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

May 11, 1981

MEMORANDUM FOR: Chairman Hendrie
Commissioner Gilinsky
Commissioner Bradford
Commissioner Ahearne

FROM: William J. Dircks
Executive Director for Operations

SUBJECT: TRANSMITTAL COPY OF WORKING DRAFT 19 OF 40 CFR 191

As requested by Chairman Hendrie in the meeting of May 8, 1981, enclosed is a copy of the draft Federal Register Notice containing the draft environmental standard for high-level waste being developed by the Environmental Protection Agency (EPA). Note that the draft standard has not yet been made public by EPA.

The standard itself begins on page 33 and extends to page 43 of the EPA document. The first 32 pages are introductory material which explains the rationale and background for the standard.

Also enclosed for information is the staff's memorandum commenting on a preliminary draft of the standard.

for

William J. Dircks
Executive Director for Operations

CONTACT: MJ Bell (WMHL) 427-4173

cc: Samuel Chilk
Leonard Bickwit
Dennis Rathbun
Robert Minogue
John Davis

Enclosure: As stated

ENVIRONMENTAL PROTECTION AGENCY

40 CFR 191

ENVIRONMENTAL STANDARDS AND FEDERAL RADIATION PROTECTION GUIDANCE FOR MANAGEMENT AND DISPOSAL OF SPENT NUCLEAR FUEL, HIGH-LEVEL AND TRANSURANIC RADIOACTIVE WASTES

AGENCY: U.S. Environmental Protection Agency

ACTION: Proposed Rule

SUMMARY: The Environmental Protection Agency requests comments on proposed radiation protection standards and Federal radiation protection guidance for the management and disposal of spent nuclear reactor fuel and high-level and transuranic wastes. The proposed guides would establish seven general criteria to be followed when these wastes are disposed of. They address problems inherent in the design and construction of systems that must isolate hazardous materials for very long periods of time without human intervention. The proposed standards would limit the amount of radioactivity that may enter the biosphere. The standards require a reasonable expectation that these limits will be satisfied for ten thousand years after disposal. These requirements would apply to disposal by any method, except disposal directly into the oceans or ocean sediments. The proposed standards also would limit the radiation exposure of members of the public from management of spent fuel and of waste prior to disposal.

After we consider the comments received on this proposal, we will develop final versions of the standards and guides. We will then recommend that the President approve the guides as Federal Radiation Protection Guidance for all agencies. The final standards will be promulgated as a new Part 191 to Title 40 of the Code of Federal Regulations (40 CFR 191). The standards and guides will be implemented by the Nuclear Regulatory Commission and the Department of Energy under their respective statutory responsibilities.

DATE: Comments should be received on or before (180 days after publication).

Public hearings to receive comments on the proposed standards and guides will be held in several cities.

ADDRESS: Comments should be sent to the Director, Criteria and Standards Division (ANR-460), Office of Radiation Programs, U.S. Environmental Protection Agency, Washington, D.C. 20460. Copies of all documents will be available in Docket No. _-__-_ , which is located in the West Tower Lobby, Gallery 1, Central Docket Section, Environmental Protection Agency, 401 M Street, S.W., Washington, D.C. Single copies of the Draft Environmental Impact Statement for this action may be obtained by writing to the Director.

FOR FURTHER INFORMATION CONTACT: Daniel Egan, telephone number (703) 557-8610, or Dr. Abraham Goldin, telephone number (703) 557-7380.

SUPPLEMENTARY INFORMATION: Proper management and disposal of the wastes produced by the irradiation of fuel elements in nuclear reactors are important because of the inherent hazards of the large amounts of radioactivity they contain. Large quantities of these wastes already exist and more are being produced in national defense programs, commercial nuclear power plants, and research reactors. They are being held in storage facilities until disposal methods are developed.

These wastes contain many different radionuclides. Some of these nuclides emit alpha particles; others emit beta particles. Some radionuclides emit gamma rays in addition to alpha or beta particles. The radionuclides decay with half-lives ranging from less than one year to millions of years. We have concentrated our attention on radionuclides with half-lives greater than 20 years because they must be isolated from people for very long times. Thus, we exclude radionuclides such as tritium, krypton-85, and plutonium-241, which are present in large quantities in freshly discharged fuel, but they decay so rapidly that they do not require long-term isolation. Radionuclides with half-lives of 20 years or less will decay to less than 0.1% of their original activity in 200 years.

Reprocessing reactor fuel used for national defense activities has produced about 500 million curies of radionuclides with half-lives greater than 20 years. Most of the activity is due to strontium-90 and cesium-137. These wastes are stored in various liquid and solid forms on three Federal reservations in Idaho, Washington, and South Carolina. Relatively small additions are being made from ongoing defense programs.

Spent fuel from commercial nuclear power reactors contains about 800 million curies of radionuclides with half-lives greater than 20 years. About 10 million curies of this radioactivity are due to radionuclides, such as plutonium, which emit alpha particles. Most of this spent fuel is stored at reactor sites. Over the next few years, this inventory is expected to grow at a rate of about 200 million curies per year from reactors currently licensed to operate. At some reactor sites, spent fuel storage capacity is almost used up. Plans to store additional spent fuel at locations away from reactor sites are under consideration by the Federal Government.

Nuclear reactors use some isotopes of uranium, plutonium, or thorium to produce energy from nuclear fission. These elements are commonly referred to as "heavy metals." The amount of wastes produced is roughly proportional to the amount of these elements placed into a reactor. We use the unit "wastes generated per metric ton of heavy metal (MTHM)" to measure the amount of waste placed in disposal systems. The amount of ore needed to produce one MTHM depends on the reactor type, degree of reprocessing, and quality of ore. For the light water reactors currently used in the United States, about 6,000 metric tons of uranium ore are used to produce one MTHM of reactor fuel. We have used this relationship to associate amounts of waste from reactor fuel with uranium ore.

The Agency's purpose in proposing these standards and guides is simply to protect the public health and the environment from the hazards these wastes present. We neither favor nor oppose nuclear power. Similarly, we do not advocate any particular method for disposing of these materials. We do require that any disposal method offer at least as much protection as the one we have assessed as part of the basis for these standards and guides.

