Natural Resources Defense Council, Inc.

917 15TH STREET, N.W.
WASHINGTON, D.C. 20005
202 737-5000

Western Office
2345 YALE STREET
PALO ALTO, CALIF. 94306
415 327-1080

New York Office
122 EAST 42ND STREET
NEW YORK, N.Y. 10017
212 949-0049

Radioactive Waste Disposal Criteria

by

Thomas B. Cochran

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Introduction

One of the most dangerous aspects of the high level radioactive waste management problems is the impact that current pressures to get on with solving the problem is having on current planning. The prospect of a severe logistics problem ahead is already leading policy makers to conclude that they must solve the radioactive waste problem, and do so soon. This is an invitation to mistakes. Geologic media sites will be chosen hastily. Assumptions concerning long term integrity will be made in the absence of confirmatory data. Corners will be cut to meet unrealistic deadlines. There is a real danger that the Federal Government in the interest or promoting nuclear power will start repeating the same kinds of mistakes that led to the controversies over reactor safety and nuclear weapons proliferation. We are already witnessing this in the approach the Government has taken toward establishing regulatory criteria for waste disposal. One would have presumed that first the problem would be carefully defined, next an adequate set of waste criteria would be established which must be met in order to solve the problem, then a methodology to determine whether the geologic medium and site meet the criteria would be developed, and finally instrumentation would have to be developed to assure that the criteria are in fact being met. Yet the Federal Government's present approach is just backwards in this regard. The geologic media of choice -- salt -- and the site -- yesterday it was Lyons, Kansas, today it is near Carlsbad, New Mexico -- were chosen first, and now the Nuclear Regulatory Commission (NRC) and the Environmental Protection Agency (EPA) are being asked to develop the criteria.

Moreover, as Commissioner Varanini has noted:

> Currently the entire [radioactive waste] program is being driven by the DOE [Department of Energy] target for a licensed repository for initial operations by 1985. This schedule and the DOE program place NRC and EPA in a policy dilemma. Activities of EPA and NRC being done in parallel are better done sequentially. EPA is developing waste repository environmental standards which in turn are to form a basis for NRC site selection and suitability criteria. In fact, though, NRC may issue its criteria before EPA has finished its standards. This circumstance coupled with the lack of large-scale testing before standards are set means that these EPA and NRC standards will likely change dramatically over time.

If one examines the past history of these bureaucracies, principally NRC (AEC), one finds that the regulations and regulatory guides were prepared, as often as not, to support decisions already made. Likewise, environmental statements for nuclear waste facilities (e.g. the Barnwell Receiving and Storage Facility) were prepared to support decisions previously made rather than serve as adequate and honest environmental assessments. This past experience suggests that the waste criteria will be compromised to satisfy the choice of medium and site in order to respond to the pressure for licensing a repository as soon as possible.

Considerable attemtion already has been given to the criteria by EPA and NRC as evidenced by the documentation developed recently */. However, the draft criteria that are presently being reviewed by interested parties within and outside these agencies are cause for some alarm. These draft criteria represent hard evidence that mistakes of the past are being repeated with respect to high level radioactive waste disposal and the development of disposal criteria. The criteria that are being proposed are ill-conceived, weak, and more likely designed to facilitate licensing of the waste repository proposed by DOE, than to protect the health of future generations. The criteria are in some respects less stringent than those recommended in 1966 by a National Academy of Sciences (NAS) Committee on Geological Aspects of Radioactive Waste Disposal. It has not been lost on the NRC and EPA that DOE has already voiced its preference for the medium and site for the first high level radioactive waste repository - salt and the WIPP facility near Carlsbad, N.M.

