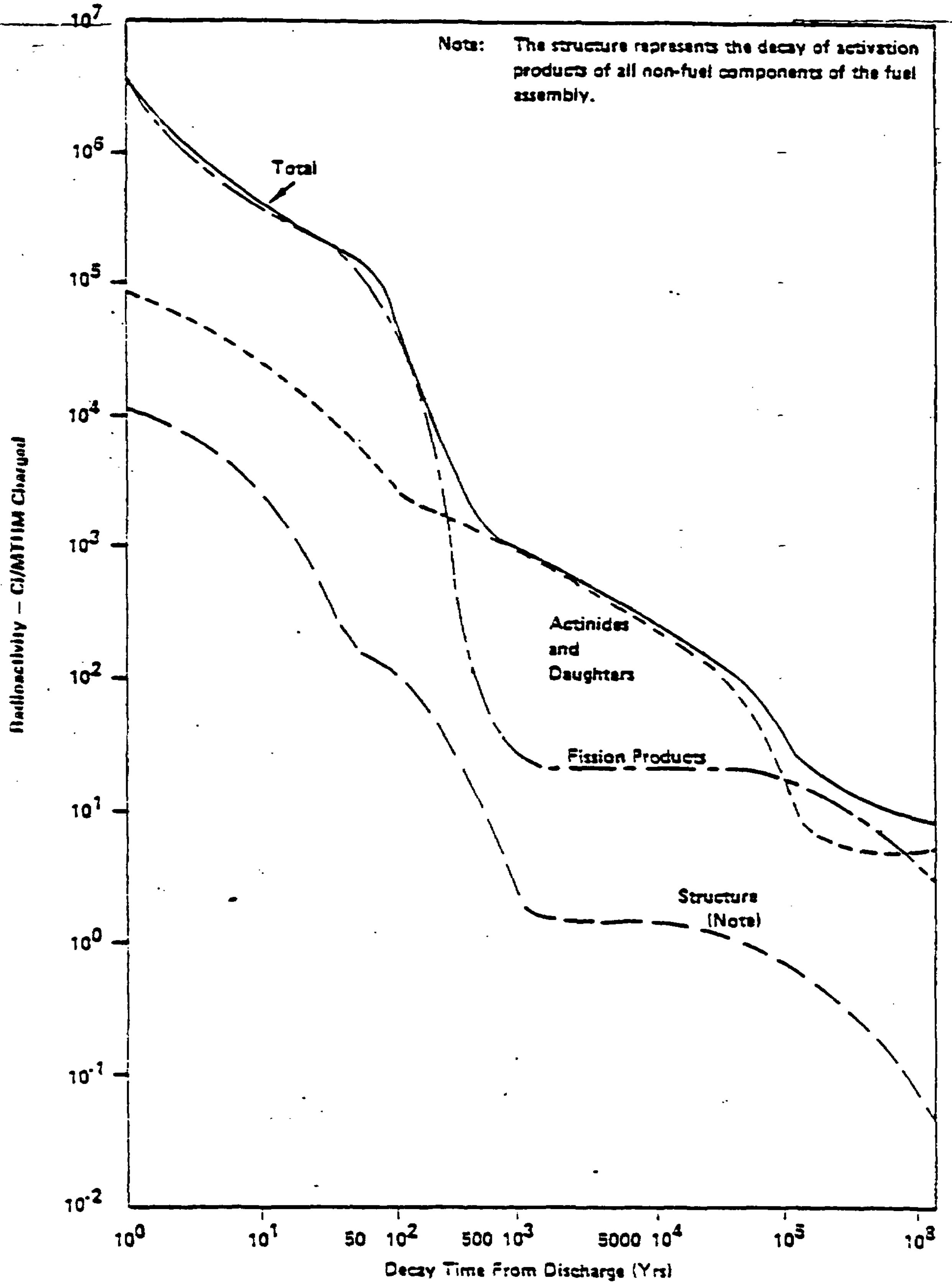



FIGURE 12 - Radioactivity as a Function of Decay Time for Reprocessed High-Level Waste from PWR Mixed Oxide Recycle (ref. 1).

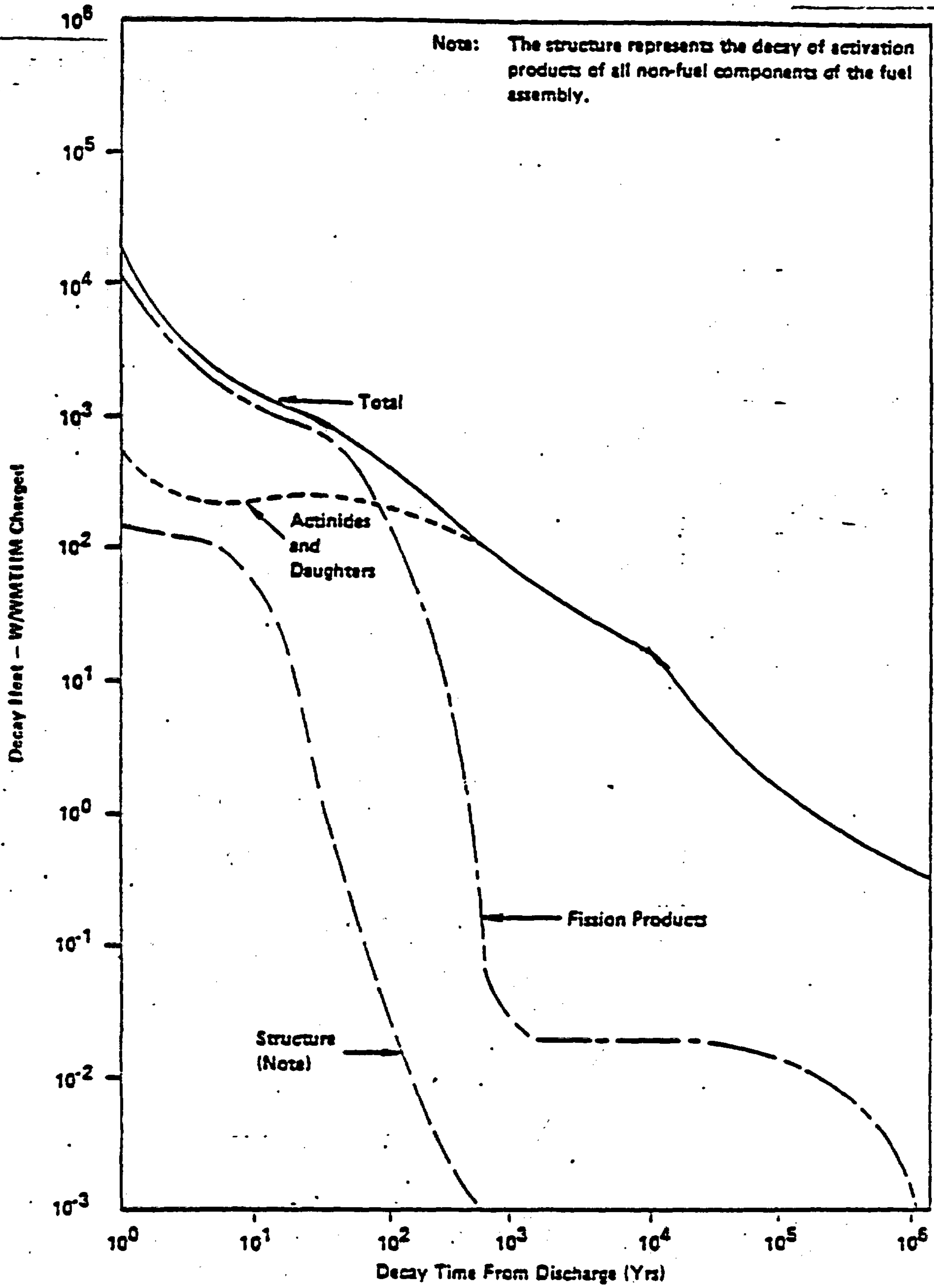



FIGURE 13 - Decay Heat as a Function of Time for High-Level Waste from PWR Throwaway Fuel Cycle (ref. 1).

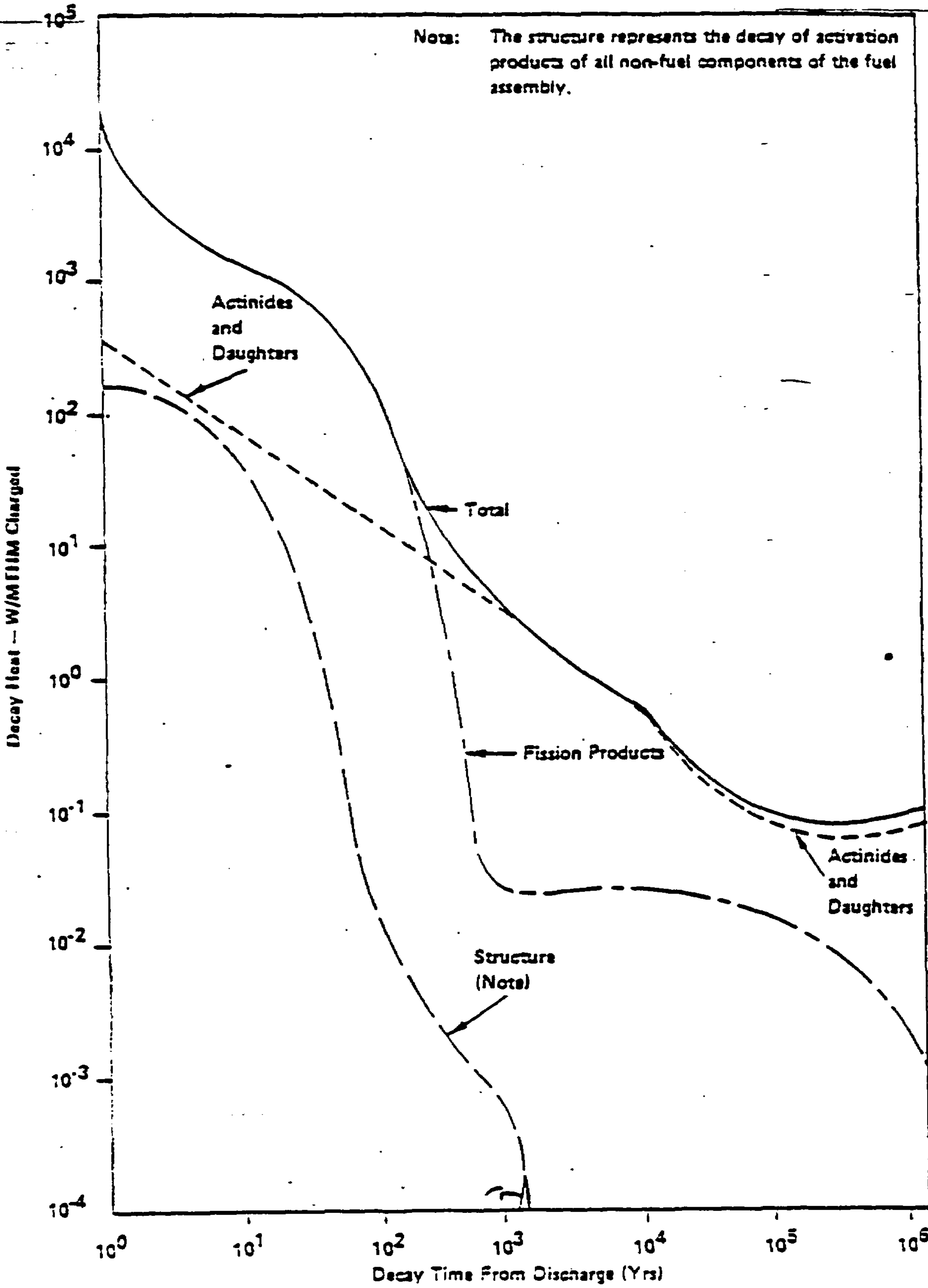



FIGURE 14 - Decay Heat as a Function of Time for Reprocessed High-Level Waste from PWR Uranium Recycle (ref. 1).

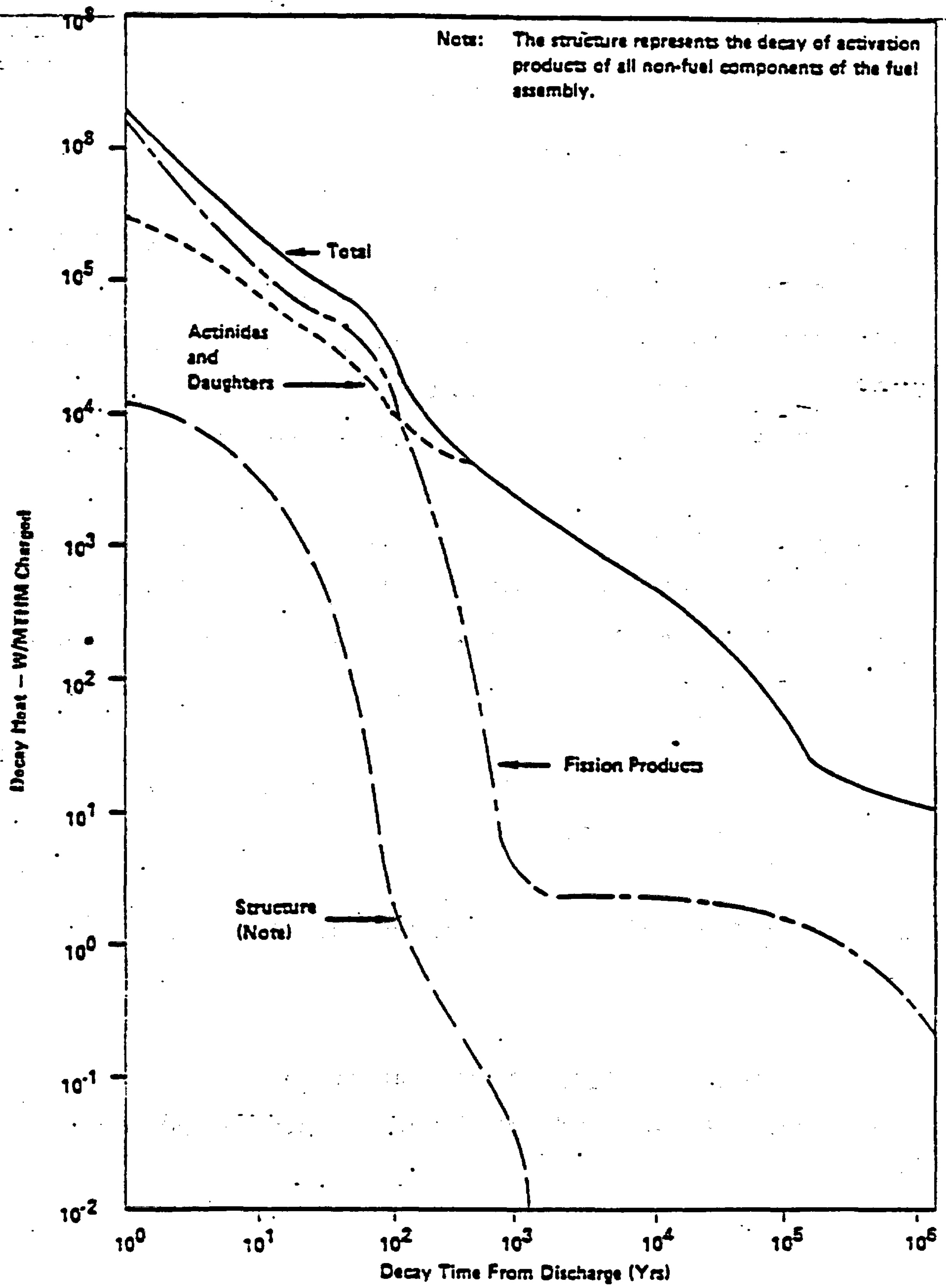



FIGURE 15 - Decay Heat as a Function of Time for Reprocessed High-Level Waste from PWR Mixed Oxide Recycle (ref. 1).

