GENERIC ENVIRONMENTAL ASSESSMENT FOR IMPLEMENTING A RADIOACTIVE WASTE CLASSIFICATION SYSTEM

FOR

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1. Description of Proposed Action

This generic environmental assessment addresses the environmental effects associated with implementing on a national scale a radioactive waste classification system that is based on the ultimate disposition of the wastes. This waste classification system, described in detail in reference 1, involves three categories for radioactive wastes; namely: high-level wastes, those requiring isolation in a repository because of high or persistent radio-toxicity; low-level wastes, those that are acceptable for disposal in near-surface facilities such as shallow land burial; and innocuous wastes, those with such diminimously low levels of radioactivity that they can be considered essentially non-radioactive.

Obviously, this proposed action, implementing this type of waste classification system, implies that practices similar to current radioactive waste management activities will extend into the future. By definition of the waste categories, some type of low-level waste

disposal is contemplated. Any environmental effects will be associated with operation of these future (and existing) waste facilities, and not directly with the implementation of the waste classification system.

Because nuclear wastes involve a large range of contamination levels (more than seven orders of magnitude), there are both economic benefits and health-risk advantages in categorizing the waste according to the associated radioactivity and the kinds of radioactive elements present. Costs for handling and sequestering the categories are not equal per unit volume, hence a drive exists to place a maximum amount of waste in the cheaper (lower concentration) category. On the other hand, the health-risk from the cheaper method are mostly proportional to the concentration of radioactivity. Thus, raising the interface concentration between two categories has the effect of increasing the health-risk. Since costs and health-risks are in opposition, analysis of the trade-offs has been made in order to establish an overall optimum for handling and sequestering the entire spectrum of wastes. Details of this analysis, including basic data and results, are presented elsewhere.

Briefly, there are three categories: the most concentrated waste form comprises the smallest volume fraction (0.4 to 8% of the total) but requires the highest expenditure per unit volume (\$3500 per cubic meter). The lowest category comprises levels of contamination so low as to be innocuous. The volume involved is indefinite

(but in the range of 10-20% of the total and the costs are essentially similar to handling non-contaminated waste (\$30 per cubic meter). The intermediate category, involves about 90% of the total volume and costs of about \$100 per cubic meter. The upper boundary of concentration for this intermediate category identifies a most significant feature since its implementation will fix both the amount of waste to handle with expensive methods and the level of health-risk over the long term due to the intermediate category. Long-term environmental risks due to the highest waste levels are considered zero once the wastes are in their repository.

Identifying categories of waste comes logically once a decision is made that results in radioactive wastes being generated. The wastes must be handled and sequestered to some degree regardless of where the interface concentration is chosen. Refusing to establish categories is equivalent to placing the interface at zero (or infinity). Such a situation would be evaluated for costs and health-risks in ways identical to those used already. Thus, the alternative of making only a single waste category is not distinct from making multiple categories. Consequently, the relative impacts due to choosing one interface concentration or another will differ only in degree, not in kind.

Since the intermediate category will be buried or otherwise similarly contained and eventually left to the elements of climate and time, the environmental impacts are of two periods. From the time of burial and for the first few

hundred years institutional controls will limit access to the wastes and the packages will provide substantial isolation from the environment. Thus, impacts during this first interval of time will be partly controlled and limited in type.

Beyond a few hundred years the packages cannot be credited with providing isolation. On the other hand, the fission products of the waste will have decayed to insignificance. The remaining radiation risk would be due largely to the transuranic elements for which the cost-impact trade-offs will have been calculated according to their concentration and a pathway analysis. Such a calculation should presume a total, though somewhat gradual, release of all TRU to the environment.

In the shorter term, cost-benefit calculations should be made in terms of packaged waste, packaging and transport operations, and resource commitments according to general guidelines for environmental impact assessments.

Some scenarios propose that at some future time the burial site might be partly excavated by curious or unguided persons who are then exposed to a singular, possibly serious, radiation risk. The probabilities of such happenings are obscure, and, possibly site-specific. The degree of exposure is still more obscure. Furthermore, for the times more than hundreds of years into the future there is little consensus now about what we owe to such persons in terms of making their possible exposure small, especially if at a substantial

cost increment to our own generation. Almost as uncertain is what might be done to warn those persons in their time. These points deserve to be addressed in specific environmental assessments which deal with the impacts of nuclear waste burial.

