

CHAPTER 1

INTRODUCTION

The U.S. Environmental Protection Agency (EPA) is responsible for developing and issuing environmental standards and criteria to ensure that public health and the environment are adequately protected from potential radiation impacts. The EPA is promulgating in 40 CFR Part 197 site-specific environmental standards to protect public health from releases from radioactive materials disposed of or stored in the potential repository to be constructed at Yucca Mountain in Nevada.³ These standards provide the basic framework to control the long-term storage and disposal of three types of radioactive waste:

- Spent nuclear fuel, if disposed of without reprocessing
- High-level radioactive waste from the reprocessing of spent nuclear fuel
- Other radioactive materials that may be placed in the potential repository

The other radioactive materials that could be disposed of in the Yucca Mountain repository include highly radioactive low-level waste, known as greater-than-Class-C waste, and excess plutonium resulting from the dismantlement of nuclear weapons. However, the plans for placement of these materials are very uncertain and therefore, for the purpose of the present rulemaking, the information presented in this Background Information Document (BID) is limited to spent nuclear fuel and high-level radioactive waste. More details about the current and projected inventories of these wastes can be found in Chapter 5 of the BID.

1.1 PURPOSE AND SCOPE OF THE BACKGROUND INFORMATION DOCUMENT

This document presents the technical information used by EPA to understand the characteristics of the Yucca Mountain site and to develop its rule, 40 CFR Part 197. The scope of the BID encompasses the conceptual framework for assessing radiation exposures and associated health risks. In general terms, this assessment discusses the radioactive source term characterization, movement of radionuclides from the repository at Yucca Mountain through the appropriate environmental exposure pathways, and calculations performed to date of doses received by members of the general public.

³ No decision has been made regarding the acceptability of Yucca Mountain for storage or disposal. In this document, the characterization of the Yucca Mountain repository as “potential” is often omitted but always intended.

The significant alternative models for site and engineered barrier performance are presented in the BID to the extent necessary to portray the current understanding of the site and the major uncertainties in that understanding. Most of the technical information discussed in the BID is derived from investigations sponsored by the Department of Energy (DOE). DOE has conducted years of research; most of what is known about Yucca Mountain and the performance of an underground radioactive waste repository is the result of this research. However, where appropriate, information from other sources is presented to supplement the DOE data base, to fill data gaps, and to illustrate alternative conceptualizations of geologic processes and engineered barrier performance.

The BID is not intended to be a technical critique of the investigations conducted by DOE and other parties. Nor is it a regulatory compliance or criteria document. The BID is a summary of the technical information considered by EPA in developing the rationale for, and specifics in, 40 CFR Part 197.

In addition, the BID discusses only those issues related to the disposal of radioactive wastes in a geologic repository. Although additional disposal strategies have been examined by the U.S. and other countries, a geologic repository continues to be the most promising. Technologies to separate and transmute long-lived radionuclides in the waste to a stable form were examined recently by the National Research Council. The Council concluded that such technologies do not obviate the need for a geologic repository. The use of other disposal environments, such as the seabed or natural or artificial islands, is fraught with political issues and therefore considered infeasible. A final alternative of placing the waste into earth's orbit and accelerating it toward the sun may be theoretically possible, but would require decades of technological development and is likely to be much more costly than placing the waste in a geologic repository (NOR97).

Chapter 1 of the BID discusses EPA's regulatory authority for the current rulemaking and summarizes the recommendations of the National Academy of Sciences report to Congress entitled *Technical Bases for Yucca Mountain Standards* (NAS95). A summary of key events in the history of EPA's rulemaking is also included. Chapter 2 provides a brief history of the evolution of radiation protection activities in the United States as well as current U.S. regulatory programs and strategies. A summary of key international programs for high-level waste disposal is presented in Chapter 3. Chapter 4 describes U.S. programs for the management and disposal of high-level radioactive waste and spent nuclear fuel. Current and projected inventories of spent nuclear fuel and DOE defense high-level radioactive waste are presented in Chapter 5. Chapter 6 describes the methodology used by EPA for dose and risk estimation. Chapter 7 provides

descriptions of the natural features of the Yucca Mountain site, the concepts under consideration for the engineered features of a potential repository at the site, and analyses to date concerning safety performance of a disposal system at the site. Chapter 8 describes the environment in the Yucca Mountain region, current conditions of human radiation exposure in the region, and concepts that could be used to evaluate the consequences of radioactivity release from a repository at Yucca Mountain. Chapter 9 discusses Yucca Mountain exposure scenarios and compliance assessment issues, and finally, Chapter 10 provides a literature review of radiological risks from alternatives to geologic disposal of high-level radioactive waste.