DESCRIPTION OF THE PROPOSED ACTION

Under authorities established by the Atomic Energy Act and Reorganization Plan No. 3 of 1970, we are proposing generally applicable environmental standards and Federal radiation protection guides for disposing of these wastes. The Draft Environmental Impact Statement (EIS) published with this proposal includes detailed discussions of the reasons for our selections of proposed standards and guides, and provides extensive summaries of the technical analyses used. This preamble describes the proposed action and highlights features that we believe are of major interest.

The proposed standards and guides apply to spent reactor fuel, highly radioactive wastes derived from reprocessing spent fuel ("high-level wastes"), and to certain wastes containing long-lived radionuclides of elements heavier than uranium ("transuranic wastes"). Transuranic wastes are covered if they contain 100 nanocuries or more of alpha-emitting transuranic isotopes, with half-lives greater than one year, per gram of waste. People could receive, under some possible (but not likely) circumstances, more than 500 millirems per year from wastes containing more than 100 nanocuries of transuranic elements per gram if these wastes were not well isolated. 500 millirems per year is the Federal limit for individuals in the general population. Because these circumstances could last for very long times, we are proposing the same controls for these wastes as required for high-level wastes. Protection requirements for transuranic wastes containing less than 100 nanocuries per gram will be considered in future standards.

In developing the proposed standards, we estimated the risks from disposal systems that use methods of controlling releases which either are available now or are likely to be available in the near future. We also estimated the doses to individuals and populations from waste management. From these evaluations, we conclude that:

1. Any harm to people, including future generations, from the management and disposal of spent fuel, high-level, and transuranic wastes can be kept very small. The assessments which support this conclusion are outlined below and are discussed extensively in the Draft EIS.

2. These standards and guides adequately protect the public from harm. Under them, the risks to future generations from the wastes will be no greater than the risks from equivalent amounts of unmined uranium ore. These risks will also be less than the other risks currently associated with generating electricity from nuclear energy, and they will be very much less than the risks from natural background radiation.

In determining the release limits given in the standards, we had to project the performance of disposal systems which have not yet been demonstrated. There are significant uncertainties inherent in such projections. To avoid underestimating the risks associated with such systems, we assumed levels of performance that we are confident will be met by well-designed systems. Our estimates are, therefore, upper bounds of the risks. When actual control methods are selected and demonstrated at specific sites, estimated releases are likely to be well below the amounts allowed by the proposed standards. Accordingly, the proposed guides instruct the implementing agencies to reduce releases below these upper bounds to the extent reasonably achievable, taking into account technical, social, and economic considerations.

The standards apply to both management and disposal. Subpart A applies to management and includes storage, preparation of the wastes for disposal, and placing them in a disposal site. Off-site transportation is not covered. Subpart B applies to releases after the wastes are isolated enough so that it would be much harder to get them out of the disposal system than it was to put them in. With a geologic repository, for example, Subpart B would take effect when the mine was backfilled and sealed. The proposed Federal guides, included as Appendix A to the standards, apply only to disposal.

DECISION NOT TO PUBLISH GENERAL WASTE DISPOSAL CRITERIA

On November 15, 1978, we proposed general Federal Radiation Protection Guidance for the disposal of all types of radioactive wastes (43 FR 53262). After further thought, we believe that the characteristics of different kinds of radioactive wastes are too dissimilar for general criteria to be appropriate. Therefore, we do not plan to issue them. We believe the best course is to write a series of standards and guides for disposing of specific types of radioactive waste. The insights we gained from working on the general criteria have been useful in developing these standards and guides.

REGULATORY ANALYSIS

Executive Order 12044, "Improving Government Regulations," requires Federal agencies to prepare a regulatory analysis for significant regulations. This analysis should contain: (1) a succinct statement of the problem, (2) a description of the major alternative ways of dealing with the problem, (3) an analysis of the economic consequences of each of these alternatives, and (4) a detailed explanation of the reasons for choosing one alternative over the others. EPA's plan (40 FR 30988) to implement Executive Order 12044 contains more detailed guidelines for the economic portions of a regulatory analysis.

Most of the topics required for a regulatory analysis are considered in this Federal Register notice and in the Draft EIS supporting this action. Both documents discuss the problems associated with these wastes and indicate why we are developing environmental standards and radiation protection guidance. The Draft EIS describes the possible alternative regulatory approaches that we considered, and it also explains why we chose this proposed action. We did not have sufficient information to determine the economic impacts of choosing either a more restrictive or a less restrictive numerical standard, because the data required to make such evaluations are not available now and may not be available for a long time. Our analyses are based only on information about the costs and effectiveness for a model of a mined deep geologic disposal repository. Both the cost and effectiveness of geologic disposal depend on the characteristics of the particular site. Information on cost and effectiveness for other methods is even more uncertain than for the mined geologic repository. As a result of these limitations, we have not been able to estimate the costs of different levels of protection. Therefore, economic considerations have played a very minor role in our comparison of alternatives.

We believe our proposed standards and guides provide adequate protection of public health and the environment. We think that they can be met by careful use of existing technologies, and would not cause unreasonable economic consequences.

Most of the information required for a regulatory analysis is also required for an environmental impact statement. Therefore, because of the lack of the required information described above, we did not prepare a separate regulatory analysis document.

The remainder of this notice describes our proposed action in more detail, summarizes its potential health and economic effects, and discusses the implementation of these requirements. In several places, we identify topics on which we would especially like comments.

(40 CFR 191 Subpart A)

WASTE MANAGEMENT

Certain operations required before disposing of high-level or transuranic radioactive wastes are not regulated under our Uranium Fuel Cycle Standards (40 CFR 190). These operations principally involve storage of the materials, solidification or other preparation for disposal, and placing the wastes in disposal sites. Subpart A applies to spent fuel management, regardless of whether the fuel is considered to be waste, except for management already regulated by 40 CFR 190.