2. Potential Impact on the Environment

By selecting a waste classification system, disposal methods are assumed to be suitable for the categories of waste to be handled. Usually, the geology of the site will be relied upon for containment of the radioactivity in the wastes.

Local and regional geologic conditions constrain the possible movements of radioelements; they moderate what the climate can do to the waste packages and the dispersion of their contents. Geologic factors, and to a lesser degree climatic factors, are the overriding considerations in selecting a site so that environmental impact will be minimized. An astute choice of geologic context can make up for weaknesses in engineered parts of the burial site and its safeguards, whereas no engineered structure can reliably counter unfavorable geologic conditions for more than a few hundred years at most. One can hardly overemphasize the importance of geologic considerations in site selection. To subrogate them to other site selection criteria would imperil the success of the burial plan.

Additional factors, approximately in order of their

importance to overall environmental impact, are: hydrology, climate, population density, bio-uniqueness, bio-diversification, biomass, engineering design, closing and maintenance costs, transportation cost, and construction cost.

Because the radioactive wastes are committed to the environment, the impact assessment should be made by a thorough pathways analysis. Two somewhat separate analyses are indicated; one for the shorter term which would involve (among other things) fission products and mishaps; a second for the longer term aspects of transuranic dispersions.

Establishing a (possibly) new site, with transportation connections and living facilities will create an environmental impact of a rather common kind. Effects on land use and local ecologic factors can be assessed independently of the radiologic considerations. Dose commitments for alternative interface concentrations will change little since they vary with the average concentration in the buried waste, not with the maximum concentration.

On a larger scale, there will be little nation-wide impact on transportation, resources, land use, etc., as a result of where the interface concentration is established. Mainly this is because about 90% of the waste will go to burial in any case--less than 10% of the wastes involve great enough potential danger to require isolation in a repository.

3. Compliance with Applicable Water and Air Quality Standards

The interface concentration itself will be kind of standard, although of a secondary kind, since it is based on other criteria. Implementing the selected interface with real wastes will be self-fulfilling in the context of meeting criteria.

Behind the interface, however, are the standards listed in 10 CFR 20 with which the interface is in compliance through calculational methods of pathway analyses.

4. Cost-Benefits Due to the Interface

Waste management exists purely as an overhead item and deserves to be minimized in all aspects of material and human resources and actual dollars expended.

The draft environmental assessment should identify whether the minimized costs are consistent with human and environmental protection. Such an assessment must somehow make connections between units of dose (e.g. rems and man-rems) and units of costs (e.g. dollars). One approach is to use guideline values for population doses such as the \$1000 per man-rem value which has been proposed in 10 CFR 50 for power reactors. This criterion can be implemented in a two-step way.

There is a relationship between the volumes of waste and the concentration. That relationship can be combined with the increment of dose that would occur if the intermediate waste volume were to be inflated (and its concentration raised) by raising the interface concentration. This would yield a term of the form $\frac{A_{\text{dose}}}{A_{\text{conc}}}$. Additionally, the volume-concentration

relationship can be combined with the relative cost increases involved with placing more waste in a repository if the interface concentration were lowered. This would yield a term of form $\frac{\Delta \text{cost}}{\Delta \text{conc}}$. The two ratios could be combined into $\frac{\Delta \text{cost}}{\Delta \text{conc}} / \frac{\Delta \text{dose}}{\Delta \text{conc}}$ or simply $\frac{\Delta \text{cost}}{\Delta \text{dose}}$ which has the units of \$ per man-rem. The consequences of varying the interface concentration can be explored by calculating the $\frac{\Delta \text{cost}}{\Delta \text{dose}}$ for each test condition. The optimum condition would be that concentration which corresponded to a $\frac{\Delta \text{cost}}{\Delta \text{dose}}$ of \$1000/man-rem. A higher interface concentration would yield an excessively large dose, a lower interface would yield excessively high costs.

Alternatively, if an interface concentration is chosen arbitrarily, one may use the procedure above to identify the \$/man-rem that are implied by the choice and it may then be discussed in terms of whether the dose is over- or under-valued.

Because unit costs at the repository are 35 times the costs of burial, the repository budget will be sensitive to shifts in the interface. This consideration is implicit with the $\frac{\Delta \text{cost}}{\Delta \text{conc}}$ part of the analysis just described.