1.2 EPA'S REGULATORY AUTHORITY FOR THE RULEMAKING

The standards governing environmental releases from the Yucca Mountain repository have been developed pursuant to the Agency's authorities under the Energy Policy Act (EnPA) of 1992 (Public Law 102-486). Section 801 of this Act directed EPA to promulgate standards to ensure protection of public health from releases from radioactive material in a deep geologic repository to be built at Yucca Mountain (EnPA92). EPA must set standards to ensure protection of the health of individual members of the public. The EnPA also required EPA to contract with the National Academy of Sciences (NAS) to advise the Agency on the technical bases for the Yucca Mountain standards. These standards will apply only to the Yucca Mountain site and are to be developed based upon and consistent with the findings and recommendations of the NAS:

- *...the Administrator shall, based upon and consistent with the findings and recommendations of the National Academy of Sciences, promulgate, by rule, public health and safety standards for protection of the public from releases from radioactive materials stored or disposed of in the repository at the Yucca Mountain site. Such standards shall prescribe the maximum annual effective dose equivalent to individual members of the public from releases to the accessible environment from radioactive materials stored or disposed of in the repository (EnPA92).*

1.3 THE NATIONAL ACADEMY OF SCIENCES RECOMMENDATIONS

In the EnPA, the Congress asked the Academy to address three issues in particular:

- *Whether a health-based standard based upon doses to individual members of the public from releases to the accessible environment will provide a reasonable standard for protection of the health and safety of the general public;*

- *Whether it is reasonable to assume that a system for post-closure oversight of the repository can be developed, based upon active institutional controls, that will prevent an unreasonable risk of breaching the repository's engineered or geologic barriers or increasing exposure of individual members of the public to radiation beyond allowable limits; and*
- *Whether it will be possible to make scientifically supportable predictions of the probability that the repository's engineered or geologic barriers will be breached as a result of human intrusion over a period of 10,000 years (EnPA92).*

To address these questions, the Academy assembled a committee of 15 members representing a range of scientific expertise and perspectives. The committee conducted a series of five technical meetings; more than 50 nationally and internationally known scientists and engineers were invited to participate. In addition, the committee received information from the Nuclear Regulatory Commission (NRC), the Department of Energy (DOE), EPA, Nevada State and county agencies, and private organizations, such as the Electric Power Research Institute.

The committee's conclusions and recommendations are contained in its final report, entitled *Technical Bases for Yucca Mountain Standards*, which was issued on August 1, 1995 (NAS95). In this report, the committee offered the Agency several general recommendations as to the approach EPA should take in developing 40 CFR Part 197. Specifically, the NAS recommended (NAS95, p.2):

- *The use of a standard that sets a limit on the risk to individuals of adverse health effects from releases from the repository. 40 CFR Part 191⁴ contains an individual-dose standard, and it continues to rely on a containment requirement that limits the releases of radionuclides to the accessible environment. The stated goal of the containment requirement was to limit the number of health effects to the global population to 1,000 incremental fatalities over 10,000 years. We do not recommend that a release limit be adopted.*

⁴ In 1985, EPA promulgated 40 CFR Part 191, "Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes" (EPA85a). These are generally applicable environmental standards promulgated under EPA's authority under the Atomic Energy Act of 1954 as amended. As a result of court action, these standards were remanded back to EPA and were subsequently repromulgated in 1993. (See Sections 1.3.1 and 1.3.4 for more detail.)