We estimated the largest expected radiation exposures to members of the public from waste management and storage operations associated with geologic disposal and found them to be somewhat smaller than the requirements set in 40 CFR 190. We propose to extend the limitations contained in Part 190 to the operations addressed by this new Part 191 for two reasons:

1. Other strategies for disposal could involve operations, such as chemical separation of transuranic elements, which are similar to those of spent fuel reprocessing. Reprocessing operations were a significant consideration in selecting the limits of 40 CFR 190. Setting the standards in Part 191 at the levels indicated by assessments based only on geologic disposal activities could preclude other disposal strategies which might be better.

2. Some of the operations addressed by Part 191 may take place near operations regulated by Part 190. Establishing different limitations for different operations at the same site would create difficult implementation problems with little, if any, additional public health protection. The provisions of Part 191 require the combined impacts from multiple operations to meet a single set of dose limitations which will be the same in both Parts 190 and 191.

Section 191.03 therefore requires that the combined annual dose equivalent to any member of the public due to operations covered by Part 190, and to direct radiation and planned discharges of radioactive materials covered by this Subpart, shall not exceed 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ. It also requires that waste management operations be conducted so as to reduce exposures for members of the public below this level to the extent reasonably achievable, taking into account technical, social, and economic considerations.

(40 CFR 191 Subpart B)

DISPOSAL

Standards and guides for the disposal of high-level and transuranic radioactive wastes require far different considerations than those for management. These include:

1. The intent of disposal is to isolate the wastes from the environment for a longer time than that over which active institutional controls, such as monitoring the disposal site to detect releases of radioactivity, can be relied upon for protection.

2. Disposal systems must be designed so that very little radioactivity will return to the environment if the system performs as intended. Thus, the principal concern is the possibility of unintentional releases, either due to unintended events or inadequacies in the disposal system.

These considerations have several ramifications for standards development. First, the standards can only be implemented in the design phase--by setting design principles or by analytically projecting disposal system performance. The more familiar concepts of implementation involving monitoring of emissions or ambient levels of pollutants are not applicable.

Second, the standards must address unintentional releases such as those resulting from human intrusion or geologic faulting. Their provisions must be applicable to a variety of disposal strategies because the

Agency does not have the authority to specify details of disposal method designs. Regulations to be developed by the Nuclear Regulatory Commission (NRC) or DOE, as appropriate, will control specific designs.

Third, the standards must allow for unusually large uncertainties. These include both uncertainties in our current knowledge about disposal techniques and inherent uncertainties about the distant future.

We addressed these issues by developing both general criteria and projected performance requirements for disposal systems. The general criteria will be Federal guides and the projected performance requirements will be generally applicable environmental standards. These two parts of our proposed action are complementary: the general criteria provide qualitative requirements to reduce the chance of future environmental damage; the projected performance requirements set numerical limits on potential releases.

(APPENDIX A)

GENERAL CRITERIA

The proposed radiation protection guides given in Appendix A to the proposed 40 CFR 191 include these criteria:

1. The wastes should be disposed of promptly once adequate methods are available in order to reduce the chance of accidents during long-term storage. We have not established a time limit for this disposal, because the appropriate length of storage may depend on details on the disposal system design. For example, it may be desirable to store high-level wastes for ten years or more to allow for decay of most of the short-lived radionuclides. The primary intent of this criterion is to prevent wastes from being stored indefinitely in order to avoid ultimate disposal.

2. Because they must be effective for so long, disposal systems should offer as much protection as is reasonably achievable.

3. Disposal systems should reduce the consequences of possible mistakes in selection, design, or construction by using several different types of barriers, both engineered and natural, and by taking full advantage of the protection each has to offer. With this redundancy, the unexpected failure of one or more barriers will be compensated for by other barriers. We could also have required that disposal systems meet the numerical performance requirements even if some of their barriers fail. Although additional protection would be provided by such a requirement, we do not believe that this is the best way to increase protection of the public. It would create difficult implementation problems, such as defining "barrier," and it could result in large additional costs and long delays. We believe that making the overall disposal system meet numerical performance requirements by taking advantage of substantial protection from each of its components will provide adequate protection most economically. However, we particularly seek comment on this issue.

4. Protection from the wastes should not depend on the ability of people to control them for more than 100 years after disposal, although measures which require human attention are useful supplements to passive controls.

5. The dangers and locations of disposal systems should be recorded in the most permanent ways practicable in order to reduce the chances of unintended disruption of disposal systems by future generations.

6. Disposal systems should not be located where there has been mining for resources, or where there is a reasonable potential for future exploration for scarce or easily accessible resources. Furthermore, disposal systems should not be located where there is a significant concentration of any material which is not widely available from other sources. This criterion would discourage the use of geologic formations which are often associated with resources. For example, the frequent mining of salt domes either for their relatively pure salt or for use as storage caverns would argue against locating a repository in this type of structure. However, this same concern would generally not apply to bedded salt deposits because they are much more common. We particularly seek comment on this criterion because it could rule out sites which might otherwise be advantageous in meeting all of our other requirements.

7. Recovery of most of the wastes should be possible long after disposal if unforeseen events require this in the future, unless the wastes are removed from the Earth. The various isolation requirements of these standards would make recovery after disposal very difficult and expensive and probably dangerous. Nevertheless, because some of our scientific understanding may prove to be wrong in a way that would produce much greater risks than we expect, future generations must be able to recover the wastes if they deem it essential. An important implication of this requirement is that the physical location of the bulk of the wastes must be reasonably predictable after disposal. Current plans for mined geologic disposal would meet this requirement. However, some possible disposal methods, such as deep well injection of liquid wastes or rock melting concepts, may not. Since this requirement could eliminate some otherwise

feasible and perhaps advantageous disposal methods, we particularly seek public comment about it.

Executive Order 12088 makes the head of each Executive agency responsible for compliance with these guides, once the President has approved them as Federal Radiation Guidance. In addition, the Order directs the Administrator of the Environmental Protection Agency to monitor compliance by Executive agencies and to review and approve required compliance plans. Conflicts on implementation may be resolved by the Director of the Office of Management and Budget. Exemptions may be granted by the President.