GLOSSARY OF TERMS

Accessible Environment - means those portions of the environment directly in contact with or readily available for use by human beings. It includes the earth's atmosphere, the land surface, surface waters, and the oceans. It also includes presently used potable aquifers and those which have been designated as underground sources of drinking water by the Environmental Protection Agency.

Anticipated Processes and Events - means those natural processes and events that are reasonably likely to occur during the period the intended performance objective must be achieved and from which the design bases for the engineered system are derived.

Barrier - means any material or structure that prevents or substantially delays movement of water or radionuclides.

Containment - means the act of keeping radioactive waste within a designated boundary.

Decommissioning or permanent closure - means final backfilling of subsurface facilities, sealing of shafts, and decontamination and dismantlement of surface facilities.

<u>Disposal</u> - means the isolation of radioactive wastes from the biosphere.

<u>Disturbed zone</u> - means that portion of the geologic setting that is significantly affected by construction of the subsurface facility or by the heat generated by the emplacement of radioactive waste.

<u>Engineered system</u> - means the waste packages and the underground facility.

<u>Far field</u> - means the portion of the geologic setting that lies beyond the disturbed zone.

<u>Geologic repository</u> - means a system for the disposal of radioactive wastes in excavated geologic media. A geologic repository includes (1) the geologic repository operations area, and (2) the geologic setting.

<u>Geologic repository operations area</u> - means an HLW facility that is part of a geologic repository, including both surface and subsurface areas, where waste handling activities are conducted.

<u>Geologic setting or site</u> - is the spatially distributed geologic, hydrologic, and geochemical systems that provide isolation of the radioactive waste.

<u>High-level radioactive waste or HLW</u> - means (1) irradiated reactor fuel, (2) liquid wastes resulting from the operation of the first cycle solvent extraction

system, or equivalent, and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuel, and (3) solids into which such liquid wastes have been converted.

HLW facility - means a facility subject to the licensing and related regulatory authority of the Commission pursuant to Sections 202(3) and 202(4) of the Energy Reorganization Act of 1974 (88 Stat 1244).

Host rock - means the geologic medium in which the waste is emplaced.

Hydrogeologic unit - means any soil or rock unit or subsurface zone that has a distinct influence on the storage or movement of ground water by virtue of its porosity or permeability.

Isolation - means inhibiting the transport of radioactive material so that amounts and concentrations of such material entering the accessible environment will be kept within prescribed limits.

Medium or geologic medium - is a body of rock characterized by lithologic homogeneity.

Overpack - means any buffer material, receptacle, wrapper, box or other structure, that is both within and an integral part of a waste package. It encloses and protects the waste form so as to meet the performance objectives.

<u>Radioactive waste or waste</u> - means HLW and any other radioactive materials other than HLW that are received for emplacement in a geologic repository.

<u>Site</u> - means the geologic setting.

<u>Site Characterization</u> - means the program of exploration and research, both in the laboratory and in the field, undertaken to establish the geologic conditions and the ranges of those parameters of a parameters of a particular site relevant to the procedures under this part. Site characterization includes a program of borings, surface excavations and borings, and in situ testing at depth needed to determine the suitability of the site for a geologic repository, but does not include preliminary borings and geophysical testing needed to decide whether site characterization should be undertaken.

<u>Stability</u> - means that the nature and rates of natural processes such as erosion and faulting have been and are projected to be such that their effects will not jeopardize isolation of the radioactive waste.

<u>Subsurface facility</u> - means the underground portions of the geologic repository operations area including openings, backfill materials, shafts and boreholes as well as shaft and borehole seals.

<u>Transuranic wastes or TRU wastes</u> - means radioactive waste containing alpha emitting transuranic elements, with radioactive half-lives greater than one year, in excess of 10 nanocuries per gram.

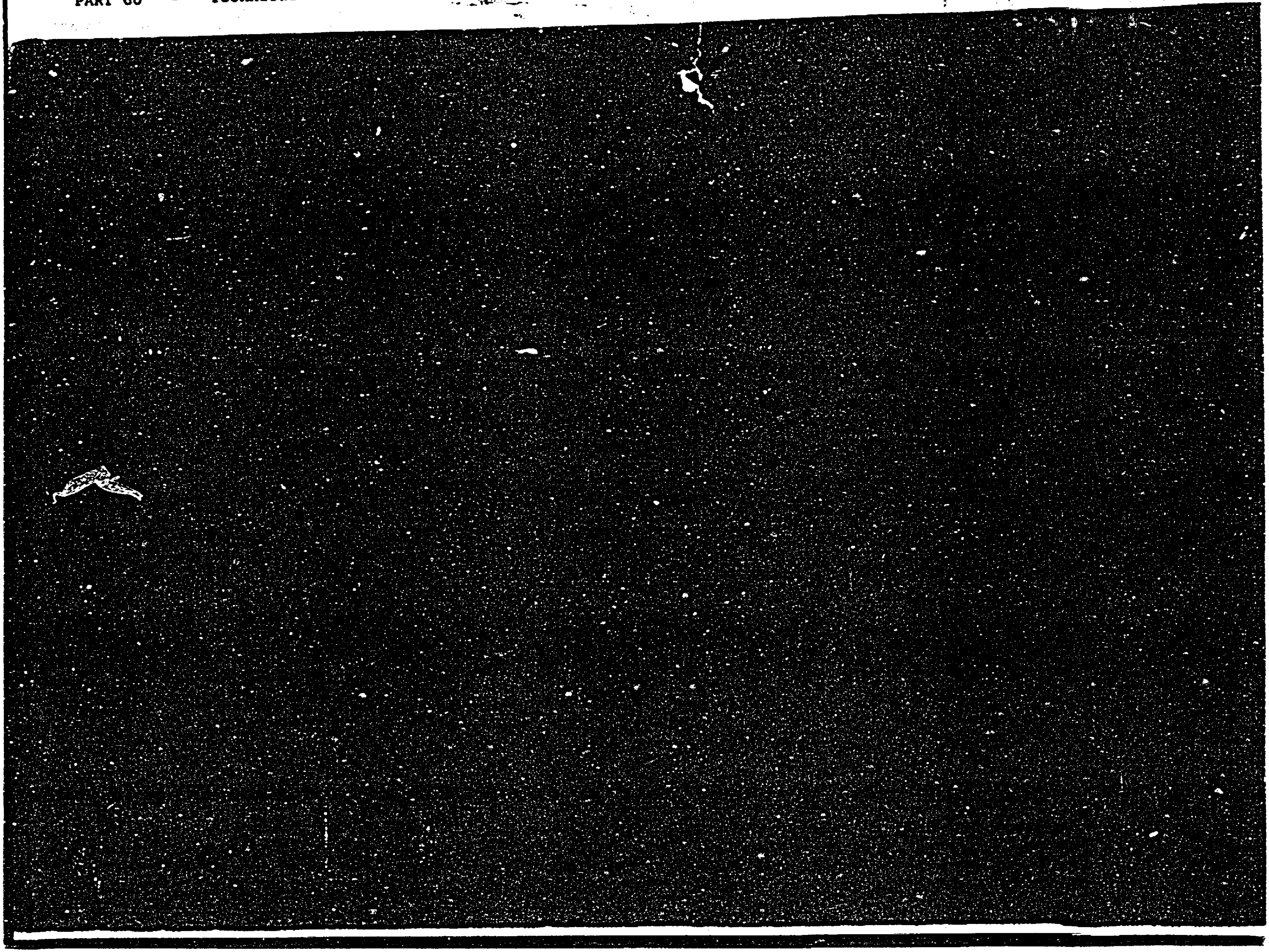
Tribal organization - means a Tribal organzation as defined in the Indian Self-Determination and Education Assistance Act (Public Law 93-638).

Underground facility - means the underground structure, including openings and backfill materials, but excluding shafts, boreholes, and their seals.

Unrestricted area - means any area access to which is not controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials, and any area used for residential quarters.

Waste form - means the radioactive waste materials and any encapsulating or stabilizing materials, exclusive of containers.

Waste package - means the airtight, watertight, sealed container which includes the waste form and any ancillary enclosures, including shielding, discrete backfill and overpacks.



PART 60

PRECEDURAL

2 EXPANDING FOLDERS

PART 60

TECHNICAL

6 EXPANDING FOLDERS

A.nelg

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

OFFICE OF THE COMMISSIONER

May 26, 1981

MEMO TO: Chairman Hendrie
Commissioner Gilinsky
Commissioner Ahearne

P.B.

FROM: Peter A. Bradford

SUBJECT: SECY-81-267 10 CFR PART 60 - "DISPOSAL OF HIGH LEVEL RADIOACTIVE WASTES IN GEOLOGIC REPOSITORIES: TECHNICAL CRITERIA"

The following are some suggested revisions to the subject draft rule. Another set of more narrow and specific changes will follow tomorrow.

1. I would prefer to include Enclosure J as part of the document that we publish. It seems incongruous to request public comment on a rule of this sort without providing the reasoning that justifies the fundamental choices to the prospective commenters. However, if publication of Enclosure J is too cumbersome, then the supplemental information needs to say more than that "the rationale for the performance objectives and environmental impact assessments supporting this rulemaking are also available in the Commission's public document room" (page 3). Instead, it should state that the rationale and the EIA have been published separately and are available without charge to those writing to a named official at a specific address.

2. If the foregoing suggestion is adopted, then I think that the justification as given at pages 12-13 of Enclosure J could be clarified. Specifically, I would propose striking the last line of page 12 and the first eight lines of page 13 and replacing t m as follows:

"The advantage of multiple independent barriers is that, by ensuring that each one contributes some measure of the necessary isolation independently from the others, they provide a redundancy that gives greater assurance of isolation than would a single performance standard. A single standard does not require the designer to take advantage of the conservatisms that are inherent in ~~redundant~~ barriers even when, as here, no one of the barriers is required to be capable of meeting the EPA standard by itself."

independent

~~8106110261~~ 2 pp.

3. The rule does not give any indication of what events NRC considers to be likely or unlikely. In order that there may be meaningful comment, examples should be given of "anticipated processes and events" and unlikely processes and events. On page 4 of the Supplemental Information, the last sentence should end with the phrase "consistently with the EPA standard ~~for unlikely events."~~ as applied to such events,"

4. In Enclosure J, page 12, the characterization of alternative 1 for the regulatory approach as the "systems approach" is quite misleading. That term as used by the IRG referred to an approach to site location and characterization and to repository design, not at all to the regulatory approach. The systems approach as used by the IRG and DOE is compatible with either regulatory option 1 or 2. Because the desirability of adopting a systems approach to repository design and siting has now been widely accepted, the Commission ought not to claim that its regulatory option is not consistent with the systems approach, particularly since that claim could arguably be incorrect.

5. As I now understand it, the ~~statement~~ qualify on page 45 of Enclosure J that "it seems prudent to select the water travel time rather than Kd, ~~to meet the overall performance~~ standard" is not quite right. That is, primary reliance may be on water travel time but we are looking to the geochemistry as well. Wouldn't it be better to state that (1) we expect the geologic setting at least to meet the EPA standard assuming that the waste package and the engineered systems function as designed, (2) that we expect at least a 1000-year travel time and a factor of 10 from the geochemistry, and (3) that here, as with the waste package and the engineered systems, ALARA principles apply.

6. 60.102(e), last sentence, page 31: "Decisions in the licensing process take future events and processes into account," is quite unclear. I suspect it actually adds nothing new to the paragraph and would best be dropped.

cc: William J. Dircks
Samuel J. Chilk
Dennis Rathbun
Leonard Bickwit

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

OFFICE OF THE COMMISSIONER

Ahl

May 28, 1981

MEMO TO: Chairman Hendrie
Commissioner Gilinsky
Commissioner Ahearne

FROM: Peter A. Bradford P.B.

SUBJECT: SECY-81-267 10 CFR PART 60 - "DISPOSAL OF HIGH LEVEL RADIOACTIVE WASTES IN GEOLOGIC REPOSITORIES: TECHNICAL CRITERIA"

Below are additional comments on Part 60:

1. It is unclear what procedures would be used and who it is that would decide that waste must be retrieved. I would suggest a brief section noting that waste may be retrieved upon NRC approval of a DOE application or upon order by NRC.

2. Page 60, Section 60.141(d): The second sentence should be changed as follows: "If significant differences exist between the measurements and observations and the original design bases and assumptions, the need for modifications to the design or in construction methods shall be determined and these differences and the recommended changes reported to the Commission."

3. Page 33, Section 60.111(b)(2)(ii)(A): The second sentence should be changed as follows: "As a minimum, the design shall provide that, assuming anticipated processes and events, the annual release from the engineered systems into the geologic setting of any radionuclide does not exceed...."

4. Page 53, Section 60.133(b)(ii): The first sentence should be changed as follows: "At the time of permanent closure, and for as long thereafter as reasonably achievable, sealed shafts and boreholes will inhibit transport of radionuclides...."

~~5.~~ Page 35, Section 60.112(c): This section should be changed as follows: "The geologic repository shall be located so that pre-waste emplacement groundwater travel times through the far field to the accessible environment are at least 1,000 years and for as long thereafter as is practical and consistent with other safety features."

drop - per 6/1 p 13 memo

8106110265 2pp.

6. Page 23, Section 60.10(d)(i & iii): If there is no difference between "to the extent practicable" and "to the extent practical," only one should be used.

7. Page 41, Section 60.124: I understand it is the staff's intent that a, b, <u>and</u> c must be demonstrated in order to rebut the presumption that the geologic repository will not meet the performance objectives. This should be made explicit by inserting the word "and" after both Section (a) and (b).

8. Page 43, Section 60.130(b)(3): This section should be changed as follows: "The structures, systems, and components important to safety shall be designed to [resist] <u>withstand</u> dynamic effects that could result from equipment failure, missile impacts...."

9. Page 43, Section 60.130(b)(4): This section should be changed to read: "The structures, systems, and components important to safety shall be designed [to reduce the potential for impairment of their ability] to perform their safety functions during and after fires or explosions in the geologic repository operations area." The bracketed language should be omitted.

10. Page 47, Section 60.132(a)(1): This section should be changed as follows: "The underground facility shall be designed so as to <u>perform its safety functions assuming</u> [take into account] interactions among the geologic setting, the underground facility and the waste package."

11. Page 51, Section 60.132(i)(3)(i): This section should be changed as follows: "Backfill placed in the underground facility shall [be compatible with] <u>perform its function assuming</u> anticipated changes in the geologic setting."

chg. per 6/1 p.13 mem

~~12~~. Page 53, Section 60.133(b)(i): I suggest that this section remain as it was originally written so that it would read: "Shafts and boreholes will be sealed <u>along their entire length</u> as soon as poss'rle after they have served their operational purpose."

13. Page 26, Section 60.21(c)(3): The omitted language "with particular attention to the alternatives which would provide longer" should be reinserted.

cc: William J. Dircks
Samuel J. Chilk
Dennis Rathbun
Leonard Bickwit

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

andy

OFFICE OF THE
SECRETARY

May 28, 1981

MEMORANDUM FOR: William J. Dircks, Executive Director for Operations

FROM: Samuel J. Chilk, Secretary

SUBJECT: STAFF REQUIREMENTS - BRIEFING ON SECY-81-267 - 10 CFR 60, DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES IN GEOLOGIC REPOSITORIES: TECHNICAL CRITERIA, 10:05 A.M., WEDNESDAY, MAY 20, 1981, COMMISSIONERS' CONFERENCE ROOM, D.C. OFFICE
(OPEN TO PUBLIC ATTENDANCE)

The staff continued their briefing of the Commission on the proposed rule on Technical Criteria for High-Level Waste Repositories.