- *That compliance with the standard be measured at the time of peak risk, whenever it occurs. (Within the limits imposed by the long-term stability of the geologic environment, which is on the order of one million years.) The standard in 40 CFR Part 191 applies for a period of 10,000 years. Based on performance assessment calculations provided to us, it appears that peak risks might occur tens or hundreds of thousands of years or even farther into the future.*
- *Against a risk-based calculation of the adverse effect of human intrusion into the repository. Under 40 CFR Part 191, an assessment must be made of the frequency and consequences of human intrusion for purposes of demonstrating compliance with containment requirements. In contrast, we conclude that it is not possible to assess the frequency of intrusion far into the future. We do recommend that the consequences of an intrusion be calculated to assess the resilience of the repository to intrusion.*

The NAS committee also recommended that policy issues be resolved through a rulemaking process that allows opportunity for wide-ranging input from all interested parties (NAS95).

The committee also addressed each of the specific questions posed to it by the Congress in the EnPA. With regard to the first issue, protecting human health, the NAS committee recommended (NAS95, pp. 4-7):

- *...the use of a standard that sets a limit on the risk to individuals of adverse health effects from releases from the repository.*
- *...the critical-group approach be used in the Yucca Mountain standards.*
- *...compliance assessment be conducted for the time when the greatest risk occurs, within the limits imposed by long-term stability of the geologic environment.*

The NAS also concluded that an individual-risk standard would protect public health, given the particular characteristics of the site, provided that policy makers and the public are prepared to accept that very low radiation doses pose a negligibly small risk. A necessarily important component in the development of a standard for Yucca Mountain is the means of assessing compliance. The NAS committee concluded the following (NAS95, p. 9):

- *...physical and geologic processes are sufficiently quantifiable and the related uncertainties sufficiently boundable that the performance can be*

assessed over time frames during which the geologic system is relatively stable or varies in a boundable manner. The geologic record suggests that this time frame is on the order of 10⁶ years. The Committee further concluded that the probabilities and consequences of modifications by climate change, seismic activity, and volcanic eruptions at Yucca Mountain are sufficiently boundable that these factors can be included in performance assessments that extend over this time frame.

- *...it is not possible to predict on the basis of scientific analyses the societal factors required for an exposure scenario. Specifying exposure scenarios therefore requires a policy decision that is appropriately made in a rulemaking process conducted by EPA.*

With respect to the second and third questions posed by the Congress in Section 801 of the EnPA, the NAS Committee concluded (NAS95, p. 11):

- *...it is not reasonable to assume that a system for post-closure oversight of the repository can be developed, based on active institutional controls, that will prevent an unreasonable risk of breaching the repository's engineered barriers or increasing the exposure to individual members of the public to radiation beyond allowable limits.*
- *...it is not possible to make scientifically supportable predictions of the probability that a repository's engineered or geologic barriers will be breached as a result of human intrusion over a period of 10,000 years.*

1.4 HISTORY OF EPA'S RULEMAKING

Many significant events have occurred in the past 50 years concerning the management of high-level radioactive waste and spent nuclear fuel. Table 1-1 provides a timeline of these events. The following sections describe them in detail.

Table 1-1. Significant Events in the History of High-Level Radioactive Waste and Spent Nuclear Fuel Disposal