(SECTION 191.13)

PROJECTED PERFORMANCE REQUIREMENTS

The projected performance requirements assume that we can predict some aspects of the future well enough to use the predictions for selecting and implementing disposal methods. Assessment of any disposal plan will require the combination of assumptions about the future with engineering and design information about the disposal method and geologic data for the site. Such assessments can be used to decide whether a particular disposal method provides adequate protection and to compare various methods to determine the degree of protection that is reasonably achievable.

To develop these standards, we assessed the environmental impacts of high-level waste disposal in mined geologic repositories. Geologic repositories were chosen because much more information is available on this method than on others. The projected performance requirements, however, are meant to apply to any method of disposal except disposal directly into the oceans or ocean sediments. Thus, any other disposal method would have to provide at least as much protection as that projected for geologic disposal.

The standards do not apply to disposal in oceans or ocean sediments because such disposal of high-level waste is now prohibited by the Marine Protection, Research, and Sanctuaries Act of 1972 and the London Dumping Convention of 1972. However, disposal in deep ocean sediments is currently being studied and may prove to be a technically feasible option. Thus, we specifically request public comment on extending these standards to include possible ocean disposal methods so that, if the law and treaty were changed, these standards could apply to disposal of high-level waste in the oceans or ocean sediments.

In our assessments of geologic disposal, we identified expected and accidental releases of radioactivity from a generic model of a repository. The model repository contains 100,000 metric tons of heavy metal (MTHM) as spent reactor fuel, about as much as would be generated during the operating lifetimes of 100 reactors of current design. The initial amounts of some of the principal radionuclides in this model repository would be: eight billion curies of cesium-137; six billion curies of strontium-90; 200 million curies of americium-241; 30 million curies of plutonium-239; and one million curies of technetium-99.

We examined the capabilities of waste canisters, waste chemical forms, repository design, and geologic media to prevent or delay the release of radionuclides. We selected reasonably achievable characteristics for each portion of the disposal system. For accidental releases, we estimated the probabilities of events leading to releases. Intentional disruption of the disposal system was not considered.

Radionuclides were considered to be released from the disposal system if they reach the "accessible environment," which includes: surface waters, land surfaces, the atmosphere, and underground formations which might provide ground water for human consumption. Including these formations in the definition of "accessible environment" protects aquifers which might become significant sources of water in the future, regardless of whether they are now being used as water supplies.

We propose to use the designations to be established under Agency regulations for underground injection control (UIC) programs (40 CFR 146) to identify ground water supplies which should be part of the "accessible environment." Under these rules, most geologic formations which can provide useable quantities of water with a total dissolved solids (TDS) content less than 10 grams per liter are protected. Specific exceptions can be made for formations which are impractical sources of water, for example, because of depth or low productivity.

We plan to make one exception to the UIC procedure. The proposed disposal standards do not limit releases to geologic formations which are within one mile of a disposal system, because the formation itself can be an important barrier in a disposal system. A one-mile distance is long enough to allow significant retention of radionuclides by geologic barriers, but short enough so that only a very small part of available ground water could be significantly contaminated.

Our regulations and the assessments on which we base them cover releases of radionuclides to the accessible environment for a period of 10,000 years after disposal. We believe that a disposal system capable of meeting these requirements for 10,000 years will continue to protect people and the environment beyond 10,000 years. We selected 10,000 years as the assessment period for three reasons:

1. It is long enough for releases through groundwater to reach the accessible environment. If we had selected a shorter time, such as 1,000 years, our estimates of radionuclides reaching the accessible environment would be deceptively low, because groundwater could take 1,000 years to travel a mile at a well-selected site, and most radionuclides would take much longer. Choosing 10,000 years for assessment encourages selection of sites where the geochemical properties of the rock formations can significantly reduce releases of radioactivity through groundwater.

2. Major geologic changes, such as development of a faulting system or a volcanic region, take much longer than 10,000 years. Thus the likelihood and characteristics of geologic events which might disrupt the disposal system are reasonably predictable over this period.

3. Radioactive decay will reduce the radionuclide inventory of the wastes to about 0.1% of its original value in 10,000 years. Any hazards from the radioactivity in the wastes will have decreased to about those from the equivalent amount of unmined ore.

We estimated the amounts of radioactivity that might reach the accessible environment over this time period under various circumstances. Then, the premature deaths from cancer caused by these releases were estimated using very general models of environmental transport and a linear, nonthreshold dose-effect relationship between exposure and cancers caused. This relationship assumes that the number of premature cancer deaths induced in a population is proportional to the total dose received by the population, even at very low individual doses, and does not depend on the population size.

Releases from geologic repositories fall into three general categories. Relatively small releases would be caused by expected processes and by fairly likely but unintended events, such as human intrusions. These processes and events lead to what we call "reasonably foreseeable" releases. Moderate releases would result from much less likely events, such as fault movements or other disruptive geologic events and these we call "very unlikely releases." Very large releases would result only from the intrusion of volcanos or impacts by huge meteorites. If sites are selected away from regions of volcanic activity, these large releases will be extremely unlikely.

We used our estimates of releases and their likelihood to select limits on total releases of radioactivity over 10,000 years. Limits were set for two categories of releases in terms of their probabilities: "reasonably foreseeable," and "very unlikely." Reasonably foreseeable releases are those which have more than one chance in 100 of occurring within 10,000 years. Very unlikely releases are those whose chance of occurring within 10,000 years is less than one in 100 and more than one in 10,000. No limits were set for releases which have less than one chance in 10,000 of occurring within 10,000 years.

Our assessments of repository performance gave estimates of the possible premature cancer deaths expected from releases after disposal. These estimates can vary considerably depending upon the assumptions used and the geologic media considered. For well-designed 100,000 MTHM model repositories in salt and granite, we estimate several hundred premature deaths over 10,000 years. Because our analyses are too uncertain to determine reliably more than the order of magnitude of the risks, we adjusted our estimates to 1,000 premature deaths over 10,000 years for a 100,000 MTHM repository. We then used these adjusted estimates as the basis for calculating the release limits specified in Appendix B of the standards.