The Commission asked the staff to review the definition of high-level waste facility and the footnote on page 20 of the proposed rule to make sure that the definitions are consistent. The staff should also include in the Statement of Consideration a review of the type of facility to be covered by the rule.

Chairman Hendrie requested the Staff to review the requirements in Subpart E to determine if some of the language (i.e., pg. 33, (2)(i) "...the waste package will contain all radionuclides for the first 1,000 years...") places an impossible standard of proof upon DOE. The requirement should be a reasonable assurance (or other similar language) that all radionuclides will be contained. The staff should provide a recommendation as to how this idea can be expressed in the rule.

Chairman Hendrie requested the staff to review their intent with regard to calculation of doses to members of the public and report back to the Commission with a recommendation as to whether "...and will not result in significant doses to any individual" can be eliminated from lines 7 and 8 of paragraph (3)(ii) on page 34. The staff should also review the division of responsibilities between EPA and NRC with respect to dose standards to see if the NRC has the authority to act in this area.

Commissioner Bradford indicated he would prepare a memorandum to the other Commissioners to cover various points he wanted to raise. (This was subsequently issued on May 26, 1981.)

~~8106110464~~ 2pp.

Commissioner Ahearne asked the staff to consider asking for public comment on how the EPA Standards for doses to the public from the HLW repository should be treated in the NRC rule.

The Commission reached no decision at the meeting. The Chairman indicated that further consideration would be given to the proposed rule at a meeting at a later date.

(Subsequently, a meeting was scheduled for Tuesday, June 2, 1981.)

cc: Chairman Hendrie
Commissioner Gilinsky
Commissioner Bradford
Commissioner Ahearne
Commission Staff Offices
Public Document Room

Department of Energy
Washington, D.C. 20545

MAY 2[illegible] 1981

Mr. John B. Martin, Director
Division of Waste Management
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Martin:

The Department has been following the recent series of Commission briefings relative to issuance of the 10 CFR 60 technical criteria as a proposed rule with great interest. As you know, the Department commented on the draft criteria as they were published in the advance notice of rulemaking on May 13, 1980. Our comments, provided in a letter dated July 15, 1980 and discussed in many meetings between our respective staffs, raised both general and special concerns. We are pleased to note that many of our comments have been addressed by your staff in the draft rule as it now exists. However, we have not been able to reach agreement on certain major issues and now feel it imperative to elevate those of a fundamental and major policy nature to the attention of NRC management.

Our principle objection to the draft regulation is that, given the present state of knowledge, it is premature to set quantitative numerical values as performance objectives, and particularly to constrain portions of the total system without allowing for decisions which trade off component performance for total system safety. We urge that your staff adopt an approach that is similar to and consistent with that of the EPA which is based on total system performance. Further, we believe your rule should be numerical only as can be supported by explicit technical data, again related to total system performance. Specifically, we object to the annual fractional release rate and waste package containment time. The inherent difficulties in demonstrating compliance with the criteria specified in the May 13, 1980 draft continue to exist and have been exacerbated by the deletion of the term "reasonable assurance" from the present draft. We understand that the Commission has requested that the staff address this omission in the proposed rule prior to publication. We believe that explicit statement of the reasonable assurance test for compliance is critical to ensure that actions taken under this regulation will be subjected to a reasoned judicial review. Further, designing licensable components (e.g. waste packages) will require that engineers have technical evidentiary tests or standards of compliance as part of a complete set of design criteria. The numerical limits on waste package lifetime and repository release are particularly troublesome in terms of the feasibility of establishing compliance tests and timely availability of such tests for design purposes.

8106110269 3pp.

The continued application of the one part in $10^5$ annual release rate appears to have little direct correlation to exposures that could be anticipated at the accessible environment and has been indiscrimately applied to all isotopes. By placing limits only on those radionuclides that present a demonstrable hazard to man, for example, we would avoid having to expend our limited research resources on (1) isotopes that are of low toxicity and (2) elements that are present in such low quantities as to present negligible radiological hazard. Instead, those resources could be focused on improving our compliance with "as low as reasonably achievable" releases of significant nuclides. Preliminary calculations by the Department, based on the listing of isotopes provided in EPA's draft 40 CFR 191, Appendix B, indicate that only the nuclides Pu, Np, Am, and "other alpha emitters", present any potentially significant hazard to the public from 2,000 to 10,000 years post-disposal.

Although a number of the design and construction requirements have been modified in the present draft, the Department still feels such criteria would best be set forth in regulatory guides as a basis for licensing review.

Your recent proposed amendment to the Procedural Rule raised a new difficulty which we have not had opportunity to discuss. The Department would now be required to calculate exposures for inclusion in the Safety Analysis Report, but no guidance is provided as to (1) what acceptable exposures may be, (2) what assumptions and site-specific mitigating factors may be applied, and (3) what level of precision may be acceptable to the Commission. Consequently, it is felt that the licensing process may be unnecessarily protracted by debate over the related system safety objective.

The Department proposes the following changes to the draft rule:

- o Specify general system performance objectives related, for example, to exposures limits or curie release limits to the accessible environment. Delete performance criteria for components of the repository system (waste package, waste form, etc.) as suggested below.

- o Replace the specification of a 1000 year waste package with a design objective that the Department provide reasonable assurance that the waste package will contain the wastes until temperature perturbations in the vicinity of the wastes allow acceptable predictability of repository and host rock function.

- o Modify the specification of the one part in $10^5$ release rate for all radionuclides to curie releases or to fractional releases of only those radionuclides which have a potential for reaching the accessible environment in biologically significant quantities.

- o Provide for inclusion of site-specific mitigating factors (such as geochemical retardation factors, ground water travel time, etc.) in the calculation of overall system performance.

While we recognize that comments may be exchanged after the technical criteria are published as a proposed rule, we submit that the wide range of technical positions involved and the current state of the proposed EPA rule suggest that extending the period of "advanced notice" status for 10 CFR 60 would assure a profitable exchange of ideas among all parties involved.

The Department feels that the present rule should provide general performance objectives rather than specific quantitative limits which may need to be restructured as the technology develops. Regulatory Guides and other mechanisms are available to provide such detailed guidance in a format that is easily updated.

We appreciate the consideration you have given our comments in the past and look forward to a successful resolution of the above issues. DOE staff are available to meet with you at any time to explore our concerns in more detail.

Sincerely,

Sheldon Meyers

Sheldon Meyers
Acting Deputy Assistant Secretary
for Nuclear Waste Management
and Fuel Cycle Programs
Office of Nuclear Energy

cc: W. Dircks, NRC
J. Davis, NRC
R. Minogue, NRC

SECY

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

OFFICE OF THE
COMMISSIONER

June 1, 1981

MEMORANDUM FOR: Chairman Hendrie
Commissioner Gilinsky
Commissioner Ahearne

FROM: Peter A. Bradford

SUBJECT: SECY-81-267 - 10 CFR PART 60 - "DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES IN GEOLOGIC REPOSITORIES: TECHNICAL CRITERIA"

As a result of further conversations with the staff, my May 26 and May 28 memoranda on this subject should be modified as follows:

1) Item 5 in the May 28 memorandum should be dropped. It will be replaced by a paragraph in the rule justification to the effect that ALARA principles have not been applied to natural features because these features are not susceptible to modification once the site has been selected. The concept that the NRC encourages the best possible mixture of natural features appears in both the procedural rule and in the proposed technical rule on pages 36-41.

2) Item 12 in the May 28 memorandum should be dropped.

3) With regard to item 1 in the May 26 memorandum, it will suffice to publish the suggested sentence. The publication of enclosure J in the Federal Register is not necessary.

4) In item 2, the phrase "inherent in redundant barriers" should become "inherent in independent barriers." I do not see a difference myself, but the staff feels that the word "independent" is more consistent with the last two lines of the suggested modification.

5) Item 3, third sentenc[illegible] the modification to the end of the section entitled "Dis[illegible]ptive processes and events" should read " . . . consistently with the EPA standard as applied to such events."

6) Item 5, the troublesome sentence on page 45 should be revised along the following lines: "Because . . . . it seems prudent to quantify the water travel time rather than Kd, at least until the EPA standard is final."

8106110276 2pp.

A new final sentence to that paragraph should state "It is conceivable that site geochemical parameters may need to reduce some of the radionuclides by an additional factor of 10-100 to meet the EPA standard, but no requirement can be quantified in rule form at this time.

The other concerns in item 5 of my May 26 memo are inoperative.

I think that I am accurate in saying that the staff does not object to the other items in these two memoranda, although item 4 in the May 28 memo extends the ALARA approach into an area where they are not sure that it is worth the effort. The staff also agrees with the first five points in this memo, and, I hope, with the sixth.

cc: W. J. Dircks, EDO
L. Bickwit, OGC
D. Rathbun, OPE
S. Chilk, SECY

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

OFFICE OF THE
COMMISSIONER

June 2, 1981

MEMORANDUM FOR: Chairman Hendrie
Commissioner Gilinsky
Commissioner Ahearne

FROM: P.B.
Peter A. Bradford

SUBJECT: SECY-81-267 - 10 CFR PART 60 - "DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES IN GEOLOGIC REPOSITORIES: TECHNICAL CRITERIA"

Attached are the modifications I think should be made to the June 1, 1981 version of Part 60. I understand that all of these modifications are acceptable to the staff. The changes are:

1) Page 46, Enclosure J (attached)

2) Page 5, Enclosure A (attached)

3) The staff will supply language before the next meeting to the effect that ALARA principles have not been applied to natural features because these features are not susceptible to modifications once the site has been selected.

4) The staff will supply language before the next meeting which gives examples of processes and events which NRC considers to be unlikely.

As a result of this morning's discussion, I suggest we handle the reasonable assurance issue on page 29 by adopting the suggestion of Commissioner Ahearne. This suggestion as I understand it is attached. I have not taken this issue up with the staff.

I would urge that we meet again Friday, June 5, on this matter to see if we can at least agree in principle. The Office of the Secretary is requested to track responses.

cc: W. J. Dircks, EDO
L. Bickwit, OGC
D. Rathbun, OPE
S. Chilk, SECY

8106190044 5pp.

Groundwater travel times from repository depths to the accessible environment of 1,000 years are achievable in many hydrologic systems. For a groundwater travel time of 1,000 years, sorption equilibrium coefficients of 100 ml/g or less are sufficient to prevent most of the principal contributors to dose from reaching the accessible environment. Sorption equilibrium coefficients measured in the laboratory for the actinides and other nuclides that are principal contributors to dose are in the range of $10^2$-$10^4$ ml/g, so that some margin is provided to compensate for the uncertainty in actual values of Kd under repository conditions. Because of the greater confidence in our ability to measure hydraulic rather than geochemical parameters, and the conservatism that is introduced, it seems prudent to select the water travel time rather than Kd to be the parameter to be regulated. [~~meet the overall performance standard.~~] Therefore, we have framed our site performance objective so that the travel time from the repository to the accessible environment be at least 1,000 years and we intend that DOE consider during site screening that sites with longer water travel time are preferred. insert attached

If sites with long enough water transport times are selected as potential repository sites, some of the major uncertainty in site evaluation can be resolved. Licensing issues will then mainly be restricted to ensuring that the proposed repository does not disrupt the hydrologic flow pathways such that shorter travel times to the environment are created, and the adequacy of engineered barriers dealing with disruptive events and natural processes that could result in shorter flow pathways.

INSERT TO PAGE 46 OF ENCLOSURE J

It is likely that site geochemical parameters may need to reduce some of the radionuclides by an additional factor to meet the EPA standard, but no requirement can be quantified in rule form at this time. Gross estimates of this factor range from 10-100 and even beyond depending on what values are in the EPA standard and depending upon further analyses.

a finding that the issuance of a license will not constitute an unreasonable risk to the health and safety of the public. The purpsoe of this subpart is to set out performance objectives and site and design criteria which, if satisfied, will support such a finding of no unreasonable risk. ~~While these objectives and criteria are stated, in many cases, in unqualified terms, rigorous proof of their satisfaction may not always be achievable;~~ For the Commission to find that is no unreasonable risk, it must have reasonable assurance on the basis of the record before it that these objectives and criteria will be met.

(b) Subpart B of this part also lists findings that must be made in support of an authorization to construct a geologic repository operations area. In particular, §60.31(a) requires a finding that there is reasonable assurance that the types and amounts of radioactive materials described in the application can be received, possessed, and disposed of in a repository of the design proposed without unreasonable risk to the health and safety of the public. As stated in that paragraph, in arriving at this determination, the Commission will consider whether the site and design comply with the criteria contained in this subpart. Once again, while the criteria may be written in unqualified terms, the demonstration of compliance may take uncertainties and gaps in knowledge into account, provided that the Commission can make the specified finding of reasonable assurance.

(a) [This-subpart-states-the-performance-objectives-to-be-achieved and-the-technical-criteria-to-be-met-by-the-DOE-in-order-for-the-Commission-to-make-the-findings-called-for-in-Subpart-B-of-this-part.]

by DOE in its license application. If the process or event is unlikely, then the overall system must still limit the release of radionuclides[.], consistent with the EPA standard ~~for unlikely events.~~ as applied to such events.

Multiple Barriers

The proposed technical criteria were developed not only with the understanding that EPA's generally applicable environmental standard would need to be implemented, at least in part, by performing calculations to predict performance, but also with the knowledge that some of those calculations would be complex and uncertain. Natural systems are difficult to characterize and any understanding of the site will have significant limitations and uncertainties. Those properties which pertain to isolation of HLW are difficult to measure and the measurements which are made will be subject to several sources of error and uncertainty. The physical and chemical processes which isolate the wastes are themselves varied and complex. Further, those processes are especially difficult to understand in the area close to the emplaced wastes because that area is physically and chemically disturbed by the heat generated by those wastes.

However, a geologic repository consists of engineered features as well as the natural geologic environment. Any evaluation of repository performance, therefore, will consider the waste form and other engineering which is elemental to the repository as a system. By partitioning of the engineered system into two major barriers, the waste package and the underground facility, and establishing performance objectives for each, the Commission has sought to exploit the ability to design the engineered

ORIGINAL

U.S. NUCLEAR REGULATORY COMMISSION

RETURN TO SECRETARIAT RECORDS

COMMISSION MEETING

In the Matter of: PUBLIC MEETING

BRIEFING ON PROPOSED [illegible]
DISPOSAL OF HIGH-LEVEL RADIOACTIVE
WASTES IN GEOLOGIC REPOSITORIES:
TECHNICAL CRITERIA

DATE: June 2, 1981 PAGES: [illegible] 82

AT: Washington, D.C.

ALDERSON REPORTING

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8106110256 83pp.

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

BRIEFING ON SECY-81-267 - 10 CFR 60, DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES IN GEOLOGIC REPOSITORIES: TECHNICAL CRITERIA

PUBLIC MEETING

Nuclear Regulatory Commission
Room 1130
1717 H Street, N.W.
Washington, D. C.

Tuesday, June 2, 1981

The Commission met, pursuant to notice, at 10:05 a.m.