Year	Event
1944	Construction of first storage tanks for high-level radioactive waste (HLW).
1949	The Atomic Energy Commission (AEC) initiates work to convert high-level liquid waste into a stable form.
1955	The National Academy of Sciences (NAS) Advisory Committee is established to consider disposal of HLW in U.S.
1957	The NAS suggests geologic disposal be investigated, particularly in naturally occurring salt formations.
1962	The AEC determines waste management to be technically feasible.
1965-1967	Project Salt Vault demonstrates the safety and feasibility of handling and storing waste in salt formations.
1968	The AEC requests NAS to establish a Committee on Radioactive Waste Management (CWRM).
1970	The CWRM concludes that the use of bedded salt is satisfactory for the disposal of radioactive waste.
1970	The AEC announces tentative selection of a site at Lyons, Kansas, for the establishment of a national radioactive waste repository.
1971	The AEC pursues alternative sites for repository.
1974	The AEC publishes its first analysis of methods for long-term management of HLW.
1974	Congress passes the Energy Reorganization Act which abolishes AEC and creates a developmental agency, the Energy Research and Development Agency (ERDA-now DOE) and an independent regulatory commission, the Nuclear Regulatory Commission (NRC), which has authority to regulate DOE facilities used for receipt and storage of HLW.
1976	The Office of Management and Budget (OMB) establishes an interagency task force on commercial HLW.
1976	The Federal Energy Regulatory Commission (FERC) publishes a status report on the management of commercial radioactive waste.
1976	President Ford issues a major policy statement on radioactive waste which includes a charge to the EPA to issue general environmental standards governing releases of radioactive material to the biosphere.
1976	The EPA announces its intent to develop environmental radiation protection criteria for radioactive waste.
1978	The EPA proposes criteria for management and disposal of radioactive wastes.
1978	President Carter establishes the Interagency Review Committee.
1979	The DOE publishes a draft GEIS and decides to concentrate on mined geologic repositories as a means for waste disposal.
1980	President Carter outlines a national radioactive waste management program. The President decides to investigate four to five sites in a variety of environments before a license application is submitted to NRC.
1981	The EPA withdraws its proposed "Criteria for Radioactive Wastes."

Table 1-1. Significant Events in the History of High-Level Radioactive Waste and Spent Nuclear Fuel Disposal (continued)

Year	Event
1982	Congress enacts the Nuclear Waste Policy Act which requires characterization of three sites and construction of a geologic repository available to receive spent nuclear fuel and HLW by 1998.
1982	The EPA proposes 40 CFR Part 191, "Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes."
1985	The EPA issues a final rule under 40 CFR Part 191.
1987	Congress passes the Nuclear Waste Policy Amendments Act which identifies Yucca Mountain as the single site for characterization.
1987	The EPA's 40 CFR Part 191 is remanded by the Court.
1992	Congress enacts the Waste Isolation Pilot Plant Land Withdrawal Act which reinstated sections of 40 CFR Part 191 and exempted Yucca Mountain from the generic disposal standards set forth in Subpart B of 40 CFR Part 191.
1992	Congress enacts the Energy Policy Act and directs EPA to develop regulations for Yucca Mountain.
1993	The EPA issues amendments to 40 CFR Part 191.
1996	The DOE acknowledges it cannot proceed directly to License Application, but only to a determination of site viability, by 1998.
1998	The DOE publishes a "viability assessment" concluding that Yucca Mountain is a promising site for a geologic repository and that work should proceed toward a site recommendation in 2001.
1999	The DOE published a "Draft Environmental Impact Assessment" for a geologic repository at Yucca Mountain.
2000	The DOE published the Total System Performance Assessment for Site Recommendation

1.4.1 Legislative History

EPA has the authority to set generally applicable environmental standards for radioactive releases under the Atomic Energy Act (AEA) of 1954, as amended, and the EPA Reorganization Plan No. 3 of 1970 (NIX70). The basic authority under the AEA, as transferred to the EPA by Reorganization Plan No 3, includes the mandate of:

- ...establishing generally applicable environmental standards for the protection of the general environment from radioactive materials. As used herein, standards mean limits on radiation exposures or levels, or concentrations or quantities of radioactive material, in the general environment outside the boundaries of locations under the control of persons possessing or using radioactive materials (AEA54).*

In 1982, the Nuclear Waste Policy Act (NWPA) (Public Law 97-425) established formal procedures regarding the evaluation and selection of sites for geologic repositories, including procedures for the interaction of State and Federal Governments. The Act established provisions for the selection of at least two independent repository sites. Further, the NWPA limited the quantity of spent nuclear fuel to be disposed of in the initial repository to 70,000 metric tons of heavy metal (MTHM)⁵, or a quantity of solidified high-level radioactive waste resulting from the reprocessing of such a quantity of spent nuclear fuel, until a second repository is in operation (NWP83). The NWPA also reiterated the existing responsibilities of the Federal agencies involved in the national program and provided a timetable for several key milestones to be met by the Federal agencies. As part of this national program, the EPA, pursuant to its authorities under other provisions of law, was required to:

- *...by rule, promulgate generally applicable standards for the protection of the general environment from off-site releases from radioactive material in repositories (NWP83).*

In September 1985, EPA published 40 CFR Part 191, "Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes" (EPA85a). These standards were to apply to all sites for the deep geologic disposal of high-level radioactive waste. In 1987, the U.S. Court of Appeals for the First Circuit responded to a legal challenge by remanding Subpart B of the 1985 standards to the Agency for further consideration.