According to our model, more of the projected harm from releases results from possible human instrusions than from geologic processes. However, predicting human actions is much more uncertain than predicting natural events. In particular, we could only guess at the frequency at which some actions (such as drilling for resources) would be taken. We considered setting separate performance requirements that would limit the radioactivity that could be released by any one likely human intrusion, in order to avoid having to estimate such frequencies. However, we did not do this because: (1) setting separate requirements for natural and human events would not place an upper limit on risk; and (2) setting separate requirements for individual intrusions in addition to the total combined requirements would not appreciably increase confidence that the overall limits would be met unless we made the individual limits unreasonably low. We specifically request comments on this issue.

The release limits are given in Table 1 in terms of curies per 1,000 MTHM. The release limit for each radionuclide is the number of curies of that radionuclide that we estimate could cause 1,000 premature deaths over 10,000 years if it were the only radionuclide released from a 100,000 MTHM repository. For releases involving more than one radionuclide, the allowed release for each radionuclide is reduced to the fraction of its limit that insures that the overall limit on harm is not exceeded. For transuranic wastes, the release limits are in units of an amount of wastes containing three million curies of alpha-emitting transuranic radionuclides. These units were chosen so that the standards would require alpha-emitting radioactivity from either high-level or transuranic wastes to be isolated with about the same degree of effectiveness. This procedure for using the release limits is described in Appendix B to the proposed standards. Compliance with these performance requirements will be achieved if the projected releases from a disposal system do not exceed these release limits.

EFFECTS ON HEALTH

A disposal system that could hold wastes from 100,000 MTHM could contain all existing wastes and the future wastes from all currently operating reactors. We estimate that this quantity of wastes, when disposed of in accordance with the proposed standards, would cause no more than 1,000 premature deaths from cancer in the first 10,000 years after disposal: an average of one every 10 years.

Our estimate of 1,000 deaths over 10,000 years is not intended to be a precise projection of the actual risk from waste disposal. Food chains, ways of life, and the size and geographical distributions of populations will undoubtedly change over any 10,000 year period. Unlike geological processes, factors such as these cannot be accurately predicted over long periods of time. Thus, in making our health effects projections we found it necessary to depend upon the use of very general models of environmental pathways, and to assume current population distributions and death rates. As a consequence, these projections are intended to be used primarily as a tool for comparing the performance of one waste disposal system to another and for comparison of the risks of waste disposal with those of undisturbed ore bodies. The results of our analysis should not be considered a reliable projection of the "real" or absolute number of health effects resulting from compliance with our standards.

Most of the excess cancer deaths caused by the waste would occur more than 1,000 years after disposal. This discontinuity between when the wastes are generated and when the projected health effects manifest themselves has resulted in a particularly difficult problem in determining what level of residual risk should be reasonably permitted by these standards. The difficulty arises from the fact that most of the benefits derived in the process of waste production fall upon the current generation while most of the risks fall upon future generations. Thus, a problem of intergenerational equity with respect to the distribution of risks and benefits becomes apparent. This problem is sometimes referred to as the intergenerational risk issue, and it is not unique to the disposal of high-level radioactive wastes. If we were to insure that our standards fully satisfy a criterion of intergenerational equity with respect to the distribution of risks and benefits, it appears we should require that no risk be passed on to future generations. This is a condition which we conclude cannot be met by disposal technologies foreseeable within this century.

In the face of this dilemma, we are left with two major options: (1) delay setting standards in the hope that future technologies would provide better control, or (2) proceed to set standards on the basis of the best technology that can reasonably be achieved given current scientific, technical, and fiscal capabilities. We have chosen the latter approach. In so doing we have made the judgment that current knowledge is sufficient to allow for the development of repositories which will reduce risks to a reasonable level. We believe these risks are reasonable because they are very small and the only alternative available is to delay disposal to some indefinite time in the future.

There is one additional factor which has contributed to our decision on the reasonableness of the risks permitted under our proposed standards. This is an analysis we have prepared of the risks associated with undisturbed uranium ore bodies.

<u>Uranium Ore:</u> Most uranium ore in the United States occurs in permeable geologic strata containing flowing ground water. Radionuclides in the ore, particularly uranium and radium, continuously enter this

ground water. We estimated the harm from these undisturbed ore bodies using the same environmental models that we used for releases from the waste repository. The effects associated with the amount of ore needed to produce the high-level wastes that would fill the model geologic repository can vary considerably. Part of this variation corresponds to actual differences from one ore body to another; part can be attributed to uncertainties in the assessment. The estimates ranged from 300 to 1,000,000 excess cancer deaths over 10,000 years. Thus, leaving the ore unmined presents at least as great a risk to future generations as disposal of the wastes covered by these standards.

It remains unclear to us whether this analysis provides an adequate means of resolving the question of intergenerational risk. It has, however, helped to influence our decision of what is an acceptable level of residual risk given our current scientific, technological, and fiscal capabilities. We particularly invite comment upon the questions of intergenerational risk and the acceptability of risk. Additionally, for purposes of comparisons of risks permitted under the standards to radiation risks we are currently exposed to, we have included a brief discussion of the risks from natural background and from the uranium fuel cycle.

<u>Variations in Natural Background:</u> Radionuclides occur naturally in the earth in very large amounts, and are produced in the atmosphere by cosmic radiation. Everyone is exposed to natural background radiation from these natural radionuclides and from direct exposure to cosmic

radiation. These natural background radiation levels have remained relatively constant for a very long time. According to the same linear, nonthreshold dose effect relationship used in the other analyses, an increase of one millirem per year (about one percent) in natural background in the United States would result in about 40 additional deaths per year, or 400,000 over a 10,000 year period. Natural background rates vary within the United States by tens of millirems per year, and future generations will experience this same variation.