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*/ 1. "Workshop Material for State Review of Site Suitability Criteria for High-level Radioactive Waste Repositories"

2. "Report of Findings of the Peer Review of the Site Suitability Criteria for Geologic Disposal of High-level Nuclear Waste"

3. "Proposed Goals for Nuclear Waste Management"

4. "Determination of Performance Criteria for High Level Solidified Nuclear Waste" (NUREG-0279)

5. "Workshops for State Review of Site Suitability Criteria for High-level Radioactive Waste Repositories" (NUREG-0353)

6. "Proceedings for Conference on Public Policy Issues in Nuclear Waste Management"

7. "Selection Factors for Repositories of Solid, High-Level and Alpha Bearing Wastes in Geological Formations"

EPA's latest Background Report */, which discusses determining the acceptable level of risk from radioactive wastes, suggests that future generations, who will receive no benefits, could be subjected to the same risks as the waste producing generations. Moreover, it suggests that this acceptable level of risk could be determined through benefit-risk analysis. The NRC's draft criteria **/ are written largely in terms of "objectives" and filled with weasel phrases such as "all reasonable steps will be taken", "using techniques . . and assumptions which are not likely to significantly underestimate potential radiological effects," and "risks should be below . . ." Additionally, the NRC's draft criteria are for the most part vague and at best based on currently perceived standards thought by the nuclear industry to be acceptable to the present generation rather than future societies.

It is not too late to correct these deficiencies. This paper is an effort to develop a more rational set of waste criteria. The attempt here is to establish early a set of fundamental criteria or principles which will guide and constrain the more technical and narrowly defined criteria which, as Commissioner Varanini notes, will inevitably follow. Draft criteria are presented below, followed by a discussion of the rationale. Interested readers are encouraged to send their comments and any new ideas to the author.

1. The waste management or disposal scheme of choice should be just to future generations. Where there is an inequitable distribution of benefits and risks, justice should take precedence over benefits in evaluating waste management decisions.

2. In assessing the adequacy of radioactive waste management or disposal schemes, or in comparing waste management or disposal alternatives, risk-benefit analysis is an inappropriate tool and should not be the principal basis for evaluating decisions (e.g. where the benefit-to-risk cost ratio comes out greater than one). The risk-benefit tool should be limited to risk comparisons of alternative disposal schemes.

Discussion

It is well known that benefit-cost analysis was not designed to make judgments about the fair distribution of economic well-being (either between people living in the present or between people living in different generations of time).

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*/ U.S. Environmental Protection Agency, Office of Radiation Programs, Background Report, Consideration of Environmental Protection Criteria for Radioactive Waste, February, 1978.

**/ Unpublished and still subject to internal NRC Staff review.

Benefit-cost analysis alone cannot decide whether it is just or fair for the present to impose upon the future the burdens of essentially perpetual care for highly poisonous materials. Even if the benefit-to-cost ratio comes out greater than one, a waste disposal alternative may be unacceptable because the distribution of risk may be considered unacceptable.

Benefit-cost analysis is generally based on expected outcomes. Radioactive waste management should not do so, directly, rather it should at a minimum set an "acceptable risk level" and compare alternatives which meet that.

The foundation of any waste disposal criterion must be based on ethical rather than economic considerations, and consequently derive from a theory of justice.

3. Safety to future generations is a primary concern, and should always take precedence over cost.

Discussion

This straightforward criterion was first proposed in 1966 by the NAS Committee on Geological Aspects of Radioactive Waste Disposal. It has apparently fallen on deaf ears at EPA and NRC, where instead the staffs appear to have been captured by the inappropriate virtues of benefit-risk analysis.

4. The objective of geologic disposal of high-level radioactive waste disposal should be the permanent isolation of the waste from any future possible contact with living organisms.

Discussion

This is a slight variation (wording change) of another criterion first proposed by the 1966 NAS Committee on Disposal of Radioactive Waste. The NAS Committee stated:

> Radioactive waste, if disposed of underground, should be isolated as permanently as possible from contact with living organisms.