BEFORE:

JOSEPH M. HENDRIE, Chairman of the Commission
VICTOR GILINSKY, Commissioner
JOHN F. AHEARNE, Commissioner
PETER A. BRADFORD, Commissioner

STAFF PRESENT:

S. CHILK, Secretary
W. DIRCKS, Executive Director for Operations
P. COMELLA
J. MARTIN
J. WOLF
M. BELL

## DISCLAIMER

This is an unofficial transcript of a meeting of the United States Nuclear Regulatory Commission held on JUNE 2, 1981 in the Commission's offices at 1717 H Street, N. W., Washington, D. C. The meeting was open to public attendance and observation. This transcript has not been reviewed, corrected, or edited, and it may contain inaccuracies.

The transcript is intended solely for general informational purposes. As provided by 10 CFR 9.103, it is not part of the formal or informal record of decision of the matters discussed. Expressions of opinion in this transcript do not necessarily reflect final determinations or beliefs. No pleading or other paper may be filed with the Commission in any proceeding as the result of or addressed to any statement or argument contained herein, except as the Commission may authorize.

P R O C E E D I N G S

CHAIRMAN HENDRIE: The meeting will be in order.

Why don't we start by asking the staff to relate the contents of their paper, which was last night's arrival, and is the thickest of the recent additions to the literature on this subject.

MR. DIRCKS: Let me mention another arrival that Jack is going to distribute. It is a letter that he received from Shelly Meyers with some last minute suggestions.

CHAIRMAN HENDRIE: Shelly wants to come back, does he?

MR. DIRCKS: He has come back in spirit.

He has a list of suggestions here that he wants incorporated. I will let Jack give you his opinion of it, and I think, in reviewing it, there are not too many additional new issues in there. I think that we have reviewed some of these in the past.

Jack, why don't you provide a capsule summary of that.

MR. MARTIN: I think a capsule summary, as Bill said they are not new issues, they would really rather not have any numbers placed on the waste package performance. They would really rather just have an overall figure of merit for the total system, as comment number one, essentially.

But then, if we insist on having some numbers on the waste package, they would rather that we would put the reasonable assurance back in there, which we have done. Also, on the fractional release that that be reworded so that it does not include all the nuclides, just the ones of concern, which we talked about a couple of meetings ago, and to fix that as well.

So I believe that we have gone a long way to resolving the details of what we can resolve, but we would rather stick with the multiple barrier and defense in-depth approach rather than the single figure merit for the overall system. Of course this has been debated and discussed for the last two years.

COMMISSIONER AHEARNE: Jack, you say that you have put the reasonable assurance back in?

MR. MARTIN: Yes, sir. We have also fixed the part about limiting the -- We previously had a leach rate of one part and 10 to the 5th of individual nuclides. We had some discussion a couple of meetings ago of, shouldn't we limit that to the important nuclides, and not get down to atomic quantities of release. We have fixed that as well by limiting that requirement of those nuclides that are at least a tenth of one percent of the total Curie release, which essentially boils it down to about a dozen long-lived plutonium, Neptunium, Technetium.

COMMISSIONER AHEARNE: What have you actually eliminated when you did -- The tenth of a percent is the curie release in the waste package itself; is that correct?

MR. MARTIN: It is the release from the engineered system, depending on how the engineers did it. It is the man-made portion of the waste package, the backfill. If they choose to make an engineered system of the excavated repository itself. It is the release from that manmade part to the --

COMMISSIONER AHEARNE: Geological site?

MR. MARTIN: Yes.

COMMISSIONER AHEARNE: Are you saying that if they were to propose an engineered system which has some unique capture sections for one of these long-lived materials, they could then not have to worry about that particular material?

MR. MARTIN: That is correct. That is what we are trying to encourage by rewriting it the way we did. What they were concerned about is, let's take very short lived things, theoretically they are still there in very small quantities, and they don't want to spend a lot of time researching and proving that tritium is still, because for all practical purposes it is gone. So by doing it our way, we eliminate everything except the americium 241 and 243, neptunium, the three plutoniums, technitium 10, and uranium 234.

So there are about a dozen isotopes that are still to be concerned, and I think that that takes care of their problem.

COMMISSIONER AHEARNE: Do you have any comment on their alternative proposal for the waste package, the temperature perturbation argument?

MR. MARTIN: We considered that, and decided not to go that way because one of the things that we are trying to do in this rule is to add some certainty to the licensing process, and having a rather vague statement like that doesn't really settle what the design requirements are, it just leaves it to be litigated later.

That was similar to other suggestions about why not design the waste package so that they are no more hazardous than a ore body at some certain point in time. We rejected that for the same reason, because it just doesn't settle what the design requirements are until very late in the game.

COMMISSIONER AHEARNE: They seem to have some misimpression, I believe. Their last bullet on page 2 could be read as saying that you would not allow the site specific mitigating factors in a calculation of overall system performance.

It is my understanding from what you said before, in the calculation of the overall system performance, in order to meet, say, EPA standards, they are going to have take that.

MR. MARTIN: Absolutely. The only part that we are holding fast on is that we do want a multiple barrier system, with some defense in-depth, and not leave what defense in-depth you have as an ill-defined thing to be defined by the applicant.

CHAIRMAN HENDRIE: "Your recent proposed amendment to the Procedural Rule," says Shelly in the middle of page 2, "raised a new difficulty we have not had an opportunity to discuss." Did we discuss it?

MR. MARTIN: We did discuss it ad infinitum at the last meeting, and this was your point as to why we have these extra requirements on doing analyses that are not in the EPA standard. We have resolved it by deleting it all, and moving up paragraph No. 2, which also says that the design and construction requirements look too involved, can't you put some of that in Reg Guides. We agreed that probably some of that ought to be in Reg Guides, and we have a statement in the introduction asking for comment on that. We probably can back off on that a little bit.

CHAIRMAN HENDRIE: I must say that I got caught short last night. I got yesterday's paper, but I did not have 81-266 with me, so I had to work from the less than complete proposition, although most of the pages from about 28 on are there, I guess.

It looks to me that once you get passed 61-21, now we have additional requirements for the geologic setting. We have got a batch of favorable ones, a batch of unfavorable ones. I couldn't decide whether those set better in the rule or were covered in the rule by a general statement, and then appeared in the staff document.

You say, "Each of the following may contribute to the ability to meet the performance objectives," and it is okay.

In addition to having the 112 characteristics, which pertain to stability and water travel time chiefly, "the setting shall exhibit an appropriate combination of these conditions," conditions that follow, "together with the engineered system, the favorable conditions present are sufficient to provide reasonable assurance that the performance objectives will be met." With that kind of an introduction, I am not quite sure how to read any one of these favorable ones or, taking the reserve side of it, the adverse ones.

If sort of the bottom line with regard to one of these is, are the performance objectives met, or at least a reasonable showing made that the performance objectives are met, then that might be because of one of these elements, or in spite of it, or without regard to it, in which case do I still regard one of these elements as counting either favorably or adversely with regard to the additional requirements for the setting. Do all of them apply? That is, the site has to show all of the favorable ones and none of the adverse ones.

I sort of gathered from the first paragraph language that that was not the case, and that it was not 100 percent in and 100 percent out sort of situation.

MRS. COMELLA: That is right.

CHAIRMAN HENDRIE: On the other hand, it is not very clear what a passing score card would look like in order to satisfy 60.122.

As I say, even when I understand that, I am not sure exactly what I do with these things in light of the proposition that these thing together with the engineered system, the favorable conditions present are sufficient to provide reasonable assurance that performance objectives will be met.

Tell me how these things fit in the context of the rule, and do we really have quite the right words at the start of the section?

MRS. COMELLA: The staff had spent a great deal of time dealing with the question of whether or not one could come up with site acceptability requirements where, if they were present, yes, you knew you had an acceptable site; if they were absent, or if the adverse conditions were present, you knew you had an unacceptable site.

After a great deal of discussion internally and externally with other experts in the area, it was determined that really we were not in a position to come up with site acceptability requirements, but we could identify conditions which if present would increase confidence that that site appeared indeed to be suitable to host a repository, and we could identify characteristics which if present certainly required further examination to see whether indeed they eliminated a site.

This section 122 was an attempt to identify the favorable ones, which if present would enhance the quality of the site, and others, which if present could make it unsuitable. That is what it is there for. We recognize that the site selection process would involve balancing, looking at what was there and what was not there in an attempt to arrive at the site which would host the repository.

Jack, do you want to add anything?

MR. MARTIN: We were basically faced with a dilemma. On the one hand, just about everybody who has looked at the siting question has urged that we have a set of definitive siting criteria to go find sites, and that they be decided before and not after the fact.

When we looked at all the siting criteria that we have come up with, and the American Physical Society has come up with, and the other groups that have looked at this, every definitive set of criteria seemed to us to have a couple of features that might well reject an acceptable site.

So, instead, we hit on an alternate approach, which I might add has not gotten much comment, it seems to be favorably view, where we have more of a balancing approach, where we list the favorable conditions that you ought to find fairly definitively -- you ought to have these; then we list the conditions that you ought to avoid, and if you have them, they raise the presumption that the site is rejected.

Then towards the end, we provide a conflict resolution section on page 42, I think, that shows that if you can really make a case that you, in fact, understand this condition, like tectonic instability, for example, and in fact can make a case that you have enough favorable conditions to offset that situation, then the site will still be considered acceptable.

This scheme works or should work, of course, because in the procedural rule we have required that there be a number of sites to look at, so it is really linked quite closely, and if there were only one site to look at, this might be rather cumbersome. But it is the only way we could think of to resolve the question of not having siting criteria that rejected sites that might be acceptable, yet provided some definitive --

We feel that this approach, coupled with the fact that we are going to have at least three sites to look at, will result in a good site and not reject any that might be acceptable. As I say, this approach has not received any negative comment that I can think of from anyone.

CHAIRMAN HENDRIE: What do you do with a site that does not have three of the ten favorable conditions?

MRS. COMELLA: Are you asking whether all of the favorable conditions have to be present to some degree or another?

CHAIRMAN HENDRIE: More or less.

MRS. COMELLA: They don't all have to be present.

COMMISSIONER AHEARNE: Is there any statement anywhere that is sort of a converse of what happens if you have adverse conditions?

MRS. COMELLA: You mean a presumption of acceptance if they are all present?

COMMISSIONER AHEARNE: Yes.

MRS. COMELLA: No, there isn't.

COMMISSIONER AHEARNE: Similarly there is no statement that would say that the absence of some of all or a large number of the potentially favorable conditions would be --

MRS. COMELLA: --regarded as an adverse condition?

COMMISSIONER AHEARNE: Yes.

MRS. COMELLA: No. That is a very interesting point. No, that is not there, but perhaps it should be.

COMMISSIONER AHEARNE: I was not suggesting it.

MRS. COMELLA: No, I was not responding to it that way. I was saying that perhaps this is something that could be given some thought.

CHAIRMAN HENDRIE: You see, some of the favorable conditions are such that they do seem reasonable to me. "(a) The nature and rates of tectonic processes that have occurred since the start of the Quaternary Period," how far back is that?

MR. MARTIN: About two million years. It is basically the time period since mountain building stopped and nothing much has happened except the Ice Ages. It is a pretty uninteresting geological time.

CHAIRMAN HENDRIE: -- are such that when projected they would not affect or would favorably affect the isolation capability of the repository.

Because you have phrased it, "would not affect," as well as "favorably affect," the option which is left is that those processes, if projected, would affect unfavorably the ability of the site to isolate waste. Indeed, in that case, it is not so clear that you can make the case required under 60.111, or indeed whether under section whether that is a very important consideration. So that one is okay, good.

Let's get down to some of the others. "Mineral assemblages that, when subjected to anticipated thermal loading, will remain unaltered or alter to mineral assemblages having increased capacity." I am not sure whether this is the same kind of thing or not, if they alter under thermal loading to be unfavorable, I guess one has to say how unfavorable before you know if you have got a no go.

You say that these ten-odd possible favorable conditions in the site, if one or more of them are not present, that means you don't cross the site off under this paragraph. On the other hand, if they are all there, you still don't check the site off under this paragraph.

MR. MARTIN: Because you still have the adverse conditions to get through.

CHAIRMAN HENDRIE: You have the performance criteria and all kinds of other sections.

MR. MARTIN: You see, it is important to

understand why these are here. Almost all of them bear on your ability to predict the site performance. The performance criteria are essentially for just normal design assumed conditions, but one still has to do some sort of a prediction into the future as to how the site is going to act, and that is the backdrop for these sorts of requirements.

If one does not have a stable site, it gets very troublesome to predict the future. If one has mineral assemblages that alter in some way that is not understood very well, then that confounds prediction. So they are really complementary to the performance objectives, and provide for each of demonstrating the performance objective and meeting the EPA standards.

COMMISSIONER GILINSKY: By the way, what happened to the population densities?

MR. MARTIN: That was one of the Chairman's comments that we complied with and struck.

CHAIRMAN HENDRIE: They struck that.

COMMISSIONER GILINSKY: What was the idea behind that?

CHAIRMAN HENDRIE: The idea is that if we are going to talk about geologic times and so on, it makes relatively little sense to talk about population densities.

MR. MARTIN: We did get at it by another way, saying that you ought to keep away from areas that are attractive for resource exploration, and that sort of thing, which is really a surrogate, it seemed to us, for population density, if the thing is very unattractive.

COMMISSIONER GILINSKY: What is going to keep this out of the cities?

CHAIRMAN HENDRIE: Expense. It is very expensive to put a repository in the city.

COMMISSIONER AHEARNE: But what is going to keep cities out of it? I think Joe's point is that when you start talking about a thousand years --

COMMISSIONER GILINSKY: We don't have to have it that long. It could be one hundred years.

CHAIRMAN HENDRIE: Remember the argument that I made to you the last time. When there are two periods of time which are of interest here. The period of time in which the present social institutions continue and there is a societal memory, and so on, and in this period, it makes very little sense.

From the standpoint of keeping people from intruding into the repository, one of the best places to have it, as I pointed out to you, is under Manhattan. You could not build it under Manhattan as a practical matter because of the expense of procuring the right-of-way, then providing the protection needed for material to come in and the operation to go on, and so, it all would be prohibitive.

So as a practical matter, you are not going to build it under Manhattan. On the other hand, if you want a place where human intrusion will be noticed and monitored, at least through the survival of the present society, By George that is the place. There are people, and things go on around the clock.

On the other hand, once you get out to geologic times, you are saying, don't build it here, muttering about low population density in 1985 just has no meaning with regard to where cities will be sited.

COMMISSIONER BRADFORD: What about saying, reasonable assurance of low population densities for -- I don't know what the right number is -- one or two hundred years, or at least the period in which the thing is being loaded up.

CHAIRMAN HENDRIE: I see no reason to set up a standard which --

MR. MARTIN: Another point of reasoning we had on deleting that is that it is certainly one of the factors that will be balanced and weighted in the NEPA evaluation. So that was another thing that led us to not agonize too much on taking this out, as it will be taken into account in that form, and maybe that is a better way to consider this one.

COMMISSIONER BRADFORD: But how does it get in there, Jack?

CHAIRMAN HENDRIE: Because the environmental costs are higher if you deal with a population where you have to move a lot of people around during the time that you are building and operating the facility, and up through closure.

COMMISSIONER BRADFORD: I am assuming that, in fact, even medium size communities are unlikely to be the direct host. That is, no one is going to take the park in the center of a city of even 50,000 as a repository site. The real question is whether there is a concentration of population of some size a relatively short distance away, in a direction that one should worry about.

I would think that there is some way to say that either the presence of such a group is an unfavorable characteristic, or the absence is a favorable one.