The cost-dose criterion cannot be used alone; however the other factors are difficult to cast into the same units. Non-human exposures might be assessed and perhaps valued at something less than \$1000/rem. Such an approach would yield a weighting factor with which to arrange trade-offs between human and non-human radiation exposure. More difficult, still, to quantify are features of biologic uniqueness, diversity,

geologic interest, and other aesthetics that might be compromised by the burial site. These aesthetics are more important to site-specific impact assessment relative to a proposed site than to the choice of interface level. This is because choice of level has only an incremental effect on impact whereas the decision about site location is an either-or kind of consequence. Thus, aesthetics deserve only minor involvement in the interface assessment, in contrast to a significant involvement with site selection.

Additionally, doses to the few individuals who may receive maximum exposures require consideration. Protection of the public health and safety is one of the criteria upon which the classification system is based.

Since transportation costs will be a major consideration in siting the burial ground, some consideration will be given to establishing multiple sites. Such a course could yield cost advantages for the short term while possibly incurring greater total impact on the environment. Human dose commitment would not likely be much increased, if at all. All of these factors can be assessed with methods described in the last few paragraphs above. The analysis would be complicated but new kinds of health or environmental insult need not be expected.

5. Unavoidable Adverse Effects

The option for avoiding all adverse effects hinges totally on the non-pursuit of nuclear energy. Thus it lies beyond

the scope of this environmental assessment, being properly a subject of impact assessment for an entire nuclear energy program.

A related possibility would be the use of some thoroughly different method for waste disposal, for example, disposal in some well-selected part of the seabed. Such an alternative would involve an impact assessment with few elements in common with land disposal, especially with respect to the pathways analysis. Not only would the pathways calculations be qualitatively different in several important aspects, but also the distribution of the perceived impacts would affect international institutional arrangements. In the face of this institutional complication, comparison of the real environmental impacts, sea-bed vis-a-vis land disposal might not be possible. Whether sea-bed disposal actually is safer than disposal on land deserves to be assessed, yet there is not clear assurance that sea-bed disposal could be supported internationally. One must question whether the sea-bed option today exists for comparison with land disposal.

Embedded within such a comparison is the choosing of an interface concentration. In the previous section, the interface concentration described as a derived value based on an equality between the factor \$1000/man-rem and the calculated value $\frac{\Delta \text{cost}}{\Delta \text{conc}} / \frac{\Delta \text{dowc}}{\Delta \text{conc}}$. The same approach could be used with the concept of sea-bed disposal but the resulting interface concentration would be different (except fortuitously). Comparison of land vs. sea-bed disposal would be made by comparing

their impacts and total cost when each alternative involved its respective optimum interface concentration. Note that using the same interface concentration for both alternatives would prejudice the comparison.

In principle, adverse effects are site-specific, hence the avoidabilities and trade-offs must await the specific assessment. Practically it would appear that from among a broad range of candidate sites, several would be free of some unique feature that should not be compromised. Thus, an assessment for the selected interface concentration need not concern unusual features of geography, biology or aesthetics, but may properly deal with generalized impacts free from unique features.

Consequently the impacts that merit full discussion belong to two sets and both are approachable in objective ways, one corresponding to the repository, the other to the burial site. Although the choice of interface determines how the total waste volume is apportioned to the two kinds of sites, the sites themselves will change only in relative size, affecting impacts incrementally, not in an either-or sense.

Among the unavoidable effects are direct radiation exposures to workers who package, handle and transport the wastes. Inadvertent exposures to the general population and the environment are calculable only in statistical senses, hence their unavoidability is obscure.

In one sense, a random exposure of individuals will be

due to postulated incidents which release radioactive material. In principle, one fraction of the exposed population could be identified as directly involved and given medical treatment, if required. The remainder of the exposed people would be affected too little to be measured directly. Their exposures would be calculated according to pathway analysis methods yielding a part of the population dose.

In the other sense, postulated incidents have only statistical chances of happening. In an assessment the probabilistic exposures to people and the environment deserve to be tallied as distinctly different from the direct exposure to workers, even if both are categorized as unavoidable.

Other classes of unavoidable impacts concern construction activities at the sites and along transportation routes; interference with biologic patterns of growth or behavior and others commonly itemized in procedures for making assessments. These must await an identification of specific alternative sites before detailed discussions can be made. As a first approximation, the several candidate sites might be expected to be rather similar, at least if the selection criteria are ranked geology, hydrology, climate, etc. If such is the case, then a changed interface concentration would tend to affect the several site assessments in similar ways. Such parallel effects would not be expected to change the ranking of candidate sites.