Nuclear Power Generation: The model geologic repository considered in developing these standards contains the wastes produced in generating about 3,000 gigawatt-years of electricity. This is the output of about 100 large nuclear power plants operating for 40 years each. We estimate that the normal operations of these reactors and their supporting facilities, such as uranium mills and fuel fabrication plants (but excluding uranium mines), will cause about 3,000 excess deaths in the first 100 years after the power is produced. (These estimates do not include deaths from any accidental radioactive releases at these facilities.) Therefore, risks to future generations from disposal of high-level wastes are significantly less than the risks to the generations receiving the immediate benefits from the electric power generated.

ECONOMIC ANALYSIS

The proposed standards for disposal of high-level radioactive wastes will be applied to a developing technology, where the available information base is still incomplete. Therefore, it is difficult to determine the added costs of compliance with the standards. Instead, we have designated a reference program, which is based on disposal cost estimates previously published by DOE. We then increased these DOE estimates to allow for additional expenditures which might be needed to implement a high-level waste disposal program in full compliance with our proposed standards and guides. The difference between the cost of the reference program and the cost of a program in compliance with these proposed standards does not necessarily represent the cost of implementing these standards. In fact, it seems likely that prudent considerations and current public opinion will require that any waste disposal method will cost more than the earlier DOE estimates. Thus, the incremental difference represents our estimate of the maximum potential economic impact of the proposed standards. Commercial and military high-level wastes are considered separately in this section.

Commercial Waste

We assumed a reference waste management and disposal program based upon studies performed by DOE to support the President's spent fuel policy. This reference program involves the geologic disposal of spent fuel in salt formations using carbon steel canisters. We based our estimates of the economic impacts of this reference program on potential charges to utilities for waste management services to be provided by the Government. From the DOE analyses, we estimate that the cost to utilities in 1990 would range from 0.6 to 1.4 (1978) mills per kwh. The total annual cost for 1990 would be 500 million to 1.2 billion (1978) dollars. This charge covers all waste management costs, except for reactor site storage of spent fuel. The year 1990 was selected because the DOE estimates were based on the waste management program being established by then.

We assessed the costs, above those for the reference program, that might be caused by our proposal. First, we estimated the cost for each component involved in the management and disposal of spent fuel. The costs of the management and disposal of spent fuel include: storage of spent fuel for ten years after discharge from the reactor, which covers both reactor-site and away-from-reactor storage; transportation of the spent fuel from the storage site to a facility designed for encapsulation of the waste; the encapsulation of the waste, which includes the necessary handling and processing before disposal; disposal in a geologic repository; Government research and development; Government overhead; and decommissioning of waste management facilities and post-operational activities.

Three of these components may be affected by this action. Encapsulation costs may be larger if compliance requires more durable canisters (e.g., stainless steel or titanium canisters). Disposal costs, which include constructing, operating, and backfilling a geologic repository, will be affected if compliance requires the use of geologic media which are more expensive to mine than salt formations (e.g., granite). Research and development costs may increase because of additional site evaluation and additional research for improved control technologies (e.g., more stable waste forms). Based on these three possible effects, we estimate that the proposed action could result in commercial waste management costs up to 50 percent larger than those for the reference program. The total waste management costs would increase the cost of nuclear generation of electricity by about 10 percent. We estimate the total annual cost of the waste management program in compliance with the standards in 1990 as no more than 1.8 billion (1978) dollars. These waste management and disposal costs would be less than 3 percent of total electric utility revenues in 1979, and should be a smaller portion of future revenues. Thus, they should cause no more than a 3 percent average increase in future electricity rates.

Military Waste

We considered a DOE reference program based on disposal in on-site geologic repositories. We estimated that the total cost of this reference program would be about 3.7 billion (1978) dollars to dispose of all existing military wastes and additional military wastes generated through 1990. The present value of this reference program cost, at a discount rate of 10 percent, is 1.8 billion (1978) dollars.

Our proposed requirements could increase this cost in five areas: waste processing, encapsulation, transportation, disposal, and research and development. In the reference program, long-lived technetium-99 would be left in processed salt cake and stored in existing on-site tanks. Under our standards, additional processing would be required to separate technetium-99 for disposal. Encapsulation costs would be increased if a canister providing greater protection is needed. Transportation would cost much more if the high-level wastes must be disposed of off-site. If the selected off-site geologic media are more difficult to mine than the on-site media, disposal costs may be increased. Research and development costs would be increased because more extensive site evaluation and research on better control technologies may be needed.

We calculated the extra costs for each of these areas, considering both projected costs and potential delays. We estimated that the extra costs could be as large as 1.7 billion (1978) dollars, for a total defense waste program cost of 5.4 billion (1978) dollars. This would be an increase of almost 50 percent over the cost of the reference program. Our estimate of the present value of the additional cost is 320 million (1978) dollars, for a total discounted cost for the defense waste program of 2.1 billion (1978) dollars. This would be an increase of less than 20 percent over the discounted cost of the reference program.

IMPLEMENTATION

Standards for operations (Subpart A) will be implemented by the NRC for commercial nuclear power activities and by the DOE for national defense facilities. Implementation procedures for Subpart A will be very similar to those for the Uranium Fuel Cycle Standards (40 CFR 190).

DOE will select, design, and construct all disposal facilities for high-level and transuranic wastes. Our requirements for disposal (Subpart B and Appendix A) will be implemented by NRC for all high-level wastes, whether the wastes come from commercial or military activities. NRC will do this by developing the necessary regulations (primarily 10 CFR 60) and by issuing appropriate licenses to DOE. Under current law, disposal of transuranic wastes from military activities is not regulated by NRC; therefore, DOE will apply our requirements to the disposal of these transuranic wastes.

The standards for disposal must be implemented through design specifications. The implementing agency will have to evaluate long-term performance projections of the designed system. As a result, a vital part of implementation will be the use of adequate models, including the probabilities of unplanned events, to relate appropriate site and engineering data to projected performance.

The NRC has made substantial progress in developing such analytical models to predict long-term performance of actual geologic repositories. These models include estimates of the effects of uncertainties in the data. Thus, they give information about needs for obtaining better data to determine if repositories meet the projected performance requirements of these standards.

At our request, the National Academy of Sciences (NAS) studied the difficulties in verifying compliance with the long-term environmental protection requirements for geologic disposal. They have developed an approach that specifies the types of information needed and outlines appropriate methods for obtaining this data at prospective sites.