COMMISSIONER GILINSKY: You are going to have a lot of surface activity at one of these sites at least for some years, and do we really want to do that in the middle of Manhattan.

COMMISSIONER BRADFORD: It is not really the middle of Manhattan.

CHAIRMAN HENDRIE: If you provide me the transportation corridor and deed Central Park to me, and so on, and eliminate various other things, the Manhattan just may in fact be an ideal piece of granite, I don't know. But as a practical matter, you know that you are not going to do that.

From a health and safety standpoint, although the curie levels are large, they are in forms that just don't travel easily. You are going to have this stuff well tied up, and you don't have driving as there potentially are in the reactors.

From a public health and safety standpoint, population density to my mind just does not cut much here. What you are concerned about is having a reasonable working areas and control over them, and one should have those, so it is not a safety problem.

COMMISSIONER GILINSKY: Where does the requirement on the working corridor come in here?

CHAIRMAN HENDRIE: The transportation aspects will have to be considered in the environmental impact statement. There are certain costs associated with these things.

COMMISSIONER GILINSKY: I must say that I find it very odd that in these hard and fast requirements of favorable condition that we don't include low population density. That seems very peculiar to me.

CHAIRMAN HENDRIE: Because low population density, as far as you can control it in this regulation and by the siting of the repository has essentially no meaning over the lifetime of the repository.

COMMISSIONER GILINSKY: I think that it has a lot of meaning when you are filling up the repository.

COMMISSIONER BRADFORD: Let me suggest a formulation here that we did the other day on an unrelated matter, which is that on something like this, I feel that there ought to be some mention of low population, at least for purposes of getting comments, that we just cite Commissioners Gilinsky and Bradford are interested in comments on the low population density standard here, and the Commission therefore requests comments on those as well.

COMMISSIONER AHEARNE: I would just as soon say that the Commission is interested in comments on that.

MR. MARTIN: We could get comments on having a paragraph that would implement it. It might be interesting.

Shall we go through the rest of the paper?

CHAIRMAN HENDRIE: Where do I leave these favorable conditions? How do I understand from this that not all of them are prerequisites?

MR. MARTIN: We do have an introduction on page 37 that does discuss an appropriate accommodation.

MRS. COMELLA: There is a discussion in the supplementary information on page 14 as well of the favorable and unfavorable characteristics.

COMMISSIONER AHEARNE: Which version?

MRS. COMELLA: I was going to say the top one. It is the original 267, and I don't believe we have made any changes to that particular section. Under siting requirements, there is a very brief discussion there.

CHAIRMAN HENDRIE: "Cannot be made absolute requirements, and so on." It may be that the words in the supplementary information as well as the phrasing of the language in 60.122 can solve the problem, but I guess it is not so clear from the words themselves to me that that is the case. That tells me that it is the staff's attempt, and perhaps it will serve as legislative history on this, I don't know.

Over on the unfavorable ones, here the presence of any one of these takes out a site.

How do I show that there is no potential for mining at a site?

MRS. COMELLA: Part of that would arise out of your resource assessment and some of the inferences that one would draw from that, I would think.

CHAIRMAN HENDRIE: I am looking at (3) under adverse conditions in the geologic setting, changes in the hydrogeology, groundwater withdrawal, extensive irrigation, and subsurface injection of fluids, underground pump storage, underground military activity, or mining.

You can certainly prevent mining or underground military activity during the period in which there is continuity of the records, and continuity of human institutions, and so on. I don't read the adverse condition to be so limited.

What are you going to do with a contention that people are going to want to mine granite from this location, starting a thousand years in the future because by that time they will have discovered some great use for granite?

I keep wondering if the proposition we have in hand here constructs a framework which, well meant --

MR. MARTIN: You have to read the first sentence of the requirement which is "Potential for human activity to significantly affect the geologic repository through changes in the hydrogeology." You may be able to make a showing that even if mining takes place, it would not bring about unfavorable hydrogeologic conditions.

CHAIRMAN HENDRIE: Do you think you could show that?

If can get a contention accepted that some future generation will want to mine granite from a repository, do you think you have a chance of proving, well, that will not change the hydrogeology in ways we can't foresee, hence, cause unfavorable conditions?

MR. MARTIN: No, but I think this sets this up to deal with it in the best possible way. It would seem to me, let's say, if there were minable types of resources in the area, and let's take a more realistic case that there is oil or something nearby in the area, how does one deal with that? That was our problem, we just could not ignore it and leave it to happenstance.

So, instead, we listed it as, okay, face up to the problem. If you have got that kind of a situation, it is an adverse condition, and you are going to have to show either that it doesn't affect the repository or it is more than compensatei by these other more positive attributes, in accordance with the formula a couple or three pages further along.

I think that this is the dilemma on almost all of these siting issues, whether it be resource competition, or hydrological. I can think of one site where there are hydrological problems with, and another one where there is volcanic activity. We just did not see that we could ignore them, and instead we tried to set up a set of machinery to recognize and resolve the problem if possible, and also bearing in mind that we have a number of sites to work with.

CHAIRMAN HENDRIE: What worries me is that in setting up to deal with it, so called, you set up a machine which is intrinsically incapable of coming to a positive finding.

COMMISSIONER BRADFORD: But isn't that the point that has been made in two other respects. One you made the other day with regard to the need to specify that what we are talking about is reasonable assurance. Jack has also made it repeatedly in individual choices throughout the rule, keeping in mind the question of whether the criteria he is setting are in fact inherently provable.

In other words, will not be able, either now or when the Commission closes on the final rule, to sit here and guarantee the rationality, I guess, of our successors. But if somebody comes in with a contention having to do with the likelihood of a granite mine in a thousand, that contention, like any other than can be formulated around any one of the provisions in here, is going to run into the reasonable assurance rubric, and then the specific criteria. If it turns out to be a sufficiently likely event, then the site is not going to pass muster. If it turns out to be sufficiently unlikely, it is.

But this one item here doesn't seem to me to give rise to that problem any more than an unlikely contention on the wage package or on the 10 to the minus 5 status.

CHAIRMAN HENDRIE: But the way this is set up doesn't quite set it up the way I would prefer to set it up. I would prefer to see some language along the lines in here that there is a presumption that mining will not occur unless there are identifiable resources that have the economic value in the present society and can be reasonably projected to have economic value in future societies sufficiently unique so that you would mine this site.

That is, if you want to come in and argue with me that people will find a use for granite, and they will want to dig it up here, and you leave the rule so that it just says the potential for mining is an adverse condition that I have to somehow overcome by showing that I have characterized it adequately -- What do I do if it is granite, and what else do I know, including the extent to which the condition may be present. Granite all over the repository, is it still undetected? No, it is detected.

I am now at the mechanism for dealing with this difficulty.

MR. MARTIN: We go on to the next page to deal with the mining thing explicitly, and essentially resolve that problem by saying that you should not have resources that are of any greater value than you can find elsewhere.

Maybe what we could do is just scrub mining on page 39, and leave it to be dealt with under the middle of page 40, item (3).

CHAIRMAN HENDRIE: It is a possible out.

MR. MARTIN: What we had over here, we were not focusing on mining per se, we were talking about mining, and dewatering activities. Often they may dewater several hundred thousand gallons a day, and if this is going to upsets the hydrological basin and cause some screwy hydrological problem, that is what we are getting to there, and not actual penetration into the repository, which is dealt with over here.

MR. WOLF: It is possible to fix it in that (a)(3), you could stick in that it is not limited to reasonable foreseeable events such as, if that is the concern.

CHAIRMAN HENDRIE: I guess the best thing to do is to leave it to think about it.

As I go through and through this thing, it seems to me that I keep running up against places where I am afraid the words construct a barrier that we are not going to get over.

MRS. COMELLA: One of the problems here is that it begins to get at the human intrusion problem, which is a very difficult problem to grapple with because of the question, how do you deal with it? If it is mining, presumably it is deliberate, but is it in the face of knowledge or the absence of knowledge.

We have tried to lay out a policy discussion of the question of human intrusion because I think really one has to come at it from that way, and it begins on page 9 of the supplementary information. Perhaps a way of coming at this would be to focus specifically through asking for comment on how we have come at the resolution of the human intrusion problem.

I think that it is going to be there in any hearing because it could potentially be an Achilles' Heel in how you deal with it. Someone can always raise a "What if," and that is one of the "what if's" that is so hard.

CHAIRMAN HENDRIE: Of course, in a regulatory climate, what I would suggest is that one say, "Wait a minute, the alternative to putting this stuff down in this repository is to have it sitting around in 70 or 100 fuel pools for thousands of years, is that better? No, it is better to put it down in the earth with some care."

Having done that, and having thus made as good a provision for it as we can at the present time, never mind intrusion. They will either intrude or they won't, and they will either intrude substantially, or a delicate probe and then get back out.

All we can say is, we provide as good archiving as is reasonable, and the monument on the property is as reasonable. We will have dealt then for future generations by and large better than they have dealt in the past for us. But you can't do everything, and putting the stuff in the ground is sufficiently better than leaving it laying around on the surface, so that you are just going to have to live with human intrusion possibilities.

I am not sure but what in fact the regulation wouldn't be a good deal healthier if one took that attitude, and to lay it out for comment.

MRS. COMELLA: I think that we have done something along those lines, perhaps you would want to focus comment on that, because that was always there, the probability of human intrusion, one might as well set it at one, and then say, "How do you deal with this in the regulatory perspective?"

I think the arguments that you have laid out are the way to go, and I think that we have done something along those lines in the supplementary information.

COMMISSIONER AHEARNE: Perhaps you could write it more explicitly then, and ask for the comment.

MRS. COMELLA: Would you like that?

CHAIRMAN HENDRIE: I think it would be a help in the document, if it is going to serve.

There are a batch of places here in this proposed rule for comment, where we really need comment. I get the real feeling in talking to people outside the agency that once this thing goes out for comment that there are all kinds of things that are cast in concrete, and that it is a pro forma step. That neither we nor anybody else will be able to retreat from measures proposed in this thing, and that is very difficult.

MR. MARTIN: I think the track record of going out for comments for the agency is that unless there are alternatives, usually what goes out for comment ends up being the final version.

CHAIRMAN HENDRIE: I think that is why in part people feel as they do. Whereas there are a batch of propositions of which this one of human intrusion is but one, where the Commission needs in the worst way a substantially greater interaction than it has had.

I think that it would be helpful to throw a paragraph or two pointing out that while the proposed rule deals with human intrusion by requiring showings about it in all its various forms, and reasonable assurance that will not upset anything, that there is rather another point of view that could be taken.

That is, we just won't argue about it. It is not an arguable point in the licensing of this proposition because of the rather unique characteristic of this licensing action compared, I guess, to most others that I know about, except maybe the TMI II clean up. That, By God, almost anything you do along this line is a whale of a lot better than not doing anything.

COMMISSIONER BRADFORD: Except that if you start approaching the rule that way, none of the other criteria stand up very long either. I don't disagree with the point you make.

CHAIRMAN HENDRIE: That is right, you could drive this far enough and say, Boy, any hole in the ground is better than no hole in the ground, so never mind these criteria. That would run off the table of reason on the far side quite as vigorously as we may be beginning to get on to it on the near side.

COMMISSIONER BRADFORD: One place the point will get picked up again is in the NEPA statement. That is one of the alternatives will not to implace the waste in a long-term repository. Certainly all the points that you are making will get made in that context.

CHAIRMAN HENDRIE: Yes.

COMMISSIONER AHEARNE: I think it would be useful to make it a little more explicit in raising that as a potential.

Certainly one of the most unique features of this is, we are sitting in a very tiny slice of time, and we are trying to describe sites by what has happened over previous millions of years, and we are trying to predict what will happen to sites over tens of thousands of years, and we are sitting in this very minuscule portion of that.

CHAIRMAN HENDRIE: It is even true with regard to the engineered system where we want to talk about a thousand-year container, and what will be presented by way of the available evidence is corrosion data in elevated temperature conditions, which presumably give some elevated rate of the corrosion data, and people are going to have to wave hands over a thousand years on this one.

If you were deciding whether there ought to be waste, you might say, well, the higher standard prevails, otherwise we will not have waste. I am sorry, that is not the situation, we have got waste, and a lot of it. So doing reasonable things with it is much better than not doing anything.

I think that in the supplementary information it would be very helpful to call out that kind of an alternative approach to human intrusion, and the approach that would be reasonable to take would be, of course, to require good, vigorous archiving, monumenting, and marking of the site, and so on.

Common sense would suggest you ought to do everything that you can to encourage people not to dig into it, but having done so, then I am not sure how much good it does to argue at the hearing about people's speculations, on the one hand, that those measures will be inadequate in the future, and other people's speculations that they will be adequate. I just don't know that it gets you anyplace, and you might be better off to do without it.

John, you had a stab. I had a stab. Peter, do you have something?

COMMISSIONER BRADFORD: I do. Aside from the various memos that I have been raining down on you in the last couple of weeks, there are couple of things that are in the paper that came in last night, one of which is on page 28 of the draft, and page 29 of the paper that came in last night.

I have no problem with the proposition that what is required in all cases is reasonable assurance, and that reasonable assurance as you get out into the ten thousandth year will be something very different than it means when you are in the repository loading period.

I don't think I would include the specific phrase, "rigorous proof of their satisfaction may not always be achievable." I don't think you lose anything if you take that out, and just leave the sentence as it is. I have a similar problem in the next paragraph, but let me stop with that one.

COMMISSIONER AHEARNE: I guess I would have said, "rigorous proof of their satisfaction will not be achievable."

CHAIRMAN HENDRIE: I think that it is guaranteed.

COMMISSIONER BRADFORD: The point is, as to some of the propositions, I take it that you would demand a fairly high degree of proof.

COMMISSIONER AHEARNE: But rigorous proof will never be achievable in the technical sense of proof. You will not get that.

CHAIRMAN HENDRIE: I think where you are going to have rigorous proof will be in things like, does the Federal government own the site, or doesn't the Federal government own the site.

COMMISSIONER BRADFORD: There is something about saying that he won't be able to achieve rigorous proof, it seems to me almost to be an invitation, I don't know, to sloppiness, or slipshodness in the proofs offered.

I don't disagree with the proposition, but I just don't feel right about putting out a rule that says that we understand that --

COMMISSIONER AHEARNE: I would have no problem with deleting from "while" up to "achievable," but for the opposite reason. To me the statement implies that there are some of them that the goal is to get rigorous proof, and although in some cases you can't, in general you want to, and I don't think you can get it.

I would have no problem with saying that for the Commission to find that there is no unreasonable risk, you must have reasonable assurance.

CHAIRMAN HENDRIE: I would like to supply you some expanded words for argument.

COMMISSIONER AHEARNE: Okay.

CHAIRMAN HENDRIE: I have been trying to rewrite that section to carry two thoughts. First, instead of going through and putting reasonable assurance in subsections of the proposition, why the choice was to have sort of an inclusive statement here as to what we can conclude is assurance criteria, and we would all understand that.

Then secondly, the more I contemplate the hearing circumstances, and so on, and try to think about what I need for reasonable assurance on the proposition that a given isotope won't leak at a rate greater than a hundred thousand per year at year ten thousand, etc.

COMMISSIONER BRADFORD: That is the point I was trying to make earlier. My understanding of this is, and stop me if I am wrong, that the staff in setting these criteria have kept provability very much in mind, that is, a thousand year travel time is apparently a relatively provable travel time, even though one might like ten thousand or a hundred thousand.

CHAIRMAN HENDRIE: I think that the thousand year travel time is probably, of the subpart performance requirements, the most clearly demonstrable.