In December 1987, Congress enacted the Nuclear Waste Policy Amendments Act (NWPAA). The 1987 Amendments Act redirected the nation's nuclear waste program to evaluate the suitability of the Yucca Mountain site as the location for the first high-level waste and spent nuclear fuel repository (NWP87). Activities at all other potential sites were to be phased out. If the Yucca Mountain site is found to be suitable, the President is required to submit a recommendation to Congress to develop a repository at this location. In the event that site characterization activities indicate that Yucca Mountain is an unsuitable site for the repository, the Secretary of Energy is required to inform Congress and the State of Nevada of its findings. The NWPAA prohibits DOE from conducting site-specific activities for a second repository

⁵ This is a measure of the uranium content of the spent nuclear fuel to be emplaced in the repository.

unless authorized to do so by Congress. However, the NWPA does require a report from the Secretary of Energy on the need for a second repository no later than January 1, 2010.

Finally, the Act established a commission to study the need and feasibility of a monitored retrievable storage facility to complement the nation's nuclear waste management program. The commission submitted to Congress (required under the original Act, as amended by Public Law 100-507) a report outlining its recommendations on November 1, 1989 (NWP88, RMR89).

In October 1992, the Waste Isolation Pilot Plant Land Withdrawal Act (WIPP LWA) was enacted. While reinstating certain sections of the Agency's 1985 disposal standards, the Act exempted the Yucca Mountain site from these generic disposal standards (WIP92). However, the EnPA directed the EPA to set site-specific radiation protection standards for the Yucca Mountain disposal system (EnPA92).

As part of the Fiscal Year 1997 appropriation action, the Congress required EPA to perform a comparative assessment of risks associated with management of commercial spent nuclear fuel for three circumstances: permanent storage at the site where it is now stored; one or more centralized storage sites; and deep geologic disposal at Yucca Mountain. This requirement was established in Senate Report 104-320 at page 98 and was retained by conference committee action on the FY 1997 Energy and Water Appropriation Bill which stated that "The language and allocations set forth in House Report 104-679 and Senate Report 104-320 should be complied with unless specifically addressed to the contrary in the conference report and statement of the managers" (Congressional Record, House, September 12, 1996, page H10244).

The requirement was stated in Senate Report 104-320 as follows:

- *Any radiation protection standard proposed by the Environmental Protection Agency for the Yucca Mountain repository should consider specific alternatives to deep geologic disposal at Yucca Mountain and should include an analysis of the comparative risk to the public from each alternative. The alternatives considered should include the permanent storage of nuclear waste at the site where it is now stored and one or more centralized storage sites recommended by the administration for the above-ground, managed storage. The Agency shall evaluate each of these alternatives against the standards proposed for deep geologic disposal at Yucca Mountain.*

1.4.2 The Development of EPA's Role in the Federal Program

Since the inception of the nuclear age in the 1940s, the Federal government has assumed ultimate responsibility for the disposal of spent nuclear fuel and high-level radioactive waste, regardless of whether it is produced by commercial or national defense activities. In 1949, the Atomic Energy Commission (AEC) initiated work aimed at developing systems for converting high-level liquid waste into a stable form. Then, in 1955, at the request of the AEC, an NAS Advisory Committee was established to consider the disposal of high-level radioactive waste within the United States. Its report, issued in 1957, recommended that the AEC continue to develop processes for the solidification of high-level radioactive liquid waste and that naturally occurring salt formations be used as the medium for the long-term isolation of the solidified waste (NAS57)

Project Salt Vault, conducted from 1965 to 1967 by the AEC in an abandoned salt mine near Lyons, Kansas, demonstrated the safety and feasibility of handling and storing waste in salt formations (McC70).