Later in their report the NAS Committee stated:

> The deliberations of this Committee continue to be guided by the basic rule that concentrations of radionuclides in waste materials should not be allowed to appear in the earth's biosphere before they have decayed to innocuous levels. This concept requires assurance that during any storage or disposal operations hazardous amounts of nuclides are isolated from the biologic environment, and that upon completion of the procedures the nuclides will remain isolated as long as they might constitute a hazard. For some nuclides this requirement means isolation for periods of 600 to 1000 years, periods so long that neither perpetual care nor permanence of records can be relied upon. All supplies of potable ground water, whether or not they are now being drawn upon, are considered as being part of the biosphere. */

It is of course impossible to prove that anything is permanently isolated. It would imply that risk probabilities as low as 10^{-40} are unacceptable. Consequently, the Committee used the phrase "as permanently as possible." Alternatively, criterion (4) is simply stated as an objective. This criterion should be taken as a rejection of alternative criteria that set non-zero radioactive release limits. This can be understood by the following examples. At a bacteriological warfare laboratory, the objective is zero release. This approach would be acceptable here. On the other hand at nuclear power plants routine releases of radioactivity are permitted and release limits have been established. This would be an unacceptable approach here. The NRC Staff following this second unacceptable approach has drafted radioactive waste criteria containing the following "Numerical Radiological Performance Objectives":

*/ National Academy of Sciences-National Research Council, Division of Earth Sciences, Committee on Geologic Aspects of Radioactive Waste Disposal, Report to the ~~Division of~~ Reactor Development and Technology, United States Atomic Energy Commission, May 1966

(a) The total body dose to individuals in unrestricted areas due to either routine or highly probable releases of radioactive materials should not exceed 5 millirems/yr.

(b) The total body dose to individuals in unrestricted areas due to highly unlikely but credible accidental releases of radioactive materials should not exceed 5 rem/yr for releases that are of relatively short duration and should not exceed 100 millirems/yr for releases which could lead to continuing exposure of individuals in local population groups over extended periods (several decades) of time.

The criterion (4) above is meant to imply that alternatives, such as those above drafted by the NRC, are unacceptable.

5. There should be high confidence that the cumulative risk to all future generations from radioactive waste should be less than, or (considering uncertainties in the calculation) comparable to, the cumulative risk to all future generations from the original uranium resources from which the radioactive wastes were derived, assuming these uranium resources were unmined.

Discussion

The attempt here is to choose a criterion based on a theory of justice. It must be fair to future generations, independent of the benefits this generation reaps from the use of nuclear power. Arguably the criterion should be more broadly defined. One can argue, for example, that future generations benefit from our use of nuclear energy - i.e. it saves other non-renewable resources, it represents progress, each generation benefits from the advances made by previous generations, etc. Similarly one should consider the relative benefits and risks to future generations by this generation using nuclear rather than some other alternatives, such as coal. There one would have to weigh the risks associated with the proliferation of nuclear weapons, CO_2 buildup, etc. But these risks and benefits are impossible to quantify. Even the sign (positive or negative) of the relative risks is unknown.

increased by our generation's use of uranium resources. This criterion raises some difficulties in estimating the risk that is associated with original uranium resources, but this is not perceived to be any more difficult that estimating the risks to future generations from radioactive releases from the nuclear fuel cycle - calculations that are required and are being done today, albeit with sizable undertanties.

Criterion 4 is written as an objective and qualitatively defines the nature of what will constitute acceptable quantitative criteria. Criterion 5 appears on its face inconsistant with criterion 4 in the same manner as the NRC's draft criteria ((a) and (b) above). I accept 5 as the only workable quantitative criterion based on justice that can serve to operationally define what is acceptable. The weasel term "high confidence" in criterion 5 must still be defined.

6. Under conservative assumptions, there should be a high confidence that concentrations of radionuclides in waste materials should not be allowed to appear in the earth's biosphere before they have decayed to innocuous levels.

Discussion

This criterion requires assurance that during any storage or disposal operation hazardous amounts of nuclides are isolated from the biologic environment, and that upon completion of the procedures, the nuclides will remain isolated as long as they might constitute a hazard. For some nuclides this requirement means isolation for periods of 600 to 1000 years, or longer, periods so long that neither perpetual care nor permanence of records can be relied upon. All supplies of potable ground water, whether or not they are now being drawn upon, are considered as being part of the biosphere.