COMMISSIONER BRADFORD: Isn't it true in the other cases as well, you don't have criteria in here that you expect would be unprovable, at least among the major criteria for the package, the engineered system?

MR. MARTIN: I think that is correct. We have been very much motivated by picking those things that would lend themselves to some sort of basis where we could arrive at a consensus. Is it rigorous in the sense that one would prove an electrical circuit is going to work; no. Rigorous, I use that word quite often, it is the kind of word we would want to use on proving the overall -- It will not be the type of rigorous work that most engineers are used to doing.

MRS. COMELLA: I think proof frequently implies something that is incontrovertable in the sense of certitude when you finish you finish your derivation, and that is simply not what we are talking about here.

COMMISSIONER BRADFORD: What you are really saying is some phrase like, reasonable assurance in light of the nature of the evidence and time periods involved is what the Commission must have.

MR. MARTIN: Yes.

COMMISSIONER BRADFORD: I would prefer a phrase such as that. I guess I could swallow the rigorous proof phrase if it were followed by some other phrase, and maybe this is what your proposal does, which says, "However, the applicant is expected to do the best he can."

CHAIRMAN HENDRIE: I will tell you what, I have some draft words, but I prefer to scratch a little bit more and get them out to you rather than read them off the back of the sheet for consideration.

What I was aiming for was trying to construct a standard of proof, or a standard for findings for these long-term things. It just seems to me that the level of assurance that you are going to have for a thousand year and many thousand year propositions is just inevitably going to be less than, for instance, will a pressure vessel stand a number of stress cycles from a fatigue standpoint expected in a 40-year life time.

The problem of the thousand and many thousand year events and performance, and so on, just seems to me to have intrinsically a lower level of certainty about it. I am afraid that unless we anticipate that in the rule, recognize it and try to provide for it, that we end up formulating a rule, with the best possible intention in the world, which then becomes an impossible barrier.

As I say, this is a licensing situation in which the public safety is best served by licensing on the best effort basis that we can make to be sure. But it is not like other things where not licensing represents a safety base with regard to a given project -- it is safe from thereon, while it is getting less safe, the question is, how much can you stand.

It seems to me that if we don't build in the awareness of that circumstance in the rule, we may be constructing a maze from which there is no escape.

COMMISSIONER BRADFORD: There is nothing in the procedural rule on the standard of proof.

COMMISSIONER GILINSKY: I don't think so.

MR. MARTIN: We have some reasonable assurance, it is reasonable risk.

CHAIRMAN HENDRIE: For the construction authorization, don't you?

MRS. COMELLA: Yes.

CHAIRMAN HENDRIE: When you refer to subpart B.

MRS. COMELLA: That is correct.

CHAIRMAN HENDRIE: Where it says that there must be reasonable assurance that you can handle the stuff and tuck it away, and that everything will come out all right.

MRS. COMELLA: Then at waste implacement, it is affirmed, but in a different manner. It is after looking at what has gone on during the construction period, and comparing it against what was intended, then that is what the basis for that decision is, if I recollect correctly.

COMMISSIONER BRADFORD: I think that it is important to keep that in mind because we don't want the two rules to get cross-ways with each other as to what the standards would be.

MRS. COMELLA: It is a very succinct expression, if I remember. I don't think that there was a great deal of elaboration of it, if any, in the supplementary information either.

MR. WOLF: As I understand any adjudication under the APAA in accordance with both Commission decisions and court decisions, the ultimate standard of satisfying the criteria is a showing by the proponant of the order by a preponderance of the evidence that whatever standards you have specified have been met. I think that that preponderance of the evidence underlying the basic principle does apply in this adjudication as well as in others.

CHAIRMAN HENDRIE: How would you judge the preponderance of the evidence if for each geologist who thinks the release rate will be at or less than a part at a hundred thousand per year, there is an equal and opposite geologist who thinks it is not. The credentials for these people, you know, they went to appropriate universities, and worked in appropriate fields.

What are you going to do with a container where for each metallurgist is prepared to say that the corrosion data accumulated over these accelerated tests lead him, in his best professional judgment, to think the container will last for a thousand year. For each metallurgist of that kind there is an equal and opposite one who says that his professional judgment is that it will not last for a thousand years. Now, where is the preponderance of the evidence?

COMMISSIONER BRADFORD: But if it really were true that the scientific community were split right down the middle as to whether the repository was going to work as we thought it should, then I think it would be pretty hard to go forward with licensing at that point in time, one might want more work to be done. But I don't think that that is what you are likely to see.

I think you may find, within the context of a case, that one side has a geologist or metallurgist or two who take issue with the applicant's finding. I would be surprised if we would have an application that got all the way into the licensing process with 50 percent of the scientific community thinking that it would not work.

CHAIRMAN HENDRIE: But you don't quite get a chance to get the whole scientific community duly educated, and then make everybody vote yae or nay. You get, on the one hand, the contractor's and consultants' people of the Department that will find in favor, and, on the other hand, you get people who want to go the other way, and are willing to come and take the time to bring papers and testify.

The ability of the board to hear from experts after the first ten or twenty on each side must run down, I would think, and I would expect that it would be no great shakes to produce twenty each way.

MR. MARTIN: I think that is exactly the kind of --

CHAIRMAN HENDRIE: It is hardly 50 percent of the scientific community, but a relatively small number, like a few tens of expert geologists, metallurgists, or what-have-you. I would expect that without a great deal of trouble you could produce those kinds of numbers each way.

COMMISSIONER BRADFORD: But don't you assume, for these purposes, that there will have been staff review, and ACRS review. I can't imagine that this particular board won't have a geologist among its three member. In essence, the Commission will have to go at, chew up, digest, and bring to form of that evidence much as it does other disputed evidence in its proceedings now.

COMMISSIONER AHEARNE: I would also guess that the Energy Department, if they are smart about their approach, will do a peer review process of whatever basic submission they are making, and will have collected a reasonable amount of support from the general scientific community for the packaging and the engineered barriers that they are proposing.

MR. MARTIN: I think that the problem that the Chairman is worried about is just exactly what we have oriented this rule to avoid. It is to keep away from those areas that lend themselves to that sort of 50 percent agreeing and 50 don't, and there is no in world we know to resolve it. But instead, direct attention toward those areas that are relatively more provable.

I think that it is a very good observation, and it really gets to the heart of what we have been trying to avoid.

COMMISSIONER BRADFORD: I guess you have just said better the point I was trying to make earlier. It is not that all the criteria that you have chosen are necessarily susceptible to proof, so much as you have based the specific criteria in the areas that are, and stayed away from the ones that seemed to be quagmires.

MR. MARTIN: That is right, and it is best to recognize the quagmires in the beginning, rather than wait for years and get the whole proposal based on something that is inherently not provable.

CHAIRMAN HENDRIE: I must say that I wish there was more agreement out there in the field as to which the licensability of the proposition improves, because there is a constituency out there that feel that the staff approach makes it intrinsically less licensable by a substantial margin. I will be drat if I can figure out which side is right.

What I would like to see is a rule that improves the changes that you can license a repository, because I am absolutely convinced that the desirable course for mankind is to start tucking this stuff away, rather than leaving it laying around.

COMMISSIONER BRADFORD: But there is a point where you carry that proposition too far. You wind up with a rule that is so bland, and so clearly just a four-lane highway to a license, that both the potential host state and the general public between now and then is certain that the process is without credibility, and does not protect them very much. Then, you actually have a harder time getting a facility licensed in a useful way, than you would with a rule that people can have more faith from the outset.

CHAIRMAN HENDRIE: True. In fact, if there were no licensing process, and one was simply the head of a project to do a good workman-like job of putting it away, you would take very extensive precautions. What we would like to do is to see those things imbedded in an appropriate rule here.

But the intrinsically different nature of the licensing action here, from a public policy standpoint, is something that I think we need to have in mind as we look at these provisions.

I keep hearing from folk outside the agency who seem to feel that, as Shelly suggests in his letter, that we ought to stick with the overall performance requirement, meet the EPA standard, and not be so definite about the subsections, about the thousand-year container, and the hundred part, and the hundred thousand per year leak rate.

In principle, I suppose, they would also object to the thousand year travel time, but people don't seem bothered by that, because I think most people think that any reasonable set of geology will have a thousand year travel time. So, it is sort of a freebe, and I guess people don't complain about that.

The other two there is great groaning about, and I have a lot of trouble sorting out whether the staff has read the situation correctly, and that the licensibility of a reasonable repository proposition is, in fact, enhanced by taking these sub-requirements that say, to have a good container, the design objective is a thousand years, and then the other subsections.

Or, whether, as the other side argues, that that is an unnecessary and burdensome over-constraint, and that while it would be fair enough to say, "Look, we want the repository to have some subsections to it, the container, the overpack, the engineered system, the geologic setting, and so on, and the contribution of each of those to isolation of the waste should be considered," and so on. What you ought to do then is simply have the overall EPA requirement as the licensing requirement.

I must say, I have a lot of trouble telling which gets us there in the best shape.

COMMISSIONER GILINSKY: We talked about this several times. It seems to me that since the requirements still don't get you all the way, you still have several orders of magnitude to account for.

COMMISSIONER AHEARNE: Not for all the isotopes. Some of them easily get you there. Some isotopes it will, and some it won't.

CHAIRMAN HENDRIE: The shorter-lived stuff, I think if you meet -- For some of the isotopes, the thousand-year container meets the EPA standards. For other isotopes, you need that plus the low leakage, I guess.

COMMISSIONER AHEARNE: It is a mixed bag.

CHAIRMAN HENDRIE: For others I guess, in addition to the water travel time, one or two orders of magnitude hold up in the rate of some isotopes getting out.

MR. MARTIN: I think the whole thing comes down to a question of the single merit of a figure, and that, of course, is the way to go. On the other hand, that leaves completely open the question of multiple barriers, defense in-depth, and then one is in the position of waiting a few years until we get an application to find out whether the right barriers have been picked, whether the repository that we all want to license is, in fact, based upon technical work that is defensible and you can reach a consensus on.

We have elected to try to use a reasonable approach, identify what those multiple barriers should be as at least a minimum, to ensure some diversity to the system, and try to steer the department towards those things which are more inherently provable, and away from quagmires.

I guess, from my standpoint, to wait for a few years to see if they move in the right direction is, at least in my mind, relying on hope, primarily.

COMMISSIONER AHEARNE: You also may have to wait a couple of years for the EPA standards to come.

MR. MARTIN: That is right.

MRS. COMELLA: For instance, on the question of the barriers that we have identified, when you look at a repository system, any repository system is going to have those particular features.

The waste is going to be put in a hole in the ground, and now do you do with that? You can engineer it in such a way to take advantage of the fact that you can buy something by thinking about how you construct that hole in the ground. You have to get the waste down there, so the implication is that you are going to have some forms and packaging if only to get the waste down there implaced. So it is a very natural component of any repository system. We thought about what do you buy from enhancing that in some way, so that it makes the problem of regulation more practical.

Again, the site, you have to choose the site, so think carefully about what the site is, and what sort of properties the site might have, so that not only do you have a good site that will contribute to isolation, that is a technical aspect of it, but a site that will let the regulatory agency understand what it is contributing.

That is sort of the way we have come at the problem. How can, given the fact that these barriers are going to be there, how can we use that in arriving at an understanding of how the repository is going to function, so that in fact we can arrive at a licensing decision.

COMMISSIONER GILINSKY: I was going to say, since there are still some orders of magnitude that you have not defined, some geochemistry, or whatever, it doesn't seem likely to me that one is going to be backing away from these standards, particularly when you have to demonstrate the final results with some confidence.

So I think that you will be driven to relying on the kinds of things that are more definable and more analyzable, such as the container, and the repository characteristics. ,

We talk about whether this is an over-constrained system or not, and it doesn't seem to me that it is an over-constrained system. In setting the minimum requirements, it doesn't seem to me that they have been set unreasonably high.

I can't imagine, when you are talking about a thousand-year package, that one is going to want to go to a ten-year package. There may be some adjustments you may want to make conceivably if you were not constrainted in this way, but is there a lot of difference between a five hundred-year package and a thousand year package.

CHAIRMAN HENDRIE: I would not think so, frankly, between a five hundred year and a thousand hundred year package.

The kind of agonized complaint that I hear is that some of the package people think they are not going to be able to prove that their container will container all the radionuclides through the first thousand year. What they say is, "Look, we are going to be able to come in with sort of the generalized experience of materials engineering over the past 40 years," and say, "we know some things about ours." And then we will have some specific corrosion tests in characteristic repository, like saturated media, and these will have the characteristic of so many mils for the first year, and then the rate drops to some equilibrium. The will have done them at various temperatures. And they will wave hands over what the acceleration rate of the temperature means, and give you a lot of explanations about the thermodynamics constants that neither you nor I will understand.

When you get all through, there are very concerned about their ability to make an adjudicatory environment proof that they have got everything tied up, all radionuclides for a thousand years.

There are all kinds of variabilities that are there that they are worried about, the range of the corrosion data, a thousand years is a long time. The fact that when one says, all radionuclides, one envisions a manufacturing and emplacement process which is 100 percent effective with regard to producing in each canister the quality that was intended to be there in the prototype design.

So they worry that just on the basis of normal manufacturing quality, distribution, and so on, they will not be able to show that there cannot be a canister that gets through, and it is out here on the wing, and it is not nearly as good as the others, and so on.

I think that it is mainly the long time. That you might get over by the way in which you did the manufacturing and inspection. But the long time over which this assurance has to be offered really bothers those people.

COMMISSIONER AHEARNE: How do they, then, expect to be able to meet the EPA criteria, or do they expect EPA criteria to be softened. Because if they can't meet some of those subsidiary pieces, I am not sure --

COMMISSIONER GILINSKY: Each one is counting on the others.

MRS. COMELLA: The proof problem just won't go away.

COMMISSIONER AHEARNE: The Chairman was saying that he has been hearing from the people who have been concerned about meeting the pieces.

CHAIRMAN HENDRIE: Reasonable assurance, that is why I have been muttering darkly about reasonable assurance for some time, and why I want some language which says what we mean by reasonable assurance for these long time in the future propositions.

John, the answer to your proposition is that I think the container people, at least the ones that I talked to, have confidence that they can produce a waste package which will last a long time, with really very minimal leakage for some thousand years. But when the contemplate proving that in the adjudicatory format, I guess they foresee difficulties.

COMMISSIONER AHEARNE: Won't the same difficulty arise, independent of whether there are any of these separate thousand year, ten to the minus five pieces, at the end in their vision?

Would they also propose the EPA not be met in the adjudicatory format?

CHAIRMAN HENDRIE: I think, to the extent that I can interpret what I hear, I think what they would like to do is to meet the EPA standard with an engineering design in which a reasonable professional judgment is that you have met it.

Is that the same as the preponderance of the evidence in an adjudicatory hearing, which you can reasonably anticipate is going to be long and loud and pretty contentious. I detect that their concern is that it is not, and that the latter is a much more awkward burden.

COMMISSIONER AHEARNE: I guess perhaps what you are saying is that they would prefer not to have to fight that battle on one set of numbers, which is the total performance, as opposed to the container, the engineering barrier, --

CHAIRMAN HENDRIE: Yes.

MRS. COMELLA: But when they came in with their total system, if it were not constrained by the regulation, and they got into the adjudicatory hearing, let us say they wished to take credit for very long periods of time on one particular engineered system, it would seem to me that they would still have the "proof" problem left with them.

If they wanted to take credit for that long period of time in their calculation, they would have to be able to make a showing that indeed it was reasonable to accept their contention that they could take credit for it. I am not sure what it buys in the long run, because I don't think the proof problem goes away.

