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AN APPROACH TO RADIOLOGICAL ASSESSMENT FOR COMMERCIAL WASTE MANAGEMENT[a]

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DISCLAIMER

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INTRODUCTION

The Department of Energy (DOE) is preparing a Generic Environmental Impact Statement for Management of Commercially Generated Radioactive Waste (GEIS), to aid in decision making regarding preferable methods for managing commercially-generated, postfission radioactive wastes. The statement covers the collection, treatment, packaging, interim storage, transportation, and final isolation of primary and secondary waste materials from accidents and from the operation and decommissioning of various facilities in selected fuel cycle options. Cumulative effects of waste management associated with a specified fuel cycle option through the year 2050 are also covered.

A detailed engineering description of alternative waste management facilities, plants, and fuel cycles and of an integrated system is being prepared and will be published separately. The information in this document provides the technical bases for environmental assessment of waste management activities. A detailed assessment of the environmental effects of operating these waste management facilities, plants, and fuel cycles and the integrated system is being prepared and will also be published separately.

Preliminary drafts of all of these documents are being reviewed by the document authors, DOE, and selected Federal groups. An overview of the scope of the documents and the methods used to prepare them is presented in this paper. The results of the work will be presented after the documents are made public.

PURPOSE AND SCOPE

The primary purpose of radioactive waste management is the protection of the human environment from radioactive wastes

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produced in the light-water reactor (LWR) fuel cycle. The generic facilities and assessments presented in the impact statement are intended to provide a current view of waste management options and of the effects waste management activities may have on the environment.

Radiological assessments were conducted for alternative waste management facilities operated for 1) the so called once-through or "no reprocessing" option, 2) fuel reprocessing that includes uranium-only recycle, and 3) uranium and plutonium recycle options for the LWR fuel cycle. Alternatives considered for the once-through fuel cycle include immediate isolation (fuel cooled for 6-1/2 yr), and deferred (long-term) near-surface storage of spent fuel (deferred in the sense that the decision to dispose of or reprocess the spent fuel is deferred). Alternatives considered for the uranium-only recycle fuel cycle include 1) combining the separated plutonium with the high-level liquid waste (HLLW) and then solidifying the material in borosilicate glass, and 2) converting the plutonium to PuO_2 and storing it in near-surface facilities.

The waste management processes and associated facilities for which radiological analyses were made are listed below for each plant in each fuel cycle.

Once-Through Fuel Cycle

- LWR
  - Decommissioning an LWR
- Independent Spent Fuel Storage Facility (ISFSF)
  - Water basin storage facility for unpackaged spent fuel
  - Spent fuel packaging facility
  - Excess water vaporizor
  - Vent off-gas facility
  - Decommissioning of an ISFSF
- Spent Unreprocessed Fuel Facility (SURFF)
  - Spent fuel receiving facility
  - Water basin storage of packaged spent fuel
  - Sealed cask storage of packaged spent fuel
  - Dry caisson storage of packaged spent fuel
  - Air-cooled vault storage of packaged spent fuel
- Deep Geologic Repository
  - Surface receiving and handling facility
  - Deep mine facility
- Transportation of Spent Fuel as Waste Between Plants

Uranium-Only Recycle Fuel Cycle

- Fuel Reprocessing Plant (FRP)
  - Spent fuel receiving facility
  - Dissolver off-gas treatment facility
  - Vessel off-gas treatment facility
  - HLLW solidification facility
  - Fuel residue treatment facility
  - Liquid waste pretreatment facility
  - Intermediate-level and low-level waste (ILW and LLW) treatment facility
  - Waste immobilization facility
  - Failed equipment treatment facility
  - HLLW, ILW, LLW, krypton, PuO_2, and solidified high-level waste (SHLW) interim storage facilities
  - Atmospheric protection system
  - Decommissioning an FRP
- Independent Retrievable Waste Storage Facility
  - Near-surface storage of transuranic (TRU) ILW and LLW
  - Near-surface storage of PuO_2
  - Near-surface storage of SHLW
- Deep Geologic Repository (see details above)
- Transportation of SHLW, TRU Waste, and PuO_2

Uranium and Plutonium Recycle Fuel Cycle

- Fuel Reprocessing Plant (see details above)
- Independent Retrievable Waste Storage Facility (see details above)
- Deep Geologic Repository (see details above)
- Mixed Oxide Fuel Fabrication Plant (MOX-FFP)
  - Failed equipment treatment facility
  - Atmospheric protection system
  - TRU LLW treatment facilities
  - Waste immobilization facility
  - TRU waste interim storage facility
  - Decommissioning a MOX-FFP
- Transportation of SHLW and TRU Waste

In addition, a radiological environmental assessment was conducted for an integrated system of facilities for a reference LWR economy through the year 2050. The systems and types and numbers of facilities are:

- Once-Through Fuel Cycle
  - ISFSFs (8)
  - Repositories (5)
  - Transportation
- Uranium and Plutonium Recycle Fuel Cycle
  - FRPs (7)
  - MOX-FFPs (10)
  - Repositories (5)
  - Transportation
- Uranium-Only Fuel Cycle with Pu in SHLW
  - FRPs (7)
  - Repositories (5)
  - Transportation
- Uranium-Only Fuel Cycle with PuO_2 Stored
  - FRPs (7)
  - PuO_2 storage facilities (17)
  - Repositories (5)
  - Transportation
- Deferred, Once-Through Fuel Cycle
  - ISFSFs (8)
  - SURFFs (3)
  - Repositories (5)
  - Transportation
- Deferred, Uranium and Plutonium Recycle Fuel Cycle
  - ISFSFs (14)
  - SURFFs (8)
  - FRPs (7)
  - MOX-FFPs (6)
  - Repositories (5)
  - Transportation

The scope of each radiological analysis of waste management activities included calculation of the annual and 70-yr cumulative dose to:

- The work force of each facility
- The maximum individual in the environment (at the site boundary or at the point of maximum χ/Q), from planned and accidental releases
- The population within 80 km of the facility, from planned and accidental releases
- The maximum individual and the population, from transported spent fuel and TRU waste and from transportation accidents

- The maximum individual and population, from decommissioning a plant
- The worldwide population, from planned and accidental releases of ^{3}H, C, and ^{85}Kr.