This criterion should be the governing principle of all repository safety assessments similar to the reactor accident analyses.

Criterion 5 above is tantamount to sweeping these problems under the rug - ignoring the net benefits of using nuclear energy - and instead weighing only selected risks to future generations. In other words, limiting the comparison to something that is calculable. It is nevertheless an attempt to be consistent with criterion 1 above.

Although it has these deficiencies, it is far superior - read "more just" - than other alternative criteria which have been proposed by others, considered here and rejected. For example, it has been suggested that:

(a) The risks from radioactive waste disposal should be small compared to natural background radiation.

(b) The risk of radioactive waste disposal should be small compared to other risks in the nuclear fuel cycle.

Criterion (a) is rejected because it compares a cost with unrelated cost. This comparison fails even the logic of benefit-risk analysis.

It can be argued that there is a benefit in having a criterion that states that the radiation risk from radioactive waste disposal should be small compared to natural background, provided that (a) it is clearly understood that this is a necessary and not sufficient condition, and (b) realizing that radiation exposure comparable to background is unacceptably high. Such a criterion, however, would be unnecessary if a more strict criterion is limiting, the approach proposed here.

Criterion (b) is rejected because it lacks equity - read "is stupid". It is a benefit-cost comparison where the benefits are the same. It favors those that benefit from the use of nuclear power at the expense of future generation that do not share in these benefits.

It is foolish to think that what constitutes an acceptable environmental release standard today will be acceptable to future generations. The tightening of most environmental regulations during the past five years should dispel any questions. One can postulate, and it is conceivable, for example, that in a few hundred to a few thousand years virtually all diseases with the exception of those caused by radiation induced changes in the DNA structure will be licked. It is conceivable that radiation will be the principal cause of genetic disease and death from radiation induced cancers. In such a society radiation exposure would be viewed entirely differently than it is today. Today's permissible release levels would be irrelevent and considered archaic. The approach taken by NRC and EPA of relating the criteria to "acceptable" releases today is simply shortsighted.

The criterion (5) above is based on the premise that radiation exposure to future generations should not be

7. The geologic medium and site selected for geologic disposal should be selected to minimize the possibility of future human intrusion during periods after which the permanence of records can no longer be relied upon. Hence, the medium should not be a valuable resource, and the site should not be located in an area where other valuable resources have been, or are likely to be mined. The geologic medium of choice should be a plentiful resource such that should it become a useful resource to future generations, its widespread availability will make it unlikely to be mined at the waste disposal site.

Discussion

This criterion is designed to address the risk of release by human intervention rather than by geologic events. Arguably the risk of human intervention - after records of the repository are lost - is higher, or at least less predictable.

This criterion could be viewed as eliminating salt as a storage medium, and certainly eliminates the Carlsbad site near potash deposits. This is undoubtedly why EPA and NRC have dropped it from consideration.

8. The radioactive waste should be stored in a retrievable manner for the period during which the repository is open, or until it can be assured with high confidence that all waste disposal criteria are met, whichever is the longer period.

Discussion

The waste should be stored in a retrievable mode until there is clear evidence that we know what we are doing, and have high confidence that the desired goal will be achieved. Almost anything is retrievalbe at some cost. Here, retrievability implies something that can be economically retrieved.

Again, you don't find this in EPA and NRC draft criteria most likely because DOE has its eye on salt and no one really knows how long one can guarantee retrievability in salt - beyond the first few years. In this regard, the USGS has noted:

> . . . If relatively small amounts of brine can cause substantial decrease of mechanical strength and possible movement of waste during a relatively short time, special efforts will surely be necessary to insure retrievability from a salt repository for periods as short as 10-25 years. The question of whether the workings of a mine in salt can be predicted to stay dry will have to be faced.*/

*/ Geologic Survey Circular #779, Geologic Disposal of High-Level Radioactive Wastes-- Earth Science Perspectives, by Bredehoeft, J.D., A.W. England, D.B. Stewart, N.J. Trask, and I.J. Winograd, 1978.