Based on the NAS study, NRC's models, and our own analytical efforts, we have concluded that these disposal standards can be implemented. We believe that it would be best if implementing agencies use generic rulemaking proceedings. Such proceedings would consider comprehensive risk assessments which calculate potential releases of radionuclides from various events or processes. The assessments would identify the important engineering design and site selection parameters and would indicate how potential releases depend on these parameters. The generic proceedings would then be able to establish limits for the important design and site parameters which, if met, would provide a reasonable expectation of compliance with these standards. Only these limits would need to be satisfied in subsequent licensing actions. We believe generic proceedings are the best way to proceed because the methods needed to address uncertainties could be developed more easily through generic rulemaking than in specific licensing actions.

DATED:

Administrator

A new Part 191 is proposed to be added to Title 40, Code of Federal Regulations, as follows:

SUBCHAPTER F -- RADIATION PROTECTION PROGRAMS

PART 191 - ENVIRONMENTAL RADIATION PROTECTION STANDARDS FOR MANAGEMENT AND DISPOSAL OF SPENT NUCLEAR FUEL, HIGH-LEVEL AND TRANSURANIC RADIOACTIVE WASTES

Subpart A - Environmental Standards for Management and Storage

191.01 Applicability

191.02 Definitions

191.03 Standards for Normal Operations

191.04 Variances for Unusual Operations

191.05 Effective Date

Subpart B - Environmental Standards for Disposal

191.11 Applicability

191.12 Definitions

191.13 Projected Performance Requirements

191.14 Effective Date

Appendices

Appendix A General Criteria for Disposal of High-Level and Transuranic Radioactive Wastes

Appendix B Release Limits for Projected Performance Requirements

AUTHORITY: The Atomic Energy Act of 1954, as amended; Reorganization Plan No. 3 of 1970.

SUBPART A - ENVIRONMENTAL STANDARDS FOR MANAGEMENT AND STORAGE

191.01 Applicability

This Subpart applies to radiation doses received by members of the public as a result of the management (except for transportation) and storage of spent nuclear fuel, high-level, or transuranic radioactive wastes, to the extent that these operations are not subject to the provisions of Part 190 of Title 40.

191.02 Definitions

Unless otherwise indicated in this Subpart, all terms shall have the same meaning as in Subpart A of Part 190.

(a) "Spent nuclear fuel" means any nuclear fuel removed from a nuclear reactor after it has been irradiated.

(b) "High-level radioactive wastes" means: (i) wastes resulting from the operation of the first cycle solvent extraction system, or equivalent, in a facility for reprocessing spent nuclear fuels; (ii) the concentrated wastes from subsequent extraction cycles, or equivalent; (iii) solids derived from such wastes; or (iv) spent nuclear fuel if disposed of without reprocessing.

(c) "Transuranic wastes," as used in this Part, means wastes containing more than 100 nanocuries of alpha emitting transuranic isotopes, with half-lives greater than one year, per gram of waste.

(d) "Storage" means placement of radioactive wastes with planned capability to readily retrieve such materials.

(e) "Management and storage" means any activity, operation, or process, except for transportation, conducted to prepare spent nuclear fuel, high-level or transuranic radioactive wastes for storage or disposal, the storage of any of these materials, or activities associated with the disposal of these materials.

(f) "General environment" means the total terrestial, atmospheric, and aquatic environments outside sites within which any operation associated with the management and storage of spent nuclear fuel, high-level or transuranic radioactive wastes is conducted.

(g) "Member of the public" means any individual who is not engaged in operations involving the management, storage, and disposal of materials covered by these standards and guides. A worker so engaged is a member of the public except when on duty at a site.

191.03 Standards for Normal Operations

Operations covered by this Subpart should be conducted so as to reduce exposures to members of the public to the extent reasonably achievable, taking into account technical, social, and economic considerations. As an upper limit, except for variances in accordance with 191.04, these operations shall be conducted in such a manner as to provide reasonable assurance that the combined annual dose equivalent to any member of the public due to: (i) operations covered by Part 190, (ii) planned discharges of radioactive material to the general environment from operations covered by this Subpart, and (iii) direct radiation from these operations; shall not exceed 25 millirems to the whole body, 75 millirems to the thyroid, or 25 millirems to any other organ.

191.04 Variances for Unusual Operations

The standards specified in 191.03 may be exceeded if:

(a) The regulatory agency has granted a variance based upon its determination that a temporary and unusual operating condition exists and continued operation is in the public interest, and

(b) Information is promptly made a matter of public record delineating the nature of the unusual operating conditions, the degree to which this operation is expected to result in levels in excess of the standards, the basis of the variance, and the schedule for achieving conformance with the standards.

191.05 Effective Date

The standards in this Subpart shall be effective 12 months from the promulgation date of this rule.

SUBPART B - ENVIRONMENTAL STANDARDS FOR DISPOSAL

191.11 Applicability

This Subpart applies to radioactive materials released into the accessible environment as a result of the disposal of high-level or transuranic radioactive wastes, including the disposal of spent nuclear fuel. This Subpart does not apply to disposal directly into the oceans or ocean sediments.

191.12 Definitions

Unless otherwise indicated in this Subpart, all terms shall have the same meaning as in Subpart A of this Part.

(a) "Disposal" means isolation of radioactive wastes with no intent to recover them.

(b) "Underground sources of drinking water" means aquifers which have been designated as such under Part 146 of Title 40.

(c) "Accessible environment" means the Earth's atmosphere, land surface, surface waters, and those underground sources of drinking water that are more than one mile in any direction from the original location of the radioactive wastes in a disposal system.

(d) "Barriers" means any materials or structures that prevent or substantially delay movement of the radioactive wastes toward the accessible environment.

(e) "Disposal system" means any combination of engineered and natural barriers that contains radioactive wastes after disposal.

(f) "Reasonably foreseeable releases" means releases of radioactive wastes to the accessible environment that are estimated to have more than one chance in 100 of occurring within 10,000 years.