CHAIRMAN HENDRIE: As long as we impose the proof problem, in fact, it does not really go away because somewhere among the sub-barriers you have to accumulate the degree of isolation that the EPA standard mandates, that is certainly true.

What it does do is to give them some flexibility as to how they apportion between the sub-barriers and, I must say for reasons that I am not prepared to lay out with any eloquence because it appears to me, too, that the problem remains there, but they seem to be very concerned about the container.

I don't know whether that suggests that the people

I have talked to know something about container metallurgical test that I don't know, or whether it is just that they are all metallurgists and they don't want to come to hearings, or what it is.

I have not talked to the DOE people. I hear from folks out in the industry.

COMMISSIONER GILINSKY: These are the people who will actually build the containers.

CHAIRMAN HENDRIE: I don't whether they would actually build them, but they are involved. People in labs who are working on the program, and have some chunk of it or another. I am not proposing that what I am hearing is a carefully balanced and inclusive view across all of the elements out there. I hear from folks who call in with a word.

MRS. COMELLA: But the heart of the problem seems to be their not being able to realize in a practical way what reasonable assurance is going to mean. Is that sort of the problem?

COMMISSIONER AHEARNE: To put it in a different way, from what I hear, it is a lack of confidence that what is described perhaps today as what reasonable assurance means, will also carry through five, seven or ten years from now.

CHAIRMAN HENDRIE: One of the things that has occurred to me because I do have some problems sorting out whether you folks have read the situation just right, you know, and tuned it just right. Or, whether there is some merits to the complaints from the other side that what you ought to do is to stick with the one overall objective, and that indeed you can require these subsections, but don't tie them down to specific requirements. I don't know.

One proposition might be to note specifically in the discussion of the rule that goes out that difference in point of view as we perceive it. I think Shelly's letter gives you a nice vehicle, at first glance at any rate, to have that view consolidated in a single document, to note the difference in view, to note that the staff has come down feeling that it is best, on balance, to specify the objectives, to note that we have tried, as I presume we will, to make clear that rigorous proof is not to be had here, and reasonable assurance sorts of things. I hope to get some language in there.

Then to ask for public comment on this particular point, are we in fact better off framing the requirements as the staff drafted those, or would we be better off the other way.

COMMISSIONER AHEARNE: The other way being?

CHAIRMAN HENDRIE: The other way, to have the basic regulatory finding that must be made be the meeting of the EPA general environmental standards for repository. That the way that the NRC would deal with the subsections would be not to have particular performance criteria for the subsections, but rather to note that we expect the repository to have these subsections, and each of them will have to be discussed, and together they will have to meet the overall standards.

COMMISSIONER AHEARNE: Would you have the staff put out some kind of a technical guide which would incorporate those other requirements?

CHAIRMAN HENDRIE: If we went that way, you mean?

COMMISSIONER AHEARNE: Yes.

CHAIRMAN HENDRIE: You mean a Reg Guide with the staff saying, we think it ought to be a thousand years here, and ten to the fifth there?

COMMISSIONER AHEARNE: Yes.

CHAIRMAN HENDRIE: I am not sure. If you are going to go that way, I am not sure that you would want to embed as firmly as a Reg Guide imbeds a regulatory position to go a thousand years.

COMMISSIONER GILINSKY: Would the technical rule then just become the one sentence requirement that they would have to meet the EPA overall standard?

CHAIRMAN HENDRIE: I guess it wouldn't, Vic, any more than it would if the subsection performance requirements were not in the document that is before me. It would not collapse to sort of a one-sentence document in that case. It runs 60-odd pages at present, and if we took out the performance requirements on the subsections, it would run 59.

COMMISSIONER GILINSKY: I guess I don't understand. Wouldn't you be dropping all of that favorable factors, and the unfavorable factors, and all that?

CHAIRMAN HENDRIE: No, I don't think so, because if one decided not to require a thousand year container, for instance, I don't think one would back away necessarily from what I regard as an appropriate version, if not the present version, of the favorable conditions on the geologic setting, the adverse conditions as appropriate, and so on, and all the rest of this stuff.

COMMISSIONER GILINSKY: I am just opening a page at random, and it says here, "Instrumentation and control systems," and there are certain requirements on that. Why would you keep those, or anything else for that matter. Why would you have specific inspection, testing and maintenance requirements?

CHAIRMAN HENDRIE: In either version of the rule, I think, for some of those things from somewhere between 60.122 and 60.130, I think it would go right in the margin Reg Guide question mark. The further back I go through 130 to 134, the heavier I print that. Some of those things, I think, in either version of the rule may be intrinsically Reg Guide.

You said that there is some commentary, and at the moment I don't remember the statement, consideration that discusses the point and asks for comment on whether these things should be in the rule or Reg. Guide.

MR. MARTIN: On the construction, and those detailed requirements.

CHAIRMAN HENDRIE: In particular on that 130 to 134 stuff; right? So you already have it in the rule, but you are saying, we recognize that some of this stuff might indeed to Reg Guide if the people think so.

But where something was judged to be appropriate for the rule itself of this kind, then I would not think that because one had perhaps decided ultimately to go a system requirement, and not include the specific subsection requirements. I don't think that things like that necessarily either go in or come out.

COMMISSIONER BRADFORD: How does what you are suggesting, Joe, go beyond publishing a short paragraph to the effect that, of course, there is an alternative approach which would be keyed solely to a specific performance standard. That is not the Commission's preferred approach as discussed in a separately published justification, however, the Commission does solicit comments on it?

CHAIRMAN HENDRIE: I am not sure that it goes much beyond that. I don't know whether one might want to try a stab at, for instance, an alternative formulation of 60.111, which remember is about three pages of the performance objectives and sort of is the place where you really get to the heart of the matter with regard to this point. It might be useful to take a cut at that, which might serve as an alternative to get people thinking about it.

MR. MARTIN: I think that one of the problems with that, with trying to now redraft the regulation to be an alternative is that most of the siting and many of the design requirements flow from the presumption that you do have high integrity containers, and you do have low leach rate. So you don't have to be so stringent on some of the siting and other requirements.

If we take that out, I would not be satisfied with the siting approach that we have. I think it would have to be reexamined very closely. I am not sure that it is so simple as just rewriting the performance objectives, and say that everything all stays the same.

COMMISSIONER AHEARNE: Could you expand on that a minute, Jack? Are you saying that if you did not have the thousand year container, ten to the minus five, engineered barrier, ten thousand year water travel time, that the sole criteria being the EPA, you would not be comfortable with the description you have in here for the pros and cons as far as advantageous site criteria and disadvantageous?

MR. MARTIN: That is right. For example, I think the human intrusion problem then gets to be much more of an issue, with the potential disruption of the repository. I don't really know, I have not thought it out completely, but a few things come to mind that get to be a bit of a problem.

I think questions of, is there a fault nearby, the site gets to be a lot more -- Take the Nevada Test Site, for example, that gets to be more problematical in my mind, where the proposed site of interest has several faults running through it. How much of a problem is that now if you can't rely on having the waste bottled up during high danger and uncertainty. I am just not sure where we start pulling on the string.

COMMISSIONER GILINSKY: You have a carefully crafted document here, and it seems unlikely that you are going to come up with an alternative in days or weeks that has met the test that this has in terms of internal consistency.

It is one thing to ask people whether the whole approach makes sense, and that is what we are doing in putting the thing out for comment, and we explicitly do that, we explicitly point to an alternative approach. But I think to come up with another version is something that is going to take many months.

CHAIRMAN HENDRIE: I talk about possibly trying to frame the guts of how the alternative might look, I would not contemplate rewriting the whole rule and doing whatever rebalancing Jack feels is necessary, but would simply reframe 60.111 as a basis for getting people thinking along the lines of the alternative, to encourage their comments, and then just note that whatever other adjustments, if one went in that way, in other sections of the rule were necessary to make it compatible would be made.

COMMISSIONER BRADFORD: But Joe, it would have to get have to get reframed at some point, because I think, then, if the Commission were to go the way that is outlined, then you would have to go for another round of comment at the end.

CHAIRMAN HENDRIE: Then you would with another comment round, wouldn't you?

COMMISSIONER BRADFORD: I think that that is right.

CHAIRMAN HENDRIE: Wouldn't you want to do that in any case?

COMMISSIONER BRADFORD: Yes. I guess that is right, if you change the form of the rule, you do become committed to another comment round.

CHAIRMAN HENDRIE: Just from the standpoint of trying to give people a pretty shot at this one.

COMMISSIONER BRADFORD: I guess that is why I would favor just inviting comment on the question of the approach to the rule itself, without going to any very extensive redrafting at this point, since if the comments persuaded the Commission in fact to take the alternative route, whatever it is, eight or nine months, the whole rule will be out for comment again anyway. It does not seem to make much point in having the staff spend much time reformulating a few of the criteria at this stage.

COMMISSIONER GILINSKY: If there are a lot of people out there who are upset with what we are doing, they are alert to it. It is not as if we have to point out to them the alternatives. They can always say that they have alternatives in mind, and it does not sound as if they are going to fail to comment.

Certainly if we open up some other possibilities, it sounds to me that we would receive a great deal of comment on the point.

MR. MARTIN: I would not mind seeing some alternatives proposed by those that don't like it, together with some discussion of how they think it deals with these problems.

COMMISSIONER GILINSKY: Which is the point of putting out the thing for comment.

MR. MARTIN: We have really heard very little on this, other than we would really rather not do it. But how you deal with some of the sites being considered now, I am not sure how you deal with them, without what we have got outlined here. Just changing the performance objectives, I don't think really does it. I think then we would really have to give a good hard look at this whole siting question.

CHAIRMAN HENDRIE: Where are the siting requirements?

MR. MARTIN: They are those favorable and adverse conditions. That I think would have to be a much more absolute thing, rather than just sort of a relative balancing. I think we have to think in terms of real sites, how would you apply them? I am not sure how I would apply them to any of the sites being looked at today, if I could not fall back on the canisters and the leach rate. It just has not been thought through.

This whole thing has been the result of a couple of years of discussion, and give and take, public comment. The performance objectives and the siting things are all integrally entwined, and they proceed one from the other, and not independently. I really have not given a lot of thought, I don't think any of us have, as to what if we proceeded from another basis, how would that affect siting. I can think of some specifics that trouble me enough.

COMMISSIONER AHEARNE: Let me make this suggestion, Joe, if I can.

We are not at the beginning of June. I think we have go to face the fact that if we want to get a rule out for comment in the next couple of months, we really ought to get it out in the next couple of weeks, because after that there will be a number of new people coming in the Commission, and I would expect, just practically speaking, they will want to take a lengthy period of time to go through if the rule is still sitting here.

COMMISSIONER GILINSKY: That would be putting them in a difficult situation.

COMMISSIONER AHEARNE: That is right. I think they would, just as any of us coming in would, want to take the lengthy time, or some reasonable time to pull the understanding together. I think we have got a few weeks, really, to get the thing out.

As you have pointed out, obviously there are some people who are very concerned about the approach being taken on the specific details. Perhaps if you could expand a little bit that portion that is now in the statement of considerations to pick up a little bit of the concern that you have that this may be an over-specified, over-constrained approach, and the comments are requested on the alternative approach.

But I think it ought to go on and mention the concern that Jack has, that going the alternative approach kprobably would not merely mean pulling out the ten thousand years and ten to the minus five, it may well mean a substantial change in the structure of the siting approach. But at least it would highlight that we recognize that this is a real issue, and then get out basically what we have, because I am really concerned that we have the potential of coming to a standstill.

CHAIRMAN HENDRIE: Let us work on it. I will get some paper around to you.

COMMISSIONER AHEARNE: If necessary, we can take that one section that you would like to see revised, and revise those couple of pages that is an example of the alternative, but it ought to really carry with it the point that Jack has made.

MRS. COMELLA: Also, I think the practical implication of the alternative formulation, what does it mean? It is one thing to say, go the system approach, but how does one realize that in the licensing setting? I think the feedback from that would be very important.

COMMISSIONER AHEARNE: From the licensing point of view, you would then really focus upon the EPA standard, that would be the sum and substance of the final decision. Do you have reasonable assurance that you can meet the EPA standard.

MR. MARTIN: But that would focus back on the geology.

MRS. COMELLA: That focuses back on the same problem.

COMMISSIONER AHEARNE: It would focus back on the same problem, and you would have to go through an analysis of each of those segments, the package, the barrier, and the geology.

But just in response to your question, as far as the licensing decision, it would then be based upon reasonable assurance that the EPA standard is met, as opposed to currently it is reasonable assurance for separate pieces.

MRS. COMELLA: What I was keying back to you was what Jack had mentioned about coming in, then, with some discussion of what they mean. I get it.

COMMISSIONER AHEARNE: I am just trying to urge everyone to see if we can't get closure in the next week on what is going to go out, because I have a very strong sense that if we don't, it will be the end of the summer before anything goes out.

COMMISSIONER BRADFORD: I agree fully with that. In that spirit, I guess I need to know whether there are any overwhelming problems with the things that I have circulated in the last few days.

COMMISSIONER AHEARNE: Part of the problem, Peter, is that you have circulated some which were overtaken by others that you circulated.

COMMISSIONER BRADFORD: That is right. My point is, if we reach that conclusion within a week --

COMMISSIONER AHEARNE: I think the staff, at least as I skimmed, I believe they have accommodated you in many cases.

COMMISSIONER BRADFORD: That is right.

COMMISSIONER AHEARNE: I would propose we look at staff's latest version as the working document, as opposed to trying to sort out your points.

COMMISSIONER BRADFORD: It works well up to a point. There are a couple of mine that in discussion with the staff --

COMMISSIONER AHEARNE: What I am saying is that if you could take the staff's latest document and see if you have any major problems.

COMMISSIONER BRADFORD: You want another memo?

COMMISSIONER AHEARNE: Yes, I think that would probably be the most effective way for all of us to address it, if you have any real sticking points on this document.

COMMISSIONER BRADFORD: That is fair enough. It won't be a matter of sticking points. There will be one or two areas where the staff and I just left it that I would draft, and they would nod. It is not that there is a disagreement, it is just that the change has not been made.

What does that leave us by way of schedule? I can get that memo around today, I think.

COMMISSIONER AHEARNE: Let's leave it the way it is.

CHAIRMAN HENDRIE: Pre or post last night?

There was a memo from Howard having to do with the relation of this rule to other CFR rules, etc. There was a recommended clarifying statement to go in on page 11, immediately before the section on major features of the proposed rules in relation to other parts of NRC regulations. I suggest that we just include that in.

COMMISSIONER BRADFORD: This is Howard's June 1?

CHAIRMAN HENDRIE: Yes. It was that question, what do you do if you have got AFR on the site, and you license under this, because this rule talks about --

COMMISSIONER GILINSKY: He wants it circulated?

CHAIRMAN HENDRIE: I think intrinsically it says that we will do reasonable things if the matter comes up.

COMMISSIONER AHEARNE: If we find a connection.

CHAIRMAN HENDRIE: Yes. It says that we would license under 72, even if located at a repository area, provided that it is sufficiently separated to be classed as an independent --

COMMISSIONER BRADFORD: Did this one go through the full staff, and did it cause any problems?

CHAIRMAN HENDRIE: I don't know.

COMMISSIONER BRADFORD: Did this one cause any problem as far as you are concerned?

CHAIRMAN HENDRIE: Dircks' memo just said that the ELD has prepared a recommendation which is forwarded separately, but you did not say whether you liked it or not.

MR. DIRCKS: Howard and I have an understanding. When he wants to speak completely out on legal issues, he just sends it on down, but it does not conflict.