In 1968, the AEC again requested the NAS to establish a Committee on Radioactive Waste Management (CRWM) to advise the AEC on its long-range radioactive waste management plans and to evaluate the feasibility of disposing of solidified radioactive waste in bedded salt. The CRWM convened a panel to discuss the disposal of radioactive waste in salt mines. Based on the recommendations of the panel, the CRWM concluded that the use of bedded salt was satisfactory for the disposal of radioactive waste (NAS70).

In 1970, the AEC announced the tentative selection of a site at Lyons, Kansas, for the establishment of a national radioactive waste repository (AEC70). During the next two years, however, in-depth site studies raised several questions concerning the safe plugging of old exploratory wells and proposed expanded salt mining activities. These questions and growing public opposition to the Lyons site prompted the AEC in late 1971 to pursue alternative sites (DOU72).

In 1976, the Federal government intensified its program to develop and demonstrate a permanent disposal method for high-level radioactive waste. The Office of Management and Budget (OMB) established an interagency task force on commercial wastes in March 1976. The task force defined the scope of the responsibility of each Federal agency's activities on high-level

management, including the preparation of environmental standards for high-level waste by the EPA (LYN76, ENG77a, ENG77b).

Shortly after the interagency task force was formed, the Federal Energy Regulatory Commission (FERC) published a status report on the management of commercial radioactive waste. The report, issued in May 1976, emphasized the need for coordination of administration policies and programs relating to energy and called for an accelerated comprehensive government radioactive waste program plan. The report also recommended that an interagency task force be formed to coordinate activities among the responsible Federal agencies.

Subsequent to its findings, FERC established a nuclear subcommittee to coordinate Federal nuclear policy and programs. The EPA was given the responsibility of establishing general environmental standards governing waste disposal activities, including standards for high-level radioactive waste to be delivered to Federal repositories for long-term management (FER76).

In October 1976, after the OMB interagency task force proposed its plan for spent nuclear fuel and high-level waste management, President Ford issued a major policy statement on radioactive waste. As part of his comprehensive statement, he announced new steps to assure that the United States had the facilities for the long-term management of nuclear waste from commercial power plants. He also reported that experts had concluded that the most practical method for disposing of spent nuclear fuel and high-level radioactive waste would be in geologic repositories located in stable formations deep underground. The EPA was charged with the responsibility of issuing general environmental standards governing releases of radioactive material to the biosphere above natural background radiation levels (FOR76). These standards were to place a numerical limit on long-term radiation releases outside the boundary of the repository.

1.4.3 Early Federal Action

In December 1976, the EPA announced its intent to develop environmental radiation protection criteria for radioactive waste to assure the protection of public health and the general environment (EPA76). These efforts resulted in a series of radioactive waste disposal workshops, held in 1977 and 1978 (EPA77a, EPA77b, EPA78a, EPA78b). Based on issues raised during workshop deliberations, EPA published a Federal Register Notice on November 15, 1978 (43 FR 53262) (EPA78c) of intent to propose criteria for radioactive wastes and to solicit public comments on possible recommendations for Federal Radiation Guidance. In this notice,

EPA presented a set of criteria to address six key waste control decision issues: (1) the types of materials to be categorized as radioactive wastes and subject to control; (2) the efficacy of engineered controls and natural barriers to isolate wastes; (3) the usefulness of social institutions in providing control, especially their viability over time; (4) the potential health risks of wastes (over various time intervals and with differing levels of control); (5) the unacceptability of various levels of risk; and (6) other considerations such as retrievability and communication of waste disposal sites to succeeding generations to ensure continued isolation. As proposed, EPA intended that the initial set of six criteria—each addressing one of the six key issues—would serve collectively as the basis for developing environmental standards for different radioactive waste sources.

During this time, President Carter established the Interagency Review Group (IRG) to develop recommendations for an administrative policy to address the long-term management of nuclear waste and supporting programs to implement the policy. The IRG report re-emphasized EPA's role in developing generally applicable standards for the disposal of high-level waste, spent nuclear fuel, and transuranic waste (DOE79). In a message to Congress in February 1980, the President outlined the content of a comprehensive national radioactive waste management program based on the IRG recommendations. The message called for an interim strategy for disposal of spent nuclear fuel and high-level and transuranic wastes that would rely on mined geologic repositories. The message reiterated that the EPA was responsible for creating general criteria and numerical standards applicable to radioactive waste management activities (CAR80). In March 1981, the EPA withdrew the proposed "Criteria for Radioactive Wastes" because it considered the implementation of generic disposal guidance too complex given the many different types of radioactive waste (EPA81).