(g) "Very unlikely releases" means releases of radioactive wastes to the accessible environment that are estimated to have between one chance in 100 and one chance in 10,000 of occurring within 10,000 years.

(h) "Performance assessment" means an analysis which identifies those events and processes which might affect the disposal system, examines their effects upon its barriers, and estimates the probabilities and consequences of the events. The analysis need not evaluate risks from all identified events. However, it should provide a reasonable expectation that the risks from events not evaluated are small in comparison to the risks which are estimated in the analysis. The analysis should address the uncertainties in the estimates. To provide reasonable confidence in its results, the analysis shall be subjected to peer review by technically competent individuals independent of the organization preparing the assessment.

(i) "Heavy metal" means all uranium, plutonium, or thorium placed into a nuclear reactor.

191.13 Projected Performance Requirements

(a) Disposal systems shall be designed to comply with the projected performance requirements of this section. These requirements are upper limits. In accordance with Appendix A, the implementing agency should establish design objectives which will reduce releases as far below these limits as reasonably achievable.

(b) Disposal systems for high-level or transuranic wastes shall be designed to provide a reasonable expectation, based upon quantitative performance assessments, that for 10,000 years after disposal:

(1) Reasonably foreseeable releases of waste to the accessible environment are projected to be less than the quantities calculated according to Appendix B.

(2) Very unlikely releases of waste to the accessible environment are projected to be less than ten times the quantities calculated according to Appendix B.

191.14 Effective Date

The standards in this Subpart shall be effective immediately upon promulgation of this rule.

APPENDIX A - GENERAL GUIDANCE FOR DISPOSAL OF HIGH-LEVEL AND TRANSURANIC RADIOACTIVE WASTES

The general guidance recommended in this appendix, when approved by the President, would provide radiation protection guidance to all Federal agencies in accordance with Executive Order 10831 and 42 U.S.C. 2021(h). Disposal systems for high-level or transuranic wastes should comply with each of the following recommendations:

Recommendation 1: Wastes should be disposed of promptly once disposal systems which comply with these standards are developed.

Recommendation 2: Disposal systems should be designed to keep releases to the accessible environment as small as reasonably achievable, taking into account technical, social, and economic considerations.

Recommendation 3: Disposal systems should use several different types of barriers to isolate the wastes from the accessible environment. Both engineered and natural barriers should be included. Each such barrier should separately be designed to provide substantial isolation, regardless of how well the other barriers perform.

Recommendation 4: Active institutional controls should not be relied upon to isolate the wastes for more than 100 years after disposal.

Recommendation 5: Disposal systems should be identified by the most permanent markers and records practicable to indicate the dangers of the wastes and their location.

Recommendation 6: Disposal systems should not be located where there has been mining for resources or where there is a reasonable expectation of exploration for scarce or easily accessible resources in the future. Furthermore, disposal systems should not be located where there is a significant concentration of any material which is not widely available from other sources.

Recommendation 7: Disposal systems should be designed so that most of the wastes may be recovered if this is found necessary in the future, unless the wastes are removed from the Earth.

DEFINITIONS:

(1) "Active institutional controls" means maintaining an institutional capability to: (i) restrict or deny access, (ii) monitor, terminate, or clean up releases to the accessible environment, or (iii) preserve knowledge about the location, design, or inventory of a disposal site.

(2) All other terms shall have the same meaning as in 40 CFR 191.

APPENDIX B - RELEASE LIMITS FOR

PROJECTED PERFORMANCE REQUIREMENTS

NOTE 1: The Release Limits in Table 1 apply either to the amount of high-level wastes generated from 1,000 metric tons of heavy metal (MTHM), or to an amount of transuranic (TRU) wastes containing three million curies of alpha-emitting transuranic radionuclides. To develop Release Limits for a particular disposal system, the quantities in Table 1 shall be adjusted for the amount of wastes included in the disposal system. For example:

(a) If a particular disposal system contained the high-level wastes from 50,000 MTHM, the Release Limits for that system would be the quantities in Table 1 multiplied by 50 (50,000 MTHM divided by 1,000 MTHM).

(b) If a particular disposal system contained 15 million curies of transuranic wastes, the Release Limits for that system would be the quantities in Table 1 multiplied by five (15 million curies divided by three million curies).

(c) If a particular disposal system contained both the high-level wastes from 50,000 MTHM <u>and</u> 15 million curies of transuranic wastes, the Release Limits for that system would be the quantities in Table 1 multiplied by 55:

$$\frac{50{,}000 \text{ MTHM}}{1{,}000 \text{ MTHM}} + \frac{15{,}000{,}000 \text{ curies TRU}}{3{,}000{,}000 \text{ curies TRU}} = 55$$

NOTE 2: In cases where a mixture of radionuclides is projected to be released, the limiting values shall be determined as follows: For each radionuclide in the mixture, determine the ratio between the cumulative release quantity projected over 10,000 years and the limit for that radionuclide as determined from Table 1 and Note 1. The sum of such ratios for all the radionuclides in the mixture may not exceed one.

For example, if radionuclides A, B, and C are projected to be released in amounts Q_a, Q_b, and Q_c, and if the applicable Release Limits are RL_a, RL_b, and RL_c, then the cumulative releases over 10,000 years shall be limited so that the following relationship exists:

$$\frac{Q_a}{RL_a} + \frac{Q_b}{RL_b} + \frac{Q_c}{RL_c} \leq 1$$

TABLE 1 - CUMULATIVE RELEASES TO THE ACCESSIBLE ENVIRONMENT

FOR 10,000 YEARS AFTER DISPOSAL

Radionuclide	Release Limit (curies per 1000 MTHM)
Americium-241	10
Americium-243	4
Carbon-14	200
Cesium-135	2000
Cesium-137	500
Neptunium-237	20
Plutonium-238	400
Plutonium-239	100
Plutonium-240	100
Plutonium-242	100
Radium-226	3
Strontium-90	80
Technetium-99	2000
Tin-126	80
Any other alpha-emitting radionuclide	10
Any other radionuclide which does not emit alpha particles	500