To summarize, no adverse effects should be expected to arise due solely to changes in interface concentration. There may be changes in the degree of effects, but these should be expected to be small to negligible. The unavoidable effects would be due to the changed conditions at a site and along transportation routes and deserve their fullest elaboration in specific site assessments. Within this concept, the effects at the repository site are relatively more variable than at a burial site. This is because the smaller volume of waste to be committed to a repository is affected relatively more by a shift in the interface concentration.

6. Alternatives to the Proposed Action

Accepting the principle that nuclear waste will exist, choices for interfaces can involve simple categorizations (0 or 1 interface) or more complex (2, 3 or more interfaces). Whether simple categorizations yield cost/dose advantages over complex ones deserves to be studied.

Such an evaluation could be set up to involve the equality $\$1000/\text{man-rem} = \frac{\text{cost}}{\text{conc}} / \frac{\text{dose}}{\text{conc}}$ and a mathematical model with multiple interfaces. Note that the choice of no interfaces at all is a possibility in optimizing for the equality above. Hence, it cannot be considered as either a different concept or as a possibly better alternative.

7. Irreversible Commitments of Resources

Fissile and fertile components of waste are energy

resources to the extent they can be recovered in terms of energy economy. Wastes placed in the permanent repository become inaccessible to all future generations, even those existing after the fission product fractions of the waste would no longer complicate chemical recovery and purification of uranium or transuranics (TRU).

Raising the interface concentration so as to place more TRU in accessible burial sites would, in principle, preserve another increment of inventory for future generations. Whether that amounts to preserving a resource depends on future capabilities to utilize any part of the buried wastes. The point might be assessed, but the economics of recovery generations hence would be too speculative to yield a convincing "yes" as to useability. Benefits, if any, should not be claimed since our own generation (the one which pays the dollar costs) will not receive them.

Costs for placing wastes in a repository are about 35 times as large, per unit of volume, as burial costs--a measure of the relative amounts of material, energy, and human resources to be committed in caring for the wastes. Consequently, fairly small differences in the higher concentration category would be associated with substantial increments of resources. This aspect is included in the process of making cost-benefit analyses as described in part 4 above. Not included there, however, yet deserving, are considerations about whether scarce materials become unduly involved upon implementing some proposed interface concentration.

8. Summary

Identifying categories of waste comes logically. In objective evaluations of where interfaces should be set, the interface can be derived, based on criteria for minimizing cost and impact. With this approach the options of establishing no interface at all (treating all waste the same) becomes a candidate in the sense that an interface level of zero or infinity has not been arbitrarily ruled out.

Since wastes in the permanent repository will give zero radiation dose to the biosphere, dose is reduced by lowering the interface concentration. Such benefits compromise the commitment of material, energy, and human resources through their relatively large inputs to the repository per unit volume of waste stored there. Balancing the cost-dose conflict might be achieved by combining a factor of \$/dose with a mathematical model of how cost and dose change upon incrementing the interface concentration.

In order to minimize radiation dose to the biosphere over the long term the geology of the site will be relied on for containment of the buried waste. If the containment is effective, then the ultimate biologic doses of radiation will not only be smaller but also less sensitive to effects of what interface concentration is set.

The interface concentration will be a kind of second-

ary standard set up to be in compliance with environmental standards traceable to 10 CFR 20. This compliance would be in addition to cost/dose factors as mentioned above.

Comparison of a burial-repository combination for waste control with other methods would involve finding the interface concentration for each which optimized the cost/dose criteria. A sea-bed disposal was mentioned as such an alternative. The derived interfaces would likely be different concentrations. Thus, to compare sea-bed alternatives with land alternatives their respective optimum interface concentrations must be used. A prejudiced comparison would result if the same interface concentrations were used for each.

Setting of an interface concentration should not be expected by itself to result in unique adverse effects, although incremental changes in the spectrum of effects would be certain to result. Unavoidability of certain effects must await evaluations of specific sites. At this time, there is no reason to suspect that all candidate sites will involve serious complications which might be especially costly to the waste disposal program or to the environment.

Resources consumed in sequestering the wastes can be valued in terms of dollar costs that are traded against reduced doses of radiation. In addition, the relative scarcity of the resource or its source of supply deserve

separate consideration about advisability. This may be a problem in the repository which requires a large investment per unit volume of waste stored there.

REFERENCE

1. Ford, Bacon & Davis Utah Inc., "Determination of a Radioactive Waste Classification System Final Report to Lawrence Livermore Laboratory, September 1977.

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