In 1982, Congress enacted the NWPA, which established the current national program for the disposal of spent nuclear fuel and high-level waste. The Act assigned DOE the responsibility of siting, building, and operating an underground geologic repository for the disposal of these wastes and directed the EPA to "promulgate generally applicable standards for the protection of the general environment from off-site releases from radioactive material in repositories" (NWP83). In that same year, under the authority of the AEA, the EPA proposed a set of standards under 40 CFR Part 191, "Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes" (EPA82).

After the first comment period on the proposed rule ended in May 1983, the EPA held two public hearings on the proposed standards—one in Washington, DC, and one in Denver, CO. During a second public comment period, EPA requested post-hearing comments (EPA83a, EPA83b). More than 200 comment letters were received during these two comment periods, and 13 oral statements were made at the public hearings. Responses to comments received from the public were subsequently published and released in August 1985 (EPA85b).

In parallel with its public review and comment effort, the EPA conducted an independent scientific review of the technical bases for the proposed 40 CFR Part 191 standards through a special subcommittee of the Agency's Science Advisory Board (SAB). The subcommittee held nine public meetings from January to September 1983 and released a final report in February 1984 (SAB84). Although the SAB review found that the Agency's analyses in support of the proposed standards were comprehensive and scientifically competent, the report contained several findings and recommendations for improvement. The report was publicly released in May 1984, and the public was encouraged to comment on the findings and recommendations (EPA84). Responses to the SAB report were subsequently presented and released in August 1985 (EPA85c).

In February 1985, the Natural Resources Defense Council, the Environmental Defense Fund, the Environmental Policy Institute, the Sierra Club, and the Snake River Alliance brought suit against the Agency and the Administrator because they had failed to comply with the January 1984 deadline mandated by the NWPA for promulgation of final standards. A consent order was negotiated with the plaintiffs that required the standards to be promulgated on or before August 15, 1985. The EPA issued the final rule under 40 CFR Part 191 on August 15, 1985 (EPA85d, EPA85e).

1.4.4 40 CFR Part 191

The 1985 EPA standards for the management and disposal of spent nuclear fuel and high-level and transuranic waste were divided into two main sections, Subparts A and B (EPA85a). Subpart A, which addressed the management and storage of waste, limited radiation exposure to any member of the general public to 25 millirem (mrem) to the whole body and 75 mrem to any critical organ for disposal facilities operated by the Department of Energy, but not regulated by the NRC or an Agreement State. For facilities regulated by the NRC or an Agreement State, the standards endorsed the annual dose limits given in the environmental standards for the uranium

fuel cycle (40 CFR Part 190): 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any critical organ (EPA77c).

Subpart B imposed limits associated with the release of radioactive materials into the environment following closure of the repository. The key provisions of Subpart B were:

- Limits on cumulative releases of radioactive materials into the environment during the 10,000 years following disposal
- Assurance requirements to compensate for uncertainties in achieving the desired level of protection
- Individual exposure limits based on the consumption of ground water and any other potential exposure pathways for 1,000 years after disposal
- Ground water protection requirements in terms of allowable radionuclide concentrations and associated doses for 1,000 years after disposal (EPA85a)

Under sections 191.15 and 191.16 of Subpart B, the annual dose to any member of the general public was limited to 25 mrem to the whole body and 75 mrem to any critical organ. The ground water concentration for beta or gamma emitters was limited to the equivalent yearly whole body or organ dose of 4 mrem. The allowable water concentration for alpha emitters (including radium-226 and radium-228, but excluding radon) was 15 picoCuries/liter (pCi/L). For radium-226 and radium-228 alone, the concentration limit was 5 pCi/L. Appendix A of the standards provided acceptable radionuclide-specific cumulative release limits.