Health effects from planned releases were also calculated for the regional and worldwide population.

When the various alternatives, options, and modes are considered, the analysis effort was judged equivalent to that required for about 80 separate environmental statements.

METHODS OF ASSESSMENT

To assess the occupational and environmental effects of radioactive effluents, the usual procedures of investigating and evaluating potential effects associated with the operation, postulated accidents, and decommissioning of facilities were followed. Effects were first evaluated at the alternative facility (process) level; reference facilities were then chosen so that aggregate effects could be addressed at the plant level; next, reference plants were combined so that effects could be evaluated for fuel cycle modes; and finally, predicted numbers of plants for a given fuel cycle option were combined so that effects could be evaluated for an integrated fuel cycle system over a fixed period of time. To assess the integrated system, environmental effects were normalized to unit reference plant releases within the specified environment, and then summed over operating modes of fuel cycle options.

Although this statement is generic rather than site-specific, a reference environment was specified to provide a common basis for assessing and comparing the effects of waste management alternatives. The postulated reference environment is typical of certain regions of the north central United States and provides the description of the environmental characteristics (climate, land use, hydrology, water use, ecology, demography, and geography) needed to assess the effects of released radioactive materials.

Operating modes for reference plants were determined by combining selected alternative waste management facilities. Release characteristics, such as stack heights and flow rates, were determined as part of the reference plant descriptions. Fuel types were determined for selected fuel cycle modes and mixes of reactor types for a given time or time period. For all facility, plant, and fuel cycle assessments, the time selected for fuel composition was the year 2000. The integrated system was analyzed for selected fuel cycles over the period 1980-2050.

The environmental radiological effects of planned operations, postulated accidents, and decommissioning were assessed by using the calculated facility source terms, the design characteristics of the reference plants, and the characteristics of the reference environment in combination with accepted dose calculation models and values for environmental parameters. The radiological effects on work forces were assessed by considering radiation exposure guidelines, evaluating facility designs, and studying the exposure histories at similar operating facilities. Maintenance activities were assessed from experience or by evaluation of designs.

Direct radiation from planned operation, maintenance, and decommissioning were considered in determining the effects on the work forces. Releases to the environment from planned operation, maintenance, decommissioning, and postulated accidents were considered in determining the effects on maximum individuals and regional and worldwide populations. Pathways were limited to those stemming from airborne releases: air submersion, inhalation, and ingestion of foods and food products exposed to airborne radioactive materials.

Doses were calculated for the total body, lung, thyroid, and bone for all cases. Where krypton was a major contributor to dose, the skin dose was also calculated. Throughout the statement, total-body doses to individuals and populations were compared with average doses to the same individuals and populations for the same time periods from naturally-occurring sources.

Health effects were calculated using 70-yr cumulative population doses and a stylized model of health effects versus dose. The model used produces a ratio of one health effect (cancer death or serious genetic effect) for each 10,000 man-rem received by a population.

REQUIRED DATA

The data required to carry out the radiological assessment for each waste management facility are provided in the draft document Technology for Commercial Radioactive Waste Management. These data consist principally of:

- Time-dependent radionuclide concentrations of inventories
- The fraction of the facility's input inventory released to the operating cell
- The fraction of the inventory in the cell released to the plant's heating, ventilation, and air conditioning (HVAC) and off-gas systems

- The fraction of the inventory in the ventilation systems released to the environment
- The fraction of the inventory released through excess water vaporizors.

Data were provided for planned releases as well as process upsets and other accidents. Except for a few non-design-basis accidents at repositories, no radioactive materials were postulated to be released to surface or ground waters, or directly to ground. These data, along with values for release parameters of reference plants, the reference environment, dose models, and parametric values for discrimination and use factors, were used to calculate release source terms and radiation doses.

In the BEIR Report,[1] it is stated in summary that evidence to date indicates that no other living organisms are very much more radiosensitive than man. Pathways by which biota other than man may receive radiation doses in the environment are discussed in the comprehensive reports Radioactivity in the Marine Environment[2] and "Transfer of Radioactive Materials from the Terrestrial Environment to Animals and Man."[3] Depending on the pathway being considered, terrestrial and aquatic organisms will receive either approximately the same radiation doses as man or somewhat greater doses. Although no guidelines have been established setting acceptable limits for radiation exposure to species other than man, it is generally agreed that the limits established for humans are also conservative for these species.[4] Therefore, it was concluded that no separate effort was needed to assess the effects on organisms other than man in a generic statement such as this one.

SUMMARY STATEMENT

A radiological assessment was conducted in support of the Generic Environmental Impact Statement for Management of Commercially Generated Radioactive Waste. The assessment considered for individuals and populations the effects of airborne releases of radioactive materials from planned operations, decommissioning, and postulated accidents. Doses to work forces from direct radiation were estimated and health effects in populations were calculated. The preliminary drafts of the statement and the detailed environmental assessment are being reviewed by DOE; the results of this work will be presented after the documents are made public.

REFERENCES

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