CHAIRMAN HENDRIE: You don't see any problems with it?

One last thing, "With regard to the respective authorities of the NRC and the EPA," says Mr. Dircks, "we understand that the Office of the General Counsel will be prepared to speak to that issue at the June 2nd Commission meeting.

Can you do it in two minutes or three?

MR. MALSCH: I can, except I am not completely sure what the question is.

COMMISSIONER GILINSKY: It reminds me of a guy who told me he could deliver a lecture on any subject as long as he had two slides which he put in upside down, and by the time they had sorted it out, the lecture was over.

(Laughter.)

COMMISSIONER BRADFORD: I should note, Joe, that I still have a question on (7) as well.

CHAIRMAN HENDRIE: I am not sure what the question was.

MR. BELL: This is the follow on sentence where we said something about following the EPA and thereby making sure that no individual gets --

MR. MARTIN: We have deleted all of that.

MRS. COMELLA: It is the period beyond ten thousand years, the EPA was silent on what our authority was.

CHAIRMAN HENDRIE: At the moment it is not clear whether we carry beyond ten thousand years or not.

MRS. COMELLA: That is correct.

COMMISSIONER GILINSKY: It makes for rather long Commissioner terms.

CHAIRMAN HENDRIE: We ought to say, shall serve five years or such time as may be required --

COMMISSIONER AHEARNE: -- to complete deliberation on the rule.

CHAIRMAN HENDRIE: So we don't have a problem about the EPA thing. The business about whether or not our rule runs beyond the EPA thing is something we ought to hack a little bit at.

There is still some language in the supplementary information, I think, that runs that way, isn't there? It is just sort of ambiguous in a couple of places.

MR. MARTIN: I thought we had made conforming amendments to take all of that out. The idea was, if we have a problem with that, we will comment on the EPA rule.

MRS. COMELLA: Yes.

MR. MARTIN: That was the idea.

MRS. COMELLA: There is nothing that is in conflict with any draft of the EPA standards that we have seen there.

CHAIRMAN HENDRIE: Not conflict, but that there seems to be still in various places a look required, things required out after the EPA time. For instance, let's scratch heads and talk about it next time, because I am running late now, page 12, down at the bottom, it says, "The analyses," or "the analysis," depending on which version you like, "performed, can and will be largely quantitative during the period that greatest reliance can be placed upon the engineered system up to about ten thousand years after closure. Thereafter, although the issues of concern, and certainly the physics of the repository itself do not change, the numerical uncertainties begin to become so large that the calculations become more indicative of expected repository behavior rather than definitive and actual performance. Hence, such calculations," which I take it to mean post ten thousand year calculations, "will be supplemented more heavily by qualitative, etc."

I am not sure -- I have not attempted to pick out all the places, but I noted --

MRS. COMELLA: We will make sure that we have gone through and identified certainly all those places where there is ambiguity.

COMMISSIONER AHEARNE: Where is the resolution going to come out? EPA ends at ten thousand years.

MRS. COMELLA: It is not clear from the draft of the EPA standard.

MR. BELL: Their draft in the Federal Register notice indicates that they think the repository after ten thousand years should continue to perform at about the same level of performance that it was performing for the first ten thousand years.

COMMISSIONER GILINSKY: They seem to be saying that if it meets the ten thousand year standard, it ought to function reasonably well after that for some undefined period of time. The standard cut off at ten thousand years, but there is the implication that they don't think it will continue to work. We want to get that clarified in the review of the EPA standard.

MRS. COMELLA: If I am not mistaken, I thought that at one time, for instance, ELD had mentioned in some internal staff discussions that if that is not clarified, that point could be raised in one of our licensing hearings as to the period of hazard, and how long we had to deal with it. I could be mistaken, but that was certainly one of the impression that I gathered. If that is correct, it poses litigative risk when we get into licensing.

COMMISSIONER AHEARNE: It poses calculational risk if you are going to require an uncertainty into future calcultions.

MRS. COMELLA: That is true, too.

COMMISSIONER BRADFORD: Is the EPA in curies or rems?

MR. MARTIN: Curies.

CHAIRMAN HENDRIE: I think that it is a point that we ought to straighten out. It will be helpful to our own boards and adjudicatory process if we could be clear in this rule as to what we intend, so that it is not left as a vague point to be argued about and decided by the adjudicatory process in due time.

I must say to you that I don't know what the Commission's decision on the matter is. I can tell you what I think it ought to be. I think the EPA group was wise in limiting the time, in which showings have to be made, calculations and so on, to ten thousand years. I think we ought to do the same with regard to performance objectives and doses, and all the rest of that.

What I think we would like to see is that at the ten thousand year point, the gradiant is right. That is, calculations about releases, and so on, up to ten thousand years, and you then go ahead and squint into the misty future briefly, and are able to say, and I don't see anything very obvious out there to me that suggests that things are going to change radically soon after the ten thousand year period, that is, stuff leaking slowly, if at all, and that the gradiant is unchanged as you go across that boundary.

It just seems to me that you are going to have to find a way to frame that proposition without requiring people to come in and present you very much in the way of sets of calculations that go on out to hundreds of thousands of years, or whatever the heck.

I guess one could make that kind of calculation on a very simplified basis, on the proposition that there are not any unanticipated changes in the geology on the ground, or it continues to move the way it has always moved, the geochemistry is the same, and there aren't earthquakes, and so on.

Then, I guess, you could do a calculation, how much good it would do you, I don't know, because your ability to say indeed that nothing will change out there in the indefinite future gets less and less distinct.

All you can say is, it stayed about stable for a good long period up to the present, and we don't see any obvious reasons for it to change, and that is about as good as we are going to be able to do. I think that is the kind of conclusion you would like to make as you look into the future.

MRS. COMELLA: Yes.

CHAIRMAN HENDRIE: If you can find some way to scratch the rule out on that basis, I would be happy, and what my colleagues would feel, I can't tell.

COMMISSIONER GILINSKY: What is in the rule that points to that point of view?

CHAIRMAN HENDRIE: I am not sure that anything does.

MRS. COMELLA: I am not sure anything does either.

CHAIRMAN HENDRIE: Back before the last meeting or two, there was some extension beyond the EPA period, and some suggestion that the DOE would have to make showings that everything was great out there.

MR. MARTIN: I thought that we had gotten those. We will look some more.

CHAIRMAN HENDRIE: We agreed back there, on further consideration the staff did, to pull back before required findings to the EPA period, and you took them out o the rule. I am not sure they are all out of the front end of it, and the thing that I cited was at the front end, and it may just have been an oversight.

MRS. COMELLA: It was an oversight, certainly.

COMMISSIONER BRADFORD: Were these the deletions where you took out the phrase "and will not in result in significant doses to any individual members of the public?

MRS. COMELLA: Yes.

COMMISSIONER BRADFORD: How does that change the time period, as distinguished from calculating from curies to rems?

MR. MARTIN: I think that discussion was more, these are extra requirements over and above the EPA standard.

COMMISSIONER BRADFORD: Right, but it seems to me now that they were being put in the posture of also having to do with time period.

Incidentally, I am not sure I agree with those changes anyway, but that aside I don't understand them to have had to change the calculational periods.

CHAIRMAN HENDRIE: The proposition was to accept the EPA's authority to establish the generally acceptable environmental standards, and to then say that once those were established, and the EPA for instance had calculated these isotopes over ten thousand years and meet that, not more than so much of each isotope, we were then going beyond that saying, well, we are going to go ahead and calculate doses out into the future sometime which would show they are not large, and so on.

COMMISSIONER BRADFORD: One of the changes had to do with actually using the doses as a regulatory basis. The other two, I thought, just required the calculation.

CHAIRMAN HENDRIE: There was also some dose calculating out there beyond the EPA time. What I suggested is, we ought to (a) respect the EPA's authority and (b) make use of their wisdom.

COMMISSIONER BRADFORD: Accepting that, Joe, what about dose calculations within the EPA time, where does anybody do that at this point, if the EPA standard is not set in doses?

CHAIRMAN HENDRIE: We still ask for a dose calculation?

MRS. COMELLA: That was eliminated.

COMMISSIONER BRADFORD: It is on pages 8 and 25, and that is part of the overall elimination of dose rates from the regulatory portion that you had pointed out before.

MR. MARTIN: We took it all out.

MRS. COMELLA: Page 25 dealt with the calculation as described in the SAR, and that was also deleted.

CHAIRMAN HENDRIE: Good. It came out a lot better than I thought.

COMMISSIONER BRADFORD: The proposal is better than you needed. As I understand it, it does mean that at this point nobody is calculating the dose to be expected from the releases, which seems to me to be something that one would want done.

COMMISSIONER GILINSKY: Which it is.

COMMISSIONER AHEARNE: You can calculate the dose to the hypothetical individual --

COMMISSIONER BRADFORD: Whatever calculation it was that the staff had in mind.

COMMISSIONER AHEARNE: If you recall, at the previous meeting that is what was discussed, and it was that calculation they had in mind.

COMMISSIONER BRADFORD: Yes.

COMMISSIONER AHEARNE: That is really the only dose that you can calculate. You can't really do a --

COMMISSIONER BRADFORD: Yes, you don't know actually who is going to be where in a hundred, never mind ten thousand years.

COMMISSIONER GILINSKY: Or which planet.

COMMISSIONER BRADFORD: But I would like to leave that calculation in as a required calculation to be made, even it is taken out on the page where it seemed to be a regulatory requirement.

COMMISSIONER AHEARNE: Peter, do you see it more than a translation of the curie isotopes, therefore the type of radiation and, therefore, using the biological effect factors, etc.?

COMMISSIONER BRADFORD: No.

COMMISSIONER AHEARNE: In your view, it is strictly a mechanistic calculation?

COMMISSIONER BRADFORD: Yes, as it is now, I guess, with reactor licensing.

COMMISSIONER AHEARNE: The significance then is to insure that rather than our doing the calculation, the DOE does the calculation.

COMMISSIONER BRADFORD: It just seems to me that it ought to be part of the process, yes.

COMMISSIONER AHEARNE: By making it part of the process, the significance of it would be what?

COMMISSIONER BRADFORD: The significance of it would be that we would be stating what the maximum dose was as it could affect the hypothetically person as distinguished to simply stating it in curies. After all, the end result of this process should be one that focuses not just on a number of curies, but links that number of curies to a dose.

COMMISSIONER AHEARNE: But would you embed in the concept that it would then open to question whether the EPA standard was acceptable?

COMMISSIONER GILINSKY: Acceptable?

COMMISSIONER AHEARNE: Yes.

COMMISSIONER GILINSKY: Met or acceptable?

COMMISSIONER AHEARNE: No, acceptable, because meeting the EPA standard has nothing to do with the dose. The EPA standard has to do with the curie release. If we are going to do the calcuation of the dose, I am trying to understand what is the significance of doing the calculation?

COMMISSIONER BRADFORD: If it turned out that it was a terribly high number, then I guess I would want to know that.

COMMISSIONER AHEARNE: But is the purpose of it to then raising to question the acceptability of the EPA standard?

COMMISSIONER BRADFORD: It could be. If it turned out that we could not question the EPA standard in our proceeding, then we ought at least to let our Congressional committees know that we thought there was a problem.

COMMISSIONER AHEARNE: But you can do that immediately.

COMMISSIONER BRADFORD: By calculating the EPA standard.

COMMISSIONER AHEARNE: That is right. If it is strictly a mechanistic calculation, then given the EPA release numbers, you can do that calculation and conclude whether or not they are acceptable. If you conclude they are acceptable, I am not sure how they would fit the process.

COMMISSIONER BRADFORD: I guess that depends on whether the actual license as applied for would contemplate releasing right at the EPA standard, or to have the EPA standard --

COMMISSIONER AHEARNE: Sure, but the acceptability of the EPA numbers could be determined immediately.

COMMISSIONER BRADFORD: Yes.

COMMISSIONER AHEARNE: Because if one of the criteria is that they must be met, they could not exceeded anyway.

COMMISSIONER BRADFORD: Right.

COMMISSIONER AHEARNE: Therefore, you can do the calculation immediately, now.

COMMISSIONER BRADFORD: That is right.

COMMISSIONER AHEARNE: Then, if they are unacceptable, then you point to it to raise it whatever place you feel that ought to be raised.

COMMISSIONER BRADFORD: Within the context of the EPA standard.

COMMISSIONER AHEARNE: But if they are acceptable, I am having difficulty understanding how you would fold into the process the results of that dose calculation.

COMMISSIONER BRADFORD: Well, I had not really thought it through, except that I would like to have it. It seems to me that it always clarifies a little bit to be thinking of it in terms of potential dose.

COMMISSIONER AHEARNE: I agree with you that it is a more readily understandable set of numbers, but what I would expect is relying on the staff to do that calculation as opposed to imbedding it as part of the process.

COMMISSIONER BRADFORD: You may be right.

CHAIRMAN HENDRIE: I just wouldn't do it in the context of review of the specific applications because as formulated you don't see this dose, in fact it probably occurs somewhere out between five and ten thousand years in the future. It just seems to me to be not a very useful proposition to say that we have calculated the dose to an individual.

COMMISSIONER BRADFORD: EPA, however they state their standard, has got to have done it.

CHAIRMAN HENDRIE: Yes, but presumably they have done that calculation or range of calculations as a part of determining the curie release standard, and found that they believe them to be acceptable small, and so on. Having that determination made by EPA, I would not tinker with it.

I believe that is why that Federal Radiation Council authority was passed, so that they would do things like that, decide what release levels ought to be on the basis of appropriate calculations in proceedings and considerations, and that they publish. Then all the rest of us take guidance from them.

As John said, the staff can back calculate, and so on, in the context of commenting on the EPA proposal. That is something that could be done, but I just would not do it for specific applications.

COMMISSIONER BRADFORD: You would not require it of a specific applicant. I can't believe we would actually license a repository without knowing what we thought that number was in the licensing process.

COMMISSIONER AHEARNE: My concern was just trying to fit it into the process. I agree that it would definitely be a number that you would want to know.

CHAIRMAN HENDRIE: I am not sure where that leaves you, John.

COMMISSIONER AHEARNE: I just don't see a need for it to be imbedded in the rule as a requirement. I would want the staff, when they are providing the comments on the EPA numbers to do that calculation for us. I think that that is the place where we ought to join the issue early.

COMMISSIONER BRADFORD: I am prepared to leave it for now. I guess we will all be smarter about what the EPA standard is actually going to be by the time they publish the final rule, and if it is a real source for concern there, we can raise it again.

CHAIRMAN HENDRIE: By the way, any late word on progress?

COMMISSIONER AHEARNE: Whatever it may be, I am confident that Mr. Nicholas will still be here when that rule gets out, but the rest of us, it is much less optimistic.

MR. DIRCKS: I think their rule slipped a bit. It is due to be reviewed in July now for a possible publication.

CHAIRMAN HENDRIE: It is better than I thought it was.

Okay, thank you very much.

(Whereupon, at 12:35 p.m., the Commission adjourned.)

NUCLEAR REGULATORY COMMISSION

This is to certify that the attached proceedings before the

COMMISSION MEETING

in the matter of: Public Meeting - Briefing on SECY-81-167 - 10 CFR 60, Disposal of High-Level Radioactive Wastes in Geologic Repositories: Techni Criteria

Date of Proceeding: June 2, 1981

Docket Number:

Place of Proceeding: Washington, D. C.

were held as herein appears, and that this is the original transcript thereof for the file of the Commission.

Patricia A. Minson

Official Reporter (Typed)

Patricia A. Minson

Official Reporter (Signature)