In March 1986, five environmental groups led by the Natural Resources Defense Council and four States filed petitions for a review of 40 CFR Part 191 (USC87). These suits were consolidated and argued in the U.S. Court of Appeals for the First Circuit in Boston. The main challenges concerned:

- Violation of the Safe Drinking Water Act (SDWA) underground injection section
- Inadequate notice and comment opportunity on the ground water protection requirements
- Arbitrary standards, not supported in the record, or not adequately explained

In July 1987, the Court rendered its opinion and noted three findings against the Agency and two favorable judgments. The Court's action resulted in the remand of Subpart B. The Court began by looking at the definition of "underground injection." In the view of the Court, the method envisioned by DOE for disposal of radioactive waste in underground repositories would "likely constitute an underground injection under the SDWA."

Under the SDWA, the Agency is required to assure that underground sources of drinking water will not be endangered by any underground injection. With regard to such potential endangerment, the Court supported part, but not all, of the Agency's approach. Inside the controlled area, the Court ruled that Congress—through the EPA—had allowed endangerment of ground water. However, the Court accepted EPA's approach of using the geological formation as part of the containment.

Outside the controlled area, the Court found that Section 191.15 would allow endangerment of drinking water supplies. In the context of the SDWA, "endangerment" was considered when doses higher than those allowed by the Primary Drinking Water Regulations could occur. Section 191.15 permitted an annual dose of 25 mrem to the whole body and 75 mrem to any critical organ from all pathways. Existing EPA regulations promulgated under the SDWA allowed an annual dose of 4 mrem from drinking water. Although the Court recognized that an exposure level less than 4 mrem could result from the ground water pathway, it rejected this possibility because the Agency stated that radioactivity could eventually be released into the ground water system near the repository and that substantially higher doses could result. Therefore, the Court decided that a large fraction of the 25 mrem limit could be received through the ground water exposure pathway. Accordingly, the Court found that the Part 191 standards should either have been consistent with the SDWA or the Agency should have justified the adoption of a different standard.

The Court stated that the Agency was not necessarily incorrect in promulgating the proposed standards. However, it noted that the Agency never acknowledged the interrelationship of the SDWA and the Part 191 standards nor did it present a reasonable explanation for the divergence between them. The Court also supported the petitioner's argument that the Agency had not properly explained the selection of the 1,000-year limit for individual protection requirements (Section 191.15). The Court indicated that the 1,000-year criterion was not inherently flawed, but rather that the administrative record and the Agency's explanations did not adequately

support this choice. The criterion was remanded for reconsideration, and the Agency was directed to provide a more thorough explanation for its basis.

Finally, the Court found that the Agency did not provide sufficient opportunity for notice and comment on Section 191.16 (Ground Water Protection Requirements), which was added to Subpart B after the standards were proposed. This section was remanded for a second round of notice and comment. There were, however, no rulings issued on technical grounds about Section 191.16.

In August 1987, the Department of Justice petitioned the First Circuit Court to reinstate all of 40 CFR Part 191 except for Sections 191.15 and 191.16, which were originally found defective. The Natural Resources Defense Council filed an opposing opinion. The Court then issued an Amended Decree that reinstated Subpart A, but continued the remand of Subpart B.

In 1992, the WIPP LWA reinstated Subpart B of 40 CFR Part 191, except Sections 191.15 and 191.16, and required the Administrator to issue final disposal standards no later than six months after enactment. On December 20, 1993, EPA issued amendments to 40 CFR Part 191 which eliminated section 191.16 of the original rule; altered the individual protection requirements; and added Subpart C on ground water protection (EPA93). The amended standards represent the Agency's response to the above legislation and to the issues raised by the court pertaining to individual and ground water protection requirements. In so doing, EPA did not revisit any of the regulations reinstated by the WIPP LWA.

The WIPP LWA also exempted Yucca Mountain from the generic disposal standards set forth under 40 CFR Part 191, Subpart B. Pursuant to specific provisions in the EnPA, EPA was charged with setting site-specific environmental radiation standards for Yucca Mountain. The EPA rule, 40 CFR Part 197, is responsive to this mandate.

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